Powerful-CB

Project Progress Report – December 2019

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Glossary

Term	Description
ABB	Our technology partner for Method 1
AMAT	Applied Materials, our technology partner for Method 2
BAU	Business As Usual
CB	Circuit Breaker – Protection device that interrupts the flow of current in an electric circuit in the event of a fault
DG	Distributed Generation
DNO	Distribution Network Operator
EMC	Electromagnetic Compatibility
ENA	The Energy Networks Association
EPN	Eastern Power Networks plc
ENWL	Electricity North West Limited
FATs	Factory Acceptance Test
FCL	Fault Current Limiter – a FLMT that attenuates fault current by increasing its impedance (only) during a fault.
FLMT	Fault Level Mitigation Technology – a technical solution that reduces fault levels on the network
FLCB	Fault Limiting Circuit Breaker – a FLMT that blocks fault level contributions from a transformer / bus coupler / generator by disconnecting it before the first current peak of the fault
FNC	Frazer-Nash Consultancy
FSP	The Powerful-CB Full Submission Proforma - http://bit.ly/Powerful CB-fsp
GB	Great Britain
GT	Grid Transformer
HAZID	Hazard Identification
HSE	The Health and Safety Executive
HV	High Voltage
Imperial	Imperial Consultants (Imperial College London's consultancy company)
IPR	Intellectual Property Rights
LCNI	Low Carbon Networks & Innovation Conference
LPN	London Power Networks plc
M1	Method 1 - Installation of a FLCB at a substation
M2	Method 2 - Installation of a FLCB at a customer's premises
NIC	Network Innovation Competition
PPR	Project Progress Report

RIIO-ED1	The current electricity distribution regulatory period, running from 2015 to 2023
SCADA	Supervisory Control and Data Acquisition
SDRC	Successful Delivery Reward Criteria
SPN	South Eastern Power Networks plc
TRL	Technology Readiness Level
UKPN	UK Power Networks

1. Executive summary

1.1 Project background

The Powerful-CB (Power Electronic Fault Limiting Circuit Breaker) project aims to demonstrate that fault-limiting circuit breakers (FLCBs) can enable distribution networks to connect more distributed generation (DG) to fault-level constrained 11 kV distribution networks without the need for network reinforcement.

A FLCB is a solid-state circuit breaker that operates 20 times faster than existing vacuum circuit breakers. This high-speed operation can mitigate fault level contributions from distributed generation, allowing us to connect more DG (including CHP) to fault-level constrained networks in dense urban areas. This will help accelerate the decarbonisation of heat, which is a key element of the Government's Carbon Plan.

The project team had been working with two technology partners to develop two types of FLCB. ABB will develop a FLCB for use at a primary substation, known as Method 1 (M1). We believe Method 1 will be the world's first demonstration of a FLCB with a fast commutating switch. Applied Materials Inc. (AMAT) were to develop a FLCB for use at a customer's premises, known as Method 2 (M2).

A change request was submitted to Ofgem in November 2018 to remove M2 from the scope of the project following the withdrawal of AMAT from the project. As highlighted in the December 2018 report, the project team made efforts to find a suitable replacement partner for M2 by engaging the market however no suitable partner was found.

The project team continues to work with Frazer-Nash Consultancy (FNC) and Imperial Consultants (Imperial) to develop the safety cases for the M1 device.

The project started on 1 January 2017 and is on track to complete on 31 August 2021.

1.2 Summary of progress

This Project Progress Report (PPR) covers the period July to December 2019. The next reporting period will cover January to June 2020. Collectively, these PPRs form the annual progress report required by Ofgem's Network Innovation Competition Governance Document.

Overall, the project has made good progress during the reporting period focussing on completing the type tests and factory acceptance tests (FATs) of the FLCB, extending the existing busbar, installation of protection and supervisory, control and data acquisition (SCADA) panels, and installation of cabling at the trial site, and commissioning of the device. At the time of writing, energisation of the device is planned for December. The following section provides an update of key progress from each workstream.

As highlighted in the December 2018 and June 2019 PPRs one of our project partners, AMAT did not sign onto a collaboration agreement and subsequently withdrew from the project. We received a draft decision from Ofgem during this period and formal confirmation is expected in the following period. It has been agreed that M2 and associated budget will be removed from the project and returned to customers via Ofgem; this affects workstreams 1, 2 and 3.

Workstream 1 – Development of a FLCB Device

During this reporting period, Workstream 1 (WS1) completed the type testing of the FLCB as the initial internal arc test had failed in May 2019. ABB modified the panel design and the re-test was successfully passed in July 2019, however this failure resulted in approximately two months of delay.

Following the completion of all type tests, ABB were also able to complete all FATs successfully with only a few minor safety additions requested by UK Power Networks. This signified that the FLCB was ready to be shipped to the trial site.

The project team also published the learning report SDRC 9.1.1 which includes recommendations for specifying a substation-based FLCB, results and learning from type tests (including a short circuit test) conducted at an accredited high power laboratory, requirements for integrating FLCBs into existing networks and ensuring safety. To view SDRC 9.1.1 please visit https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2019/11/Powerful-CB-SDRC-9.1.1-v1.0-DP.pdf.

Workstream 2 – Network Demonstration

During this reporting period, Workstream 2 (WS2) focused on completing the necessary trial site busbar extension and installation of protection panels, SCADA panel and cabling. Once this was completed commissioning of the equipment was carried out.

At the time of writing energisation of the FLCB is planned for late December; it will follow after all the commissioning and final high voltage (HV) cable terminations have been completed. Risks R15 (project partners unable to deliver on commitments on time because of lack of resources and/or other commitments), R17 (UK Power Networks not able to deliver on commitments because other teams supporting the project have operational resource constraints) and R34 (delay and/or cost overrun – commissioning) involve resource availability and completing HV cable terminations and energisation are at risk as it has been shifted towards the end of the year (Christmas holiday period) due to a knock-on effect of risk R41 (delay in testing and/or FAT of FLCB device). R41 saw a fault of the generator at the high power test lab and failure of the first internal arc test, which caused a delay in the completion of type testing of the FLCB.

Additionally energisation is at risk due R42 (delay in energisation and commencement of trial period (due to defect identified in QF switchgear (retrofit circuit breakers)). A defect was discovered with a batch of retrofit ABB VOR-M CBs of the same type as the ones being used for the trial site. Failure of the capacitor in the magnetic actuator mechanism or loss of DC supply would prevent the CB from opening/tripping. UK Power Networks has requested the development of a portable power pack from the manufacturer that would enable the CB to be opened in the event of a DC supplies failure at the substation. Until this has been produced, Asset Management teams have requested that these retrofit CