Low Carbon Networks Fund
Full Submission Pro-forma
Section 1: Project Summary

1.1 Project Title:

Fault Level Active Response (FLARE)

1.2 Funding DNO:

Electricity North West

1.3 Project Summary:

*The Department of Industry[1] wrote in 2005 that **active fault level management** will help distribution network operators to quickly connect customers' low carbon demand and generation and at a lower cost than traditional reinforcement.*

By combining innovative technical and commercial solutions with existing assets, the FLARE project will make that vision a reality.

FLARE utilises an intelligent Fault Level Assessment Tool coupled with two novel technical solutions and a revolutionary commercial concept. This commercial concept will benefit customers by establishing a new market in which they can participate to solve network fault level issues.

The Fault Level Assessment Tool provides a platform from which a range of innovative fault level mitigation techniques can be adaptively controlled. FLARE will actively monitor demand and generation on the network, continually assess the fault level and automatically enable one of the innovative techniques when necessary. This is the first time that fault level will be actively managed on 6.6kV, 11kV and 33kV networks.

Combining existing assets and innovative solutions in this way will accelerate the uptake of low carbon demand and renewable generation, avoid the need to replace expensive switchgear and cables prematurely and deliver savings to all distribution network customers.

The FLARE Method releases the same capacity as traditional reinforcement but up to 18 times faster and at much lower cost – up to 80% cheaper – potentially saving GB £2.3 billion by 2050.

1.4 Funding	
1.4.1 Second Tier Funding Request (£k):	**£4 425**
1.4.2 DNO Compulsory Contribution (£k):	**£502**
1.4.3 DNO Extra Contribution (£k):	
1.4.4 External Funding - excluding from NICs (£k):	**£515**
1.4.5 Total Project cost (£k):	**£5 539**

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1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more interlinked Projects with one Project requesting funding from the Low Carbon Networks (LCN) Fund and the other Project(s) applying for funding from the Electricity Network Innovation Competition (NIC) and/or Gas NIC.

1.5.1 Funding requested from the Electricity NIC or Gas NIC (£k, please state which other competition):

1.5.2 Please confirm if the LCN Fund Project could proceed in absence of funding being awarded for the Electricity NIC or Gas NIC Project:

- ☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**
- ☐ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

Project Partners:

ABB
Parsons Brinckerhoff
ENER-G
Impact Research
Combined Heat and Power Association
Schneider Electric
United Utilities

Project Supporters:

The University of Manchester School of Electrical & Electronic Engineering
Tyndall Manchester Centre for Climate Change
Greater Manchester Combined Authority

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
January 2015	October 2018

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title: Steve Cox, Head of Engineering	**1.8.3 Contact Address:** Electricity North West Limited Networks Strategy and Technical Support Hartington Road Preston Lancashire PR1 8LE
1.8.2 Email & Telephone Number: steve.cox@enwl.co.uk 01772 848805	

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Section 2: Project Description

This section should be between 8 and 10 pages.

FLARE will be the first UK demonstration of centralised real time fault level management and of how that assessment can be used to enable innovative fault level mitigation techniques.

Background to fault current and fault level

Normal current and fault current are very different. Normal current is a steady flow of electricity through the network. Fault current occurs only when there is a fault on the network. It is an instantaneous surge of electrical energy, which is **significantly higher** in magnitude than normal current and flows towards the point of the fault. Fault level is **the potential maximum** amount of fault current that will flow when a fault occurs. Additional demand and generation connecting to the network increase fault level. **Fault level fluctuates throughout the day** depending on the network configuration and customers' load / generation. The ability to actively manage and mitigate fault level would be a valuable tool for DNOs.

2.1 Aims and Objectives

FLARE aims to demonstrate that fault current can be managed at lower cost using existing assets and new commercial techniques. It will use intelligent software, namely the **Fault Level Assessment Tool** to continually assess the fault level. Where this is found to be higher than a pre-set threshold, it will issue commands to enable a fault level mitigation technique that will operate in the event of a fault to manage the fault current safely.

FLARE has four objectives:

1. To trial the Fault Level Assessment Tool software;
2. To trial two **technical** and one **commercial** techniques which, when deployed on existing network infrastructure, will provide effective and efficient fault level control;
3. To deliver **novel and highly transferable solutions** that can be applied to the HV and EHV networks by any GB DNO; and
4. To demonstrate **release of network capacity** allowing **quick and lower cost connection for customers'** demand and generation, enabling DNOs to support the UK's decarbonisation strategy.

Problem

The transition to a low carbon economy, guided by The Carbon Plan[2], will encourage greater use of electricity as reliance on fossil fuels reduces. Low Carbon Technologies (LCTs), and more two-way flows of energy arising from the connection of LCTs will present a range of new challenges to DNOs, one of which is an increase in fault current.

DNO networks are designed and operated to provide safe, reliable and cost efficient distribution of electrical energy. On occasion networks experience faults; when these occur, protective devices such as circuit breakers (CBs) safely interrupt the flow of fault current. The purpose of CBs is to remove fault current from the network safely and quickly. All network equipment ie switchgear, cables and overhead lines etc, is designed with a fault current capability rating, also known as the **fault level rating**. The UK standard specifies that network switchgear has a fault level rating of **three seconds** (ie it can **withstand** the flow of fault current for up to three seconds).The purpose of switchgear is to remove fault current from the network safely and within three seconds.

Figure 2.1 below shows the flow of fault current **to the point of the fault**. The total fault current the switchgear will be expected to break is 20 000 amps. For this fault, the network is operating within its designed rating of 21 000 amps.

Low Carbon Networks Fund
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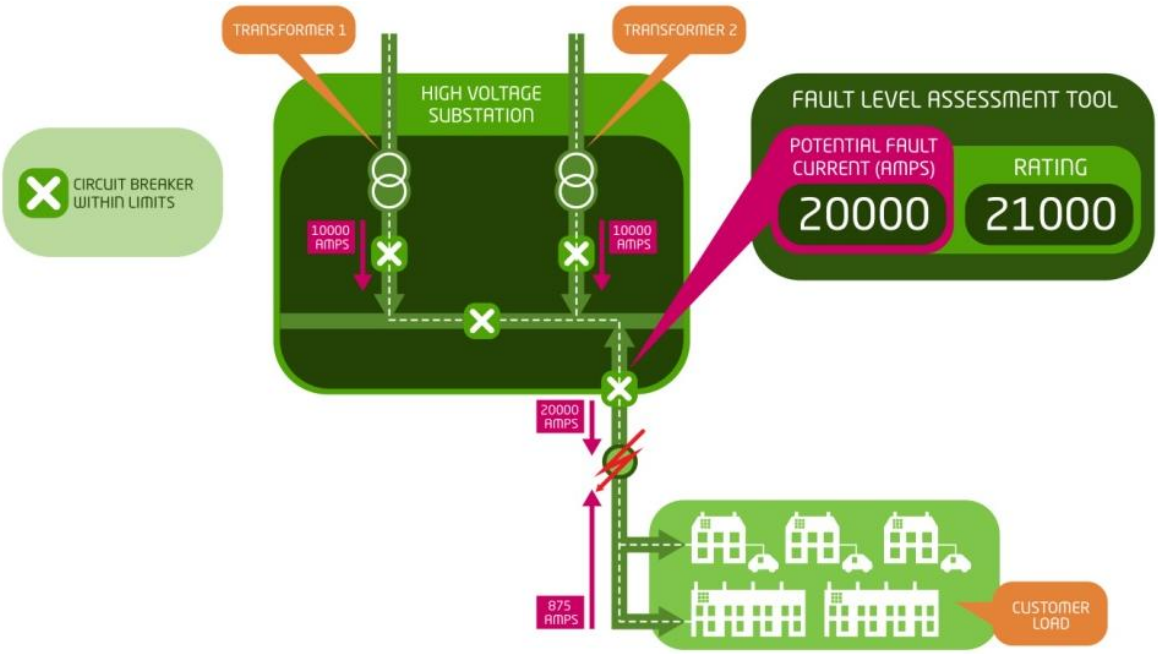
Project Description continued

Figure 2.1: Network operating within fault level rating



In the event that new demand or generation connects to the network, the potential maximum fault current may rise above the network fault level rating. If the network has an excessive fault level then CBs may not be able to interrupt the flow of fault current and could disruptively fail.

What is the effect of this issue?

Fault levels fluctuate on the network throughout the day and there **may only be a short time period when switchgear ratings could be exceeded**. The traditional solution to this issue is to replace existing switchgear with a type that has a higher fault level rating. In RIIO-ED1, the cost of replacement for a single substation is around £500 000 for high voltage (HV) and starts at £1.2m for extra high voltage (EHV). DNOs are required to maintain safe operation, so even if the switchgear rating is only exceeded infrequently, this would trigger asset replacement. Installing expensive, higher specification switchgear in these circumstances could mean the extra fault level capacity installed is effectively unused for the majority of the time.

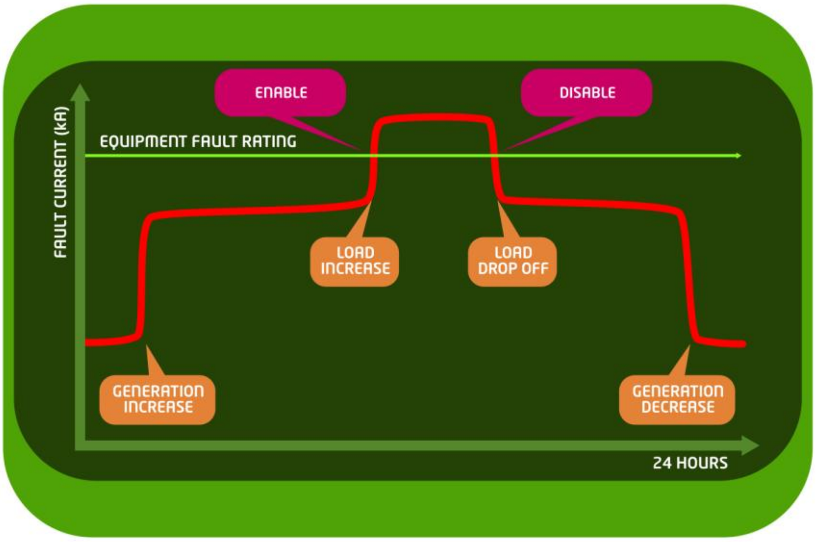
The cost of resolving this issue and the connection time associated with the design, procurement and installation of new switchgear or complete substations can often make it uneconomic for a customer to accept a connection offer. These problems are recognised in the 2013 IET technical report *Electricity Networks – Handling a Shock to the System*[3], which states "one of the principal challenges facing power networks is high fault levels . . ." Given the UK carbon targets, this requires the development of new methods such as FLARE to address this constraint.

The FLARE Method being trialled to solve the Problem

FLARE will be the **first demonstration** of near real time fault level assessment and **adaptive mitigation techniques** to overcome the fault level challenge faced by all DNOs at much **lower cost**.

Our approach is to take advantage of the fault level fluctuations using existing assets. We will achieve this by deploying **intelligent software** together with innovative technical and commercial fault level mitigation techniques alongside **existing assets**. The Fault Level Assessment Tool assesses the potential maximum fault current. When potential fault current exceeds the existing switchgear rating, the Fault Level Assessment Tool will issue an "**enable**" command to one of the innovative fault current mitigation techniques retrofitted alongside existing assets. The FLARE mitigation technique will then only operate if a fault occurs.

Figure 2.2: Fluctuating fault level



The three FLARE techniques, designed to **regulate** fault current across HV and EHV distribution networks, are described in more detail below and will be demonstrated during a two-year live Trials period:

1. **Adaptive Protection** – also known as sequential tripping. This technique re-sequences the operation of CBs and is retrofitted into existing substation equipment.
2. **Fault Current Limiting service (FCL service)** – Industrial, commercial and generation customers can operate their equipment so they can offer fault level management services to DNOs using new technology trialled under FLARE. This **commercial solution** will enable customers to earn rewards and will benefit all distribution customers through reduced reinforcement.
3. **I_S-limiters** – an existing technology used on private networks in the UK and extensively on public networks in Europe, USA and Australia as a fault current mitigation technique. This will be the **first installation of an I_S-limiter** on a GB DNO network. A 2004 report written by Parsons Brinckerhoff *Development of a safety case for the use of current limiting devices*...[4] suggested that installation of I_S-limiters would lead to difficulties in complying with a number of Electricity Safety, Quality and Continuity Regulations (ESQCR) and Electricity at Work regulations. PB Power is the technical support Partner for this Project. Together we aim to demonstrate how these devices can be deployed safely and legally and **unlock the benefits** this technology can provide for customers.

The new fault level mitigation techniques will only operate in those rare occurrences when they are **enabled and a fault occurs**. Standard protection will operate for faults when the technique is disabled. Having this active response ability enables FLARE to extend the useful life of switchgear, benefiting customers, stakeholders and the environment and **avoids the need for costly reinforcement**.

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The Trials being undertaken to test the Method works

The FLARE Project will test the following hypotheses *(in the identified Workstreams)*;

1. The Method is faster and cheaper to apply than traditional reinforcement *(Technology Workstream).*
2. The Method will deliver a buy order of fault level mitigation solutions based on a cost benefit analysis *(Trials & Analysis Workstream).*
3. The Method facilitates the active management of fault current, using a combination of retrofit technologies and commercial services *(Trials & Analysis Workstream).*
4. The Method enables a market for the provision of a FCL service *(Customer and Trials & Analysis Workstreams).*
5. The Method uses existing assets with no detriment to asset health *(Trials & Analysis Workstream).*
6. The Method reduces bills to customers through reduced network reinforcement costs *(Trials & Analysis Workstream).*

Like Capacity to Customers (C_2C)[5], FLARE potentially **offers additional value** to those customers who are willing and able to provide a response to Electricity North West. Within FLARE this takes the form of a Fault Current Limiting service (FCL service).

Prior to the purchase of the FCL services, we will undertake a customer survey with Industrial and Commercial (I&C) demand and generation customers. This survey, led by Impact Research, could include distribution network customers from across GB and is supported by our Project Partners ENER-G, the Combined Heat and Power Association (CHPA) and United Utilities. We have learned from experience in previous projects such as C_2C that collaborating with trusted partner organisations such as those above who have access to third parties, helps us to find the right person to talk to within participant organisations. The aim of the survey is to determine the willingness and ability of customers to provide FCL services and the price at which those customers would consider engaging in the provision of the service.

In the Trial period, we will demonstrate the purchase, implementation and operation of the FCL service with an Electricity North West customer. We will review the number and duration of "enable" and "disable" instructions issued by the Fault Level Assessment Tool and conduct post event analysis to ensure the technologies operate as intended and that a high quality service is maintained. The post fault event analysis will investigate every operation and review the fault type, location and fault current to ensure the FLARE techniques work as intended. In addition, transformers and circuit breakers will be monitored to prove that Adaptive Protection has no detrimental impact on asset health. The Trial data will provide evidence to determine the Cost Benefit Analysis, Carbon Impact Assessment and Safety Case for the design and operating arrangements for each of the FLARE mitigation techniques. **All techniques and applications of technology within FLARE will ensure continued safe operation at all times.**

Solution

The FLARE Method will reduce overall costs of the distribution network, avoid fault level reinforcement and enable much quicker connection of low carbon demand and generation. FLARE could deliver savings for DUoS customers of around **£2.3 billion by 2050** and reduce costs for connections customers. It could also be used to enhance other fault level mitigation techniques such as those being trialled as part of FlexDGrid, a Second Tier LCN Fund project run by Western Power Distribution (WPD)[6].

FLARE could release **127 275MVA** of capacity for the connection of customers' new low carbon generation and demand.

The use of FLARE will open further network configuration options for DNOs. For example, substations previously run with one transformer circuit breaker open to mitigate a known fault level issue will be able to run with both transformers in service thereby increasing the security and quality of supply to customers.

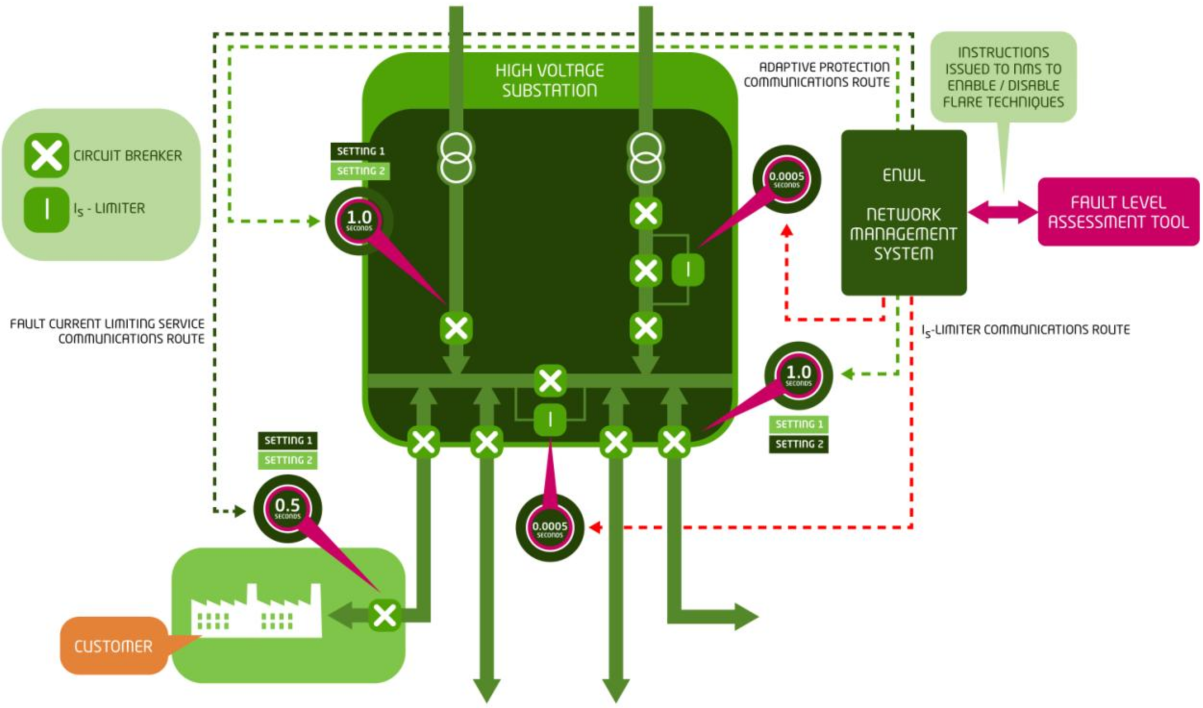
All FLARE and FlexDGrid techniques regulate fault current on HV and EHV networks. We will collaborate with WPD on outputs from both projects. PB Power provides technical support on FlexDGrid and has been selected as the preferred technical support Partner for FLARE. This will enable incremental learning benefits to be maximised by combining knowledge and outputs from both projects. We will compare the techniques and report which would be most beneficial in a range of scenarios. We will then establish a suite of available solutions to inform DNO decisions on fault level mitigation.

2.2 Technical description of Project

This section provides an overview of the technical aspects of FLARE. A more detailed explanation of the technical aspects of FLARE can be found in Appendix B1.

All switchgear on a DNO network has three fault level ratings assigned by the manufacturer: "**through fault withstand", "breaking capacity"** and **"making capacity"**. The through fault withstand is the amount of current that can safely pass through the unit and for what length of time eg 20 000 amps for three seconds. The breaking capacity is the maximum current that the switchgear can safely interrupt. The making capacity is the maximum current which the device can safely conduct at the instant of closing. Fault level changes depending on the network configuration and the amount and type of demand and generation on the network. At the margins of the decision to reinforce or not, there may only be short periods of time where fault level exceeds ratings. The FLARE Method seeks to deploy technologies to manage the breaking capacity and through fault withstand during these short periods, or manage the issue permanently if required, to ensure all switchgear is operated within its ratings. Fault making capacity will continue to be managed by operating protocols.

Figure 2.3: Representation of the FLARE Method



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Central assessment and management of fault levels

FLARE will use the Fault Level Assessment Tool to calculate fault levels in near real time across the Trial areas; using network configuration, generation and demand (MWh and MVArh) data from the Network Management System (NMS). The Fault Level Assessment Tool uses the calculations described in IEC60909 to determine the fault level. Based on predefined settings, the tool will then instruct, via the NMS, a fault level mitigation technique to "enable" or "disable". The techniques will only be enabled at times when the fault level approaches or rises above equipment ratings. The technical concepts of these technologies have been investigated under our First Tier LCN Fund project, Fault Current Active Management (FCAM), to provide an initial understanding of how and where they can be used and to assess their suitability to be deployed as part of an active network management scheme.

Unlike the FlexDGrid project, the FLARE approach to fault level management ensures that the techniques are only enabled **when the fault level is close to or exceeds equipment rating and only operates in the event of a fault during this time.** Appendix L compares the varying technical solutions to fault level management across the FlexDGrid and FLARE projects.

Once the fault is cleared from the system Electricity North West's Automatic Restoration System will reconfigure the network. The Automatic Restoration System is the business as usual fault response, and operates to restore customers within three minutes except those within the isolation points of the fault. For FLARE, this means that customers providing a FCL service will be reconnected within three minutes unless they are without supply due to being within the faulted circuit.

We will install fault level monitors on the network and use the results from these to validate the tolerance and accuracy of the Fault Level Assessment Tool, recognising that there may be a difference between measured and modelled values. The learning WPD has shared with us in respect of the use of the Outram fault level monitors, has allowed us to understand and adopt the most cost effective purchase and application of these devices for validation purposes.

Fault level mitigation techniques

The fault level mitigation techniques fall into two distinct categories: technical solutions which include the Adaptive Protection for distribution switchgear and I_S-limiters and a commercial solution which involves Adaptive Protection for electrical machines: ie alternating current (AC) generators and motors; to facilitate FCL service provision.

Technical Solution 1: **Adaptive Protection** is the use of adjustable protection relay settings that can be changed to alter how the protection scheme operates. The settings are changed on signals from local sensors or a central control system. For FLARE this means that the NMS will, following instruction from the Fault Level Assessment Tool, instruct the relays to switch to alternative settings at times of higher potential fault current to change the sequence of CB tripping. This will usually result in a transformer or bus section switch opening before a feeder CB. In this manner the fault current will be reduced by the first CB opening and then completely interrupted by the feeder CB. Adaptive Protection will be deployed at our HV and EHV substations and may require the installation of new relays with multiple settings groups depending on the type and age of the current protection installation.

Commercial Solution 1: Large AC electrical machines such as motors or generators can contribute significantly to fault current. We are proposing to trial the rapid disconnection of such machines when a network fault occurs. Similar to above, when needed, our NMS will communicate with the AC machine and set it to automatically disconnect should a fault occur. Where possible, the **Adaptive Protection for electrical machines** will use the existing AC machine's protection and trip the customer's motor or generator CB to **enable the FCL service**. The Fault Level Assessment Tool and NMS will instruct the protection to enable its settings at times of higher fault level to ensure that the contribution from the machine is disconnected **only in the event of a fault occurring at those times**.

Technical Solution 2: An **I_S-limiter** is a device capable of detecting and interrupting part of the fault current in less than one millisecond. This fast interruption prevents the fault current reaching its peak value. The electronics in the device use the rate of rise of fault current to calculate what the peak fault current will be. If this peak fault current is larger than a predefined setting the electronics will then trigger the device to operate. I_S-limiters will be deployed as part of the FLARE project and their installation will take one of two forms. At two HV substations, we will install the full I_S-limiter with appropriate settings so that it will operate in the event of a fault. At other substations we will install only the electronic sensing equipment which will detect the fault and issue the command instruction to operate as required. This command instruction will register in the NMS but not actually operate a device. This allows us to trial their functionality and gain increased operation and maintenance learning at much lower cost. As with the other techniques, these devices will only be enabled at times of higher fault level, meaning they will not operate for every fault but **only those faults that may pose a risk to the network**. The I_S-limiters will only be deployed on Trial networks that do not require the operation of the limiter to operate safely.

Asset health

Adaptive Protection will result in some network equipment operating more frequently. To confirm that this change is not detrimental to the health of the assets, we will install monitoring equipment. The results will allow recalculation of the health indices using our standard methodology.

Network management system and interface

To enable FLARE to be deployed, modifications will be made to our NMS to facilitate commands to be sent to the new fault current mitigation devices deployed on the network.

There will be a requirement to label the Trial networks in the NMS and adequately brief and train all relevant operational teams to ensure that they are aware of the new operating regime. All network diagrams will be updated in a timely manner so that the correct information can be passed to the Fault Level Assessment Tool. The network model in the Fault Level Assessment Tool will be updated in line with our NMS to ensure that it remains a true representation of the network.

The NMS will interface with the Fault Level Assessment Tool using a standard inter control communications protocol (ICCP) link. This link, being developed as part of our Second Tier project, Smart Street, will require some modifications to include the FLARE functionality. Making use of this previously funded equipment will reduce the overall cost of FLARE.

2.3 Description of design of Trials

The FLARE Trials will demonstrate how a DNO can successfully implement one of three fault level mitigation techniques (Adaptive Protection, FCL service and I_S-limiter), each enabled based on information from a Fault Level Assessment Tool as demonstrated in Figure 2.4 below. These techniques will operate **only in the event of a fault**.

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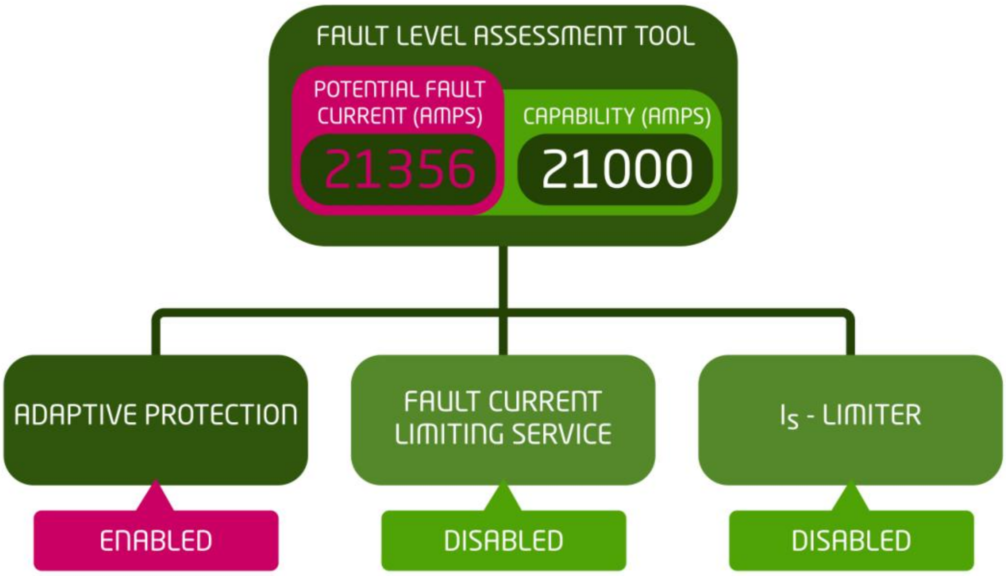
Figure 2.4: FLARE active management



Trial activities

The activities in the Trials are summarised below, and have been designed to provide evidence to support the hypotheses identified in Section 2.1.

The FLARE Trials will include a preparation or installation phase, followed by an evaluation phase to assess the three fault level mitigation techniques. The evaluation phase will span **May 2016 to April 2018.** Two years will allow the gathering and analysing of data from sufficient fault occurrences to prove the effectiveness of the techniques.

The Fault Level Assessment Tool will be implemented in the preparation phase, ready for the two-year evaluation phase. During this preparatory phase, the Trial will:

1. Demonstrate successful installation and configuration of the Fault Level Assessment Tool; and
2. Validate the Fault Level Assessment Tool calculations against the Outram fault level monitors.

Validation of the software against the fault level monitors will be conducted at two further points during the two-year evaluation phase.

In addition to the implementation of the software, the Trials will cover specific activities related to the three specific fault level mitigation techniques shown in Figure 2.5 overleaf.

We have spoken to WPD to discuss FLARE and explore the scope for **combining the outputs from FLARE and FlexDGrid**. This will be achieved through regular project meetings and the sharing of output reports and, where possible, joint knowledge dissemination events. This will further **enhance the reach and robustness of the learning from both sets of Trials**.

Figure 2.5: Activities during trials of the three fault level mitigation techniques

	Adaptive Protection	Fault Current Limiting service	I_S-limiters
Identify installation methods and costs	Retrofit installation of Adaptive Protection at sites with range of equipment ages	1. Installation of protection requirements for generator and motors 2. Purchase price and contract approach for FCL service	Retrofit installation of Is-limiter in two different configurations (bus section and transformer circuit)
Interaction with Fault Level Assessment Tool	For each technique, check correct enable/ disable operation, and the correct timing and duration of enable/ disable period		
Post-fault operational analysis	1. Correct operation of protection relays and timing of circuit breakers 2. Fault current calculated by Fault Level Assessment Tool compared with the fault current measured by the relay		Correct operation and timing of I_S-limiter and I_S-limiter sensing equipment
Post-fault evaluation of existing network assets	Asset health assessment of circuit breakers and transformers		n/a, since I_S-limiter avoids extra switching operations on existing network assets
Operation and maintenance	For each technique, understand the operation and maintenance activities and quantities		
Summarise impacts	Based on Trial evidence, deliver a Safety Case, a Cost Benefit Analysis and a Carbon Impact Assessment for each technique. This will inform a buy order of fault level mitigation solutions		

Scale and Site Selection Methodology for Adaptive Protection and I_S-limiter Trials

FLARE will be trialled on seven HV (6.6kV and 11kV) primary substations and two EHV (33kV) bulk supply point substations, with a range of differing characteristics. Five primaries and two bulk supply points will be used to demonstrate Adaptive Protection. This will demonstrate the range of equipment ages on which Adaptive Protection could be installed. I_S-limiters will be installed at two primary substations to cover the **two different configuration types**. A further five substations (three HV and two EHV substations, each with above average fault rates) will be fitted with I_S-limiter sensing equipment to gather additional operation and maintenance data. Given the cost profile of I_S-limiters, as described in the business case in section 3, this approach allows additional learning on the operation of I_S-limiters while limiting the additional cost.

Preliminary FLARE Trial sites (on which to deploy the Adaptive Protection, I_S-limiters and I_S-limiter sensing units) have been identified during the bid development phase to reduce risk and ensure accuracy of costs. The location of the indicative sites and the site selection methodology can be found in Appendix B2. This identifies substations based on the following considerations:

1. Voltage levels ie 6.6kV, 11kV and 33kV;
2. Existing or potential future fault level issues;
3. Fault history of outgoing circuits;
4. Age of substation switchgear and protection relays; and
5. Physical constraints (desktop initially).

The Trial sites have been selected to be representative of the size and types of substations that exist in all DNOs' asset bases. They contain a **range of ages of protection** relays (electro-mechanical, static electronic and numerical) and are in city or town centre locations where fault level issues are most prevalent. The site selection methodology will be reviewed and refined during Project delivery to ensure that the techniques are applied to HV and EHV substations with differing relay ages and types to ensure the learning captured will be transferrable to other DNOs. The updated site selection methodology will be peer reviewed by PB Power to confirm that the sample is statistically representative using data from the Long Term Development Statements of GB DNOs.

Scale and location of Fault Current Limiting service Trial

Following the customer survey and analysis we will seek up to five I&C or distributed generation (DG) customers to trial the technical and commercial elements of the FCL service. The customer survey and subsequent commercial Trial are not restricted to the pre-selected Trial sites. I&C demand or DG customers who have installations of the type that will be relevant to FLARE will be asked a series of questions to determine their willingness and the price of a potential FCL service. The design and geographical scope of the survey will provide statistically robust customer survey data. We wish to remain flexible in our approach to demonstrating the FCL service and extend the opportunity to suitable participants **from anywhere in the Electricity North West region**. When an interested customer is identified at a reasonable price for the FCL service provision, we will classify their network as an additional Trial site for demonstration of the commercial solution.

2.4 Changes since Initial Screening Process (ISP)

The scope of the FLARE Project has not changed since submission of the Initial Screening Pro-forma. Following a detailed costing exercise during development of the first full submission, overall costs for FLARE decreased to £5.75 million. Following appointment of a software Partner, this has now reduced further to £5.5 million.

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

FLARE will show how the alternative fault level mitigation techniques permanently mitigate the need for traditional reinforcement thereby ***extending the operational life and maximising the use of existing switchgear and HV cables****.*

Background

The anticipated fault level related reinforcement expenditure by all DNOs for the RIIO-ED1 price control period is significantly more than DPCR5. The total DNO forecasts show that fault level related expenditure will be £156m, **a 60% increase over the annualised DPCR5 expenditure**.

The traditional fault level reinforcement approach is the costly and disruptive replacement of switchgear and cables, which significantly increases the cost and time to connect new distributed generation and/ or load customers. Traditional planning and design approaches would require the reinforcement, even if the anticipated fault level rises above the network equipment fault level nameplate rating for only a fraction of a year.

Customer benefits

Financial benefits

The business case for FLARE is that instead of reinforcing HV and EHV switchgear and cables to permanently mitigate a fault level issue, it proposes retrofit techniques that enable the existing switchgear and cables to be utilised until they need to be replaced because of their condition. The principal benefit of the FLARE Solution is that by retaining existing assets it offers a **rapid and permanent intervention** to facilitate the **low cost connection of distributed generation and/ or LCTs**. FLARE offers alternatives to traditional HV and EHV switchgear reinforcement by the application of:

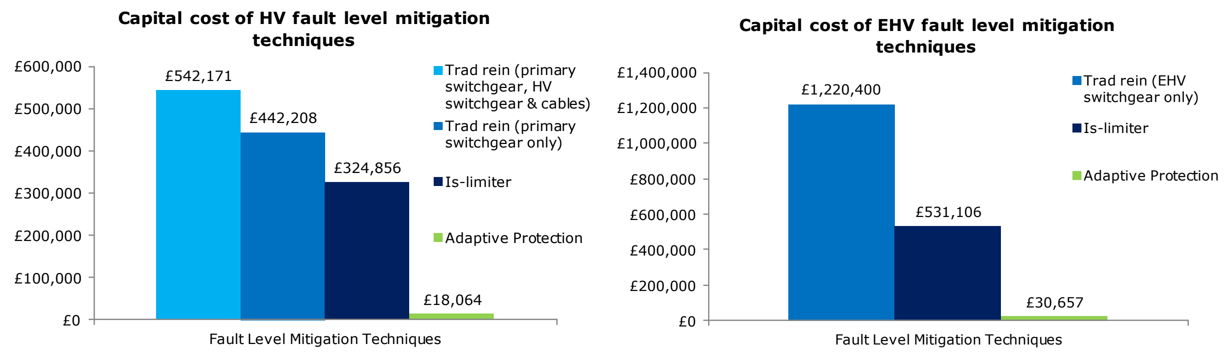
- Adaptive Protection, (technical Solution 1), or
- A Fault Current Limiting service (commercial Solution 1), or
- An I_S-limiter (technical Solution 2),

coupled with a Fault Level Assessment Tool to manage the application of these mitigation techniques. To assess the benefits of the FLARE approach, we have compared the cost of the most efficient method for addressing fault level issues currently in use on the distribution system ie the replacement of switchgear and cables at the HV and EHV voltage levels against the two retrofit technical solutions proposed within FLARE. We have taken a whole life costing approach, over 45 years, incorporating capital costs (including replacement, where applicable), operational and maintenance costs and apportionment of the Fault Level Assessment Tool costs. The potential commercial solution, the FCL service, has not been included in the analysis as we do not yet know the cost of provision; the planned survey and Trial provision will determine whether it is financially viable. However, it is expected to be viable because of similarities with other demand side response (DSR) products being trialled in a number of existing Second Tier projects.

FLARE proposes the application of a centralised active network management tool, the Fault Level Assessment Tool. But the choice of which fault level mitigation technology to apply is contingent upon the **type of fault level issue**: (ie is the issue the switchgear closing onto a fault – "make", opening for a fault – "break" or the capability to pass through fault current – "withstand") and the **network it is to be retrofitted into**. For example the age and rating of the existing switchgear, any associated HV network reinforcement requirements and the fault history of the network will vary the whole life costs and so dictate the choice of fault level mitigation technique.

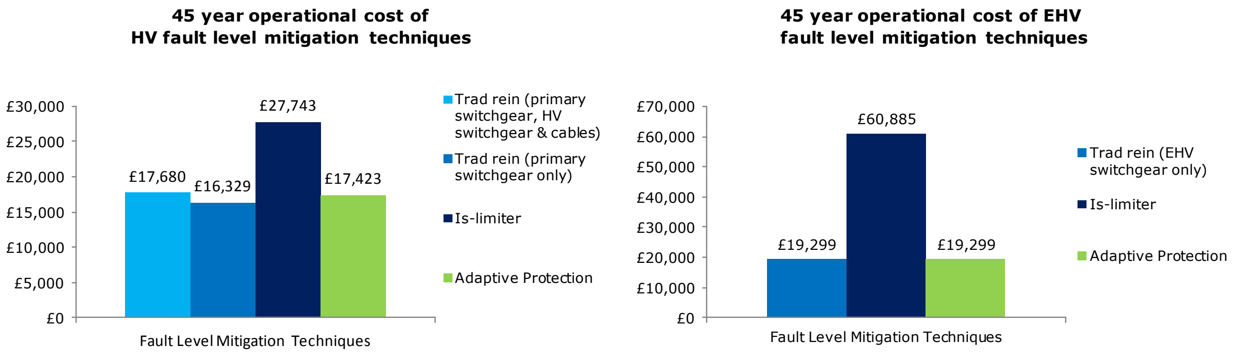
Initial capital retrofit costs of the techniques at HV and EHV are shown in Figure 3.1. The HV chart shows two cost columns for traditional reinforcement; one represents the cost of reinforcing the primary switchgear only and the second includes costs for reinforcing some HV distribution switchgear and HV cables as could be the case in city and town locations.

Figure 3.1: HV and EHV capital cost comparisons



Both charts show that it is cheaper to implement the two FLARE technical solutions in terms of initial capital expenditure, but the operational and maintenance practices are different for these technologies and drive different cost profiles. Figure 3.2 shows the discounted operation and maintenance costs for 45 years. This is unlikely to be a realistic life extension period for switchgear but is viable for cables. These costs are estimated with the following key assumptions: 1) A 12 year switchgear maintenance cycle for switchgear and protection equipment, 2) Four faults per substation per annum, 3) Existing switchgear insulating material is oil (the worst case in terms of cost and carbon impacts), 4) Oil circuit breakers are maintained after every fourth fault clearance, 5) Likelihood of Is-limiter operation of 30% ie fault level rises above equipment rating for 30% of the time, 6) Cost of Fault Level Assessment Tool is allocated to alternative techniques only, and 7) Discount rate is 6.7%.

Figure 3.2: HV and EHV operational cost comparisons



The costs vary substantially across the three fault level mitigation techniques at HV and EHV. The key determinant as to whether these retrofit techniques are applied is the length of time that the reinforcement can be delayed. Assuming for the I_S-limiter and Adaptive Protection techniques that the traditional reinforcement cost is incurred at a point in the future it is possible to calculate the minimum deferral period (ie the financial breakeven point) for each technology.

Figure 3.3: Reinforcement investment deferral in years

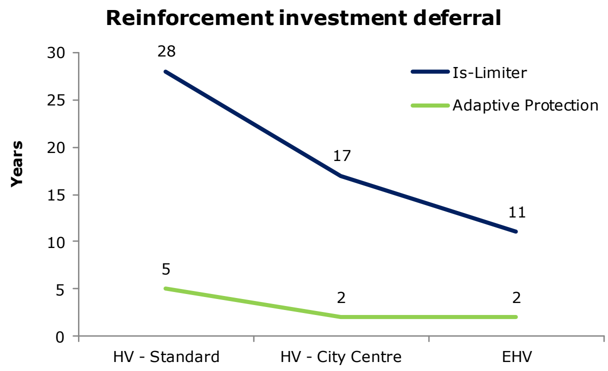
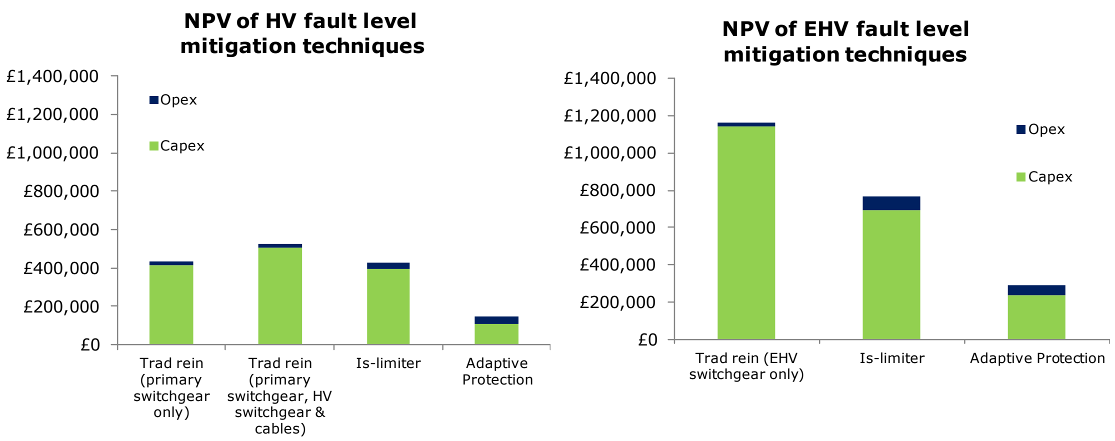


Figure 3.3 shows the breakeven point in years of the two technical solutions. The breakeven point for the most capable yet most expensive retrofit technology, the I_S-limiter, is between 11 and 28 years. Figure 3.4 below compares the discounted whole life costs, up to 28 years, for all the traditional and alternative technologies at both HV and EHV. This includes the traditional reinforcement costs in year 28 for I_S-limiter and Adaptive Protection technologies. These charts show that the retrofitting of the I_S-limiter and the Adaptive Protection technologies can provide cost savings by extending the life of the existing assets, through the deferral of network reinforcement. This gives network operators important options in an uncertain world as decisions can be delayed until conditions become clearer.

Figure 3.4: HV and EHV cost comparisons



The FLARE Trials have been designed to determine the range of total costs for the installation, operation and maintenance for the two technical solutions, Is-limiters and Adaptive Protection, and the commercial solution, the FCL service. This will facilitate the development of the Cost Benefit Analysis for all three fault level mitigation techniques and will also enable comparison with the solutions being trialled in the FlexDGrid project.

Net benefits evaluation of an I_S-limiter protecting for HV cable withstand

In the evaluation of FLARE a question was raised on the size of benefit that could arise from installing an I_S-limiter to only protect HV cables for through fault withstand.

The methodology (detailed in Appendix A1) estimates the length of HV cable at risk from increased fault levels and therefore calculates the replacement cost for these HV cables. This value is compared against the installation cost of an I_S-limiter to derive a net benefit. It is expected that by 2050 the net benefit of using an I_S-limiter instead of the traditional approach of replacing the cable will deliver savings of £161 million at the Electricity North West scale and £619 million at the GB scale.

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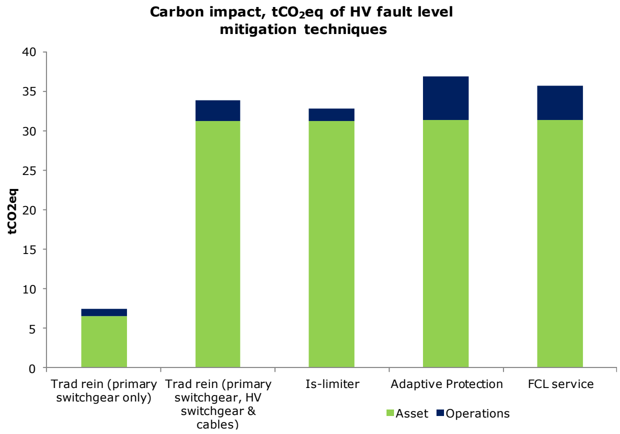
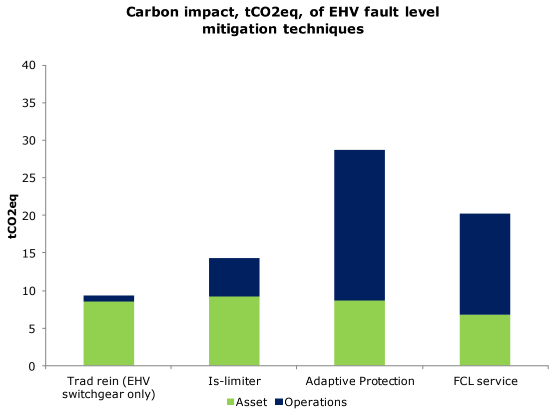
Carbon benefit

Initially, the FLARE interventions are less carbon intensive than reinforcing the existing assets. But as the FLARE intervention only delays network reinforcement, the asset carbon is incurred at some point in the future. Figure 3.5 overleaf shows the carbon impact of the traditional and alternative fault level mitigation techniques at HV and EHV, with the same assumptions as described above in the financial benefits section. The initial analysis suggests that assets rather than operations dominate the impact profile. It should be noted that the leftmost column on the HV graph includes only consideration of the HV switchgear at the primary, but the other four columns include switchgear and cables in the downstream system.

Figure 3.5: HV and EHV carbon impact of fault level mitigation techniques





While the life extension enabled by FLARE's novel solutions makes a significant difference to discounted cash flows, because all carbon impacts are treated equally through time, application of the FLARE solutions shows only a small difference in carbon impact. The I_S-limiter solution is seen to perform similarly to traditional reinforcement, whilst Adaptive Protection and the FCL service increases carbon at both voltage levels. There are three key areas to be developed in understanding the carbon impact of the FLARE project during its planning/operation: 1) the cable upgrade requirement which dominates asset calculations and will determine the relative benefit of the various interventions; 2) the frequency of faults which determine maintenance rates and I_s-limiter operation; and 3) the emissions attributable to consumption, reconditioning and leakage of insulating materials. A description of the carbon impact methodology applied by Tyndall Manchester can be found in Appendix A3.

Operational benefits

Near real time assessment of prospective maximum fault current across the distribution network will give DNOs an understanding of how fault current changes on a daily, weekly and seasonal basis; something presently not possible without extensive time-series data and modelling effort. This knowledge could be utilised within our planning processes to allow more refined analysis of when reinforcement may be required.

FLARE will produce a series of techniques which can be deployed either in response to customer choice or network constraints. Deployment of these techniques helps Electricity North West to maximise the use of existing assets in line with our innovation strategy. Additionally, use of these techniques may allow us to remove operational restrictions, currently in place at some sites, allowing the network to be operated as per standard operational practice.

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Costs and assumptions

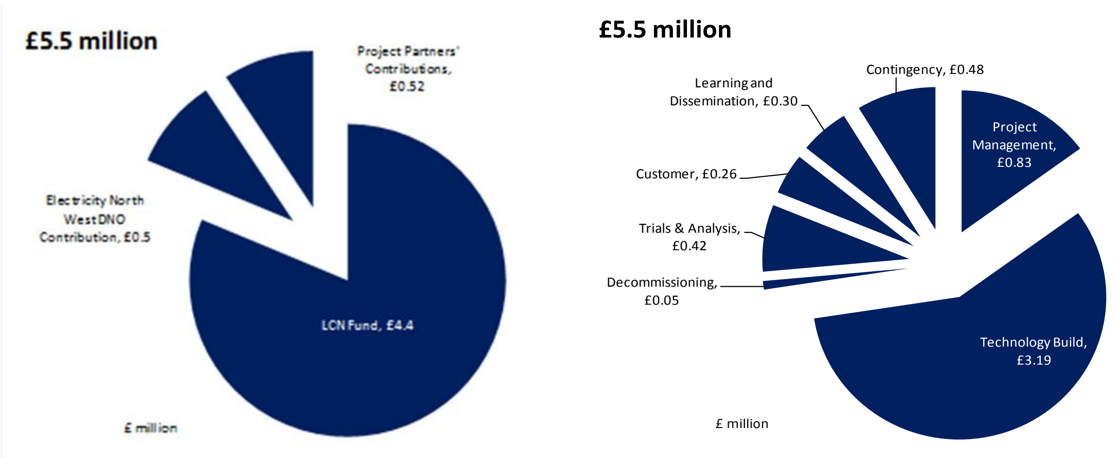
We have learned in the development of our previous Second Tier projects that it is vital to clearly define the roles and responsibilities of internal and external resources in order to develop robust project costs. This robust and standardised financial costing methodology has been applied to the FLARE Project to provide an accurate cost model, offering exceptional value for money for customers and stakeholders. The following key assumptions have been made developing the FLARE Project costs: 1) all costs include RPI; 2) RPI rates are those issued by Ofgem; and 3) Project funding includes an 8.7% contingency.

The FLARE Project has been through the Electricity North West internal approval process and has been signed off by a designated subcommittee of the Board.

Project funding and costs

Figure 3.6 below shows the total cost of delivering FLARE is £5.5 million, with a significant proportion, 18%, funded by Electricity North West and the Project Partners. Figure 3.6 also shows how the total cost is been broken down into the main cost segments.

Figure 3.6: FLARE funding proposal and high level cost overview



The individual Workstream costs have been broken down in figures 3.7 to 3.10.

Figure 3.7: Technology Workstream cost overview

[redacted]

In the Technology Workstream, shown in Figure 3.7, it can be seen that the main two cost elements are: purchase of the Fault Level Assessment Tool; its integration into the

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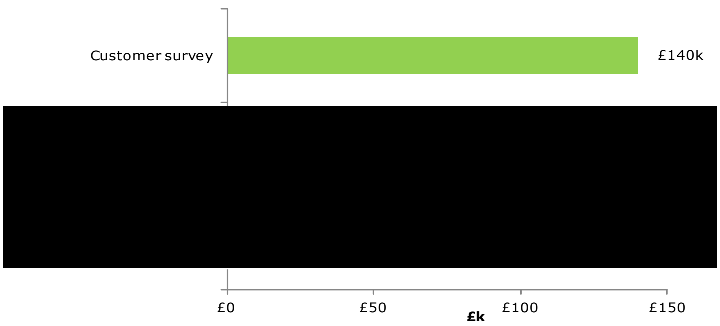
Electricity North West NMS and its validation; using the Outram fault level monitor; and purchase of two I_S-limiter units and associated switchgear, and five I_S-limiter sensing devices. The other significant costs are for the retrofit of the Adaptive Protection in Electricity North West substations, including the protection setting calculations performed by PB Power and the adaption of existing protection to enable the provision of a FCL service for up to five customers.

The cost breakdown for the Trials & Analysis Workstream, in Figure 3.8 overleaf, shows the significant costs are for the purchase of the Fault Current Limiting service and the Asset Health Studies on the transformer and the transformer circuit breaker which under the Adaptive Protection Trial will be required to operate more frequently than previously.
EA Technology Limited will analyse the Trial results, develop asset health indices and incorporate the revised indices into the condition based risk management (CBRM) methodology applied within Electricity North West. As is normal with our Second Tier projects, we will develop a Cost Benefit Analysis report and a Carbon Impact Assessment for each solution.

Figure 3.8: Tri[redacted]

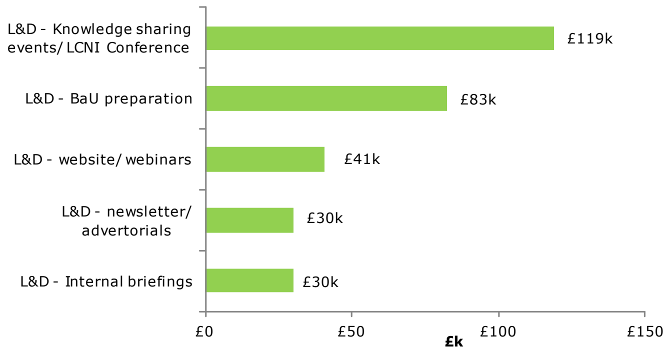
Figure 3.9: Customer workstream cost overview



[redacted]

Figure 3.9 shows the cost breakdown for the customer engagement activities planned within FLARE, namely the development and delivery of the customer survey and the customer contact to purchase a Fault Current Limiting service. Figure 3.10 below, shows the cost breakdown for the Learning & Dissemination Workstream.

Figure 3.10: Learning & Dissemination Workstream cost overview



Direct Benefits

There are no Direct Benefits identified for inclusion in this Full Submission as FLARE will be delivered in RIIO-ED1, whereas paragraph 3.19 of Section Two of the LCN Fund Governance Document v.6 refers to benefits associated with DPCR5. As a consequence, none of Electricity North West's DNO Contribution, which represents a contribution of £0.5 million, will be funded by Direct Benefits as currently defined. However, there will be Direct Benefits accrued in RIIO-ED1 and these will be shared with customers through the sharing mechanism.

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Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

*FLARE's alternative retrofit techniques **release capacity up to 95% faster** than traditional reinforcement for the connection of new LCTs and distributed generation.*

a) Accelerates the development of a low carbon energy sector & has the potential to deliver net financial benefits to future and/ or existing customers

FLARE's accelerated contribution to The Carbon Plan

The Carbon Plan[2], published by the UK Government in 2011, describes the importance of moving to a low carbon economy and sets out how the legally binding targets in the reduction of greenhouse gas emissions will be achieved. This has encouraged uptake of LCTs, including combined heat and power units (CHP). New LCT connections are at risk of delay due to the time and cost of traditional fault level network reinforcement.

The sections of The Carbon Plan which the FLARE Solution facilitates are:

Reform of the electricity grid - Expected increases in localised electricity generation and the move to electricity for heat and transport will drive a need for more sophisticated system control. FLARE will trial active network management techniques, focused on fault level. With customers' help, we will demonstrate how commercial mechanisms can incentivise industrial and commercial customers and generators to alter the way in which they connect to and use the network. This will contribute to the reform of the electricity grid and reduce the energy bills of all distribution network customers by avoiding the shared costs of network reinforcement. FLARE will help identify decision points relating to the electricity distribution infrastructure in GB by demonstrating new fault current mitigation technologies and establishing the likely uptake of the commercial alternative to infrastructure investment. This will help DNOs decide on the strategy to mitigate fault level issues and ascertain the reinforcement expenditure that can be deferred or avoided.

Secure, sustainable low carbon electricity - Local planning authorities have implemented changes in planning guidelines that stipulate that where there is an option to fit CHP then this must be explored. Greater Manchester Combined Authority (GMCA), one of our Project supporters, is one such organisation with challenging carbon target aspirations including local, low carbon generation and a future vision of district heating networks. The fulfilment of these aspirations is likely to involve electrical connections that will contribute to rising fault levels and expensive network reinforcement may be required to accommodate them. By unlocking capacity in the existing network, FLARE will support a faster move to "almost entirely carbon free" power generation by 2050 and facilitate the faster connection of low carbon generation. Trials and analysis will determine how and whether FLARE improves the reliability, affordability and sustainability of the distribution networks and helps maintain an economic and secure electricity supply.

The impact FLARE could have is quantified in this section and Appendices A1 (Benefits Tables), A2 (Method and Base Case Methodologies), and H (Withstand Capability Study). These benefits are then extrapolated across Electricity North West and GB.

FLARE Project: The site selection methodology, described in Appendix B2, has been applied to the Electricity North West substation population and nine provisional sites have been identified for inclusion in the FLARE Trials. The FLARE Method is expected to give enough headroom for the connection of approximately **23MVA** of additional generation/ demand **at each primary substation** and **90MVA** of additional generation/ demand **at each bulk supply point** (BSP) where the switchgear fault rating is 13.1kA or less. The nine Trial substations (seven primary and two BSP sites), where fault level mitigation techniques will be trialled, could release up to **341MVA** of network capacity for the connection of local carbon generation/ demand.

Electricity North West: There are approximately 365 primary substations and 65 BSPs in the Electricity North West distribution network. It is expected that by 2050 fault level issues will arise on 269 primary and 37 BSP sites; so the FLARE Solution will permit the connection of **9 517MVA** of low carbon generation/ demand.

Great Britain: There are approximately 5 300 primary and 875 BSP substations across GB. It is assumed by 2050 that 67% of primary substations and 57% of BSPs will have switchgear rated at the system design fault level or below, so the rollout of the FLARE Method for the whole of **GB** would be **127 275MVA** of additional low carbon generation/ demand.

How a rollout of the Method across GB will deliver carbon benefits more quickly

By avoiding expensive traditional approaches for mitigating fault level issues, application of the FLARE fault level mitigation techniques is expected to facilitate the development of low carbon load and generation by reducing connection costs and the time to connect. The FLARE Method will also accelerate the development of low carbon load and generation connections because the alternative construction time will be **between one and five months**, which is significantly **less** than the 18 month period typically required for switchboard replacement or construction of a new primary or BSP substation.

Quantifying the potential carbon contribution of a rollout of FLARE across GB

Tyndall Manchester has assessed the carbon impact for the FLARE Project, for an Electricity North West and a GB rollout. The carbon impact analysis of FLARE suggests that **assets rather than operations dominate the impact profile**. The I_S-limiter solution performs similarly to traditional reinforcement at HV level but not EHV, with Adaptive Protection and FCL service delivering a noticeable increase at both voltage levels. There are three key areas to be developed in understanding the carbon impact of the FLARE project during its planning/operation: 1) the cable upgrade requirement which dominates asset calculations and will determine the relative benefit of the various interventions; 2) the frequency of faults which determine maintenance rates and I_S-limiter operation; and 3) the emissions attributable to consumption, reconditioning and leakage of insulating materials.

An executive summary of the methodology applied by Tyndall Manchester and the results can be found in Appendix A3.

FLARE has the potential to deliver net financial benefits to existing and/or future customers

FLARE Method and costs: The application of FLARE on the nine Trial networks (seven primary and two BSP sites) releases the same 341MVA of network capacity as traditional techniques. The components of the FLARE Method are:

Fault Level Assessment Tool application upgrade to the NMS; and installation of (one of the three) fault level mitigation techniques:

1. Adaptive Protection; or
2. Fault Current Limiting service; or
3. I_S-limiter.

At the scale of the Project the total costs of implementing the Fault Level Assessment Tool software and a single fault level mitigation technique ranges from [redacted] using Adaptive Protection to [redacted] using I_S-limiters. Figure 4.1 overleaf shows the capital costs of applying the same fault level technique for the nine Trial networks. These costs assume Electricity North West uses the existing NMS with some functionality amendments to include the Trial networks within the system and the ICCP interface built for Smart Street. This approach minimises costs and is a possible enduring solution, so the development costs could be reduced to [redacted] to make the amendments and represent the networks within others' NMS. The Fault Level Assessment Tool is an off-the-shelf product to be configured for FLARE at a cost [redacted]. Future applications would benefit from the development work undertaken for FLARE and so replication would cost around 25% less [redacted]

Figure 4.1: FLARE scale project cost summary

Traditional reinforcement	Adaptive Protection	Fault Current Limiting service	I_s-limiter
£6 136 031	[redacted]	[redacted]	[redacted]
Savings	[redacted]	[redacted]	[redacted]

This analysis only considers asset costs, including the whole cost of the Fault Level Assessment Tool [redacted], which is unlikely to be allocated in this manner as business as usual. It also excludes: 1) the additional operation and maintenance costs and future reinforcement costs as studied in the Project Business Case; and 2) the annual purchase costs of a Fault Current Limiting service.

Base Case costs: The traditional reinforcement interventions for the nine Trial networks would release 341MW of network capacity at a cost of £6.1 million as shown in Figure 4.1 above. See Appendix A2 for information on Method and Base Case Methodologies.

Summary of benefits analysis: In all cases, **the FLARE Method costs less than traditional reinforcement**. Figure 4.1 above shows the financial benefit for each of the three techniques at the scale of the FLARE project. The financial benefit ranges from [redacted] for Adaptive Protection to [redacted] for I_S-limiters.

The potential for replication across GB

The FLARE Method releases capacity up to 18 times faster and up to 80% cheaper than traditional reinforcement techniques for fault level issues. Using the scaling methodology, proposed by PB Power, the FLARE Method will deliver **3 868MVA** and **127 275MVA** for Electricity North West and GB respectively.

b) Provides value for money for distribution customers

Based on FLARE, DNOs will be able to manage fault level at lower cost. This is because FLARE will develop new fault level mitigation management options, from which DNOs will be able to choose the most cost-effective. Crucially, to manage the operational cost of fault level mitigation, the Fault Level Assessment Tool will ensure DNOs **only act to mitigate fault level when necessary.**

Electricity Distribution Licence Conditions 13 and 14 require DNOs to formulate, publish and apply a Common Connection Charging Methodology (CCCM) for calculating the costs to new or existing customers wishing to connect to their distribution network or increase their power requirements from an existing connection. The principle underpinning the methodology is that the connectee pays for the cost of the new connection assets and a proportion of the cost of reinforcement to accommodate the new connection up to one voltage level above the voltage of connection. All customers, through the Distribution Use of System (DUoS) charges, fund the reinforcement costs not funded by the connectee. All customers fund fault level reinforcement associated with general growth in load and micro-generation. FLARE will prove **lower cost solutions** to managing fault level that will reduce the cost to connect, to both new connectees and all existing customers.

The current CCCM does not facilitate the cost apportionment of the alternative fault current mitigation techniques considered by the FLARE and FlexDGrid projects. Appendix J describes the issues with the current version of the CCCM. FLARE will investigate how to amend the

CCCM, consult, and recommend a Distribution Connection Use of System Agreement (DCUSA) Change Proposal.

In addition to the DUoS customer benefits FLARE will introduce a new market concept for the purchase of a FCL service. Some existing and/ or new connection customers will financially benefit from offering this service to DNOs. For the owners/ operators of both generation and/ or demand there is thus a possibility for further return on their capital investment should they have the desire and ability to participate in the market for FCL services.

Open competitive procurement processes to ensure value for money

During the bid development phase, our Project requirements were advertised on the Energy Networks Association (ENA) Smarter Networks Portal. Subsequently we conducted **open competitive procurement processes** to drive value for money in the customer, technical consultants and Fault Level Assessment Tool software requirements. Impact Research and PB Power were assessed as offering the best value for money and selected as Partners following this process.

The Fault Level Assessment Tool software assesses potential fault level on the network and issues "enable" or "disable" commands to one of the three fault level mitigation techniques. The Fault Level Assessment Tool will be installed on the NMS platform. [redacted] Project Partner for FLARE is Schneider Electric.

ABB is the sole supplier of I_S-limiter technology and a key Partner in this project. We have negotiated Partner funding from them in order to reduce the overall cost of project delivery. ABB recognises the importance of this Project and is providing a substantial contribution.

Clear roles and responsibilities for all Project participants ensure value for money and that there is no duplication of activities. Figure 4.2 below shows the expected number of person days and day rates per partner.

Figure 4.2: Project resources

Organisation	ENWL	Schneider Electric	ABB	Impact	PB	ENER-G	CHPA	United Utilities
No. of days	3831	880	82	227	358	45	39	39
Day rates (range)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Electricity North West has negotiated a contribution from all of the potential Partner organisations. This represents 9.2% of the total project expenditure and **reduces the cost of the project to customers** by £0.515 million.

Justification that the Project is innovative and requires LCN Funding

A review of utilities in the UK and internationally has been undertaken by our technical consultant partner and our future networks team. This provides some context when considering the technology and operational practices proposed. The review confirmed that FLARE is the **first demonstration of active management** of fault levels. A Fault Level Assessment Tool for near real time assessment of potential fault current and issuing of enable/ disable commands, Adaptive Protection, FCL service and the I_S-limiter have **never been applied on any GB distribution network** either individually or combined as proposed**.** The novelty of the individual FLARE techniques and their integration means that they need to be demonstrated within a project environment on a representative network to examine the technical, commercial and operational risks and benefits. Detailed learning is required to develop the concept and prove that the techniques can deliver a fundamental change in the management of fault level and prepare for wider scale deployment to unlock the expected benefits for customers. The Project Trials will provide essential understanding of practical installation risks and provide a carefully monitored environment for minimising the operational risks affecting customer service and the distribution network.

Innovation funding for this project will enable development of the commercial terms, operational processes and procedures which will **remove barriers to widespread uptake** of the techniques. PB Power, embedded in FLARE and FlexDGrid, will evaluate the benefits and applicability of each of the project techniques to show how they can be adopted by GB DNOs to provide value for money for all distribution customers. PB is a key learning and dissemination Partner; they will produce electricity policy documents (EPD) and codes of practices (CoP) to support transition of the techniques to business as usual, and rollout requirements for the uptake of FLARE across GB.

c) Generates knowledge that can be shared amongst all DNOs

Incremental learning

FLARE builds on the knowledge gained from previous IFI, First and Second Tier LCN Fund projects and will generate incremental learning in a number of key areas. This will be of particular interest to other GB DNOs.

The following IFI projects are looking at fault level mitigation:

- Fault Infeed Calculations and Outram Fault Level Monitor (SPEN);
- Fault Level Monitor (SPEN and WPD);
- Superconducting Fault Current Limiter (ENWL, NPg and SPEN);
- Active Fault Current Management (WPD); and
- Fault Level Management Study (UKPN).

The learning from the IFI projects has informed FLARE in the following ways: FLARE builds on the active management principle by the implementation of a centralised scheme assessing substations across a wide area; FLARE will use the fault level monitor investigated under IFI to assist with our validation work of the Fault Level Assessment Tool.

First Tier projects looking at the problem of fault level mitigation are:

- Electricity North West's Fault Current Active Management (FCAM);
- 33kV Superconducting Fault Current Limiter (NPg); and
- Implementation of an Active Fault Level Management Scheme (WPD).

As with the IFI project on active management, the First Tier project has reinforced the need to implement a centralised scheme to control multiple substations whilst FCAM has informed FLARE of the viability of the techniques to be implemented.

There is currently only one Second Tier project looking at the problem of fault level mitigation. FlexDGrid has provided learning in the areas of fault level assessment, real time fault level measurement and the installation of three fault level mitigation technologies (ie a pre-saturated core fault current limiter, two resistive superconducting fault current limiters and two power electronic fault current limiters). We have reviewed the FlexDGrid project and outputs to date and this review can be found in Appendix L.

FLARE will also deliver learning to support the outputs of FlexDGrid. FLARE will provide the WPD project with some further context and allow the comparison of all techniques to establish a hierarchy of options for varying network scenarios. The sophistication of the FLARE software solution will enable the following FlexDGrid techniques to be improved:

- Commercial agreements for generation connections;
- Activation of fault current limiting techniques; and
- Network reconfiguration.

WPD and Electricity North West will work together and collaborate on knowledge dissemination events to maximise the learning from both projects.

Applicability of the new learning that can be shared amongst all DNOs

The DTI report[1] identified nine options for managing increased fault levels including traditional reinforcement. FlexDGrid reviewed the feasibility of some of these in Appendix L of their full submission document[6]. FlexDGrid demonstrates three of the options on 132/ 11kV substations in Birmingham. FLARE will demonstrate a further four solutions on a much greater variety of substations across a number of urban and dense urban locations. This will increase the applicability of the new learning to other DNO substation populations.

FLARE will provide DNOs with knowledge in a number of key areas:

Customer engagement: FLARE will provide new information on how to best engage with customers for the FCL service and share with the DNO community the most effective route to market for these new commercial arrangements. This learning will help frame propositions to both new connections customers and existing customers and will inform how DNOs can best include customers in the operation of the network.

Fault Current Limiting service price and contracts: FLARE will test the willingness of customers to engage in FCL service contracts. During the customer survey we will establish the appetite among new and existing customers to engage in FCL service contracts and will also ascertain the prices at which customers are willing to engage in these response contracts. FLARE will deliver new commercial templates for purchasing a FCL service.

Economic and carbon modelling: FLARE will deliver carbon and economic analysis that will allow a DNO to assess the carbon savings and customer benefits of the solutions on its own networks. The output learning from the modelling work learning will inform the development of a buy order of fault level mitigation solutions from FlexDGrid and FLARE.

Specifications and installation methodologies: FLARE will deliver ready to use specifications enabling a DNO to purchase and install the FLARE technologies. The installation requirements (including any local planning considerations) and proposed substation configurations for the I_S-limiter and an updated and peer reviewed Safety case, developed under the First Tier project will be shared.

Device settings and configurations: FLARE will share device settings, configuration parameters and operating procedures for each piece of fault level mitigation equipment and the appropriate software algorithms. For the I_S-limiter the settings are calculated by the manufacturer therefore the Project will produce the list of parameters required by the manufacturer to enable this calculation.

Near real time control of devices to manage fault level: The planning, design and operation standards for near real time fault level management will be shared, as will the identified benefits from centralising control and improving network operating costs. The developed health and safety documentation and operational training guides will also be shared.

Network management system and interface: The configuration and interface specifications for the Fault Level Assessment Tool with the NMS via a standard ICCP link will be shared.

Analysis and validation studies: FLARE will deliver supporting reports to demonstrate the accuracy of the calculations carried out by the Fault Level Assessment Tool, and demonstrate the success of the Trial via post fault analysis and confirmation that there are no asset health issues. Full details of our knowledge dissemination can be found in Section 5.

d) Involvement of other partners and external funding

Electricity North West's approach to identify and select Second Tier project ideas

We engage with potential contributors to innovation projects through a variety of channels and **encourage participation** in our innovation work. These channels include the Electricity North West website and various social media channels. Our senior managers and innovation engineers are active and accessible attending and speaking at conferences and seminars to engage in discussion on technical and commercial concepts with other DNOs, SMEs and product developers. We garner useful feedback from developers, independent connection providers and generators by chairing and hosting events such as the Distributed Generation Forum, and via monthly sessions for connection customers, held across our licence area. This delivers opportunities for improving our services through collaborative innovation with customers. Fault level issues have been raised through these routes, showing that there is keen interest and support across stakeholder groups for the technological and commercial innovations FLARE explores.

Electricity North West's future networks steering group (FNSG) meets quarterly and comprises representatives from all directorates. The FNSG considers and evaluates project ideas from numerous sources and progresses those concepts likely to maximise benefits for customers. FLARE has been developed in response to evidence that fault level constraints will become more prevalent across our distribution network in RIIO-ED1 and beyond. As part of the forerunner First Tier FCAM project, the concepts in FLARE were evaluated by PB Power and the University of Manchester as meriting Second Tier project funding.

Identification of appropriate Project Partners

FLARE will be delivered with the **contribution and expertise** of the Project Partners listed in Figure 4.3. Partners were selected for the skills, knowledge and value that can enhance outputs and learning. As described in section 4b, competitive processes selected PB Power, Impact Research and Schneider Electric, as Partners. In addition to the above, we have developed a relationship with CHPA as a national customer stakeholder, and strategic relationships with United Utilities and ENER-G, both influential local stakeholders that could contribute to the FCL service demonstration. With United Utilities, we have explored the provision of post fault DSR services and the trialling of FLARE's FCL service was raised as part of our on-going stakeholder engagement. Our other customer Partner, ENER-G, represents the CHP industry at forums and working groups and engages in the future energy debate. Last year ENER-G also acted as "critical friend" in the formulation of our RIIO-ED1 well justified business plan.

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Evaluation Criteria continued

Figure 4.3: Project Partners and supporters

Prior experience	Role on project
ABB – a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact	
ABB is the sole supplier of I_S-limiter technology and has experience in successfully implementing projects of all sizes in partnership with power industry customers and working with DNOs on smarter solutions for future networks including the recent IFI funded Aura project.	• Supply, install and provide maintenance services for I_S-limiters and sensing equipment • Work with Electricity North West and PB Power to configure protection settings • Provide technical support • Key learning and dissemination partner
Parsons Brinckerhoff (PB Power) – leading provider of engineering and project management in power generation, transmission and distribution	
PB Power has expertise in the development and delivery of LCN Fund projects, and in particular, FlexDGrid and is in an excellent position to incorporate all relevant learning.	• Technical consultancy support to FLARE • Support across work packages including: modelling accuracy; protection settings; post fault analysis; system design; protection policy documentation update; and preparation for business as usual • Key learning and dissemination partner
Schneider Electric –leading technology vendor of power generation and energy delivery technologies	
Schneider has extensive experience in successfully providing and implementing smart solutions to DNOs. Schneider offers a portfolio of smart grid services and products, and will be able to draw from their global experience and knowledge.	• Supply, configure and commission the Fault Level Assessment Tool software • Support to ensure successful implementation and testing of software and hardware • Key learning and dissemination partner
Impact Research – a leading UK marketing and customer engagement organisation	
Impact Research has extensive experience in customer engagement activities in the utilities industry and has successfully supported Electricity North West in the delivery of a number of LCN Fund projects.	• Support Customer Workstream activities including survey and analysis • Gather robust data to evidence that the Method creates a market for FCL services • Key learning and dissemination partner
ENER-G – the number one name in cogeneration across Europe	
ENER-G has over 25 years experience in CHP projects from initial design stages to maintenance and operation of an installation. ENER-G provides representation at a number of industry forums and has extensive contacts throughout their sector.	• ENER-G's CHP test cell will be utilised to test the retrofit arrangements • Support customer engagement and customer survey activities • Engineering support for FCL service Trial: install protection at customer generator/ motor

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Evaluation Criteria continued

Combined Heat and Power Association – representing electricity generation from CHP	
The CHPA is a trade body representing and the leading advocate of an integrated approach to delivering energy services using CHP and district heating.	• Support customer survey and customer engagement activities • Facilitate introductions to potential customer survey and FCL service participants
United Utilities – water and wastewater services provider for the North West of England	
United Utilities owns a number of large AC electrical machines that may provide an FCL service during the FLARE Trials.	• Test Adaptive Protection for electrical machines • Develop retrofit procedures for protection amendments to a motor installation • Input to specification of operating procedures • Post fault analysis • Assist with customer engagement and survey activities

e) Relevance and timing

The timing of the FLARE Project is opportune: there are increasing business demands to connect customers quickly and economically. Using the techniques proposed in FLARE helps us meet these demands.

We have completed preliminary work under our First Tier LCN Fund project, FCAM, and the technologies look feasible. We now need to prove that these alternative techniques can work together and at scale. Just like our previous Second Tier projects, the core principle of FLARE is to manage the existing assets in a smarter way to help resolve future challenges being driven by the transition to a low carbon economy. FLARE looks at using small enhancements on existing assets to manage them in a smarter way and shape how the future distribution system will be operated.

FLARE dovetails with and complements FlexDGrid, a Second Tier project looking at other fault level mitigation techniques. With the completion of both projects DNOs will have explored the technologies and techniques originally scoped as solutions by the DTI report. Appendix L reviews the DTI report and the scope of FlexDGrid. We believe that the FLARE fault level mitigation techniques will be more relevant to other DNO networks than those of FlexDGrid as the Trial substations used are more representative of the type and configuration found across GB. Furthermore, we also envisage that the Fault Level Assessment Tool could enhance the technologies being demonstrated by FlexDGrid. FLARE needs to be trialled, with the support of LCN Funds, so the business cases for all the DTI's defined fault level mitigation techniques and FLARE's new FCL service can be established. This will help DNOs understand the cost benefit of each technique in differing scenarios for normal business deployment rollout at GB scale.

Future business planning and price controls

Our smart grid benefits forecast to deliver £133m of savings to customers in the RIIO-ED1 period, including £10m savings related to customer connections reinforcement. FLARE targets fault level reinforcement mitigation and will enable quicker and cheaper LCT and DG access to our network.

The technologies to be investigated in FLARE will add to those already under investigation in FlexDGrid to produce a comprehensive set of solutions. These solutions will be available to the GB market in the latter half of RIIO-ED1 and early RIIO-ED2 when, according to DECC projections, the uptake of LCTs and DG will increase significantly. The portfolio of solutions available will give more choice to customers and allow improved planning for RIIO-ED2.

The engagement with customers in FLARE for the FCL service response contracts coupled with work already underway on demand response contracts will result in a better view of the distribution system operator (DSO) market for RIIO-ED2.

Knowledge and learning

FLARE will expand knowledge in the electricity distribution industry by showing how fault level can be assessed in near real time to provide a DNO with the ability to actively respond to fluctuating fault level issues. The Project will create technical and practical learning related to the use of I_S-limiters and Adaptive Protection on a GB distribution network. In addition, it will show how through deploying I_S-limiters or Adaptive Protection at an affected substation or through purchasing FCL services from new or existing customers, additional connections can be facilitated and costly network reinforcement avoided. FLARE builds upon the learning from FlexDGrid **by exploring the techniques that FlexDGrid does not investigate**. The active response element of FLARE means that the commercial offering can be achieved with minimum impact on customers' operational activities.

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

*FLARE will deliver a **tool kit** that enables a **GB DNO network designer** to choose which FLARE or FlexDGrid fault level mitigation technique to apply in different situations.*

Learning capture and knowledge dissemination is central to FLARE's success. To ensure it has prominent focus and visibility, Learning and Dissemination has a dedicated Workstream. Inputs and support is provided from all other Workstreams and Project Partners/ suppliers. Scheduled activities relating to milestone outputs are defined and flexibility for less routine learning is built in to the dissemination programme through website functionality and social media activity. A knowledge dissemination roadmap will be refined at the start of FLARE project delivery in order to produce a clear and effective dissemination plan. The goal of this dissemination plan is to define the milestones, products and responsibilities between Partner organisations that ensures accessibility to, and dissemination of, the FLARE Project results.

FLARE will deliver learning from the earliest phases of the project. Disseminating knowledge as soon as possible will maximise the value derived from such projects. The key knowledge outputs to be disseminated to our stakeholders are shown in Figure 5.1 below.

Figure 5.1: Key deliverables

Milestone	Product	Responsible
Award of funds for FLARE	Nameplate rating study and HAZOP/ Safety case for I_S-limiter.	Electricity North West
Installation of fault level mitigation technologies	Functional and technical specification documentation, installation methodologies. Project model illustration within the Smart Grid Architecture Model (SGAM)	Electricity North West ABB, Schneider, ENER-G
Network management system and interface commissioned	Functional specification documentation on the operational link between optimisation software and Electricity North West's NMS	Electricity North West, Schneider
Validation of the Fault Level Assessment Tool completed	Report demonstrating the accuracy of the near real time Fault Level Assessment Tool calculations.	Electricity North West, PB Power, TNEI, Outram, Schneider
Customer survey completed	Customer survey report detailing results of willingness and price for purchasing of a Fault Current Limiting service	Electricity North West, Impact Research, CHPA, ENER-G
Commercial templates for FCL service developed	Contract templates for new and existing customer provision of a FCL service	Electricity North West

Knowledge dissemination continued

Purchase of FCL service	Pricing structure (£/kA per event or £/kA per contract) of FCL service	Electricity North West
Operational equipment analysis	Post fault analysis studies	PB Power
Asset health analysis and health indices updates	Transformer and circuit breaker asset health studies and associated changes to asset health indices in CBRM	Electricity North West and Kelvatek
FLARE Business Case	Cost Benefit Analysis and Carbon Impact Assessment for each fault level mitigation technique/ device. "Buy order" of fault level mitigation techniques from the FLARE and FlexDGrid Trials Input of FLARE cost models into the smart grid forum Transform model	Electricity North West, UoM, Tyndall Centre
Planning and design policy amendments	Safety Case for each technique, updated fault level management, planning, design, protection settings and operation and maintenance policies	Electricity North West
CCCM amendments	DCUSA Change Proposal for CCCM	Electricity North West

Audiences

A number of audiences are identified as key stakeholders for learning derived from the FLARE project and our dissemination activities are planned to reflect the diverse needs and interests of each group.

We will deliver FLARE information through a number of dissemination methods to suit a range of learning focus requirements including a general description of the Project within Smart Grid Architecture Model (SGAM). We will use best practice developed from both delivering and attending LCN Fund dissemination events. Our principles are to keep FLARE information accessible at all times and match the dissemination methods to our stakeholder audiences.

The main audiences that have been identified are:

1. **Distribution network operators**: including IDNOs, Ofgem, DECC and wider government will be keen to appreciate how the FLARE Method can be applied. Information for this audience will focus on how active fault level assessment and response will delay or potentially avoid the requirement for reinforcement investment, reducing costs for customers, improving quality of supply and network reliability. This will assist in decision making for future strategies and price control reviews and industry regulation including the potential move to a DSO model. In addition, groups such as the Health and Safety Executive (HSE) and UK and EU industry lobbyist groups will be interested in any potential impact on network design and operation.
2. **Industry groups**: this will include various industry groups such as the ENA, the Combined Heat and Power Association (CHPA), D3 stakeholder initiative, the

Knowledge dissemination continued

Association of Electricity Producers (AEP) and Smart Energy Demand Coalition (SEDC). Their primary interest will be with new network design and operating standards, system configurations and demand and generation response agreements.

3. **I&C and generation customers**: informing these customers will form a crucial part of the dissemination agenda. These customers will be interested in understanding the effect on their current business models from the learning of the new contractual agreements that we will explore in collaboration with the FCL service Partners. The customer survey and Trials will provide an important opportunity to start engaging with customers and providing education about DSO commercial solutions. Achieving customer buy in will be critical to the success of the FLARE Project. We will need to address a variety of stakeholders. These will include renewable generator developers, owners and operators who will want to understand how they can connect to the network at lower cost and other I&C load customers with similar interests in low cost of connection and enhancing their return on existing investments.
4. **Other energy industry participants**: such as technology and LCT vendors and equipment manufacturers who will want to identify possible opportunities for product development and ascertain any operational effects of the techniques applied.
5. **Academic institutions**: such as universities and higher education establishments will have a likely interest in using data generated throughout FLARE to support their own programmes in the area of fault level research. Knowledge dissemination with this stakeholder group presents a unique opportunity to invite alternative conclusions.
6. **Electricity North West**: Knowledge will be shared and discussed with the future networks and policy & standard teams and wider Electricity North West community. They will be interested in all aspects of FLARE and working to establish how learning/ knowledge will be incorporated into future business as usual.
7. **Local groups**: There will be interest from a number of other local groups including local planning authorities, Local Enterprise Partnerships, councillors, business leaders, Chambers of Commerce, Greater Manchester Energy Group and various policy makers.

Dissemination methods will encourage feedback from stakeholders.

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Knowledge dissemination continued

Figure 5.2: Audience and dissemination methods

Audience	Dissemination Method	Milestone
Distribution network operators, including IDNOs	FLARE website, ENA Smarter Networks Portal, webinars, knowledge sharing events, consultations and advertorials	All key deliverables
I&C customers and generators and energy industry participants	FLARE website, ENA Smarter Networks Portal, webinars, knowledge sharing events, consultation and advertorials	Various depending on area of interest
Academic institutions	FLARE website, ENA Smarter Networks Portal, webinars, consultations and knowledge sharing events	Network data and academic reports
Government/ Regulators/ Health & Safety Executive	FLARE website, ENA Smarter Networks Portal, webinars, knowledge sharing events, consultation and advertorials	Customer survey, carbon assessment, losses and energy reduction values
Consumer groups	FLARE website, ENA Smarter Networks Portal, publicity, learning events	Customer survey, carbon assessment, energy reduction values
Electricity North West	Internal workshops, intranet, newsletters etc	All key deliverables
Other	All of the above depending on individual or group	Various depending on area of interest

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Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%): 0%

Requested level of protection against Direct Benefits that they wish to apply for (%):0%

*We have secured the input of **highly regarded industry professionals** with the expert knowledge to deliver the FLARE project and their partnership funding significantly reduces our customers' investment.*

Electricity North West is confident that it can start FLARE in a timely manner owing to the robust delivery plan we have put in place should the submission be successful. A significant amount of preparatory work has taken place prior to the Full Submission using knowledge gained from previous projects, both from within Electricity North West and from other DNOs and Partners. These factors are discussed in more detail below but can be summarised as:

- Forerunner First Tier LCN Fund project;
- Review of FlexDGrid project and international review of FLARE concepts;
- Partnership, consortium and contractual arrangements;
- Project costs and Direct Benefits;
- Programme management and governance;
- Project plan;
- Risks, mitigation and contingencies; and
- Customer engagement.

Forerunner First Tier LCN Fund Projects

In September 2013 Electricity North West started the First Tier LCN Fund project, Fault Current Active Management (FCAM) to explore the potential of using alternative techniques to manage the size and flow of fault current in distribution networks. With the assistance of ABS Consulting, EPS, ABB, The University of Manchester and Siemens we identified that it is possible to employ different approaches to manage fault current. This is based around an enhanced centralised network management tool that assesses the potential maximum fault current at a point in the network and then enables a device to stand ready to operate in a prescribed manner should a fault occur. This work has provided us with confidence that the concepts and Trials proposed within the FLARE Project are ready to be demonstrated at network scale.

Review of FlexDGrid project and international review of FLARE concepts

As part of the development of the bid materials for the FLARE Project, PB Power were contracted to review the technical feasibility of the FLARE concepts and the use of these techniques in distribution networks in the UK and worldwide. PB Power reviewed the technical aspects of the FLARE concepts and their comments are detailed below:

- Through a literature search PB Power reviewed the use of Adaptive Protection in distribution networks and identified that "the adaptive protection concept or protective sequence switching [as named by PB Power] was not being implemented by distribution networks operators around the world" but highlighted the approach is similar to the "operational tripping schemes used by National Grid UK" for other purposes. They commented that "protective sequence switching can be used to reduce fault currents by tripping a designated breaker through which fault contribution would normally be supplied".
- As part of the concept review for the provision of a Fault Current Limiting service PB

Power undertook a technical review of the protection for AC electrical machines, specifically looking into how the protection could be modified to quickly disconnect the fault current. For generation PB Power specifically considered, at our request: 1) switching off the rotor field current of the generator; and 2) the normal disconnection using the opening of the incoming circuit breaker to quash the fault current contribution. The University of Manchester was also independently commissioned to consider these two methods. Both organisations highlighted technical issues and the potential risk with de-energising the rotor field. Both recommended that the preferred option is to open the generator AC circuit breaker and that the existing generator protection could be easily adapted or replaced for the FCL service.

- The PB Power review of the contribution to fault currents by large synchronous or induction motors highlighted that "although opportunities are expected to be limited, we would recommend that large motors are included in the proposed [FLARE] Project where appropriate" but further research is necessary to adapt the existing protection for the motors to be involved in a Fault Current Limiting service.
- With the assistance of ABB, PB Power reviewed the use of I_S-limiters in public and private distribution networks in the UK and worldwide and commented that "I_S-limiters are a proven short-circuit current limiting device used around the world at distribution voltage levels, but have not been used on British (public) distribution networks". PB endorsed the proposed installations for use of I_S-limiters in the FLARE Project, namely in series with the bus-section circuit breaker and in series with the transformer incoming circuit breaker (see Figure B1.1 in Appendix B1). PB Power also recommended that we "develop a safety case for the use of I_S-limiters on UK DNO systems". This has been developed and is included as Appendix G. It is of note that within FLARE the limiter will be used to control through fault current levels and not act as the primary means of breaking fault current. The specific mode of operation of the limiter **has been discussed with the HSE who are supportive** of the approach used within FLARE.

Additionally PB confirmed that the FLARE concepts, generated from the First Tier LCN Fund project, Fault Current Active Management (FCAM) complement and more importantly do not duplicate the techniques being trialled in the FlexDGrid project. Electricity North West has confirmed this via a scope review meeting with WPD's FlexDGrid delivery team.

Partnership, consortium and contractual arrangements

The selection of Project Partners and suppliers is dependent on experience, skills, cost and the organisation's ability to commit resources to deliver both the FLARE Project and disseminate the learning to other GB DNOs. The decision on which Project Partners are selected is taken by Electricity North West's FNSG and the identification of our preferred Partners started with a series of Expressions of Interest (EoI) and Requests for Information (RfI) in spring 2014. This approach promotes wider awareness of, and involvement in, our LCN Fund projects and generates keener costs through competition. This maintains value for money when delivering the FLARE Project for our customers.

In February 2014 we issued an EoI through the ENA Smarter Networks Portal, to seek potential Partners or suppliers for the specialist skills and understand their associated costs and contributions. We chose our technical support Partner, PB Power from this initial EoI, but due to the high response for our customer engagement Partner we then ran a much more detailed tender process. This resulted in the selection of our customer engagement support, Impact Research. We have discussed with software providers their capability to develop a Fault Level Assessment Tool and conducted an RfI to seek a potential Partner to understand their costs and potential contributions for the FLARE software. [redacted]

Low Carbon Networks Fund
Full Submission Pro-forma
Project Readiness continued

[redacted]

The formation of a strong dedicated consortium where every Partner or supplier understands its roles and responsibilities is a key success factor for delivering the FLARE Project. As part of the development of this proposal, we generate work schedules together with our Partners/ suppliers that define their roles and responsibilities as well as costing and timing schedules. The agreed work schedules form the basis of our contractual arrangements with each partner/ supplier. The defined roles and responsibilities are included within the Project plan (See Appendix C); and their financial costing and contributions for the provision of services and/ or products are included in the Full Submission workbook (See Appendix K). A key outcome of this approach is that Electricity North West minimises time spent on agreeing contractual agreements and ensures that the FLARE Project is ready to go once funding has been granted.

Where a technology element is a commodity (ie protection relays, switchgear and cable) we will use existing framework agreements for the procurement of these items.

Project costs and Direct Benefits

The costs and Direct Benefits have been compiled by a management accountant federated into the bid team, from inputs generated by our internal and external Project Partners/ suppliers and have been approved through Electricity North West's internal investment appraisal process. The cost information included in the proposal has an accuracy of between 3 and 5% and within the overall cost calculation, we have added an additional 8.7% as contingency against any potential changes to costs as the FLARE Project progresses.

A management accountant, responsible for managing all costs and constructing and delivering the reporting requirements will be embedded in the Project team to manage the budget. Electricity North West runs a robust financial tracking and reporting system in line with its current internal policies and frameworks. The Project finances will be held in a separate Project Bank Account required by the LCN Fund Governance Document. This shall meet the following requirements:

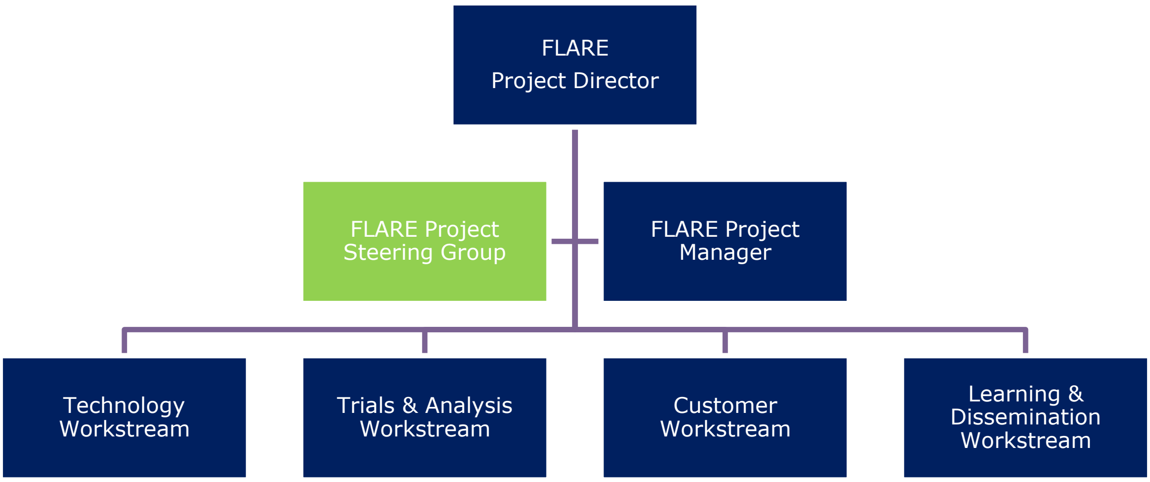
- Show all transactions relating to (and only to) FLARE;
- Be capable of supplying a real time statement (of transactions and current balance) at any time;
- Accrue expenditures when a payment is authorised (and subsequently reconciled with the actual Bank Account);
- Accrue payments from the moment the receipt is advised to the bank (and then subsequently reconciled with the actual Bank Account);
- Calculate a daily total; and calculate interest on the daily total according to the rules applicable to the Bank Account within which the funds are actually held; and
- Electricity North West's auditors, Deloitte, will be made aware of its responsibilities should FLARE be awarded LCN funding.

Low Carbon Networks Fund
Full Submission Pro-forma
Project Readiness continued

Programme management and governance

FLARE will use the programme management and governance approach currently being employed for the delivery of the C_2C, CLASS and Smart Street projects. This proven project governance methodology will ensure that FLARE delivers the defined milestones and successful delivery criteria. The project delivery teams co-exist together, under three team managers in the future networks team. This means that when methodology improvements are identified in the delivery of our Second Tier projects these can be easily transferred into FLARE. The philosophy to be open and collaborative, with the commitment to get it right first time to achieve delivery success already seen in the three project delivery teams, will be embedded in the FLARE Project team. The Project management structure is shown below in Figure 6.1.

Figure 6.1: High level Project management structure

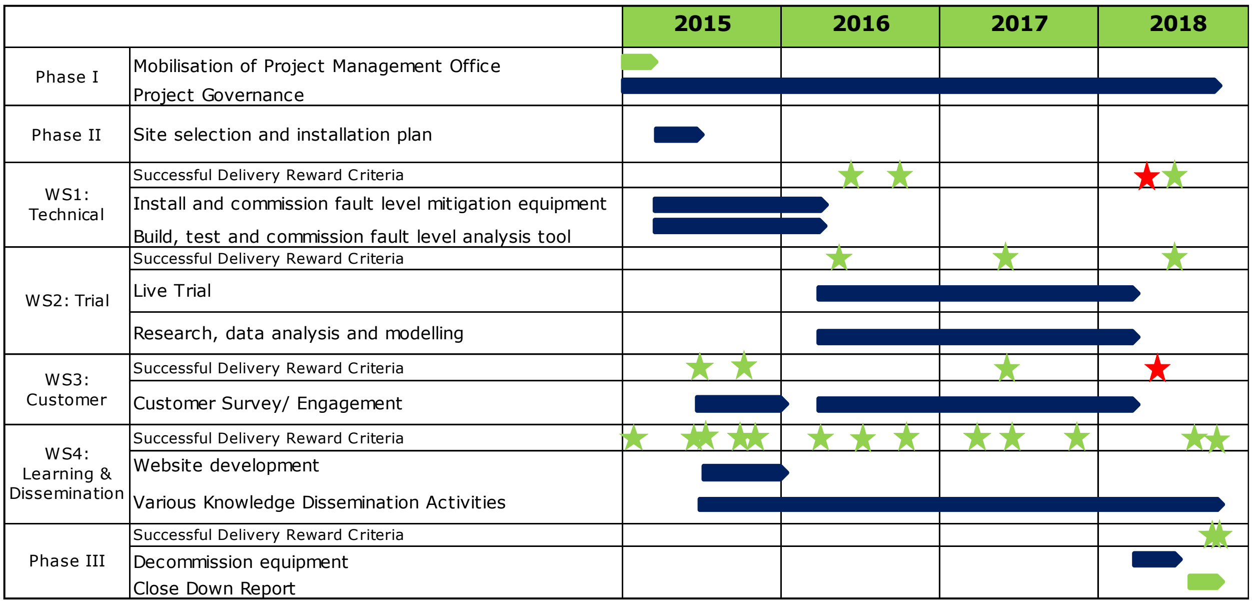


Project plan

The FLARE Project plan details the approach that the delivery team has determined to ensure successful outcomes. The plan identifies four Workstreams in addition to the mobilisation and close down phases. The activities in the Project plan have been designed to deliver learning irrespective of the take up of low carbon technologies and renewable energy in the Trial areas. The plan is described below and shown diagrammatically in Figure 6.2, and a more detailed version is in Appendix C.

Project Readiness continued

Figure 6.2: High level Project plan



Risks, mitigation and contingencies

A key aspect of our Project management methodology is the capability to manage risks and issues. FLARE will employ the proven risk and issues process currently in operation within Electricity North West, but modified from our experience in the delivery of LCN Fund projects. The risk and issues model employed considers risks and issues that are business as usual and those specifically related to FLARE, all of which will be articulated in a common format.

Appendix D contains a table of the risks, mitigating and contingency actions identified prior to the start of the FLARE project; as well as the format and description of the Electricity North West scoring matrix used to evaluate the identified risk and controlled risk following use of any mitigating action(s). Mitigation and contingency creation and definition form a key part of our risk management strategy. The Project management team and Project steering committee will use this methodology to continually identify and review FLARE risks, their mitigating action(s) and controls and to ensure that risks are managed in priority order. When a risk is raised the Project management team will be responsible for creating a mitigation action that can be brought into play should the risk be realised. Standard topic areas in the risk identification process include cost monitoring and management particularly considering cost overruns or shortfalls in Direct Benefits.

The Project steering group (PSG) will also identify the circumstances that may lead to the Project being suspended, until such time as sufficient risk mitigation has occurred to enable on-going management of the risk or issue; or to halt the Project and defer further commitment until agreement has been reached with Ofgem on how to proceed.

Customer engagement

The knowledge gained from delivering the Capacity to Customers customer survey has helped us scope out a comprehensive approach to managing the customer relationship, using a trusted agent to advocate the completion of the customer survey materials. Through the bid preparation, we have engaged with our customers ENER-G and United Utilities. Both organisations are keen to be involved in the development and delivery of this Project. These customer Partners will work with our selected customer engagement support, Impact Research, and with the assistance of the Combined Heat and Power Association

Project Readiness continued

(CHPA), to develop the customer survey and include the CHPA's members to achieve a higher than normal survey response.

United Utilities is the North West's water and wastewater supplier and operates large electrical pumps in several of its processes. UU has agreed to participate in the FCL service Trials subject to identification of a suitable site.

ENER-G will also be directly involved in the Trials. ENER-G will provide access to their CHP test cell to understand generator behaviour during the tripping event, introduce potential customers to the Trials, and provide engineering support to change the protection settings of units for the FCL service Trials.

Project Code/Version No: ENWT206/02

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Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

FLARE will propose changes to the Common Connection Charging Methodology to ensure that the cost apportionment methodology for the new fault level mitigation techniques is defined.

FLARE's regulatory impact

We do not expect that the FLARE Project will require any derogation, licence consent or licence exemption for its delivery.

FLARE could have profound implications on the design and operation of distribution networks through the use of a centralised Fault Level Assessment Tool as part of network management systems. When the fault level rises above a designated value in a particular area of the network, the Fault Level Assessment Tool will enable or disable the fault level mitigation techniques. In the event of a fault occurring on that part of the network, the enabled mitigation technique will manage the level and flow of fault current.

The FLARE Method will prove that there are three additional fault level mitigation techniques, in addition to the three being trialled by WPD's FlexDGrid, that could be employed by DNOs to manage network fault levels and is complimentary to the FlexDGrid project.

The trialling of new HV and EHV fault level mitigation equipment will not require planned supply interruptions to install this equipment.

FLARE will consider the impact on the CCCM, assuming the trialled fault level mitigation techniques are successful, and recommend change proposals for the Fault Level Cost Apportionment Factor calculation to accommodate the charging for the deployment of alternative fault level mitigation techniques (see Appendix J for further details).

Long-term regulatory impact

The learning from FLARE will enable updates to the planning, design and operation standards for distribution networks, particularly for HV networks facing fault level issues.

The longer term impact on the regulatory regime applied to network operators is significant and positive with the following areas potentially seeing change:

- Regime for load related capital expenditure, especially for the connection of distributed generation;
- Common connection and use of system charging methodologies applied by distribution network operators;
- National Terms of Connection within Distribution Connection and Use of System Code (DCUSA);
- Distribution Code; and
- Future DSO operational management.

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Section 8: Customer impacts

This section should be between 2 and 4 pages.

FLARE will ascertain whether customers are ***willing to provide a new Fault Current Limiting service*** *and if so* ***at what price.***

Increasing customer choice

Electricity North West is committed to building strong and long lasting relationships with customers and works hard to cater for everyone so they can enjoy a reliable and efficient electricity supply and the best customer service possible.

Our innovation strategy and associated programme is targeted at maximising the use of the existing assets thereby driving value for our customers and shareholders. FLARE offers potential additional value to all DUoS customers and, like our C_2C project, to those I&C and DG customers who are willing and able to provide a service to Electricity North West. FLARE seeks to trial the provision of a Fault Current Limiting service from customers.

Scope of FLARE

The FLARE Method will be trialled on seven primary substations and two bulk supply point (BSP) substations located across Electricity North West's network involving around 105 000 customers. We will develop a Customer Engagement Plan and a Data Privacy Statement in the delivery of the FLARE project along the lines of the previous documents developed for the delivery of our other Second Tier LCN Fund projects: C_2C, CLASS and Smart Street. The main focus of the Customer Engagement Plan will be the customer survey and purchase of a Fault Current Limiting service from at least one Electricity North West demand customer and one Electricity North West generation customer.

For clarity on the scope of the Customer Engagement Plan, the potential customer impacts in the delivery of the FLARE project are detailed below, grouped by Workstream. All FLARE activities will be conducted in a manner so as not to disrupt the smart meter programme.

Technology build

New fault level mitigation technology will be installed on the selected HV and EHV networks; but the installation works will not require planned supply interruptions.

During the site selection process, we will develop procedures to identify those customers that have their own electricity infrastructure. We will then decide how to engage with such customers to discuss fault level issues as business as usual; this is not required within the FLARE Project, as the maximum fault current will not exceed the design fault level or the installed network equipment ratings.

Customer

Electricity North West will engage with selected I&C and DG customers across distribution networks to seek involvement in a customer survey to ascertain their willingness to provide a Fault Current Limiting service and if so at what price. Where practical, we will include potential connection customers in the survey, especially when a fault level issue with their proposed connection is identified.

The customer survey approach will be similar to the method adopted in the Capacity to Customers project, but amended to take into consideration the learning from that project. For example, we will make greater use of trusted third parties to engage with our customers ie trade associations, such as CHPA. We will use the relationships with CHPA and ENER-G to assist with the drafting of the customer survey and customer engagement materials, paying particular attention to the language used by this customer segment. Similarly to the learning from other Second Tier projects we will employ an Engaged Customer Panel of I&C customers to help shape our customer survey approach and survey materials. Figure 8.1 below shows diagrammatically our approach to establishing which customers to contact in the customer survey and how we will use third party relationships to identify specific customer groups and encourage them to complete the customer survey.

Customer impacts continued

Figure 8.1: Reaching relevant customers

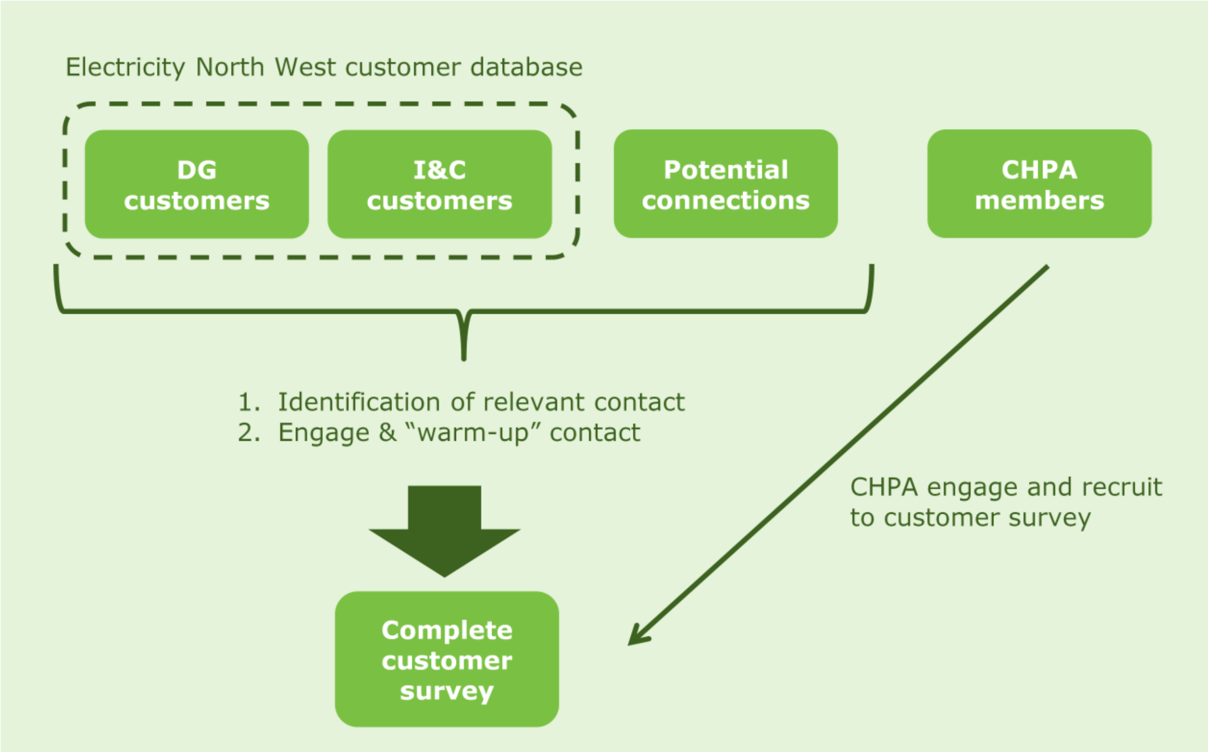
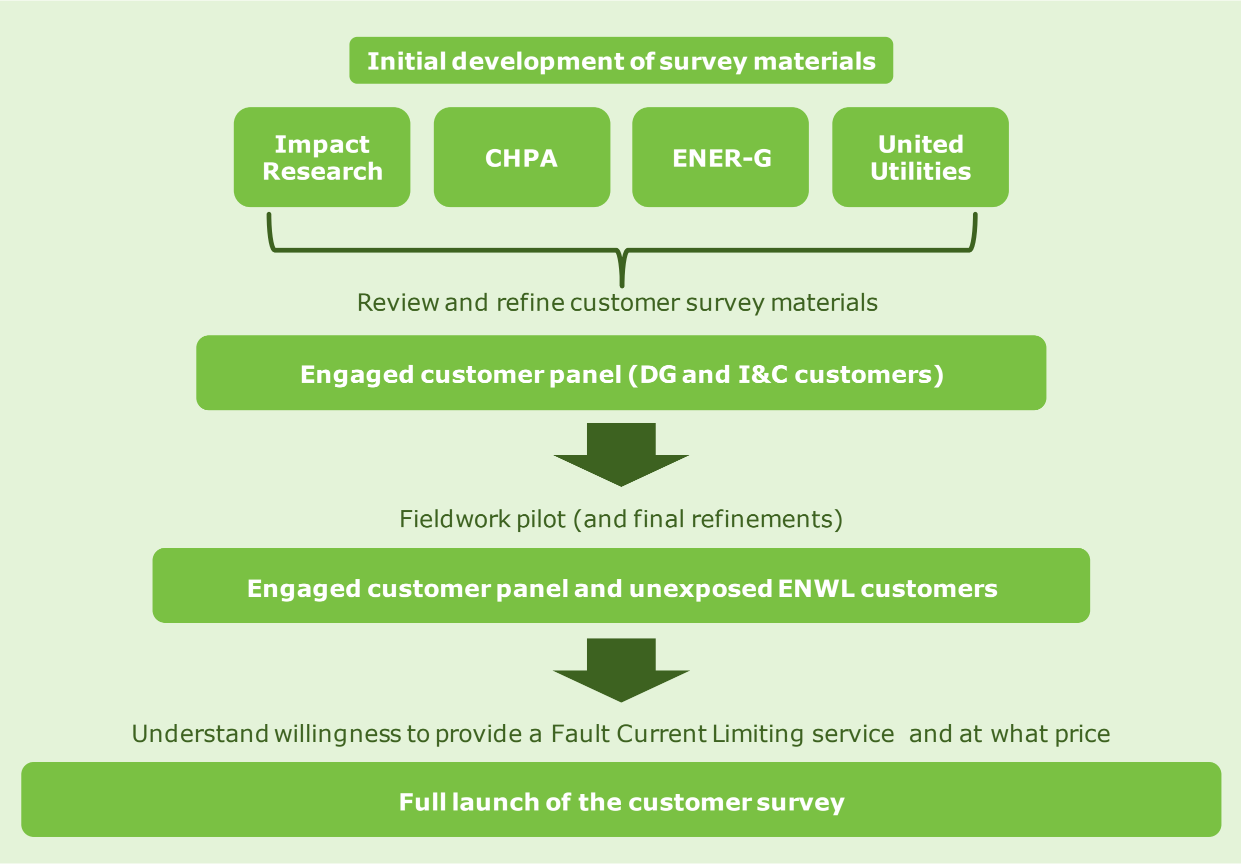


Figure 8.2 overleaf shows the steps from original design with assistance from our Project Partners, through refinement and testing with the assistance of an Engaged Customer Panel to the launch of the customer survey.

Customer impacts continued

Figure 8.2: Designing the customer survey



Trials and analysis

The operation of the new fault level mitigation equipment will have no impact on the quality or reliability of supply to our customers. In the bid development we have considered how FLARE will co-exist with our other Second Tier projects and in Project implementation we will amend our systems accordingly. For example, the fast frequency response functionality under CLASS will be disabled if the Adaptive Protection fitted on the primary substation transformer circuit breakers is enabled.

In the customer survey we will ask customers to indicate if they would be interested in taking part in the Trials phase for the provision of a Fault Current Limiting service. Initially we will re-contact any of the customers from anywhere within the Electricity North West footprint that indicated an interest to discuss and agree FCL service provision in the Trials phase at an agreed price. Where required, and where appropriate, with the assistance of trade association/s we will actively seek Trial involvement across the relevant customer populations.

Where an existing or new customer agrees to provide a Fault Current Limiting service to Electricity North West as part of the Trials & Analysis Workstream, we will agree with the customer the method of retrofit. If the Adaptive Protection retrofit requires the whole or part of the customer's electrical installation to be de-energised, this will be agreed with the customer and co-ordinated with normal down times ie maintenance schedules.

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Customer impacts continued

Learning and dissemination

We have planned an extensive knowledge dissemination programme, detailed further in the Project plan in Appendix C that employs a range of communication methods and channels to engage with and impart information to our customers and/ or stakeholders.

FLARE is a technically complex project and so we have decided not to directly engage with domestic customers during Project implementation. However we will, as is normal with our Second Tier LCN Fund projects, publish all the generated materials on the FLARE website enabling any of our customers or stakeholders to download information or raise any questions, if they wish.

We will hold an initial webinar in advance of technology installation to provide a basic understanding of the FLARE objectives and the importance of the low carbon agenda. Throughout the Project we will engage with our stakeholders via tailored communications which will be a combination of written, audio and visual mediums; for example through a six monthly newsletter, through three further webinars, three knowledge learning events, etc that we will deliver throughout the life of the FLARE Project.

Managing customer enquiries

We will create a number of communication channels so that customers will find it simple to raise any questions or concerns at a time convenient for them using the following channels:

- *Telephone* – Electricity North West operates an enquiry service that is continuously staffed and can be contacted 24 hours a day and seven days a week on 0800 195 4141
- *Written correspondence* – The FLARE Project team can be contacted at the following address: FLARE Project Team, Technology House, Salford, M6 6AP; or
- *FLARE website* – The FLARE website will contain all relevant information including Trial areas, customer survey materials and Project literature and Project team contact details. *Frequently asked questions* will be posted on the website and updated regularly. If the customer is unable to find an answer to their specific issue, a "Contact Us" function will allow them to submit their query and a representative of the Project team will respond through the customer's preferred feedback method.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

Criteria (9.1)

Technology Build Workstream

9.1.1 Produce briefing and training materials on new fault level approaches and operational procedures for use in DNO internal dissemination;

9.1.2 Install and commission fault level mitigation and monitoring equipment;

9.1.3 Update NMS, develop interface and install and commission the Fault Level Assessment Tool software;

9.1.4 Validate the Fault Level Assessment Tool; and

9.1.5 Examine current fault level protocols and evaluate Adaptive Protection setting requirements.

Evidence (9.1)

Technology Build Workstream

9.1.1 Brief and train Electricity North West operational teams, including planning engineers, on fault level mitigation management protocols by April 2016;

9.1.2 Publish equipment specifications and installation reports for the Adaptive Protection and the I_S-limiter by September 2016 and the FCL service by April 2018;

9.1.3 Publish NMS interface and configuration specifications and commissioning reports by September 2016;

9.1.4 Publish report on validation of the Fault Level Assessment Tool by November 2016; and

9.1.5 Publish updated fault level management, planning, design, protection settings and operation and maintenance policies by June 2018.

Criteria (9.2)

Customer Workstream

9.2.1 Develop Customer Engagement Plan and Data Privacy Statement;

9.2.2 Design, create and test the customer survey materials using an Engaged Customer Panel;

9.2.3 Deliver the customer survey and report the findings; and

9.2.4 Develop appropriate commercial arrangements and contract templates for FCL service.

Evidence (9.2)

Customer Workstream

9.2.1 Send Customer Engagement Plan and Data Privacy Statement to Ofgem by June 2015;

9.2.2 Deliver Engaged Customer Panel workshop by September 2015, lessons learned from testing customer survey materials incorporated into survey and all survey materials published on the FLARE website by October 2015;

9.2.3 Publish customer survey report and information for customer evaluation of FCL service provision on FLARE website by May 2017; and

9.2.4 Publish contract templates for FCL service with new and existing customers and commercial arrangements learning by May 2018.

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Successful Delivery Reward Criteria continued

Criteria (9.3)

Trials & Analysis Workstream

9.3.1 Design monitoring and analysis procedures for Trial regime;

9.3.2 Commence live Trials;

9.3.3 Implement monitoring and post fault analysis procedures in Trial period;

9.3.4 Develop interim and final Cost Benefit Analysis study reports by June 2017 and July 2018 respectively;

9.3.5 Produce a draft DCUSA change proposal for amending Common Connection Charging Methodology;

9.3.6 Develop interim and final Carbon Impact Assessment reports by June 2017 and July 2018 respectively;

9.3.7 Test the market for the purchase of Fault Current Limiting services;

9.3.8 Write Safety Case for each fault level mitigation technology deployed; and

9.3.9 Conduct Asset Health study.

Evidence (9.3)

Trials & Analysis Workstream

9.3.1 Publish monitoring and analysis procedures for Trials on FLARE website by May 2016;

9.3.2 Publicise commencement of live Trials on FLARE website by May 2016;

9.3.3 Publish on FLARE website a summary of each fault event three months after each event, with the expectation that a minimum of 18 faults will be reported on;

9.3.4 Publish on FLARE website the Cost Benefit Analysis study report and the buy order of FLARE/ FlexDGrid/ traditional reinforcement fault level mitigation solutions by July 2018;

9.3.5 Submit a DCUSA change proposal for amending application approach to Fault Level Cost Apportionment Factor in Common Connection Charging Methodology by August 2018;

9.3.6 Publish on FLARE website the Carbon Impact Assessment report by July 2018;

9.3.7 Purchase a Fault Current Limiting service from at least one Electricity North West demand customer and one Electricity North West generation customer;

9.3.8 Publish peer reviewed Safety Cases on the FLARE Project website by September 2018; and

9.3.9 Publish Asset Health Study on FLARE website by July 2018.

Criteria (9.4)

Learning & Dissemination Workstream

9.4.1 Develop and launch the FLARE Project website and social media forums;

9.4.2 Produce Project progress materials for internal general awareness and a series of advertorials detailing FLARE's progress;

9.4.3 Attend Annual LCN Innovation Conferences, deliver webinars and hold Knowledge Sharing Events; and

9.4.4 Issue six monthly Project Progress Reports to Ofgem and on FLARE Project website.

Successful Delivery Reward Criteria continued

Evidence (9.4)

Learning & Dissemination Workstream

9.4.1 Deliver live FLARE website and social media forums by July 2015;

9.4.2a Publicise FLARE within Electricity North West in monthly team brief pack and/ or Volt (intranet) and/ or Newswire (quarterly employee magazine) by January 2015, September 2015, June 2016, July 2017 and October 2018;

9.4.2b Publish advertorials by July 2015, April 2016, July 2016, July 2017 and October 2018;

9.4.2c Publish newsletter by May 2015, November 2015, May 2016, November 2016, May 2017, November 2017 and May 2018;

9.4.3 Actively participate at four annual LCN Innovation conferences from 2015 to 2018; Webinars held by September 2015, by September 2016, September 2017, October 2018; and three Knowledge Sharing Events by May 2016, May 2017 and September 2018; and

9.4.4 Issue Project progress reports in accordance with Ofgem's June and December production cycle and publish on FLARE website.

Criteria (9.5)

Close Down Report and Business as Usual

9.5.1 Produce the FLARE Project Close Down Report;

9.5.2 Update Electricity North West's Network Design Policy to define FLARE Project mitigation techniques as the intervention strategy for fault level mitigation.

Evidence (9.5)

Close Down Report and Business as Usual

9.5.1 Issue FLARE Project Close Down Report to Ofgem and publish on FLARE website by October 2018; and

9.5.2 Publish Electricity North West's approach to managing fault level reinforcement on FLARE website by October 2018.

LCN Fund
Low Carbon Networks

Project Code/Version No:
ENWT206/02

Low Carbon Networks Fund
Full Submission Pro-forma
Section 10: List of Appendices

Appendix A1	**Benefits Tables**
Appendix A2	**Method and Base Case Methodologies**
Appendix A3	**Tyndall Manchester, Carbon Impact Assessment**
Appendix B1	**Technical description**
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Appendix C	**Detailed Project Plan**
Appendix D	**Risks and issues register and contingency actions**
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Appendix K	**Full Submission spreadsheet**
Appendix L	**DTI report and FlexDGrid review**
Appendix M	**References**
Appendix N	**Glossary**

Appendix A1: Benefits Tables

Figure A.1 below shows the key for the completion of the financial benefits and capacity released Figures A1.2 to A1.5 for the FLARE technologies reference by their Trial number.

Figure A1.1: Nomenclature key for Figures A1.2 to A1.5

Method	Method and Trial names
Method	Actively regulate the level and flow of fault current on EHV and HV networks
Trial 1	Adaptive Protection (AP)
Trial 2	Fault Current Limiting service (FCL service)
Trial 3	I_S-limiter (I_S)

LCN Fund – financial benefits

Figures A1.2 and A1.3 below show the financial benefits for the three technologies / techniques proposed in the FLARE project.

Figure A1.2: Financial benefits at high voltage network level

Financial benefit (£m)								
Scale	Method	Method Cost	Base Case Cost	Benefit 2020	Benefit 2030	Benefit 2050	Notes	Cross-references
Post-Trial solution (individual deployment)	Trial 1 (AP)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]	See assumptions stated below	Appendix A2
	Trial 2 (FCL service)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]		
	Trial 3 (I_S)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]		
Electricity North West scale	Trial 1 (AP)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]	*For 2020 = 29 sites.* *For 2030 = 78 sites.* *For 2050 = 162 sites.*	See assumptions stated below
	Trial 2 (FCL service)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]		
	Trial 3 (I_S)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]		
GB rollout scale	Trial 1 (AP)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]	*For 2020 = 424 sites.* *For 2030 = 1030 sites.* *For 2050 = 2131 sites*	See assumptions stated below
	Trial 2 (FCL service)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]		
	Trial 3 (I_S)	[redacted]	£0.54	[redacted]	[redacted]	[redacted]		

Figure A1.3: Financial benefits at extra high voltage network level

Financial benefit (£m)								
Scale	Method	Method Cost	Base Case Cost	Benefit 2020	2030	2050	Notes	Cross-references
Post-Trial solution (individual deployment)	Trial 1 (AP)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]	See assumptions stated above	Appendix A2
	Trial 2 (FCL service)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]		
	Trial 3 (I_S)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]		
Electricity North West scale	Trial 1 (AP)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]	*For 2020 = 5 sites. For 2030 = 9 sites. For 2050 = 23 sites.*	See assumptions stated below
	Trial 2 (FCL service)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]		
	Trial 3 (I_S)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]		
GB rollout scale	Trial 1 (AP)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]	*For 2020 = 67 sites. For 2030 = 121 sites. For 2050 = 310 sites.*	See assumptions stated below
	Trial 2 (FCL service)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]		
	Trial 3 (I_S)	[redacted]	£1.22	[redacted]	[redacted]	[redacted]		

Financial benefits

The rows of each Trial are completed in the figure above as if that technique was applied individually to all the identified Electricity North West and GB sites. The financial benefits have been estimated with the following assumptions:

- Method and Base Case costs are the asset costs of the individual deployment of each of the three techniques, as described in Appendix A2 - Method and Base Case Methodologies;
- City/ town centre traditional reinforcement or FLARE intervention occur in year 1;
- As equipment costs are uncertain over the period from now to 2050 the benefits are assumed to be constant; and
- For the Fault Current Limiting service the minimum cost is that of only the protection retrofit to enable the service (ie a customer agrees to supply this service at zero cost instead of incurring fault level reinforcement connection charges) and the maximum value is the Base Case cost (ie the city / town centre traditional reinforcement).

PB Power was commissioned to calculate the scaling factors for the Electricity North West scale and GB scale rollouts. The Electricity North West and GB rollout scaling factors have been calculated with the following assumptions:

Electricity North West scale – number of HV sites

- **Up to 2020** - In the Electricity North West licence area there are 29 HV sites (ie 8% of 365 HV primary substation population) that has a potential maximum fault current above 80% of the switchgear rating. It is assumed that the Method will be applicable at all of these sites by 2020 because the potential fault current will increase above the switchgear rating due to generation and/ or demand connections along with changes to the upstream system;
- It is assumed that the Method will eventually be applicable at sites where the switchgear is rated at the design fault level or below corresponding to 82% of the total Electricity North West population. The 8% of sites addressed by 2020 are assumed to have switchgear at the system design fault level or below, leaving 74% of the total population where the Method would be applied in future years ie 270 sites (0.74 x 365);
- **Between 2020 and 2030** - It is assumed that it is appropriate to apply the Method to 29% of the remaining sites between 2020 and 2030 because load forecasts show that reinforcement would be required at these sites by 2030 and it is assumed that this reinforcement would involve fault levels increasing above the switchgear rating ie 78 sites (0.74 x 0.29 x 365);
- **Between 2030 and 2050** - It is assumed that it is appropriate to apply the Method to a further 60% of the remaining sites based on extended load forecasts indicating that reinforcement would be required there and it is assumed that this would involve fault levels increasing above the switchgear rating ie 162 sites (0.74 x 0.60 x 365);

GB scale – number of HV sites

- **Up to 2020** – It is assumed the 8% derived for Electricity North West 2020 figure is applicable to the whole GB system ie 424 sites (0.08 x 5300) based on there being approximately 5300 primary substations in the whole of GB;
- It is assumed that the Method will eventually be applicable at sites where the switchgear is rated at 13.1kA or below. This corresponds to approximately 75% of the total population of GB primary substations from analysis of Long Term Development Statements. The 8% of sites addressed by 2020 are assumed to have switchgear rated at 13.1kA or below, leaving 67% of the total population for application of the Method in future years ie 3551 sites (0.67 x 5300);
- **Between 2020 and 2030** - It is assumed that it is appropriate to apply the Method to 29% of the remaining sites based on the extrapolation of the approach applied to the Electricity North West area ie 1030 sites (0.67 x 0.29 x 5300);
- **Between 2030 and 2050** - For the whole of GB up to 2050, it is assumed that it is appropriate to apply the Method to a further 60% of the remaining sites, again based on the extrapolation of the approach applied to the licence area ie 2131 sites (0.67 x 0.60 x 5300).

Electricity North West scale – number of EHV sites

- **Up to 2020** – Our RIIO-ED1 submission includes five EHV switchboard schemes to address fault level issues. It is speculated that one further replacement scheme may appear due to a customer connection. Allowing for the Method not being appropriate for all instances, for up to 2020, it is estimated that the Method will be applicable at five of the six sites ie five sites;
- It is assumed that the Method will eventually be applicable at the 41 Electricity North West 33kV bulk supply point sites where the switchgear is rated at the design fault level or below. The five sites addressed by 2020 are assumed to have switchgear at the system design fault level or below, leaving 36 sites where the Method could be applied in future years;
- **Between 2020 and 2030** - It is assumed that it is appropriate to apply the Method to 25% of the remaining sites because load forecasts show that

reinforcement would be required there and it is assumed that this would involve fault levels increasing above the switchgear rating ie nine sites (0.25 x 36);

- **Between 2030 and 2050** - It is assumed that it is appropriate to apply the Method to a further 64% of the remaining sites based on extended load forecasts indicating that reinforcement would be required there and it is assumed that this would involve fault levels increasing above the switchgear rating ie 23 sites (0.64 x 36).

GB scale –number of EHV sites

- **Up to 2020** - Application of the Method at five out of 65 33kV bulk supply point substations has been estimated for the Electricity North West area, corresponding to 7.7%. This has been extrapolated to the approximate number of 875 bulk supply point substations in GB. Therefore, by 2020 it is estimated that the Method will be applicable at 67 sites in GB (ie 0.077 x 875);
- Based on the Electricity North West population, it is assumed that the Method will be applicable at 63% of the GB population of bulk supply point substations where the switchgear is rated at the design fault level or below. The 67 sites addressed by 2020 are assumed to have switchgear at the system design fault level or below, leaving 484 sites for future years ie (0.63 x 875 -67);
- **Between 2020 and 2030** - Extrapolating Electricity North West system values, for GB up to 2030, it is assumed that it is appropriate to apply the Method to 25% of the remaining sites ie 121 sites (0.25 x 484);
- **Between 2030 and 2050** - Applying Electricity North West values to the whole GB system, it is assumed that it is appropriate to apply the Method to a further 64% of the remaining sites up to 2050 ie 310 sites (0.64 x 484).
- The simple approach to these evaluations is considered appropriate due to the substantial uncertainties around the future system requirements of 2030 and 2050.

LCN Fund – capacity released

Network planners consider thermal and fault level constraints when assessing the connection of new demand and/ or generation. Although the planner considers each constraint type in isolation, the constraints are closely linked; and either can constrain the maximum use of existing assets. It has been observed that these constraints become more relevant with the offer of non-firm or interruptible connection arrangements for demand and generation customers wishing to connect to the distribution network. For example, as a substation approaches its firm thermal capacity, it may be possible to release around 35% of non-firm capacity to customers, where it is possible to guarantee the disconnection of the non-firm element ie the Capacity to Customers (C_2C) arrangement. Note: the size of the maximum non-firm capacity is capped at the emergency rating of one of the transformers (nominally 135%). The C_2C type connection arrangements are becoming more prevalent amongst DNOs as they facilitate the rapid connection of demand or generation customers.

However, it is not always possible to release the non-firm capacity, if the substation is close to its fault level rating. The addition of non-firm demand, which is assumed to contribute 1MVA per 1MVA rating to system fault levels, or an AC electrical machine (ie generator or motor) which has a range of 4MVA to 7MVA per 1MW contribution to system fault levels, may increase fault levels above the rating of the network equipment. Whereas thermal capacity, both firm and non-firm, is driven equally by demand as by generation, this is not the case for fault level capacity. So in instances where the fault level headroom is low at a substation, the release of firm and non-firm capacity may be constrained by the fault level rating of the network equipment.

The application of the FLARE techniques can remove the fault level constraint and release the full thermal capacity (both firm and non-firm) without resorting to expensive and disruptive switchgear and cable replacement.

Figures A1.4 and A1.5 below show the capacity released for each of the three technologies/ techniques proposed in the FLARE Project. They have been completed recognising that the increase in the thermal capacity at an existing substation inevitably causes an increase in fault level, whether by releasing non-firm capacity or through the installation of an additional transformer or interconnection. Therefore, release in thermal capacity is an alternative way of considering the utilisation of the capacity released by the fault level headroom created by the Method. At all sites it is assumed that the fault current benefit is 100% realised by the connection of generation or demand.

Figure A1.4: Capacity released on high voltage network level

Capacity released (MVA)								
Scale	Method	Method Cost	Base Case Cost	Benefit 2020	2030	2050	Notes	Cross-references
Post-Trial solution (individual deployment)	Trial 1 (AP)	23	23	23	23	23	See explanation above and assumptions stated below	Appendix A2
	Trial 2 (FCL service)	23	23	23	23	23		
	Trial 3 (I_S)	23	23	23	23	23		
Electricity North West scale	Trial 1 (AP)	23	23	667	1,794	3,726	*For 2020 = 29 sites.* *For 2030 = 78 sites.* *For 2050 = 162 sites.*	See explanation above and assumptions stated below
	Trial 2 (FCL service)	23	23	667	1,794	3,726		
	Trial 3 (I_S)	23	23	667	1,794	3,726		
GB rollout scale	Trial 1 (AP)	23	23	9,752	23,690	49,013	*For 2020 = 424 sites.* *For 2030 = 1030 sites.* *For 2050 = 2131 sites*	See explanation above and assumptions stated below
	Trial 2 (FCL service)	23	23	9,752	23,690	49,013		
	Trial 3 (I_S)	23	23	9,752	23,690	49,013		

Figure A1.5: Capacity released on extra high voltage network level

Capacity released (MVA)								
Scale	Method	Method Cost	Base Case Cost	Benefit 2020	2030	2050	Notes	Cross-references
Post-Trial solution *(individual deployment)*	Trial 1 (AP)	90	90	90	90	90	See explanation above and assumptions stated below	Appendix A2
	Trial 2 (FCL service)	90	90	90	90	90		
	Trial 3 (I_S)	90	90	90	90	90		
Licensee scale	Trial 1 (AP)	90	90	450	810	2,070	*For 2020 = five sites*	See explanation above and assumptions stated below
	Trial 2 (FCL service)	90	90	450	810	2,070	*For 2030 = nine sites*	
	Trial 3 (I_S)	90	90	450	810	2,070	*For 2050 = 23 sites*	
GB rollout scale	Trial 1 (AP)	90	90	6,030	10,890	27,900	*For 2020 = 67 sites*	See explanation above and assumptions stated below
	Trial 2 (FCL service)	90	90	6,030	10,890	27,900	*For 2030 = 121 sites*	
	Trial 3 (I_S)	90	90	6,030	10,890	27,900	*For 2050 = 310 sites*	

PB Power was commissioned to calculate the capacity released and the presented values have been estimated, in terms of the size of LCT generation or demand that could be connected, based on the following assumptions:

- **HV Base Case** - It is assumed that typical 11kV primary switchgear rated at 13.1kA would be replaced by 25kA switchgear. The amount of generation capacity which could be connected when a primary switchboard is replaced with such higher rated switchgear would probably be limited by factors other than fault level. Assuming a typical primary transformer power capability, it is concluded that the traditional approach would facilitate the connection of a theoretical maximum of 23MVA of generation capacity or additional thermal capacity.
- **EHV Base Case** - The EHV Base Case is similar in that it is expected that the theoretical maximum amount of generation that could be facilitated by an increase in fault rating would be limited by factors other than fault level. Assuming a typical bulk supply point rating, it is concluded that the traditional approach would facilitate the connection of a theoretical maximum of 90MVA of generation capacity or additional thermal capacity.
- **HV Adaptive Protection** - It is assumed that the potential fault current could increase to 30kA (based upon the limitation of the withstand capability of a 240mm^2 Al XLPE cable and the estimated time to reduce the fault current by the operation of the protected circuit breaker ie 400ms). The embedded generation capacity or thermal capacity which could be connected due to the fault level

released by the installation of HV Adaptive Protection is also expected to be a theoretical maximum of 23MVA per primary substation and limited by factors other than fault level.

- **EHV Adaptive Protection** - At EHV, the corresponding value could be up to 90MVA per bulk supply point.
- **Fault Current Limiting service** – Again it is assumed that the potential fault current could increase to 30kA and for the reasons already discussed. Therefore, the theoretical maximum embedded generation capacity or additional thermal capacity which could be connected due to the fault level released by the application of the Fault Current Limiting service is also expected to be 23MVA per primary substation and 90MVA per bulk supply point.
- **HV I_S-limiter** - It is assumed that just one I_S-limiter is fitted in series with the bus section circuit breaker, or one I_S-limiter is fitted in series with a transformer circuit breaker. On this basis the fault level on either side of the switchboard could increase by up to 50% of the switchgear fault rating, assuming that the existing fault level is 100% of the switchgear fault rating. Again, it is judged that the ability to accept generator/ demand connections would be constrained by factors other than fault level. Consequently, it is concluded that the installation of I_S-limiters at HV could facilitate the connection of a theoretical maximum of 23MVA of generation or additional thermal capacity.
- **EHV I_S-limiter** - Installation of an I_S-limiter at EHV could facilitate the connection of up to 90MVA of generation or additional thermal capacity per bulk supply point.

Technical factors have been assumed within the evaluation of the theoretical maximum capacity released. However, it is recognised that there are other influences on whether the benefits would be fully realised. For example, the extent of the utilisation of the facilitated ability to connect embedded generation and demand depends upon the future uptake of LCT demand and generation, the locations of the new demand and generation (plus the type of generators and their fault current contribution). Also, it is recognised that the penetration of HV generation can influence the ability to accommodate additional demand or additional generation upstream in the same radial system at EHV, and vice-versa. Similarly, increases in EHV fault level where the Method is applied upstream could impact on HV fault levels and the amount of fault level capacity released by application of the Method at HV.

The capabilities of equipment downstream of the primary substations, where Adaptive Protection or Fault Current Limiting service would be applied, could limit the capacity released, or it may be necessary to upgrade equipment to realise the full benefit. To realise the theoretical maximum capacity would require a different spend profile including the upgrade of the downstream system equipment earlier than previously necessary. Limitations due to the ratings of downstream system equipment are expected to be less of an issue with the application of the I_S-limiter which reduces the fault current very quickly.

Net benefits evaluation of an I_S-limiter protecting for HV cable withstand

In the evaluation of FLARE the question of the size of benefit that could arise from installing an I_S-limiter to only protect HV cables for through fault withstand was raised. Figure A1.6 below shows the potential net benefits arising from the installation of an I_S-limiter to fulfil that duty.

The results from this analysis should be considered as a separate scenario and not as a sub-set of the analysis presented in earlier sections of this Appendix. This more comprehensive analysis on the length of cable at risk from limited fault withstand capability has revealed that the length of cable that would be replaced is significantly more than the 500 metres assumed in the City/ town centre Base case.

Figure A1.6: Financial benefit for withstand protection of HV cables only

Financial benefit (£m)								
Scale	Method	Method Cost	Base Case Cost	Benefit				Notes
				2020	2030	2050	TOTAL	
Post-trial solution *(individual deployment)*	I_s-limiter at 6.6kV	[redacted]	£1.15	[redacted]			[redacted]	See explanation and assumptions below
	I_s-limiter at 11kV	[redacted]	£0.45	[redacted]				
Electricity North West scale	I_s-limiter at 6.6kV	[redacted]	£1.15	[redacted]	[redacted]	[redacted]	[redacted]	*For 2020 cable at risk= 115 km at 6.6kV and 43 km at 11kV, corresponding to 15 6.6kV and 14 11kV sites.* *For 2030 additional cable at risk = 385 km at 6.6kV and 142 km at 11kV, corresponding to 50 and 47 sites respectively.* *For 2050 additional cable at risk = 796 km at 6.6kV and 293 km at 11kV corresponding to 104 and 98 sites respectively.*
	I_s-limiter at 11kV	[redacted]2	£0.45	[redacted]	[redacted]	[redacted]		
GB rollout scale	I_s-limiter at 11kV	[redacted]	£0.45	[redacted]	[redacted]	[redacted]	[redacted]	*For 2020 cable at risk= 1272 km at 11kV corresponding to 424 sites.* *For 2030 additional cable at risk = 4242 km at 11kV corresponding to 1414 sites.* *For 2050 additional cable at risk = 8777 km at 11kV corresponding to 2926 sites.*

Financial benefits

The financial benefits have been estimated with the following assumptions:

- As equipment costs are uncertain over the period from now to 2050 the benefits are assumed to be constant;
- Method cost is the asset cost of an I_S-limiter deployment, as described in Appendix A2 - Method and Base Case Methodologies; and
- Base case cost is the replacement cost of the length of cable designated at risk recognising that the lengths of cable at risk are different for 6.6kV and 11kV networks (see methodology and assumptions below).

Parsons Brinckerhoff was commissioned to calculate the length of HV cable at risk for the Electricity North West scale and GB scale rollouts. The Electricity North West and GB length of cables at risk have been calculated with the following assumptions.

Estimating I_S-limiter benefits in terms of avoided HV cable replacement

- Some cables may be at risk of experiencing fault flows greater than their fault withstand capability.
- The application of an I_S-limiter would limit the potential fault current so that cable is no longer exposed to fault flows above its withstand capability.

- The length of cable at risk depends upon the fault level and the cable withstand capability which depends upon the cable's type and size. Potential fault currents decrease as the fault location moves away from the primary along a cable, due to the impedance of the intervening cable. Consequently, there becomes a point along a cable where the potential fault current falls below the cable's withstand limit and the cable beyond this point is no longer at risk.
- The benefits of the application of I_S-limiters in terms of the length of replacement cable that can be avoided has been evaluated by considering the theoretical lengths of cables at risk and the population of these cable types within the Electricity North West HV distribution network.

Estimating lengths of cables at risk

- The length of cable at risk has been evaluated on the basis that the fault level at any primary substation can increase to the system design fault rating without consequences to downstream customer's equipment.
- Based on a 250MVA design fault rating, the assumed maximum fault current for 6.6kV systems is 21.9kA and 13.1kA for 11kV systems.
- The withstand capability of a range of cables used in Electricity North West's HV distribution network was evaluated upon the basis of temperature rise in the cable during a fault. In the literature used for this evaluation, the short circuit current is assumed to be steady and the cables were assumed to be operating at their maximum permissible continuous temperature when the fault occurs resulting in an estimate of the withstand capability. When determining the withstand of each cable type, a fault duration time of 1.5 seconds was considered with a constant fault current flow equal to the primary maximum fault level.
- The length of cable required for the fault level to drop from the maximum fault level at the primary to the withstand limit was evaluated for each cable type based upon the cable's impedance at 20^{o}C. In reality the cable's starting temperature is variable depending upon ambient conditions and initial loading conditions, also the cable's temperature will increase with the flow of fault current. However, the impact of the assumed temperature on the calculated length is expected to be within the tolerance of the analysis because only the cable resistance, not reactance, is significantly affected by temperature.

Electricity North West – Estimating total length of cable at risk

- The length of cable at risk ranges from less than 100m for the larger cables to above 1km for smallest cable sizes. These lengths typically correspond to a limited number of sections of a circuit after it has left the primary substation.
- The population of each type of cable within these first sections away from the primary has been evaluated for a sample of Electricity North West 6.6kV and 11kV primary substations; with the sample considered as being representative.
- The cables leaving all Electricity North West primary substations have been assumed to exist in the proportions found from the analysis of the sample.
- The lengths at risk for each cable type have been multiplied by the estimated number circuits of that type and summed to evaluate the total length of cable in the Electricity North West HV network at risk should the fault level at every primary rise to the design fault rating based on the given assumptions.
- The eventual total length of cable at risk based upon the above assumptions was estimated to be 1975 km within the Electricity North West HV network.
- The estimated eventual total length of cable at risk corresponds to approximately 31.1% of 6.6kV cables and approximately 6.1% of 11kV cables or approximately 14.9% of all HV cables in the Electricity North West network.
- The estimated total length of cable at risk corresponds to approximately 7.6 km per 6.6kV primary and 3 km per 11kV primary.

Electricity North West scale – Estimating the length of cable at risk over time

- For the Electricity North West network the potential fault current at 8% of the HV primary substations is already above 80% of the switchgear rating. It is assumed that the Methods will be applicable at all of these sites by 2020 because the potential fault current there will increase above the switchgear rating due to generation connections along with changes to the upstream system. The estimated length of HV cable at risk in the Electricity North West network is 158 km (1975 km x 0.08), split 115 km at 6.6kV and 43 km at 11kV.
- For the Electricity North West network up to 2030, it is assumed that it is appropriate to apply the Methods to 29% of the remaining 92% of primary substations because load forecasts show that reinforcement would be required there and it is assumed that this would involve fault levels increasing above the switchgear rating. The estimated additional length of HV cable at risk in the Electricity North West network is 527 km (1975 km x 0.29 x 0.92), split 385 km at 6.6kV and 142 km at 11kV.
- For Electricity North West up to 2050, it is assumed that it is appropriate to apply the Methods to a further 60% of the remaining 92% of primary substations based on extended load forecasts indicating that reinforcement would be required there and it is assumed that this would involve fault levels increasing above the switchgear rating. The estimated additional length of HV cable at risk in the Electricity North West is 1090 km (1975 km x 0.6 x 0.92), split 796 km at 6.6kV and 293 km at 11kV.

GB scale – Estimating the length of cable at risk over time

- The length of cable at risk in the Electricity North West system corresponds to 3 km per 11kV primary substation. It is assumed that the majority of the approximate 5300 primaries in the GB network will operate at 11kV. Therefore the result for the analysis of Electricity North West's 11kV network is assumed to be valid for the whole of GB.
- Therefore the length of HV cable at risk if the fault level rises to the design fault rating at all primary substations in the GB network is estimated to be 15900 km based on the given assumptions.
- The 8% of sites where the Methods are considered appropriate by 2020 derived for the Electricity North West network is assumed to be applicable to the GB system as a whole.
- For up to 2020, the estimated length of HV cable at risk in the GB network is 1272 km (15900 km x 0.08) corresponding to 424 primary substation sites based on the assumed 3km of cable at risk per primary.
- For the whole of GB area up to 2030, it is assumed that it is appropriate to apply the Methods to 29% of the remaining 92% of sites based on the extrapolation of the approach applied to the Electricity North West network.
- For up to 2030, the estimated additional length of HV cable at risk in the GB network is 4242 km (15900 km x 0.29 x 0.92) corresponding to 1414 primary substation sites based on the assumed 3km of cable at risk per primary.
- For the whole of GB up to 2050, it is assumed that it is appropriate to apply the Methods to a further 60% of the remaining 92% of sites, again based on the extrapolation of the approach applied to the Electricity North West network.
- For up to 2050, the estimated additional length of HV cable at risk in the GB network is 8777 km (15900 km x 0.6 x 0.92) corresponding to 2926 primary substation sites based on the assumed 3 km of cable at risk per primary.

Appendix A2: Method and Base Case Methodologies

The business case analysis of the traditional and alternative fault level mitigation techniques showed that the FLARE Method was viable and provided significant reduction in costs and implementation time while delivering the same capacity release. Figure A2.1 below shows the asset costs, capacity released in terms of facilitated generation/ demand connections and implementation time for fault level led reinforcement scenarios at a standard primary substation, a city/ town centre primary substation and a bulk supply point (BSP). For the FLARE techniques, the costs are for the initial intervention only and do not include any allowance for reinforcement of downstream systems, such as replacement of distribution switchgear or cables. Consequently, the HV costs for the Method are the same for standard and city/town centre cases.

Figure A2.1: Cost, capacity and implementation time for fault level reinforcement interventions

	Asset Cost, £	Planning & installation time, days	Capacity released, kVA
Traditional reinforcement			
HV – standard	£442 208	390	23 000
HV – city/ town centre	£542 171	390	23 000
EHV	£1 220 400	390	90 000
Adaptive Protection			
HV	[redacted]	20	23 000
EHV	[redacted]	20	90 000
Fault Current Limiting service			
HV	[redacted]	20	23 000
EHV	[redacted]	20	90 000
I_S-limiters			
HV	[redacted]	90	23 000
EHV	[redacted]	90	90 000

To create the Base Case and Method Case for the 14 substations in the FLARE Trials, it was assumed that one is a standard HV primary substation, six are city/ town centre primary substations, and there are two BSP substations. Three HV primary substations and two BSPs were excluded as these sites will be fitted with only the I_s-limiter sensing equipment ie no fault level mitigation is provided. These sites will deliver operation and maintenance data to determine the locations where I_s-limiters would be located in business as usual.

Figure A2.2 below shows the Base Case costs and capacity release in the FLARE Project.

Figure A2.2: FLARE Project Base Case cost and capacity release

	No.	Cost per substation, £	Total costs, £	Total capacity released, kVA
Traditional reinforcement				
HV – standard	1	£442 208	£442 208	23 000
HV – city/ town centre	6	£542 171	£3 253 023	138 000
EHV	2	£1 220 400	£2 440 800	180 000
Total	**9**		**£6 136 031**	**341 000**

Assumptions for Figures A2.1 to A2.2

Costs

- The costs shown in Figures A2.1 and A2.2 are the asset costs only of the traditional and alternative techniques assuming intervention at year 1;
- The asset cost per customer for a Fault Current Limiting service is shown in the Figure A2.1 but is excluded from the analysis in Section 3 (Project Business Case) to due to uncertainty on the size of the provision payments.

Capacity release

- See Appendix A1 for a detailed set of assumptions on the calculation of the capacity released.

Planning and installation times

- The average planning and installation for traditional reinforcement at HV and EHV is a year and a half ie 390 working days or 78 weeks. This could be longer at HV and EHV if a particular outage slot is required to enable the replacement of the switchgear. This assumes that the installation times for associated distribution switchgear and HV cables will be completed in parallel and do not affect the overall time.
- It is expected that the average planning and installation time for Adaptive Protection on distribution switchgear will take 20 working days or four weeks; calculating the protection settings will take up to two weeks, and installation will take a further two weeks.
- It is estimated that the planning and installation time for Adaptive Protection on electrical machines will take 20 working days or four weeks; calculating the protection settings will take half a week, and installation will take a further three and a half weeks. The installation time is longer compared with Adaptive Protection on distribution switchgear as there are more interface arrangements to be ratified.
- The average planning and installation time for I_S-limiters is on average 90 days or 18 weeks. This could be longer at HV and EHV if a particular outage slot is required for the installation.

Appendix A3: Tyndall Manchester's estimated carbon impact of FLARE

Overview and approach

This analysis and report was prepared by Dr John Broderick, Tyndall Centre for Climate Change Research at the University of Manchester, with input from Simon Brooke, Electricity North West. This report is non-peer-reviewed and all views contained within are attributable to the authors and do not necessarily reflect those of researchers within the wider Tyndall Centre or University of Manchester.

Carbon Impact Assessments for previous Electricity North West LCN Fund projects, C_2C, CLASS and Smart Street, have identified assets, operations and facilitations as the main categories for determining the emissions associated with distribution network interventions. A white paper detailing the methodology developed within the C_2C project is available on the project website. It is a project based carbon accounting approach, using input from life cycle assessments; a similar approach is appropriate to FLARE.

In summary, asset impacts arise from the production and installation of new infrastructure; they are estimated by quantifying the materials involved and referring to life cycle assessment data. Operational impacts arise from the ongoing consumption of electricity in network losses or requirements for maintenance; they are estimated using the future marginal grid emissions factors and life cycle assessments as per assets. Facilitated impacts may arise where increased network capacity enables the more rapid connection of low carbon technologies (LCTs) that are expected to have comparatively lower emissions than traditional "baseline" technologies. These putative reductions are not accounted for distinctly due to their inherent uncertainty, and risk of double counting.

The FLARE project will assess different combinations of assets required to deliver an equivalent fault level on a series of circuits. One traditional and three novel configurations are examined:

- Traditional reinforcement (Trad rein) - switchgear and circuit breaker replacement;
- I_S-limiters – fast acting isolation devices installed at substations;
- Adaptive Protection; and
- Fault Current Limiting service (FCL service).

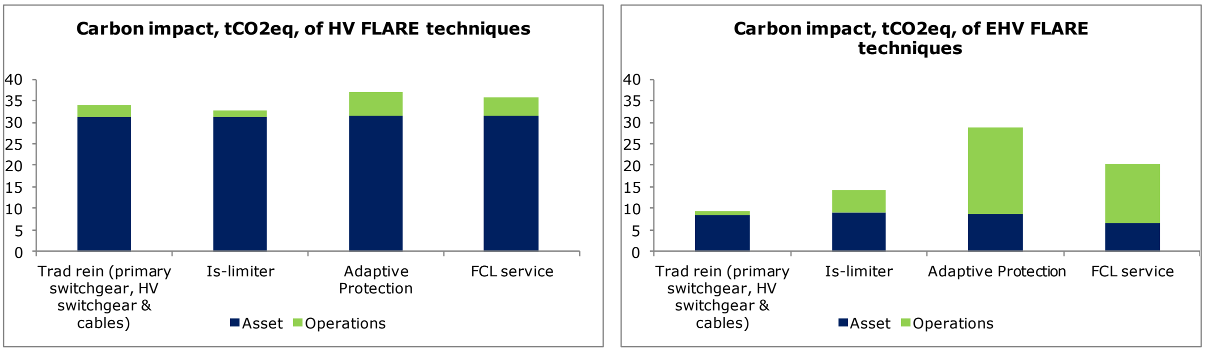
Asset, operational and facilitation impacts are considered and estimated. Initial scoping of the FLARE Project suggests that in all configurations, the network topology is conserved. The changes in assets are not anticipated to materially alter electrical losses (eg for I_S-limiters see Parsons Brinckerhoff 2014, Report 287189A), the only significant potential being the upgrade of short (<1km) sections of HV cable. Given the limited scale cable upgrade and its common requirement across multiple interventions, power flow modelling to determine changes in losses was not deemed necessary. The direct carbon impact for the FLARE solution is anticipated to predominantly arise from the assets delayed and avoided. Studies of capacity release and the respective time saved in deploying LCTs will be conducted during the Project delivery to offer an understanding of facilitated reductions.

For each network configuration, asset requirements are estimated quantitatively through time and converted to a carbon impact using life cycle emissions estimates. Data were drawn from various industry (Ecoinvent), academic (University of Bath ICE), government (DECC/DEFRA) and internal sources. Switchgear and circuit breakers will in some cases be nearing the end of scheduled life and so the benefit of investment deferral offered by the novel configuration is limited. Operational impacts arise only from asset replacement and maintenance (eg mineral oil for switchgear) and are so calculated on a similar basis with realistic schedules. Like a fuse, I_S-limiters use a consumable cartridge to deliver protection and so an estimate of frequency of activation and replacement is also incorporated into operational impact. The combination of these time dependent factors produces a profile of both investment cost and carbon impact over a 45 year period (RIIO-ED1 CBA standard).

Initial findings

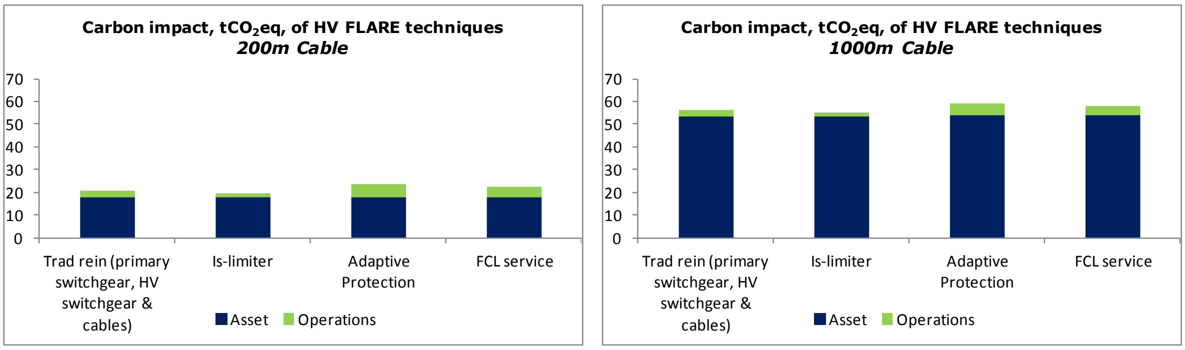
The three novel reinforcement methods may be used in combination and at different points in time. Further, circuit specific variables (frequency of protection activation, cable requirement for reinforcement, life extension enabled) have an impact on relative carbon impact. Taking initial expectations (I_S-limiters activated in 30% of faults, four faults per substation per year, 500m cable upgrade, 28 year life extension) then alternative strategies are comparable. I_S-limiters would be expected to be similar to traditional reinforcement on the HV network, with Adaptive Protection and FCL service approximately 6% to 9% more. The absolute values on the EHV network are lower as can be seen in the below figures. On the EHV network, I_S-limiters, Adaptive Protection and FCL service have increased impacts relative to traditional reinforcement, though with a different distribution between assets and operations. Differences in operational carbon are due to switchgear oil consumption (normal and fault maintenance), not evident in new switchgear. The potential for SF_6 leakage has not been accounted for but will be investigated in future due to its potency as a greenhouse gas.

Figure A3.1: Carbon impact of FLARE techniques at HV and EHV



Cable for reinforcement is the dominant component of the carbon impact except in some EHV cases. Varying the length of cable does not have a substantial impact on the ranked performance of the different solutions; at some point in their time profile the cable is required to be changed in all circumstances. However, the cable is a substantial proportion of the total absolute impact and so with a lower requirement, eg 200m shown below, the relative operational impact of I_S-limiter replacement and switchgear maintenance increases, and the increase due to the Adaptive Protection solution exceeds 15%.

Figure A3.2: Effect of HV cable length on carbon impact of HV FLARE techniques



Whilst the life extension enabled by the novel solutions makes a significant difference to discounted cash flows, because all carbon impacts are treated equally through time it makes only a small overall impact and no comparative impact. Increasing the rate of faults affects all solutions, either in terms of mineral oil consumption or Is-limiter cartridge replacement. However, in the range explored (<five faults pa, 0-100% I_S-limiter activation) a significant comparative difference is observed only on the EHV network. However, this addition is still small (<20tCO2e) in absolute terms.

Summary

A preliminary scoping of the carbon impact of FLARE suggests that assets rather than operations dominate the impact profile. The I_S-limiter solution performs similarly to traditional reinforcement at HV level but not EHV, with Adaptive Protection and FCL service delivering a noticeable increase at both voltage levels. There are three key areas to be developed in understanding the carbon impact of the FLARE project during its planning/operation: 1) the cable upgrade requirement which dominates asset calculations and will determine the relative benefit of the various interventions; 2) the frequency of faults which determine maintenance rates and I_S-limiter operation; and 3) the emissions attributable to consumption, reconditioning and leakage of insulating materials.

Appendix B1: Technical Solution

Background

This technical paper outlines proposals for methodologies to facilitate the successful implementation of the FLARE project. A high level outline of the operating principles and proposed functionality is provided; including the expected implementation methods of the various products and software algorithms.

In order to meet the decarbonisation challenge laid down by the Government, customers will be encouraged to adopt new low carbon technologies. These technologies, particularly distributed generation (DG), will contribute to the current flowing during a fault. This current flowing during a fault is commonly referred to as "fault current". Normal current and fault current are very different. Normal current is a steady flow of electricity through the network. Fault current occurs only when there is a fault on the network. It is an instantaneous surge of electrical energy, which is significantly higher in magnitude than normal current, and flows towards the point of the fault. Fault level is the potential maximum fault current that will flow when a fault occurs. Additional demand and generation connecting to the network increases fault level. Fault level fluctuates throughout the day depending on the network configuration and customers' load/generation.

All switchgear on the DNO network has three fault level ratings assigned by the manufacturer, through fault withstand, breaking capacity and making capacity. The through fault withstand is quoted as the amount of current that can safely pass through the unit and for what length of time eg 20kA for three seconds. The breaking capacity is only applied to automatic interruption class devices and is the maximum current that the device can safely interrupt. The making capacity is the maximum current which the device can safely conduct at the instant of closing.

The value of fault level changes depending on the network configuration, the amount and type of demand and generation on the network. Therefore, even without mitigation, there will typically only be short periods of time where the fault level exceeds the equipment ratings.

If the making capacity is exceeded this can be controlled operationally using alternative switching arrangements.

Traditionally the solution to issues with breaking capacity and through fault withstand would be the wholesale replacement of the affected equipment. This is expensive and where fault level increases are associated with new connections, then connection costs may be prohibitive. The FLARE Method will investigate alternative, innovative ways to control the fault level during those short periods of time leading to faster, cheaper connection of low carbon technologies.

FLARE Method

The FLARE Method will utilise an active network management solution co-ordinated by a Fault Level Assessment Tool in conjunction with the Electricity North West network management system (NMS) to enable technologies and techniques investigated under the existing Fault Current Active Management project (a First Tier LCN Fund project).

The following techniques will be trialled as part of the FLARE Method:

- Adaptive Protection at primary substations;
- Adaptive Protection for large electrical machines ie generators and motors;
- I_S-limiters: –
    - I_s-limiter across primary substation bus section. (Note: If the I_s-limiter is across the bus section, the bus section will need to be opened when the I_s-limiter is in service.); and
    - I_s-limiter installed in transformer incomer.

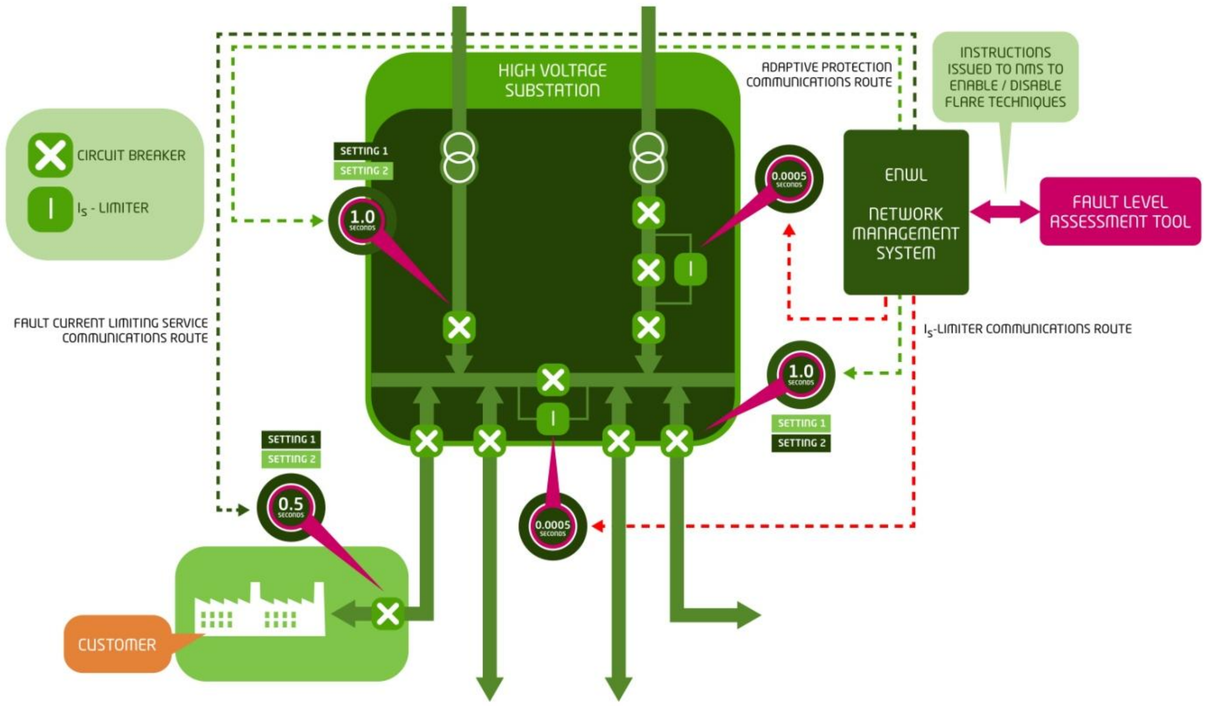
Fault Level Assessment Tool

The Fault Level Assessment Tool will be installed in the Electricity North West control room and is responsible for assessing the fault level in near real time.

The Fault Level Assessment Tool will use the network configuration from our NMS and generation/ demand data from the network to conduct this assessment. Based on predefined settings within the software, the tool will then instruct via the NMS the various fault level mitigation techniques to "enable" or "disable". The techniques will only be enabled at times when the fault level approaches or rises above equipment fault level ratings.

The overall system is shown below:

Figure B1.1: Overall system diagram



Fault level mitigation technologies

Adaptive Protection

Adaptive Protection can be described as the use of adjustable protection relay settings that can be changed in real time based on signals from local sensors or a central control system to alter how the protection scheme operates. For FLARE this means that the NMS will, following instruction from the Fault Level Assessment Tool, instruct the relays to adopt new settings. When the new settings are in operation the transformer circuit breaker will open before the feeder breaker.

Adaptive Protection can be implemented in a number of ways which vary in complexity and cost. For Adaptive Protection to be successful, at least one of the relays on site would need to be a modern numerical relay with the ability to be remotely switched between different settings groups.

The least complex implementation of Adaptive Protection is explained below.

- For sites with electro-mechanical and static electronic relays:
    - The time setting is increased on the protection of those CBs which may be at risk of exceeding fault level. This is a permanent setting change and not a relay change;
    - On one of the incomers a numerical relay is installed with two groups of settings - one for "normal" operation and one for "exceeding fault level" operation (this will have a reduced time setting); and

    - Existing SCADA is used to remotely switch between the two settings depending on network conditions.
- For sites with all numerical relays:
    - All the numerical relays are programmed with two groups of settings - one for "normal" operation and one for "exceeding fault level" operation (this will have a reduced time setting);
    - Existing SCADA is used to remotely switch between the two settings depending on network conditions; and
    - The settings are only changed on those CBs which are at risk of operating outside their rating and one of the incoming CBs.

The approaches described above provide simple retrofit solutions. There are more complicated implementations of Adaptive Protection which lend themselves to being used as part of complete substation renewal / refurbishment as opposed to retrofit solutions as above. These can be achieved by replacing all relays with numerical relays and implementing IEC61850 and GOOSE messaging. As there are good examples of application of these processes and procedures on infrastructure projects across the DNO community, we will not trial these alternative, more complex solutions during this Project.

Machine protection

Large synchronous generators and AC motors can contribute significantly to the current flowing during a fault. Therefore it seems appropriate to look at disconnecting this equipment during this time.

As an addition to the Adaptive Protection scheme it is proposed to trial combining this with generator/ motor protection. As with the adaptive protection this will only be enabled during times when fault level is likely to exceed switchgear rating and will be enabled by the Fault Level Assessment Tool via the SCADA system.

Protection will be installed at the generator/ motor and when it is enabled it will detect when it is contributing to fault current and disconnect the generator/ motor.

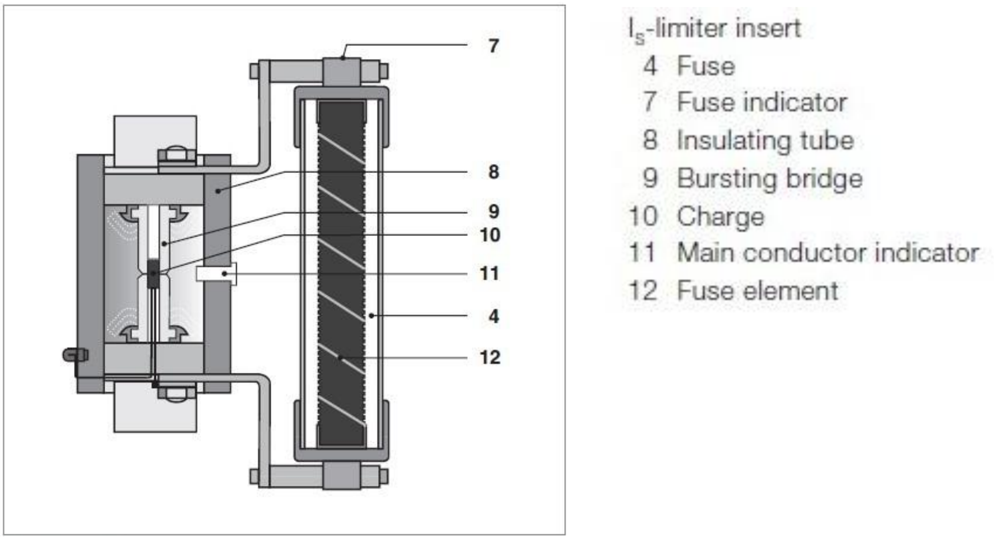
This technical solution goes hand in hand with the commercial Trial also being conducted as part of the Project.

I_S-limiter

An I_S-limiter is a device which is capable of detecting and limiting a fault current before it reaches the first peak, ie in less than one millisecond. The electronics in the device use the rate of rise to calculate what the peak fault current will be. If this peak fault current is larger than a predefined setting, the electronics will then trigger the device to operate.

The I_S-limiter insert is the operational part of the device and is shown in detail below.

Figure B1.2: I_S-limiter insert



When the electronics issue a trigger the charge operates which interrupts the main current carrying path and diverts the current through the fuse element. This element then operates and opens the circuit thus clearing the fault from the system. Once the device has operated the entire insert must be changed for a new one. Spares of the insert will be held at the substations, in secure cabinets, where the I_S-limiter is installed. Inserts will be returned to the manufacturer for refurbishment and re-use.

In the FLARE Project it is intended to install two I_S-limiters at primary substations. The arrangements proposed are for one to be installed across a bus section circuit breaker and one in a transformer incoming circuit. These arrangements are anticipated to represent the two most commonly applicable arrangements and the Project will investigate the advantages and disadvantages of the two arrangements. In both cases a bypass switch will be installed to ensure that the I_S-limiter can be taken out of service without affecting supplies to customers. In the bus section installation, the bus section circuit breaker can perform the duties of the bypass switch.

In addition to the installation of two complete I_S-limiters the Project will also install a number of “shadow” units. These units comprise only the electronics and triggering elements of the I_S-limiter; the actual cartridge will not be installed. This will show when the electronics have detected a fault and sent a trigger for the I_S-limiter to operate. The advantage of installing these is that we can gauge the maintenance and operation costs of using I_S-limiters and therefore gain increased learning at lower cost and quicker installation.

NMS requirements and communication interface

The Electricity North West NMS will require modifications to allow for the enabling and disabling of the Adaptive Protection and I_S-limiter schemes.

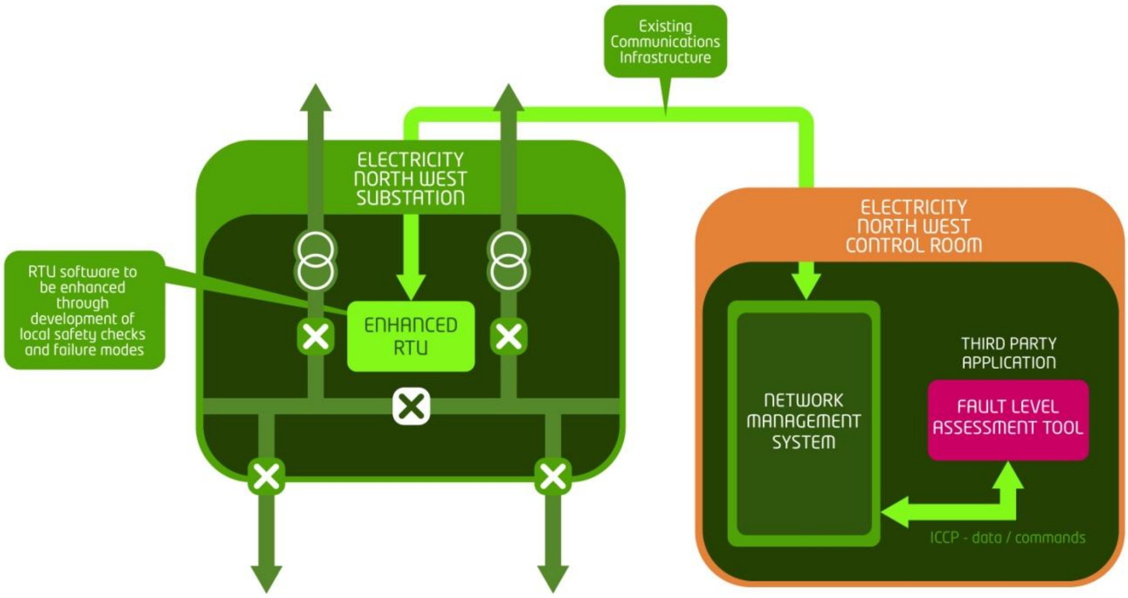
There will be a requirement to label the substations in the NMS and adequately brief all relevant operational teams to ensure that they are aware of the new operating regime.

All network diagrams shall be updated in a timely manner so that the correct information can be passed to the Fault Level Assessment Tool.

All commands for enabling and disabling the technologies will be instructed from the Electricity North West NMS. In the unlikely event of a communications failure between our NMS and the substation the Remote Terminal Unit (RTU) will automatically issue the “enable” command as a fail-safe. The RTU will require software modifications to cater for this additional logic.

If a communications failure alarm is received by the NMS for any FLARE site, particularly those sites which are subject to a commercial contract, it shall be responded to as a matter of urgency and in line with the commercial agreements.

Figure B1.3: Communications infrastructure



Interfacing

The Fault Level Assessment Tool will interface with the Electricity North West NMS via an ICCP link already developed under Smart Street. Devices in the field will communicate all their real time data to our NMS via RTUs and this will be passed to the Fault Level Assessment Tool via the ICCP link.

Development of network model

The network information will be provided to the Fault Level Assessment Tool from Electricity North West in the form of CIM files. The files will include all the network data such as all analogue information and circuit status. Switch state changes will be exchanged on an event by event basis.

The Fault Level Assessment Tool will require detailed circuit data (line lengths, impedance etc) as well as network topology to construct the network structures and power flows. Depending on the granularity of the data, the developed network models may require some user adjustments to render an accurate representation of the network – this is a one-off task.

This network model will be updated in line with our NMS to ensure that it remains a true representation of the network.

We will install fault level monitors on the network and use the results from these to validate the tolerance and accuracy network model, recognising that there may a 10% difference between the measured and modelled values. We will also investigate the use of the enhanced modelling techniques being developed in FlexDGrid to ensure our models are an accurate representation of the network.

Operator interface

There will be a clear network representation within the Electricity North West control room that will present us with real time visibility of the status of the different schemes.

The level of access will be limited via passwords and user defined levels of security.

Measurement and monitoring

Measurement and monitoring data on the FLARE project is required to provide inputs to the algorithm. It is envisaged that the current substation analogues will suffice as an input to the model but the transducers may require upgrading to allow real time measurement. The data will be transferred via the existing substation communications link shown in Figure B1.3.

Where real time monitoring data is available from generators this will be provided as an input to the algorithm otherwise we will use the contracted values of generation as we would use in our planning models.

The health indices of some assets may be affected by the implementation of the Adaptive Protection technology. In this technique one of the low voltage transformer circuit breakers will be required to open first to remove part of the fault current, increasing the number of operations it is called upon to carry out. The other transformer may be expected to carry fault current for a longer time. This is a change to our current operational practice.

In order to assess that this change in operational practice is not detrimental we will install monitoring equipment on the circuit breakers and the transformers.

For the circuit breakers we will install the "Kelvatek Profile" to record the opening time and the "EA Technology UltraTev" to record any partial discharge. It will not be necessary to monitor all 14 circuit breakers as we only require an indication of how the increased operation affects the equipment. Therefore we will install this equipment at four of the selected substations choosing those with the greatest fault history.

On the transformers we will install online dissolved gas analysis (DGA) equipment to record the various gases in the oil which is an indicator of ageing. It will not be necessary to monitor all transformers as we only require an indication of how fault current affects the oil chemistry. Therefore we will monitor two transformers (one at EHV and one at HV).

The results from this monitoring will be used to recalculate the health indices using our standard BaU methodology. In the unlikely event that there is a detrimental effect the Trial will be halted.

Installation and commissioning

NMS

It is anticipated that we will utilise Electricity North West IT employees to carry out all installation and commissioning duties for any changes to our NMS and the link to the new software.

Our IT teams will work in conjunction with teams from the software provider to install and commission the Fault Level Assessment Tool. The Fault Level Assessment Tool software will be designed to IEC61508. As the entire system is designed to fail safe, there is no requirement to test the software to this standard. Testing to this standard would not represent value for money to customers.

I_S-limiter

The contract for the I_S-limiter will be placed on a supply, deliver, off-load and erect basis. Under this agreement the equipment provider will deliver and off-load the equipment at site. The equipment provider will then erect all the equipment and conduct some pre-commissioning tests.

Our authorised employees will then cable up to the equipment and commission it onto our network.

This is a standard arrangement we have with all our suppliers of HV and EHV substation equipment.

Substation RTU changes

The changes to the logic within and connections to the substation RTUs will be carried out by our authorised employees in conjunction with the RTU supplier.

Substation protection

It is anticipated that we will utilise our authorised employees to carry out all installation and commissioning duties.

Machine protection

This equipment is owned and operated by third parties (ie generator/ motor owner) and therefore they will need to carry out any installation and commissioning duties. We will witness the final commissioning tests to ensure the scheme performs as designed.

Appendix B2: Site Selection Methodology

Introduction

Two of the three fault level mitigation technical solutions to be trialled in FLARE will be deployed in Electricity North West substations and this document describes the methodology for the selection of those substations. FLARE will trial the use of:

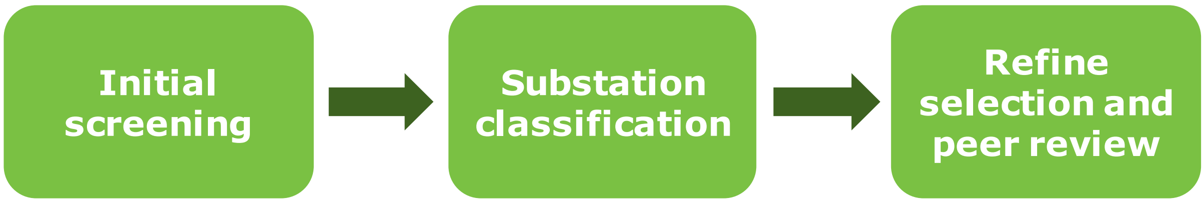
- Adaptive Protection: Five installations on 11kV and 6.6kV high voltage (HV) substations and two installations on 33kV extra high voltage (EHV) substations; and
- I_S-limiters at two HV substations.

This methodology enables the selection of a representative sample of substations covering a mix of substation ages, relay types, type of distribution RMUs on the HV networks and configuration of equipment and takes into consideration the known fault history and also the likelihood of a fault level issue arising during RIIO-ED1 or RIIO-ED2. This approach will ensure the Trial results are representative of the GB population and facilitate the take-up of the learning from FLARE. The proposed methodology takes into consideration the learning from Western Power Distribution's FlexDGrid project.

Description of site selection methodology

The substation selection methodology is outlined below in Figure B2.1, using the following steps:

Figure B2.1 Steps of site selection methodology



Each of these steps is described in greater detail below.

Step 1: Initial screening

Considering our full portfolio of EHV and HV substations, preference will be given to those assets within our RIIO-ED1 tables identified as having fault level issues either now or at some future date out to RIIO-ED2. This is part of the initial screening not classification.

Step 2: Substation classification

Substations will be classified according to the following criteria:

- Voltage levels ie 6.6kV, 11kV and 33kV;
- Existing or potential future fault level issues;
- Fault history of outgoing circuits;
- Age of substation switchgear and protection relays; and
- Physical constraints (desktop initially).

Voltage levels

The following voltage levels are considered in the selection methodology as these are the substations/ circuits where fault level issues will manifest:

- 33kV; and
- 11kV and 6.6kV

Existing or potential future fault level issue

The list of substations and equipment with a potential fault level issue in RIIO-ED1 and RIIO-ED2 is the starting point for site selection. From this list, all substations where work is to be carried out during the Project will be removed. This delivers a list of possible sites on which to deploy the techniques for FLARE.

Fault history

In order to increase the chance of the fault level mitigation technologies operating, the fault history for the substations/ circuit will be analysed to understand whether the location would be a good test bed for the Trials, fully expecting the new fault level mitigation equipment will operate in the Trials. The list produced above will be ordered by fault history.

Age and type of substation and protection equipment

This criterion is only used to select sites for the Adaptive Protection Trials to ensure we get a mix of the different relay types. Using the list developed above we will apply the ages of the equipment and select at least one of each of the categories below.

The following categories of equipment will be considered in the selection methodology, based on the number, age and type of substation equipment, defined as:

- Electro-mechanical protection (age range between 1960s and 1970s);
- Static electronic relays (approximate age range of 1980s and 1990s); and
- Numerical/ microprocessor based relays (approximate age range 2000 to date).

Physical constraints

Consideration shall be given to the following when selecting the sites for the installation of I_S-limiters:

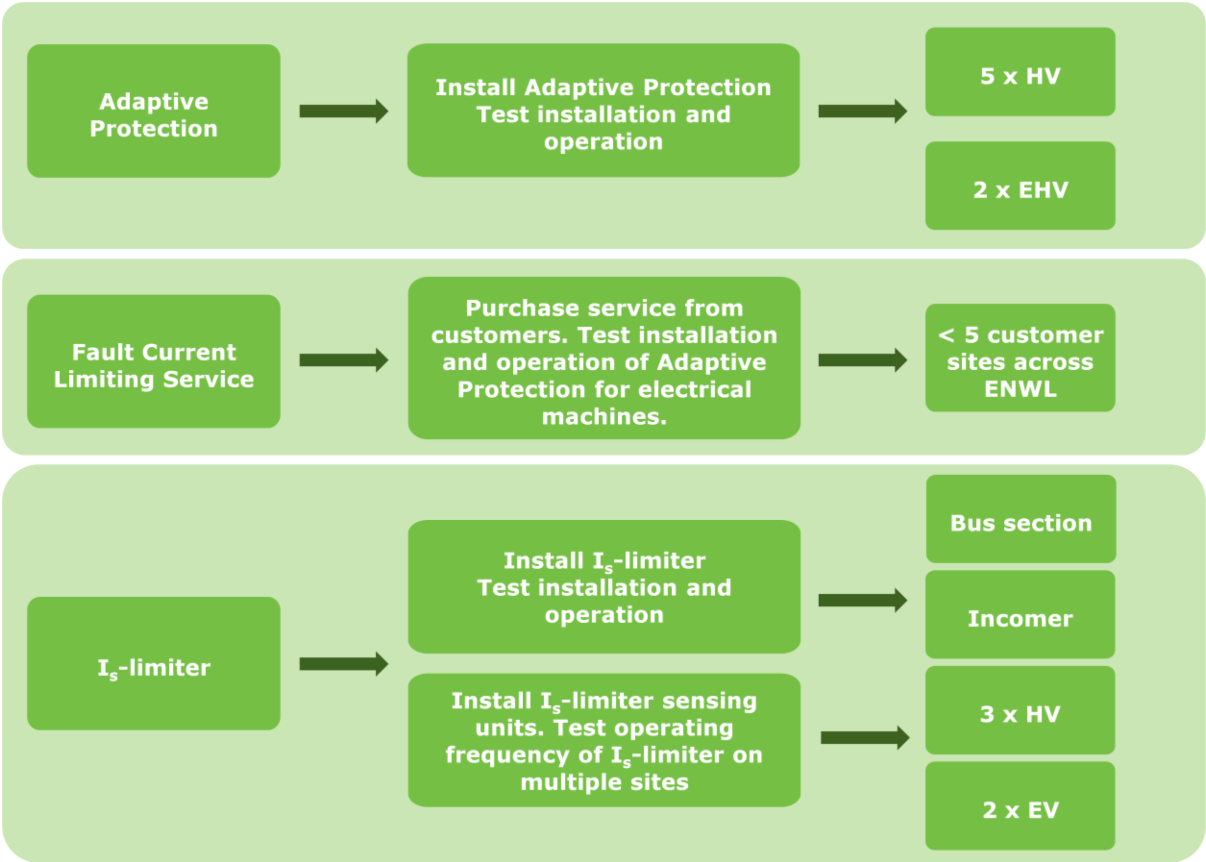
- Is the site currently operating as a standard configuration?
- Is there space available to install the new equipment?
- What is the access to and egress from the site?
- The potential for installation without planned supply interruptions.

Step 3: Refine selection and peer review

For meaningful results, primary substations will be selected to best demonstrate the Project benefits. In Project delivery the preliminary selection will be investigated in more detail to ensure they are suitable to install the techniques and to check that no issues have arisen to prevent deployment. PB Power, our technical consultants on this project, will peer review our site selection methodology and outputs.

The diagram below shows the range of FLARE installations to be catered for in the site selection methodology.

Figure B2.2: Range of FLARE installations



It is assumed that the substations selected for inclusion within the Trials are currently being operated in a standard configuration.

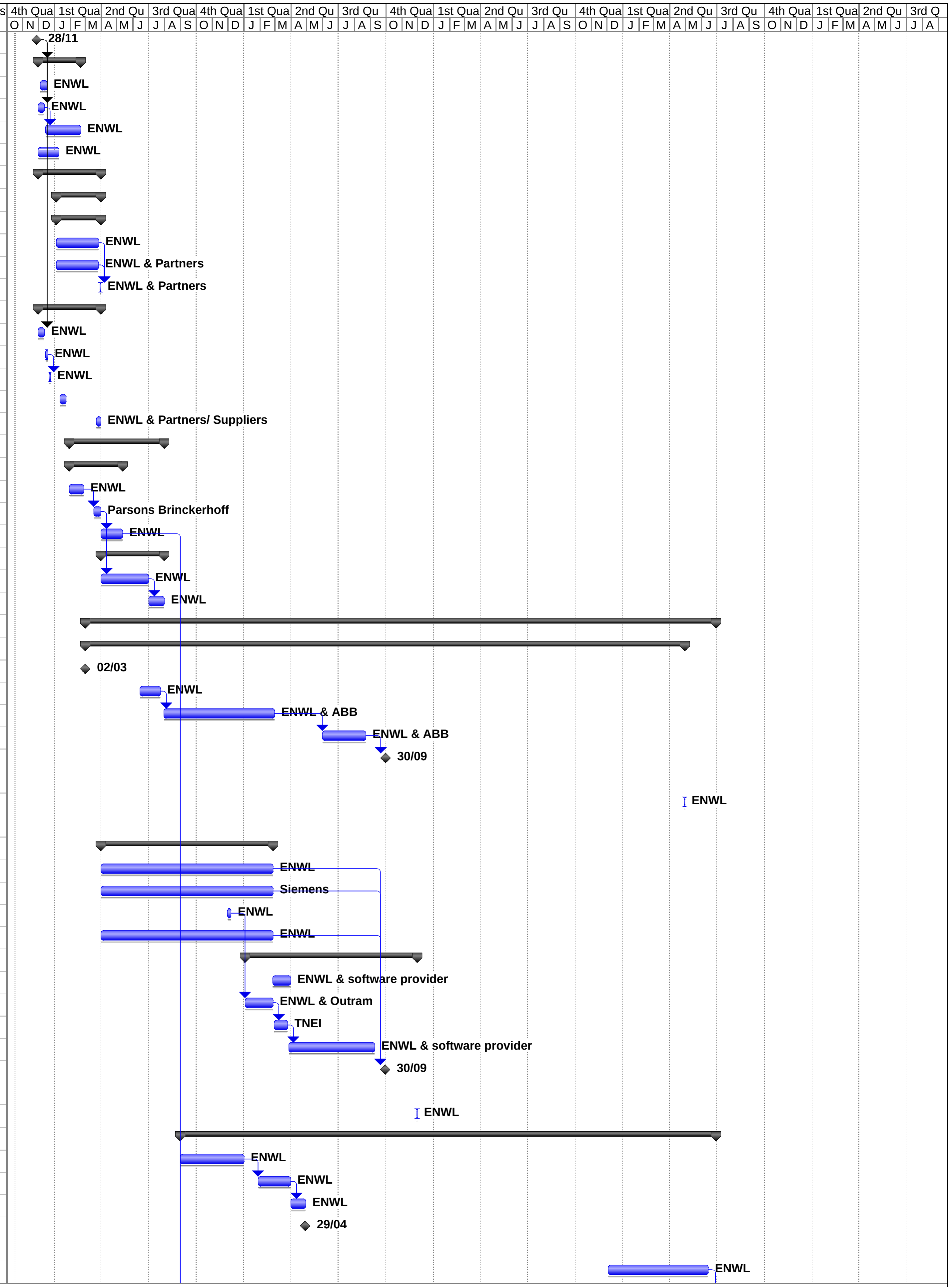
The Adaptive Protection Trial may, in the event of a fault on the system, alter the substation configuration to remove the fault contribution and then revert back to the traditional configuration using automated switching once the fault has cleared.

The total number of locations where the fault level mitigation technologies explored under FLARE will be deployed covers seven primary substations and two BSPs. These will demonstrate city and town centre locations with load patterns that include distributed generation.

Figure B2.3: Map of indicative substation selection

Appendix C: FLARE Project Plan

ID	Task Name	Duration	Start	Finish	Predecessors
1	**LCN Fund Award Announcement**	0 days	Fri 28/11/14	Fri 28/11/14	
2	**Phase I a) Project Readiness**	**60 days**	**Mon 01/12/14**	**Fri 20/02/15**	**1**
3	Review and agree Project Direction	9 days	Fri 05/12/14	Wed 17/12/14	
4	Develop and send out partner contracts	10 days	Mon 01/12/14	Fri 12/12/14	1
5	Review and negotiate partner contracts	50 days	Mon 15/12/14	Fri 20/02/15	4
6	Design, develop and issue the Project Implementation Document	30 days	Mon 01/12/14	Fri 09/01/15	
7	**Phase I b)- Mobilisation**	**87 days**	**Mon 01/12/14**	**Tue 31/03/15**	
8	**Project management office start-up**	**62 days**	**Mon 05/01/15**	**Tue 31/03/15**	
9	**Identify & mobilise project management office**	**62 days**	**Mon 05/01/15**	**Tue 31/03/15**	
10	Identify & mobilise project team	60 days	Mon 05/01/15	Fri 27/03/15	
11	Partner resourcing	59 days	Mon 05/01/15	Thu 26/03/15	
12	Project management office and partner resources mobilisation meeting	2 days	Mon 30/03/15	Tue 31/03/15	10,11
13	**Financial & Contractual**	**87 days**	**Mon 01/12/14**	**Tue 31/03/15**	
14	Identify and implement project budget controls within ENW	10 days	Mon 01/12/14	Fri 12/12/14	1
15	Set up project bank account	5 days	Mon 15/12/14	Fri 19/12/14	
16	Financial controls established	3 days	Mon 22/12/14	Wed 24/12/14	15
17	Partnership relationship discussions	10 days	Mon 12/01/15	Fri 23/01/15	
18	Contractual agreement signed	7 days	Mon 23/03/15	Tue 31/03/15	
19	**Phase II - Site Selection and Network Design**	**131 days**	**Fri 30/01/15**	**Fri 31/07/15**	
20	**Site Selection**	**73 days**	**Fri 30/01/15**	**Tue 12/05/15**	
21	Finalise site selction methodology	20 days	Fri 30/01/15	Thu 26/02/15	
22	Peer review of site selection methodology	10 days	Wed 18/03/15	Tue 31/03/15	21
23	Apply site selection methodology to select BSP and primary substations for FLARE trial	30 days	Wed 01/04/15	Tue 12/05/15	22
24	**Design of Installation & Decomissioning Plan**	**88 days**	**Wed 01/04/15**	**Fri 31/07/15**	
25	Define BSP and primary Installation Plan	66 days	Wed 01/04/15	Wed 01/07/15	22
26	Define Decomissioning Schedule	22 days	Thu 02/07/15	Fri 31/07/15	25
27	**Workstream 1 - Technology**	**875 days?**	**Mon 02/03/15**	**Fri 29/06/18**	
28	**Fault Mitigation Equipment Implementation**	**831 days?**	**Mon 02/03/15**	**Mon 30/04/18**	
29	Order Is-limiter	0 days	Mon 02/03/15	Mon 02/03/15	
30	Draft installation methodologies and compile equipment specifications	30 days?	Mon 15/06/15	Fri 24/07/15	
31	Installation of new fault level mitigation equipment at BSP and primary substations for FLARE trials	153 days	Fri 31/07/15	Mon 29/02/16	30
32	Finalise installation methodologies and equipment specifications	60 days	Wed 01/06/16	Tue 23/08/16	31
33	**9.1.2 Publish equipment specifications and installation reports for the Adaptive Protection and the Is-limiter by September 2016 and the FCL service by April 2018**	0 days	Fri 30/09/16	Fri 30/09/16	32
34	**9.1.2 Publish equipment specifications and installation reports for the Adaptive Protection and the Is-limiter by September 2016 and the FCL service by April 2018**	1 day?	Mon 30/04/18	Mon 30/04/18	
35	**OT Implementation**	**239 days**	**Wed 01/04/15**	**Fri 26/02/16**	
36	Configuration of existing Network Management System (NMS)	239 days	Wed 01/04/15	Fri 26/02/16	
37	Install, configure and test Fault Level Assessment Tool software	239 days	Wed 01/04/15	Fri 26/02/16	
38	Install fault level monitor	5 days	Tue 01/12/15	Mon 07/12/15	
39	Amend and Test NMS interface with Fautl Level Assessment Tool software	239 days	Wed 01/04/15	Fri 26/02/16	
40	**End to End System Testing and Commissioning**	**239 days?**	**Mon 04/01/16**	**Wed 30/11/16**	
41	End to end system testing and commissioning	25 days	Fri 26/02/16	Thu 31/03/16	
42	Validation monitoring - periodical retrieval of data from fault level monitor	40 days	Mon 04/01/16	Fri 26/02/16	38
43	Validation analysis report writing	20 days	Mon 29/02/16	Fri 25/03/16	42
44	Produce NMS, interface and configuration and commissioning reports	120 days	Mon 28/03/16	Fri 09/09/16	43
45	**9.1.3 Publish NMS interface and configuration specifications and commissioning reports by September 2016**	0 days	Fri 30/09/16	Fri 30/09/16	36,37,39
46	**9.1.4 Publish report on validation of the Fault Level Assessment Tool by November 2016**	1 day?	Wed 30/11/16	Wed 30/11/16	
47	**Specifications, Procedures and Training**	**744 days?**	**Tue 01/09/15**	**Fri 29/06/18**	
48	Update operational EPDs, COPs and Procedures	90 days?	Tue 01/09/15	Fri 01/01/16	
49	Operational personnel training and briefing	45 days	Fri 29/01/16	Thu 31/03/16	48
50	Incorporate feedback from training into procedures and protocols	21 days	Fri 01/04/16	Fri 29/04/16	49
51	**9.1.1 Brief and train Electricity North West operational teams, including Planning Engineers, on fault level mitigation management protocols by April 2016**	0 days	Fri 29/04/16	Fri 29/04/16	
52	Update fault level management, planning, design, protection settings and operation & maintenance policies	140 days	Mon 04/12/17	Thu 14/06/18	



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Task		Progress		Summary		External Tasks	
Split		Milestone	◆	Project Summary		External Milestone	◆

Deadline ⇩

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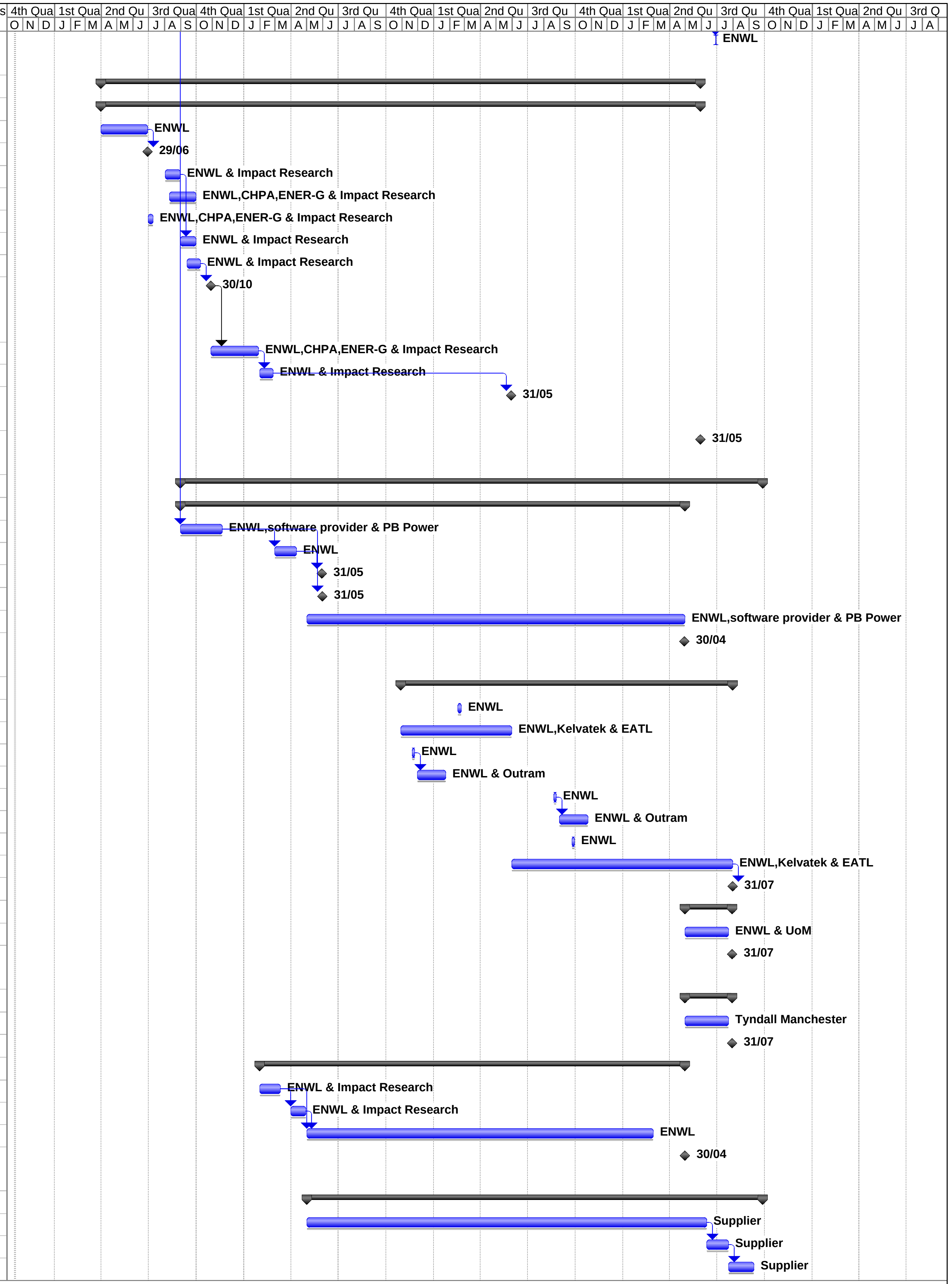
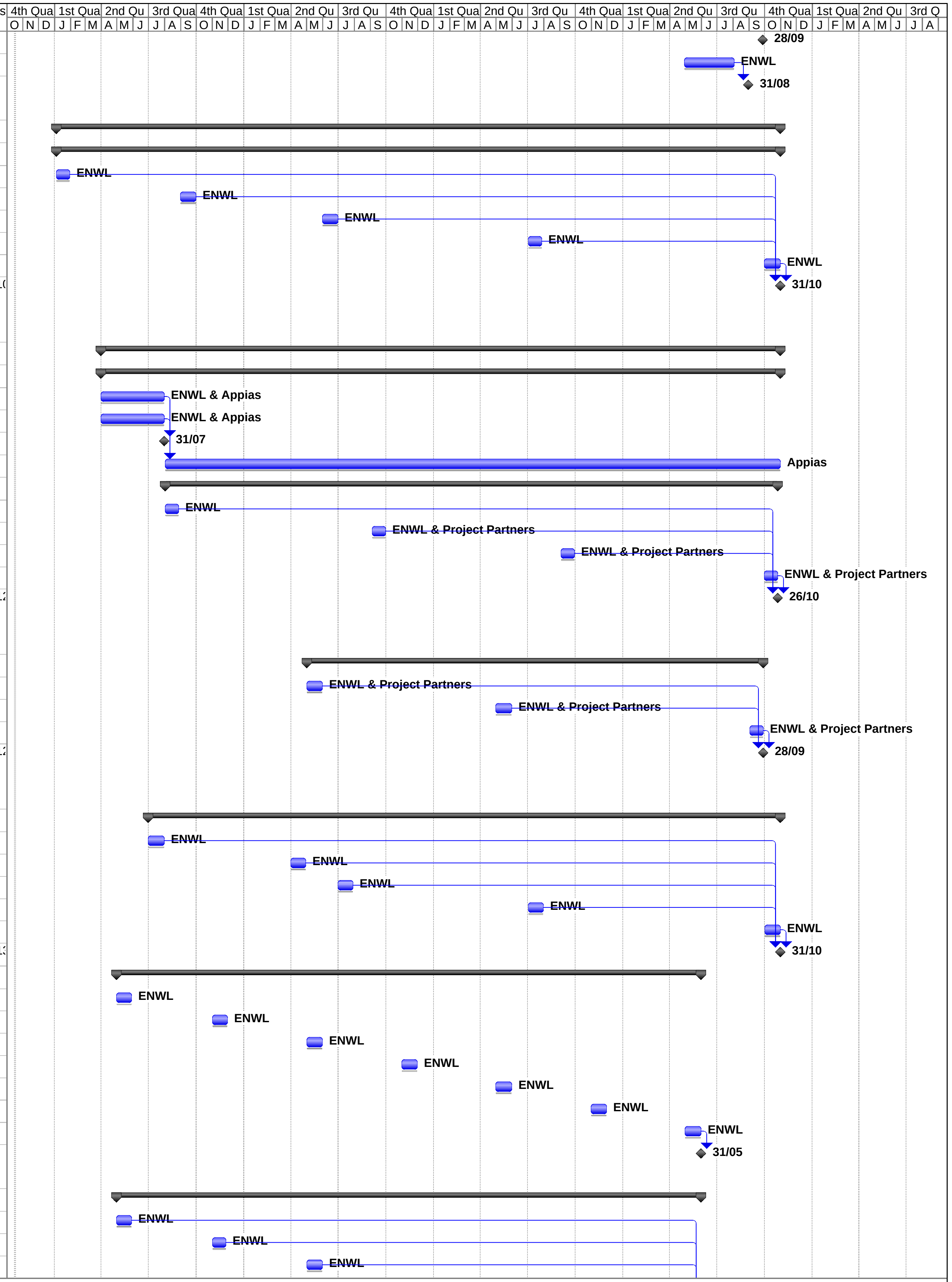
ID	Task Name	Duration	Start	Finish	Predecessors
53	9.1.5 Publish updated fault level management, planning, design, protection settings and operation & maintenance policies by June 2018.	1 day?	Fri 29/06/18	Fri 29/06/18	52
54	**Workstream 2 - Customer**	**831 days?**	**Wed 01/04/15**	**Thu 31/05/18**	
55	**Customer Survey**	**831 days?**	**Wed 01/04/15**	**Thu 31/05/18**	
56	Develop Customer Engagement Plan and Data Privacy Statement	64 days	Wed 01/04/15	Mon 29/06/15	
57	9.2.1 Send Customer Engagement Plan and Data Privacy Statement to Ofgem by June 2015	0 days	Mon 29/06/15	Mon 29/06/15	56
58	Recruit Engaged Customer Panel (ECP) - I&C customers only	21 days	Mon 03/08/15	Mon 31/08/15	
59	Identify survey customers	37 days	Tue 11/08/15	Wed 30/09/15	
60	Design & create proposed customer survey materials	7.67 days	Wed 01/07/15	Fri 10/07/15	
61	ECP to review/ approve customer survey materials	22 days	Tue 01/09/15	Wed 30/09/15	58
62	Incorporate ECP feedback, produce and deliver materials to customers	20 days	Mon 14/09/15	Fri 09/10/15	
63	9.2.2 Deliver Engaged Customer Panel workshop by September 2015, lessons learned from testing customer survey materials incorporated into survey and all survey materials published on the FLARE website by October 2015	0 days	Fri 30/10/15	Fri 30/10/15	62
64	Undertake customer survey	67 days	Fri 30/10/15	Fri 29/01/16	63
65	Analyse survey results and draft findings report	20 days	Mon 01/02/16	Fri 26/02/16	64
66	9.2.3 Publish Customer Survey report and information for customer evaluation of FCL service provision on FLARE website by May 2017	0 days	Wed 31/05/17	Wed 31/05/17	65
67	9.2.4 Publish contract templates for FCL service with new and existing customers and commercial arrangements learning by May 2018	0 days?	Thu 31/05/18	Thu 31/05/18	
68	**Workstream 3 - Trials & Analysis**	**808 days**	**Tue 01/09/15**	**Fri 28/09/18**	
69	**Post Fault Analysis**	**700 days**	**Tue 01/09/15**	**Mon 30/04/18**	
70	Design of monitoring and analysis procedures for Trial regime	60 days	Tue 01/09/15	Fri 20/11/15	23
71	Install asset health monitoring equipment (Totus, Profile and Ultratev)	30 days	Tue 01/03/16	Mon 11/04/16	70
72	9.3.1 Publish monitoring and analysis procedures for Trials on FLARE website by May 2016	0 days	Tue 31/05/16	Tue 31/05/16	71
73	9.3.2 Publicise commencement of live Trial on FLARE website by May 2016	0 days	Tue 31/05/16	Tue 31/05/16	70
74	Implementation of monitoring and analysis procedures in Trial period	525 days	Mon 02/05/16	Mon 30/04/18	
75	9.3.3 Publish on FLARE website a summary of each fault event three months after each event, with the expectation that a minimum of 18 faults will be reported on	0 days	Mon 30/04/18	Mon 30/04/18	
76	**Asset Health Study**	**461 days**	**Sun 30/10/16**	**Tue 31/07/18**	
77	Relocate Profile and Ultratev	5 days	Fri 17/02/17	Thu 23/02/17	
78	Asset health study monitoring, retrieval of data and production of interim report	155 days	Sun 30/10/16	Wed 31/05/17	
79	Relocate fault level monitor	5 days	Mon 21/11/16	Fri 25/11/16	
80	Validation monitoring - periodical retrieval of data from Outram device and produce report	40 days	Thu 01/12/16	Tue 24/01/17	79
81	Relocate fault level monitor	5 days	Mon 21/08/17	Fri 25/08/17	
82	Validation monitoring - periodical retrieval of data from Outram device and produce report	40 days	Fri 01/09/17	Wed 25/10/17	81
83	Relocate Profile and Ultratev	5 days	Mon 25/09/17	Fri 29/09/17	
84	Asset health study monitoring, retrieval of data and production of final report	306 days	Thu 01/06/17	Tue 31/07/18	
85	9.3.9 Publish Asset Health Study on FLARE website by July 2018	0 days	Tue 31/07/18	Tue 31/07/18	84
86	**Cost Benefit Analyses**	**65 days**	**Tue 01/05/18**	**Tue 31/07/18**	
87	Write initial draft, consult, finalise Report	60 days	Tue 01/05/18	Mon 23/07/18	
88	9.3.4 Publish on FLARE website the Cost Benefit Analysis study report and the buy order of FLARE/ FlexDGrid/ traditional reinforcement fault level mitigation solutions by July 2018	0 days	Tue 31/07/18	Tue 31/07/18	
89	**Carbon Impact Assessments**	**65 days**	**Tue 01/05/18**	**Tue 31/07/18**	
90	Write initial draft, consult, finalise Report	60 days	Tue 01/05/18	Mon 23/07/18	
91	9.3.6 Publish on FLARE website the Carbon Impact Assessment report by July 2018	0 days	Tue 31/07/18	Tue 31/07/18	
92	**Fault Current Limiting service**	**590 days**	**Mon 01/02/16**	**Mon 30/04/18**	
93	Develop customer engagement and materials for purchasing Fault Current Limiting service	30 days	Mon 01/02/16	Fri 11/03/16	
94	ECP to review/ approve customer engagement materials	21 days	Fri 01/04/16	Fri 29/04/16	93
95	Purchase Fault Current Limiting service	482 days	Mon 02/05/16	Wed 28/02/18	93,94
96	9.3.7 Purchase a Fault Current Limiting service from at least one Electricity North West demand customer and one Electricity North West generation customer	0 days	Mon 30/04/18	Mon 30/04/18	
97	**Safety Cases**	**633 days**	**Mon 02/05/16**	**Fri 28/09/18**	
98	Draft safety case for each fault mitigation technology deployed	555 days	Mon 02/05/16	Mon 11/06/18	
99	Peer review of safety cases	30 days	Tue 12/06/18	Mon 23/07/18	98
100	Finalise safety cases	35 days	Tue 24/07/18	Mon 10/09/18	99



Project: eta Project Delivery Updated Date: Thu 16/10/14	Task		Progress		Summary		External Tasks		Deadline	
	Split		Milestone		Project Summary		External Milestone			

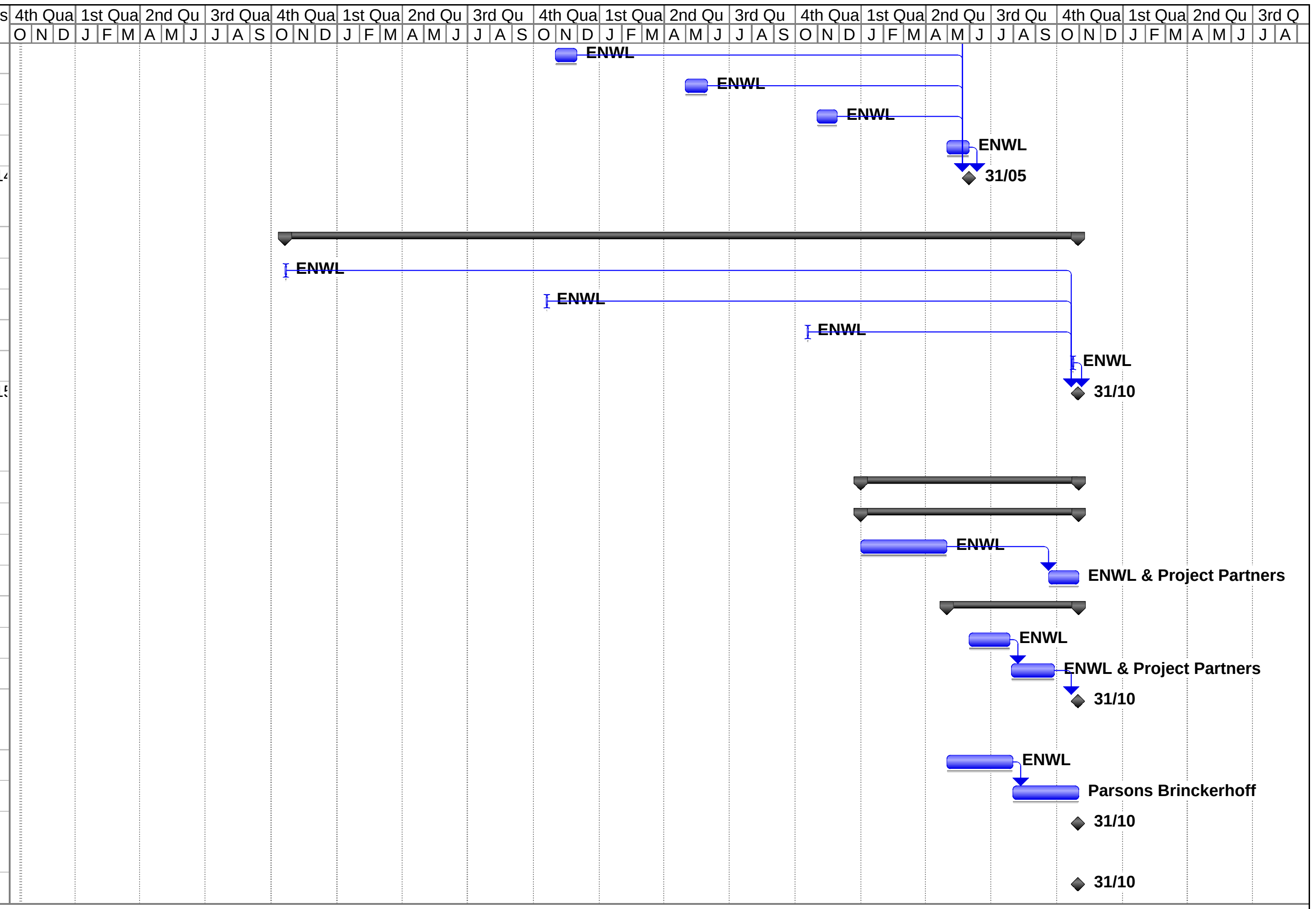
ID	Task Name	Duration	Start	Finish	Predecessors
101	9.3.8 Publish peer-reviewed Safety Cases on the FLARE Project website by September 2018	0 days	Fri 28/09/18	Fri 28/09/18	
102	Initiate discussion at the CCM Forum and draft DCUSA change proposal	70 days	Mon 30/04/18	Fri 03/08/18	
103	9.3.5 Submit a DCUSA change proposal for amending application approach to Fault Level Cost Apportionment Factor in Common Connection Charging Methodology by August 2018	0 days	Fri 31/08/18	Fri 31/08/18	102
104	**Workstream 4 - Learning & Dissemination**	**1003 days**	**Mon 05/01/15**	**Wed 31/10/18**	
105	**Internal dissemination**	**1003 days**	**Mon 05/01/15**	**Wed 31/10/18**	
106	Produce materials for Team Brief/ Volt / Newswire Article 1 - Publicise FLARE	20 days	Mon 05/01/15	Fri 30/01/15	
107	Produce materils for Team Brief/ Volt / Newswire Article 2 - Progress & learning	22 days	Tue 01/09/15	Wed 30/09/15	
108	Produce materils for Team Brief/ Volt / Newswire Article 2 - Progress & learning	22 days	Wed 01/06/16	Thu 30/06/16	
109	Produce materils for Team Brief/ Volt / Newswire Article 2 - Progress & learning	20 days	Mon 03/07/17	Fri 28/07/17	
110	Produce materials forTeam Brief/ Volt / Newswire Article 5 - FLARE project end	23 days	Mon 01/10/18	Wed 31/10/18	
111	9.4.2 (a) Publicise FLARE within Electricity North West in monthly team brief pack and/ or Volt (intranet) and/ or Newswire (quarterly employee magazine) by January 2015, September 2015, June 2016, July 2017 and October 2018	0 days	Wed 31/10/18	Wed 31/10/18	106,107,1
112	**External dissemination**	**941 days**	**Wed 01/04/15**	**Wed 31/10/18**	
113	**FLARE website & social media**	**941 days**	**Wed 01/04/15**	**Wed 31/10/18**	
114	Design, build, install, test & commission FLARE website	88 days	Wed 01/04/15	Fri 31/07/15	
115	Establish presence on social media	88 days	Wed 01/04/15	Fri 31/07/15	
116	9.4.1 Deliver live FLARE website and social media forums by July 2015	0 days	Fri 31/07/15	Fri 31/07/15	114,115
117	Support & maintenance of FLARE website & social media	853 days	Mon 03/08/15	Wed 31/10/18	115,114
118	**Webinars**	**850 days**	**Mon 03/08/15**	**Fri 26/10/18**	
119	FLARE webinar - introduction and objectives	20 days	Mon 03/08/15	Fri 28/08/15	
120	FLARE webinar - Progress update	20 days	Mon 05/09/16	Fri 30/09/16	
121	FLARE webinar - Progress update	20 days	Mon 04/09/17	Fri 29/09/17	
122	FLARE webinar - Progress update	20 days	Mon 01/10/18	Fri 26/10/18	
123	9.4.3 Active participation at four Annual LCN Fund Conferences from 2015 to 2018, Webinars held by September 2015, by September 2016, September 2017, October 2018, and three Knowledge Sharing Events by May 2016, May 2017 and September 2018	0 days	Fri 26/10/18	Fri 26/10/18	122,119,1
124	**Knowledge sharing events**	**634 days**	**Mon 02/05/16**	**Fri 28/09/18**	
125	Knowledge Sharing Event 1 - Half way through Trial	22 days	Mon 02/05/16	Tue 31/05/16	
126	Knowledge Sharing Event 2 - Trial end	23 days	Mon 01/05/17	Wed 31/05/17	
127	Knowledge Sharing Event 3 - Project end	20 days	Mon 03/09/18	Fri 28/09/18	
128	9.4.3 Actively participate at four Annual LCN Innovation Conferences from 2015 to 2018; Webinars held by September 2015, by September 2016, September 2017, October 2018; and three Knowledge Sharing Events by May 2016, May 2017 and September 2018	0 days	Fri 28/09/18	Fri 28/09/18	127,125,1
129	**Advertorials**	**876 days**	**Wed 01/07/15**	**Wed 31/10/18**	
130	Advertorial 1 - Publicise FLARE	23 days	Wed 01/07/15	Fri 31/07/15	
131	Advertorial 2 - Publicise Progress & learning	21 days	Fri 01/04/16	Fri 29/04/16	
132	Advertorial 3 - Publicise Progress & learning	21 days	Fri 01/07/16	Fri 29/07/16	
133	Advertorial 4 - Publicise Progress & learning	21 days	Mon 03/07/17	Mon 31/07/17	
134	Advertorial 5 - Publicise Close Down Report and Project learning	22 days	Tue 02/10/18	Wed 31/10/18	
135	9.4.2 (b) Publish advertorials by July 2015, April 2016, July 2016, July 2017 and October 2018	0 days	Wed 31/10/18	Wed 31/10/18	133,130,1
136	**External newsletter**	**810 days**	**Fri 01/05/15**	**Thu 31/05/18**	
137	General stakeholder newsletter 1	21 days	Fri 01/05/15	Fri 29/05/15	
138	General stakeholder newsletter 2	21 days	Mon 02/11/15	Mon 30/11/15	
139	General stakeholder newsletter 3	22 days	Mon 02/05/16	Tue 31/05/16	
140	General stakeholder newsletter 4	22 days	Tue 01/11/16	Wed 30/11/16	
141	General stakeholder newsletter 5	23 days	Mon 01/05/17	Wed 31/05/17	
142	General stakeholder newsletter 6	22 days	Wed 01/11/17	Thu 30/11/17	
143	General stakeholder newsletter 7	23 days	Tue 01/05/18	Thu 31/05/18	
144	9.4.2 (c) Publish newsletter by May 2015, November 2015, May 2016, November 2016, May 2017, November 2017 and May 2018	0 days	Thu 31/05/18	Thu 31/05/18	143
145	**Ofgem six monthly reports**	**810 days**	**Fri 01/05/15**	**Thu 31/05/18**	
146	Preparation of Report 1 - June 2015	21 days	Fri 01/05/15	Fri 29/05/15	
147	Preparation of Report 2 - December 2015	20 days	Mon 02/11/15	Fri 27/11/15	
148	Preparation of Report 3 - June 2016	22 days	Mon 02/05/16	Tue 31/05/16	



Project: eta Project Delivery Updated
Date: Thu 16/10/14

Task		Progress		Summary		External Tasks		Deadline
Split		Milestone	◆	Project Summary		External Milestone ◆	

ID	Task Name	Duration	Start	Finish	Predecessors
149	Preparation of Report 4 - December 2016	22 days	Tue 01/11/16	Wed 30/11/16	
150	Preparation of Report 5 - June 2017	23 days	Mon 01/05/17	Wed 31/05/17	
151	Preparation of Report 6 - December 2017	20 days	Wed 01/11/17	Tue 28/11/17	
152	Preparation of Report 7 - June 2018	23 days	Tue 01/05/18	Thu 31/05/18	
153	**9.4.4 Issue Project progress reports in accordance with Ofgem's June and December production cycle and publish on FLARE website.**	0 days	Thu 31/05/18	Thu 31/05/18	146,147,1
154	**Annual LCNI Conference attendance**	**795 days**	**Wed 21/10/15**	**Wed 31/10/18**	
155	LCNI Annual Conference 2015	2 days	Wed 21/10/15	Thu 22/10/15	
156	LCNI Annual Conference 2016	2 days	Wed 19/10/16	Thu 20/10/16	
157	LCNI Annual Conference 2017	2 days	Wed 18/10/17	Thu 19/10/17	
158	LCNI Annual Conference 2018	2 days	Tue 23/10/18	Wed 24/10/18	
159	**9.4.3 Actively participate at four Annual LCN Fund Conferences from 2015 to 2018, Webinars held by September 2015, by September 2016, September 2017, October 2018, and three Knowledge Sharing Events by May 2016, May 2017 and September 2018**	0 days	Wed 31/10/18	Wed 31/10/18	155,156,1
160	**Phase III - Close Down & Long Term Project Handover**	**218 days**	**Mon 01/01/18**	**Wed 31/10/18**	
161	**Decommissioning**	**218 days**	**Mon 01/01/18**	**Wed 31/10/18**	
162	Decide which equipment will require decommissioning	86 days	Mon 01/01/18	Mon 30/04/18	
163	Decommission identified equipment	30 days	Thu 20/09/18	Wed 31/10/18	162
164	**Close Down Report**	**132 days**	**Tue 01/05/18**	**Wed 31/10/18**	
165	Draft close down report	41 days	Fri 01/06/18	Fri 27/07/18	
166	Review and approval of close down report	44 days	Mon 30/07/18	Thu 27/09/18	165
167	**9.5.1 Issue FLARE Project Close Down Report to Ofgem and published on FLARE website by October 2018**	0 days	Wed 31/10/18	Wed 31/10/18	166
168	Draft updates to Electricity North West's Network Design Policy to define FLARE Project mitigation techniques	66 days	Tue 01/05/18	Tue 31/07/18	
169	Review and approval of updated Network Design Policy	66 days	Wed 01/08/18	Wed 31/10/18	168
170	**9.5.2 Publish Electricity North West's approach to managing fault level reinforcement on FLARE website by October 2018**	0 days	Wed 31/10/18	Wed 31/10/18	
171	**Project Closure**	0 days	Wed 31/10/18	Wed 31/10/18	



Project: eta Project Delivery Updated Date: Thu 16/10/14	Task	Progress	Summary	External Tasks	Deadline
	Split	Milestone	Project Summary	External Milestone	

Appendix D: Risks and issues register

The risk model employed by Electricity North West in the delivery of Second Tier LCN Fund projects looks at risks in much the same holistic manner as the proven risk model employed by Electricity North West at a corporate level. However, using previous experience, the risk and issues register has been refined to better reflect the increased significance of impacts at a Project level. In this model, risk impact areas have been categorised into time, cost and scope/quality which are given a score of 1 to 5 along with the likelihood of occurrence. The resulting product of these two ratings is used to score and rank the risks on the Project. The risk model enables the determination of an 'uncontrolled' risk score. However, if control measures are applied, aimed at reducing the hazard and/or mitigating the risk, it should be possible to produce a controlled risk score that is lower than the uncontrolled risk. The format of the Electricity North West Second Tier risk scoring matrix is below.

Risk impact descriptors

RISK AREA	1 Negligible	2 Minor	3 Moderate	4 Significant	5 Serious
Time	There will be no impact on deliverables. No re-planning necessary	Any delays are likely to be small ie <one week and manageable. Minor re-planning necessary	Some delays likely to Project/ Programme milestones, but the overall Project/ Programme delivery date will not be affected. An element of re-planning will be necessary	There is likely to be a delay which causes the overall Project/ Programme delivery end-date to slip. Significant re-planning will be essential	There is likely to be a delay which causes the overall Project/ Programme delivery end-date to slip. Serious re-planning will be essential
Cost	£0	<£10k	<£20k	<£50k	>£50k
Scope/ Quality	There will be no impact on the overall quality of the deliverables in the Project/Programme. All requirements will still be met	There will be negligible impact (if any), on the overall quality of the deliverables in the Project/Programme. Most, if not all requirements will still be met	Some requirements will not be met, or a small number of business process(es) will need to be modified to accommodate shortcomings in the delivery	A significant number of requirements will not be met, or business process(es) will need to be modified to accommodate shortcomings in the delivery	Major requirements, key to the success of the delivery are not likely to be delivered as planned

Risk probability descriptors

5	Almost certain	>80%
4	Likely	60-80%
3	Moderate	30-60%
2	Low	10–30%
1	Rare	<10%

Risk score

Impact					
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
	1	2	3	4	5
	Probability				

The following potential risks have been identified. These risks have been based on the scoring matrix set out above and linked to the Project Phase or Workstream in which they will occur. The risk headings identified by Ofgem in their "Guidance for Low Carbon Networks Fund Project Progress Reports" document (issued on 14th May 2013) are also referenced for clarity.

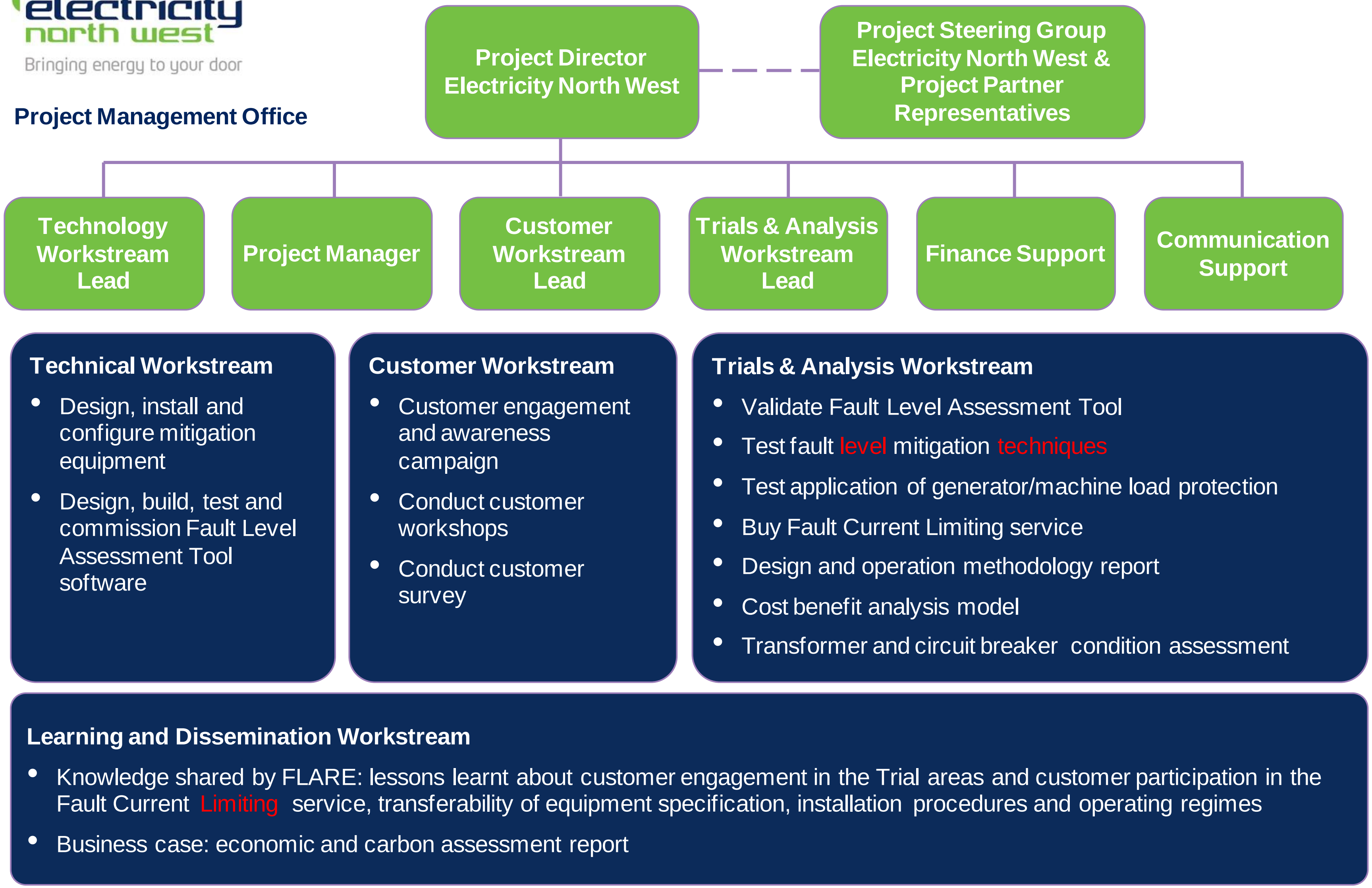
Project Phase /Workstream	Description *(Delivery Risk Category)*	Probability Score	Impact Score	Mitigating Action/ *Contingency* Action	Revised Probability	Revised Impact Score
Mobilisation	There is a risk that Project Partners are not able to mobilise their resources in time because of other commitments leading to a delay in achieving potential milestones which could have a Project, reputational, and financial repercussion. (***Other***)	2	4	• Suitable partnership agreements that ensure collaborative working, value for customers' money and achievement of learning objectives in a timely manner have been identified for all Partners. • A project initiation document will be issued to the Project Partners to ensure that all parties are ready. *Contingency: Electricity North West will seek new Partners should existing Partners fail to mobilise.*	1	4
Technology	There is a risk that installation of the new Fault Level Assessment Tool or configuration of the network management system will overrun leading to delayed start of live Trials. ***(Installation)***	3	5	• Robust T&Cs for the Fault Level Assessment Tool provision will be agreed to ensure Partner focus on achieving the FLARE project timescales. • Resources and mobilisation plan will be defined to achieve the Project milestones and will be developed in conjunction with our selected software Partner. *Contingency: Regular progress meetings/reports to track progress against the plan. Electricity North West will commit additional operational resource should any delays occur to the installation, testing and commissioning programme.*	2	5
Technology	There is a risk that the new Fault Level Assessment Tool will not perform as expected during testing and commissioning, leading to delayed start of live Trials. (***Installation***)	3	4	• Guidance on the use of a fault level monitor to validate the Tool's calculations has been sought from WPD using their learning from FlexDGrid. • Validation of the Fault Level Assessment Tool will occur prior to live Trials and periodically, and at different points on the Trial networks during the live Trial period. *Contingency: n/a*	2	4
Technology	There is a risk that the six month lead time for delivery of I_S-limiters may lead to a delay in the installation of this technology. (***Procurement***)	3	3	• Project plan specifies that a purchase order will be raised to procure I_S-limiters at the beginning of March 2015. ABB will expedite the order. *Contingency: Flexibility is built into the installation programme so that installation of this technology can occur in autumn 2015 or spring 2016.*	2	1
Technology	There is a risk that retrofit of Adaptive Protection (for distribution system and electrical machines) may be more complex than	3	3	• The installation programme will be considered alongside known operational and maintenance activity peaks to allow for extra resource to be secured and deployed. • Electricity North West has scoped FLARE with the input from a	2	2

	anticipated leading to a delay in the installation programme. (***Installation***)			generator manufacturer and a customer with motors. • Protection requirements for generators are explored in ENER-G's test cell. The project cost includes for external contractor retrofit of the Adaptive Protection for electrical machines. *Contingency: Alternative substations may be selected to ensure FLARE Trials are not delayed. Learning from every installation/ attempted installation will be published through knowledge dissemination activities.*		
Technology	There is a risk that appropriately skilled resource may not be available to perform the retrofit installation of technologies leading to a delay in the installation programme. (***Installation***)	3	4	• Guidance on the specific skills requirements has been sought and FLARE's installation programme will be designed in consideration of known operational and maintenance activity peaks. *Contingency: Contractors may be brought in to cover business as usual activities to allow internal resource to cover installation requirements of this Project.*	2	4
Technology	There is a risk that FLARE technologies do not perform as anticipated leading to Trial circuits exceeding their fault level limits. (***Other***)	3	5	• Forerunner projects explored techniques with academic and technical colleagues. • Fault level mitigation techniques will be installed at substations with no fault level constraints. Standard protection capability will not be exceeded. *Contingency: n/a*	2	5
Customer	There is a risk that our data protection strategy will be complicated by accessing customer survey participants from outside our area leading to legal and reputational issues. (***Recruitment***)	3	5	• The CHPA/ ENER-G has members/ customers across the UK and will promote involvement in the survey. • Impact Research will work with the CHPA/ ENER-G to design and undertake the customer survey work and ensure complete compliance with data privacy requirements. • Impact Research and Electricity North West will undertake a pilot communication Trial, with a range of stakeholders to ensure that we are able to effectively communicate and engage with our stakeholders. *Contingency: n/a*	2	5
Customer	There is a risk that customers with relevant demand or generation equipment do not engage in the customer survey leading to a lack of robust data for Hypothesis 5. (***Recruitment***)	3	4	• Impact Research has experience of this issue in a Second Tier project delivery environment. The survey contact list will be designed to identify key decision makers within organisations. • Incentive payments are being offered for participation. *Contingency: More customers will be approached and incentivised to participate.*	2	4

Trials & Analysis	There is a risk that the selected networks do not experience a fault during the period of the Trials leading to the techniques and devices being untested. (***Other***)	3	5	• We will use up-to-date fault statistics in the Site Selection phase to ensure that networks with higher than average faults are selected for FLARE demonstration. *Contingency: In the absence of any faults, PB Power will test, via simulation, operation of the Fault Current Assessment Tool and three mitigation techniques.*	1	2
Trials & Analysis	There is a risk that a FCL service participant decides they no longer wish to participate in the Trial. (***Recruitment***)	2	3	• The FLARE team will work with the customer to understand why customer perception has changed and to capture learning from the Trial. *Contingency: n/a*	2	2

Appendix E: Organogram

Project Management Office



Appendix F: Project Partner Details

Name	Type of organisation	Funding provided	Contractual relationship with ENWL	Role of Project Partner	Funding benefits to FLARE
ABB	ABB is a global engineering organisation specialising in power and automation technologies	[redacted]	ABB will be a Project Partner. Terms and Conditions that include the LCN Fund default IPR arrangement have been shared and agreed. This will govern the scope and obligations of Partner involvement	• To supply, install and commission the I_S-limiter • Provide ongoing support on protection settings and post fault analysis for two I_S-limiter installations and five sensing units recorded data • Knowledge dissemination	[redacted]
Schneider Electric	Schneider Electric is a European multinational corporation specialising in electricity distribution and automation management.	[redacted]	Schneider Electric will be a Project Partner. Terms and Conditions that include the LCN Fund default IPR arrangement have been shared and agreed. This will govern the scope and obligations of Partner involvement	• To supply, install, test and commission the Fault Level Assessment Tool • Provide ongoing support for the Fault Level Assessment Tool for the duration of the FLARE Project	Schneider Electric is funding the software customisation to support and providing a further contribution in the form of licence discounts
Parsons Brinckerhoff (PB Power)	PB Power is a technical consultancy organisation with experience is all aspects of power generation, transmission and distribution	[redacted]	PB Power will be a Partner organisation. Terms and conditions that include the LCN Fund default IPR arrangement have been shared and agreed. This will govern the scope and obligations of Partner involvement	• To deliver revised protection settings, validation of Fault Level Assessment Tool software, post fault analysis for FLARE techniques, plus system design and protection policy updates • To create business as usual rollout requirements for Electricity North West and GB • Knowledge dissemination	PB Power are providing in-kind contribution for delivery of work packages across the Technology, Trials & Analysis and Customer Workstreams
United Utilities (UU)	United Utilities is the water and wastewater service company for the North West of England. It operates large electrical machines (that increase the fault current on the network) to deliver their services	[redacted]	UU will be a Partner organisation. Terms and conditions that include the LCN Fund default IPR arrangement have been shared and agreed. This will govern the scope and obligations of Partner involvement	• To assist in development of a customer survey to establish FCL service interest • To work with PB and Electricity North West, to retrofit Adaptive Protection for electrical machines on two motors and devise installation procedure/ guidance notes for future FCL service providers	United Utilities will supply FLARE with a FCL service at no cost to the Project. This is subject to identification of an acceptable motor installation

				• Knowledge dissemination	
Combined Heat and Power Association (CHPA)	The CHPA plays a pivotal role in providing the focus for combined heat and power and district heating initiative and is a trusted point of reference for government as a respected lobbying voice	[redacted]	The CHPA will be a Partner organisation. Terms and conditions to govern the scope of involvement and set out the LCN Fund default IPR arrangement have been shared and agreed	• To assist in development and delivery of customer survey • Support Impact Research in identification of, and introductions to, potential FCL service participants • Knowledge dissemination	The CHPA is funding its support in customer identification and introductory access and additional knowledge dissemination activities across the CHP community
ENER-G	ENER-G is a CHP manufacturer, owner and operator with active participation in trade industry bodies in an advisory capacity	[redacted]	ENER-G will be a Partner organisation for the purposes of FLARE. Terms and Conditions that include the LCN Fund default IPR arrangement have been shared and agreed. This will govern the scope and obligations of Partner involvement	• To assist in development of customer survey to establish FCL service interest • Work with PB and ENWL to test Adaptive Protection on CHP and devise installation procedure/ guidance notes for future CHP providers of FCL services • Knowledge dissemination	ENER-G will fund the bench test of Adaptive Protection for CHP generation at the ENER-G test cell and provide engineering support for the testing
Kelvatek	Kelvatek is a market leader in distribution network automation and fault management technology	[redacted]	Kevlatek will be a Partner organisation. Terms and conditions to govern the scope of involvement and set out the LCN Fund default IPR arrangement have been shared and agreed	• Kelvatek will supply monitoring equipment for asset health evaluation	Kelvatek is providing a discount on the purchase cost of monitoring equipment and providing support for analysis of asset health data

Appendix G: I_S-limiter safety case

Summary report

Developing the safety case for ABB surge current limiters for Electricity North West.

ABS consulting report 3166069/R/03 Issue 1 Draft A

Introduction

The I_s-limiter device is a combination of a fast acting switch with high current carrying capability but low switching capacity and a fuse with high breaking capacity, mounted in parallel. When a short circuit is detected a small explosive charge in the main current carrying conductor is detonated. This ruptures the main current carrying path thus diverting the current to the fuse which quenches it. The operation takes a few milliseconds.

The principal reason for the fitting of an I_s-limiter is that it will trip before the first peak of a short circuit current. Therefore the switchgear and cabling downstream of the I_s-limiter will not be subject to the full fault current, and can either be of lighter construction, or of increased capacity.

The use of I_s-limiters in the UK is not permitted by the regulatory authorities. Specifically, that if the I_s-limiter fails to operate on demand the down-stream equipment may be damaged. This would be a breach of Distribution Code of Licensed Distribution Network Operators 4.4.4.d.

The concerns are addressed and a draft Safety Case has been produced. This will show that failure on demand to be highly unlikely based on manufacturer's data and evidence from Europe. This will allow regulatory review for approval for the use of Is-limiters in the UK.

Outline of safety case

A Safety Case refers to the totality of a duty holder's documentation to demonstrate safety. The documentation demonstrates the safety argument during the design, construction, manufacture, commissioning, operation and decommissioning phases of the installed equipment. A safety case contains the following information:

- A hazard identification technique appropriate to the complexity of the installation, the stage of the installation in its lifecycle and the scale and nature of the hazards on the installation. A Hazard and Operability Study (HAZOPS), Fault Tree Analysis (FTA) and Failure Modes and Effects Analysis (FMECA) have been conducted;
- A demonstration of sound engineering practice. Reference has been made to manufacturers' test results;
- Engineering justification - reference has been made to other assessment reports;
- Design for safety;
- Role and training of operators.

I_s-limiter safety case conclusions

A draft safety case has been produced. Based on the HAZOPs, it was identified that there were non-technical, minor administrative issues which would currently prevent the use of I_s-limiters in the UK. These are:

- An Explosives Certificate for each installation or an exemption;
- Suitable maintenance procedures;
- Suitable training procedures for operators and maintainers;
- A risk assessment and training to enable the storage, transportation, fitting and operation of I_s-limiters.

The most significant technical issue is:

- The consequences of the I_s-limiter failing to operate on demand.

Reliability discussion

The principal issue with the I_s-limiter is one of being able to demonstrate its reliability to operate on demand while not suffering unacceptable levels of spurious trips. Should the Is-limiter operate as designed, then there is no reason that would prevent their use in a network in the UK. However, should the I_s-limiter fail to operate, and equipment downstream was overstressed, the network operator would be in breach of current legislation.

The quantitative assessments from the FTA and FMECA support the existing safety studies which show that the expected rates are 4.9×10^{-5} failures on demand (per year). This is considered acceptable, given that in the nuclear industry, a probability of failure on demand of the order of 1×10^{-6} is required.

Within a proposed three phase circuit breaker installation there will be one I_s-limiter per phase. Only one I_s-limiter actuation is required to activate the circuit breaker for all phases. The installation can therefore be regarded as providing triple redundancy.

Recommendation

There are four administrative issues to be resolved, as listed in section 3 above, before a full Safety Case can be prepared. The reliability assessment suggests that both the probability of failure on demand or spurious operation are acceptable.

It is considered that the I_s-limiter is appropriate for use in the UK, based on its assessed reliability performance and its current use in Europe. The risks are that in the failure to operate on demand, the down-stream equipment may be damaged. Loss of life associated with this is unlikely as the down-stream equipment will be in its normal operating state with all protective features in place.

The completed safety case will allow regulatory review by Ofgem and HSE with a view for the approval for the use of I_s-limiters in the UK.

Appendix H: Withstand capability study

New ratings study for two types of ring main unit following direct testing

Summary prepared by EPS UK Ltd for: Dr Geraldine Bryson Future Networks Technical Manager Electricity North West (UK) Preston

Summary issued by A. Michel MIET 24th June 2014

EPS is an independent design consultancy specialising in the design of equipment for the medium voltage power industry. EPS designs and develops a variety of technologies used in the utility market.

Executive summary

The initial objectives

In anticipation of delivering solutions to facilitate the expected growth in renewable generation connecting to increasingly meshed distribution networks, EPS undertook a data study and subsequently proposed direct tests.

The validation of the short circuit ratings of existing circuit breakers and ring main units was included within the original objectives.

Figure H.1: Results of statistical study of installed switchgear

Type	Qty	Percent total
T4GF3	6909	59.66%
RN2C	2044	17.65%
T3GF3	869	7.50%
SABREVRN2A	641	5.54%
SABRE-VRN	318	2.75%
Sabre-VRN2	219	1.89%
T3/OF	133	1.15%

On analysis of the installed assets databases it became clear that the limiting factors for accepting higher fault levels on existing infrastructure would be the ring main units (RMUs) and associated cabling.

Furthermore, it was evident from the same statistical analysis that just two types of RMU dominated the installed base; namely Long and Crawford (GEC/Alstom) T3GF3 and T4GF3 units at 6.6kV and 11kV.

The analysis is summarised in Figure H.1.

Thus two types namely T3GF3 and T4GF3 dominate; representing 67% of all RMUs installed.

With this information, and taking into consideration the following, direct testing was recommended:

- the fact that a high percentage of installed equipment was of just two types
- that a test house was prepared to accept the risks associated with direct testing oil/liquid filled units that the withstand capabilities would be "tailored" to the actual conditions on the network rather than rely upon:
  - calculated results;
  - values recommended by standards;
  - analysis of non-rating plate data (ie type test values rather than nameplate values); and

- test costs were comparatively low and an access was immediately available.

Direct tests undertaken and why

Direct tests are those tests conducted at a test station where fault currents can be generated. The direct testing charges were relatively low and EPS had access to suitable and capable test objects and test engineering support.

The ring switches of the RMU would be required to withstand a "through" current with a designated peak for a period of time consistent with the relay and operation times of connected circuit breakers. The direct tests were designed to simulate these conditions.

While it would be normal to adopt the relevant EN standard of a three second duration test, in practice, on the Electricity North West network, the maximum is two seconds or less.

Failure normally occurs on the peak (the peak of the RMS value with a DC offset). Failure thereafter is less likely but in the case of these tests was limited to two seconds or less. The peak withstand test had approximately 300 milliseconds of follow through to verify that the switch elements had withstood the peak. Therefore each test was conducted as a pair vis-à-vis a peak withstand followed by a through current.

Direct tests were strongly advocated by EPS for speed, relevance to the Electricity North West network, cost and the (expected) high integrity of the results.

Direct tests

Thus two types of unit were taken to ABB Ratingen in Germany on 5th and 6th June 2014.

Midel 7131, a synthetic oil, and a Midel 7131/mineral oil mix were used to fill the units. With comparable physical parametric characteristics, insofar as these test conditions were concerned, there was less possibility of a catastrophic event should contacts fail.

This assumption proved valid when the T3GF3 failed at higher test levels.

A single core 185mm^2 solid aluminium core polymeric cable was chosen for the tests with a 3M cold shrink termination.

Conclusions drawn from direct tests

Long and Crawford T3GF3

Following the tests it can be stated that T3GF3 type RMUs can be used with 185 mm^2 solid aluminium core polymeric cables up to a rating of 15kA for 1.5 seconds.

The maximum fault level and peak current (created by a DC component) for the T3GF3 is 15kA for 1.5 seconds with a 37.1kA peak.

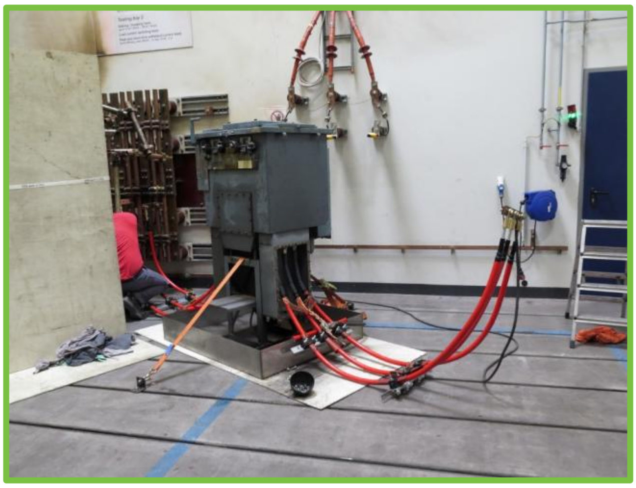
Long and Crawford T4GF3

T4GF3 type RMUs can be used for fault ratings up to 25kA for 1.5 seconds, however above 15kA 300 mm^2 cables should be used.

The maximum fault level and peak current (created by a DC component) for the T4GF3 is 25kA for 1.5 seconds with a 62.5kA peak.

It should be noted that at 18.4kA for 2.0 seconds the cables overheated to the point needing replacing. For this reason EPS recommends that 185 mm^2 should only be left in service for fault levels up to 15kA and maximum clearance times of 1.5 seconds.

Test setup



ABB

Steve Cox
Future Networks Manager
Electricity North West Limited

Peter R. Jones
Technology Strategy Manager
ABB Limited
Daresbury
Warrington
Cheshire
WA4 4BT

11th July 2014

Letter of Support for Electricity North West Ltd
LCNF Tier 2 FLARE Project

Steve,

ABB are delighted to have been selected as a partner to work with Electricity North West and other partners, to demonstrate the *Is Limiter*, Fault Limiting Technology as part of the wider FLARE Project.

Effective fault level management on the UK distribution system promises to deliver improved capital efficiency as well as improved customer service and help facilitate the further connection of renewable technologies onto the distribution system.

ABB has wide experience of the application of this technology globally and welcomes the opportunity to work with Electricity North West to bring this global experience to the UK and help determine the most effective application and more importantly the benefits this technology promises to deliver.

We look forward to learning and disseminating with Electricity North West and its partners, the knowledge and further understanding that the FLARE project will deliver.

Regards
Peter Jones
FIET, MBA, CEng

Technology Strategy Manager
For Power Products and Systems in the UK
ABB UK

ABB Limited

Please reply to:
Daresbury Park
Daresbury, Warrington
Cheshire WA4 4BT
United Kingdom

Tel: +44 (0) 1785 825 050
Fax: +44 (0) 1785 819 019

Website: www.abb.com
Email: info@gb.abb.com

Registration No:
3780764 England
VAT Reg No:
668 1364 13

Registered Office:
Daresbury Park
Daresbury, Warrington
Cheshire WA4 4BT
United Kingdom

Steve Cox
Electricity North West Limited
304 Bridgewater Place
Birchwood Park
Warrington
WA3 6XG

23 July 2014

Ref: FLARE - Fault Level Active Response Project

Dear Steve,

ENER-G provides businesses across the globe with a wide range of energy services and sustainable technologies to help them generate, buy and manage their energy. We finance, design and deliver a range of low carbon, energy efficient technologies. Our on-site generation technologies provide a sustainable, cost effective source of energy. They include combined heat and power, heat pumps and anaerobic digestion systems. Our building energy management controls help improve building efficiency and lower operational costs. Our energy procurement specialists and independent energy, carbon and water consultants offer a wealth of cost effective energy management services to help buy energy and manage consumption.

ENER-G is delighted to join Electricity North West as a Project Partner for their low carbon networks project, Fault Level Active Response. We continually engage with Electricity North West, as a distribution network operator (DNO), to seek connection of our generation products to their distribution network and we were involved in the stakeholder review of the recently submitted RIIO-ED1 price control business plan. The new commercial concept that FLARE will explore offers something new in the provision of support services to DNOs and as such, is something we are keen to see demonstrated. For this reason, we will be offering our support by promoting this opportunity to our customers so that the exciting proposition can be trialed. We will work with Electricity North West to support the customer survey and analysis and customer engagement for trials of the Fault Current Limiting service, plus the dissemination of the learning from the FLARE project.

Yours sincerely

Chris Marsland
Technical Director

ENER-G Combined Power Limited
ENER-G House Daniel Adamson Road Manchester M50 1DT UK
T: +44 (0) 161 745 7450 **F:** +44 (0) 161 745 7457 **E:** chp@energ.co.uk **W:** www.energ.co.uk
Registered in England No: 1874716

Combined Heat & Power
Association
6th Floor
10 Dean Farrar Street
London SW1H 0DX
Tel +44(0)20 3031 8740
Fax +44(0)20 7222 4253
info@chpa.co.uk
www.chpa.co.uk

chpa
Bringing Energy Together

Combined Heat & Power
Sustainable Energy Services
District Heating & Cooling

Steve Cox
Electricity North West Limited
304 Bridgewater Place
Birchwood Park
Warrington
WA3 6XG

22 July 2014

Ref: FLARE - Fault Level Active Response Project

Dear Steve,

The Combined Heat and Power Association (CHPA) is the leading advocate of an integrated approach to delivering energy services using combined heat and power and district heating and cooling. By starting with the consumer, examining their needs and considering the user in their local context it is possible to design a more local, efficient and less costly energy system where each technology and infrastructure option is considered on its merits. Our vision is for an energy system that is dictated by the consumers' needs rather than one that dictates to them.

The Combined Heat and Power Association is delighted to join Electricity North West as a Project Partner for their low carbon networks project, Fault Level Active Response. Representing member organisations from across the industry sectors we believe FLARE has the potential to facilitate the quick connection of our members' generation equipment. As an innovation project, FLARE has the potential to deliver a substantial increase in customer satisfaction and a better value energy network for all. We will work with Electricity North West to support the customer survey and analysis and customer engagement for trials of the Fault Current Limiting service.

Tim Rotheray

Dr Tim Rotheray
Director

GMCA
GREATER MANCHESTER COMBINED AUTHORITY

AGMA
ASSOCIATION OF GREATER MANCHESTER AUTHORITIES

GMCA/AGMA LOW CARBON HUB

Steve Cox
Electricity North West Limited
304 Bridgewater Place
Birchwood Park
Warrington
WA3 6XG

8h July, 2014

Ref: FLARE - Fault Level Active Response Project

Dear Steve,

Greater Manchester Combined Authority (GMCA) co-ordinates key economic development, regeneration and transport functions across the ten authorities of Greater Manchester. GMCA has established the Greater Manchester Low Carbon Hub to support delivery of Greater Manchester's collective 48% carbon reduction target by 2020. The Hub oversees delivery of an implementation plan to achieve this and support delivery of a low carbon economy. The implementation plan has a clearly prioritised co-ordinated programme for reducing CO_2 emissions from commercial and public buildings. We have specific proposals for optimising integration with smart grids, heat networks, energy generation from renewables and building-scale renewable heat models, which, by 2020, aims to deliver locally owned low carbon generation of 3TWh/y of heat and 1TWh/y of electricity.

I am delighted to support this Low Carbon Networks Fund submission for the Fault Level Active Response (FLARE) project. This innovative solution to address fault levels could support earlier and wider roll out of the energy efficiency and carbon reduction initiatives outlined above. Electricity North West Limited is considered a key partner of the GM Low carbon hub and has provided guidance on a number of the projects we have implemented in our communities. ENW have proven to be supportive and innovative in their approach to the requirements of Greater Manchester and its residents.

Having had direct experience of their expertise and professionalism I am fully confident that their team can deliver FLARE and generate great benefits for the environment and inhabitants of Greater Manchester and the wider North West.

Yours sincerely

Mark Atherton
GM Director of Environment

Contact: Mark Atherton
Telephone No: 07545 420518
E-mail: mark.e.atherton@oldham.gov.uk

The University of Manchester

MANCHESTER 1824

Prof. Jovica V. Milanović, CEng, FIET, FIEEE
Deputy Head of School & Head of Electrical Energy and Power Systems Group
Ferranti Building, Room C10
Tel:+44 (0)161 306 8724
Fax:+44 (0)161 306 4820
E-mail: milanovic@manchester.ac.uk

School of Electrical & Electronic Engineering
The University of Manchester
PO Box 88
Sackville Street
Manchester, M13 9PL
United Kingdom
Tel: +44 (0)161 306 9340
www.manchester.ac.uk

1st July 2014

Ms Cara Blockley
Future Networks
Electricity North West plc.
Birchwood Park
WARRINGTON
WA3 6XG

Re. Letter of support to Electricity North West plc. application for LCNF funding.

Dear Ms Blockley

I am very pleased to support ENW's application for LCNF funding as specified in FLARE project proposal as it addresses some of the key issues that future distribution networks will be facing.

In the future, distribution networks may experience severe fault level challenges due to the installation of distributed generation and Combined Heat and Power (CHP) plants. These fault level issues can either be solved by expensive network reinforcement or by smarter network control and operation solutions, such as active fault level response achieved through assessment, management and mitigation of fault level issues which are the main deliverables of the FLARE proposal.

The focus of FLARE project is to demonstrate active response to fault level issues, which is both timely and well thought of. The proposed techniques, if proven, will allow for higher penetration of urban distributed generation and other Low Carbon Technologies (LCT) such as Photovoltaics (PV), Electric vehicles (EV) and Air Sourced Heat Pumps (ASHP). Since the CHP and ASHP are going to be major contributors to the network fault level challenges in Manchester area, it is absolutely appropriate to select this part of the network as the area where FLARE will demonstrate its proposed innovative techniques.

I am confident that FLARE's innovative techniques will help Distribution Network Operators (DNO) nationally and internationally, to manage their network at lower cost and support the transition to a low carbon economy by facilitating evolution to flexible and reliable distribution networks.

Yours sincerely,

JMilanović

Prof. J.V.Milanović

Schneider Electric Ltd
University of Warwick Science Park
Sir William Lyons Road
Coventry
CV4 7EZ

7th October 2014

To: Steve Cox.
Electricity North West

Dear Steve

Letter of support from Schneider Electric Ltd for Project FLARE

We are pleased to write a letter of support for the Electricity North West FLARE project.

We understand that the DNO community are exploring innovative solutions in order to facilitate the transition to low carbon energy systems and are delighted that Schneider Electric has been selected to contribute to this transition as a project partner for FLARE.

Schneider Electric specialises in electricity distribution and is an industry leader in adaptive protection. FLARE explores the application of adaptive protection techniques in an entirely novel way, seeking to address the issue of increasing fault levels on distribution networks.

We are looking forward to working closely with Electricity North West and the other FLARE project partners to find viable, cost effective solutions to fault level mitigation and allow faster adoption of all types of low carbon technologies.

Yours sincerely

Barrie Cressey
Business Development Director – Smart Grids

Schneider Electric Limited
Switchgear & Transformers
123 Jack Lane, Leeds LS10 1BS
Tel. 0113 290 3500 Fax 0113 290 3710
Web: http://www.schneider-electric.com/uk

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Appendix J: Common Connection Charging Methodology Change Proposals

Background

The Electricity Distribution Licence Condition 13 requires a distribution network operator to have in force a Connection Charging Methodology, approved by the Gas and Electricity Markets Authority. The methodology for calculating connection charges is documented in each distribution network operator's Statement of Methodology and Connection Charges, available to download from their websites. The principle underpinning the methodology is that the connectee pays for the whole cost of the new connection assets and a proportion of the costs of reinforcement necessary to accommodate the new connection up to one voltage above the connection voltage.

Description of Methodology

The methodology for calculating the apportionment of reinforcement costs associated with a fault level constraint is defined by the Fault Level Cost Apportionment Factor calculation shown below:

$$\text{Fault level CAF} = 3 \times \frac{Fault\ level\ contribution\ from\ Connection}{New\ fault\ level\ capacity} \times 100\%\ (\max 100\%)$$

Where:

'Fault Level Contribution from Connection' is the assessment of the fault level contribution from the equipment to be connected taking account of its impact at the appropriate point on the distribution system. Where an existing customer requests a change to a connection then the ''fault level contribution from connection'' is defined as the incremental increase in fault level caused by the customer.

'New fault level capacity' is the fault level rating, following reinforcement, of the equipment installed after taking account of any restrictions imposed by the local network fault level capacity. For the avoidance of doubt this rule will be used for all equipment types and voltages.

Shortfalls of Methodology

This text was originally developed on the premise that fault level issues would be mitigated by the replacement of the substation switchgear. For example 150MVA fault rated switchgear would be replaced by 250MVA (or even 350MVA) switchgear.

However, the techniques and devices being trialled in the FlexDGrid project and being proposed in FLARE have not been previously applied by the industry and so there is no experience on the application of the fault level CAF rules. Until there is clarity on how the fault level CAF rule is applied to these new engineering solutions there is an opportunity for misinterpretation by the network operators, potentially negatively affecting customers' contributions.

For example, if the new fault level capacity is zero as the network has not been reinforced the apportionment method fails to allocate an appropriate proportion between the connectee and the general mass of customers; or should a new connecting customer be charged a proportion of the purchase cost if an existing customer is willing to provide a Fault Current Limiting service?

Proposals

It is proposed that FLARE will initiate a discussion at the Common Charging Methodology Forum on the impact of the alternative fault level mitigation techniques on the Common Connection Charging Methodology and specifically the Fault Level Cost Apportionment Factor. A DCUSA change proposal will be submitted following these discussions.

Appendix K: FLARE Full Submission spreadsheet

This appendix is the full submission workbook for the FLARE Project. This will be appended in a separate document.

Appendix L: FlexDGrid and fault level mitigation techniques review

The DTI report *The Contribution to Distribution Network Fault Levels from the Connection of Distributed Generation* was issued in 2005. Although this report was created ten years ago, it is viewed as the principal reference on fault level and mitigation techniques. This document has not been superseded and manufacturers have developed technologies that meet with the techniques detailed within.

The report listed the potential techniques as options for managing increased fault levels. Figure L.1 below demonstrates which of these options are already being investigated in FlexDGrid and which are proposed as part of FLARE.

Figure L.1: Fault level mitigation techniques

DTI 2005 Report	Description	Traditional Methods	FlexDGrid	FLARE
Uprating components	Change switchgear to that with higher rating - current BaU solution	✓		
Increase impedance	Introduce higher impedance transformer or a current limiting reactor		✓	
I_S-limiter	A current limiting device, which operates before the first peak is reached, installed at a substation			✓
Superconducting fault current limiter	An alternative version of a current limiting device installed at a substation		✓	
Power electronics	This is inverter technology which is part of the generator installation - now widely used in small DG ie PV			
Solid state fault current limiter	An alternative version of a current limiting device installed at a substation		✓	
Network splitting and reconfiguration	Control fault level by running network split - current temporary BaU solution	✓	✓	
Sequential switching	Adapting the "trip" order of the circuit breakers to reduce fault level when a fault occurs			✓
Active fault level management	Software solution to control some or all of the above technologies		partly	✓

It is important to note that the power electronics option refers to a generator's use of inverter technology to provide a lower fault current contribution. This is not a DNO led solution and is already widely in use in small scale embedded generation, such as PV.

FlexDGrid is investigating the use of three types of fault current limiting technologies: pre-saturated core fault current limiter, superconducting fault current limiter and power electronic limiter. In conjunction with this they are investigating commercial arrangements with generators linked to network configuration. The active fault level management element in FlexDGrid consists of switching generators off when WPD need to carry out certain network re-configurations. This will only apply to those generators which have entered into the appropriate commercial arrangements.

FLARE seeks to investigate those technologies not included as part of FlexDGrid which will give a larger range of solutions for GB. As part of FLARE we will deploy near real time active fault level management. We will be constantly assessing the fault level on the network. When the fault level exceeds ratings we will enable the relevant mitigation technologies which will **only** operate in the unlikely event of a fault occurring. The benefit of this approach is that the network will only be subjected to alternative operating arrangements when there is a fault during the time when the fault level is high and the technologies will only operate when they really need to. Following the fault our automatic restoration system will restore all healthy parts of the network, including the generator, within three minutes. This means that for the generator there will no operating constraints and they will only experience short duration interruptions for the rare occasion that a fault occurs when the fault current is above equipment rating. This active fault level management was considered as part of the FlexDGrid submission paperwork but was discounted due to the need for system wide modelling and reliable communications. Electricity North West feels that these issues are not insurmountable and can be addressed. There are systems available to carry out the modelling required and inform the NMS to enable the technologies. We intend to use our existing communications infrastructure which is used to operate our network on a daily basis and is proven to be reliable. In the unlikely event of a communications failure we can install local logic to enable the techniques and ensure fail safe operation.

Active fault level management can be applied to the techniques of FlexDGrid as well as FLARE which will further enhance the use of the fault level mitigation techniques as shown in Figure L.2.

Figure L.2: Techniques and active fault level management

DTI 2005 Report	Can active fault level management be used to control the technique?
Uprating components	No
Increase impedance	Yes
I_S-limiter	Yes
Superconducting fault current limiter	Yes
Power electronics	Yes
Solid state fault current limiter	Yes
Network splitting and reconfiguration	Yes
Sequential switching	Yes

The outputs of FlexDGrid and FLARE will give GB a comprehensive set of solutions to fault level issues which will cater for all network and business models ultimately giving generators a choice for their connection.

Appendix M: References

1. DTI report: The Contribution to Distribution Networks From the Connection of Distributed Generation
   http://webarchive.nationalarchives.gov.uk/+/http://www.dti.gov.uk/renewables/publications_pdfs/dgcg00027.pdf
2. The Carbon Plan
   https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf
3. IET Report *Handling a Shock to the System (technical report)*.
   http://www.theiet.org/factfiles/energy/elec-shock-page.cfm
4. The Parsons Brinckerhoff report *Development of a safety case for the use of current limiting devices to manage short circuit current on electrical distribution networks*.
   http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file15164.pdf
5. Capacity to Customers
   https://www.ofgem.gov.uk/ofgem-publications/46021/c2cproformaaddendumappendices.pdf; www.enwl.co.uk/the-future
6. FlexDGrid
   https://www.ofgem.gov.uk/ofgem-publications/46080/flexgridrevisedcombined.pdf

Appendix N: Glossary

Adaptive Protection	The use of adjustable protection settings that can be changed in real time
Asset Replacement	Replacement of distribution network assets (eg transformers and circuit breakers)
BaU	Business as usual
Breaking Capacity	Maximum fault current that the circuit breaker can interrupt
Capital Expenditure	Expense to acquire or upgrade network assets
Circuit Breaker	Protection device that interrupts the flow of current in an electric circuit in the event of a fault
Combined Heat and Power (CHP)	Simultaneous generation of usable heat and power (usually electricity) in a single process
Combined Heat and Power Association (CHPA)	Leading industry advocate of an integrated approach to delivering energy services using combined heat and power and district heating
Demand Side Response (DSR)	Actions undertaken by distribution network operators to influence customers to change their electricity use, in terms of quantity and/or time of use
Distributed Generation (DG)	Generation connected directly into the distribution network, as opposed to the transmission network. This generation typically supplies local demand
Distribution Network Operator (DNO)	The owner and/or operator of an electricity distribution system and associated assets
Distribution Use of System (DUoS) Charges	Use of system charges for demand and generation customers which are connected to and utilising the distribution network
District Heating	Supply of heat to a number of building or homes from a central heat source through a network of pipes carrying hot water or steam. The source of heat is typically CHP
Expression of Interest (EoI)	A invitation to express an interest in providing services or products
Fault Level Assessment Tool (FLAT)	Intelligent software which assesses near real time fault current peaks on the network and decides to enable or disable the mitigation technologies
Fault Current	Actual current which flows during a fault
Fault Current Limiting Protection	Adaptive protection equipment installed on a customer's electrical machine to facilitate the Fault Current Limiting service
Fault Current Limiting service (FCL service)	A distributed generation and/ or industrial and commercial customer provided response to reduce overall fault current on the distribution network
Fault Current Mitigation Technology	Device that responds to the flow of fault current in an electricity network and ensures that the fault current remains within network switchgear and network ratings
Fault Level	Prospective maximum current which will flow during a fault
Fault Level Headroom	Capacity to increase the fault level without exceeding the fault level limit
FlexDGrid	Second Tier LCN Fund fault level mitigation project run by Western Power Distribution
Innovation Funding Incentive (IFI)	Ofgem incentive mechanism to encourage DNO innovation
I_S-limiter	A fault current mitigation technology

Long Term Development Statement (LTDS)	Statement published annually by DNOs to make network information available to the public domain. This enables anyone interested in connecting generation or load to the network to identify opportunities or constraints on the network
Making Capacity	Maximum fault current that the circuit breaker can close onto
Near Real Time	A measure of the frequency of the calculation by the Fault Level Assessment Tool. For FLARE this will be every five minutes
Primary substation	A point on the network where the voltage changes from 33kV to 11kV or 6.6kV
Protection relays	Device that analyses power system voltages and currents to detect faults and sends signals to circuit breakers to open
Sequence tripping	A form of Adaptive Protection
RfI	Request for information
RfP	Request for proposal
Substation	A point on the network where voltage transformation occurs
Switchgear	Device for opening and closing electrical circuits (including circuit breakers)
Transformer	Device that changes the voltage of an alternating current, without changing the frequency
Withstand Capability	The number of seconds switchgear can tolerate fault current

List of Changes

This section documents the changes from the original FLARE Full Submission version ENWLT206/01, submitted on 25 July 2014, to this version, ENWLT206/02, submitted on 10 October 2014. The table below details each change and the reason for the change.

All additions to the FLARE Full Submission and Appendices documents are easily identifiable as they are coloured red. The exceptions to this rule are:

1) The opening sentence in Full Submission Sections 1.3, 2, 3, 4, 5, 6, 7 and 8 as red is used to emphasise a key message; and
2) Appendix C: Project Plan where red text denotes an SDRC.

Where a Figure heading is red, this denotes a change to the chart, table or graph. Changes within charts and graphs identified by red headings will not visually show as red.

Location	Change	Reason	Generated
Section 1.3, page 1	Higher GB potential saving value.	Clarification	Expert Panel
Section 1.4.1	Second Tier Funding Request amended to reflect lower overall project cost.	Clarification	n/a
Section 1.4.2, page 1	DNO compulsory contribution amended to reflect lower overall project cost.	Clarification	n/a
Section 1.4.4, page 1	External funding amended to reflect Schneider Electric's Partner contribution.	Clarification	n/a
Section 1.6 page 2	Update Project Partners list with Schneider Electric.	Clarification	n/a
Section 2.1, page 6	Higher GB potential saving value.	Clarification	Expert Panel
Section 2.1, page 6	Amended MVA of capacity released to correct typo.	Clarification	Q&A question 26
Section 2.2, page 8	Confirmed IEC standard.	Clarification	Expert Panel
Section 2.4, page 12	Changes to ISP: reduced project costs.	Increased value for money	n/a
Section 3, page 15	Clarifying the I_S-limiter scenario for cable withstand.	Clarification	Expert Panel
Section 3, page 17	Clarifying costs and percentages.	Clarification	n/a
Section 3, Figure 3.6 page 17	Updated pie charts showing revised cost and contribution values.	Clarification	n/a
Section 3, Figure 3.7 page 17	Updated to show Fault Level Assessment Tool costs.	Clarification	n/a
Section 3, Figure 3.8 page 18	Updated to show additional Fault Current Limiting service payment for revised SDRC 9.3.7 commitment.	Clarification	n/a
Section 3, Page 19	Revised Electricity North West contribution due to reduction in overall project costs.	Clarification	n/a
Section 4a, page 21	Scale of project costs amended to show lower Fault Level Assessment Tool costs.	Value for money	n/a
Section 4a, Figure 4.1, page 22	Revised cost and savings figures to reflect lower Fault Level Assessment Tool costs.	Value for money	Expert Panel

Section 4a, page 22	Revised Fault Level Assessment Tool costs and revised summary of benefits analysis figures.	Value for money	Expert Panel
Section 4a, page 22	GB roll out MVA amended to 127 275 MVA.	Clarification	Q&A question 26
Section 4b, page 23	Additional text to confirm software provider.	Value for money	n/a
Section 4b, Figure 4.2, page 23	Table updated with confirmed software provider, day rates and no. of days.	Value for money	n/a
Section 4b, page 24	Revised contribution and % of total figure to reflect lower project cost.	Value for money	n/a
Section 4d, page 26	Amended text to include Schneider.	Value for money	n/a
Section 4d, Figure 4.3, page 27	Project Partner table amended to include Schneider.	Value for money	n/a
Section 5, Figure 5.1, page 30	Confirm software provider as Schneider Amend contract templates to refer to new and existing customers.	Value for money	Expert Panel
Section 6, page 36	Amend text to confirm Schneider as software provider Partner.	Value for money	Expert Panel
Section 6, page 36	Contingency numbers revised to reflect known software Partner and potential payments to users.	Value for money	Expert Panel
Section 6, Figure 6.2, page 38	Updated with SDRC amendments.	Value for money	Expert Panel
Section 8, page 41	Additional sentence to confirm FCL service purchased from at least one Electricity North West demand customer and one Electricity North West generation customer.	Clarification	Expert Panel
Section 9, page 45	Amend SDRC, 9.1.2, publish FCL service installation reports.	Clarification	Expert Panel
Section 9, page 45	New SDRC, 9.2.4, within Customer Workstream for contract templates for FCL service with new and existing customers.	Value for money	Expert Panel
Section 9, page 45	Amend SDRC, 9.2.3, publish customer evaluation information for FCL service provision to support roll out.	Clarification	Expert Panel
Section 9, page 46	Amend SDRC 9.3.7 to include at least one Electricity North West demand customer and one Electricity North West generation customer.	Clarification	Expert Panel
Appendix A1, Figures A1.4 and A1.5, pages 53 & 54	Capacity released tables updated to correct initial error in completion.	Clarification	Q&A – question 25
Appendix A1, pages 55 to 58	Net benefits analysis on using an I_S-limiter to protect HV cables for through fault withstand, including new Figure A1.6.	Clarification	Expert Panel
Appendix A3, page 61	Inserted missing word “not”.	Clarification	Q&A - question 16

Appendix B1, page 69	Clarification of IEC and fail safe confirmation.	Clarification	Q&A- question 37 and "Big Questions – Q2 & Q3
Appendix C: Project Plan, pages 75 to 78	Includes the additional SDRC, the changes to existing SDRCs and amended dates to correct year on lines 163 & 164.	Clarification	Expert Panel
Appendix D, pages 80 & 81	Amend risks and issues register with revised and additional risks and mitigation identified by the Expert Panel and consultants.	Clarification	Q&A – question 22 and Consultants review
Appendix E: Organogram, page 83	Updated Organogram with minor corrections to text and added Partner logos.	Clarification	Expert Panel
Appendix F: Project Partner details, page 84	Details for the Schneider Electric contribution and roles on project included.	Value for money	Expert Panel
Appendix H: Withstand capability study, page 88	Corrected typo relating to ring main units tested.	Clarification	Q&A – question 24
Appendix I: Letters of support, page 95	Includes Schneider Electric letter of support.	Clarification	n/a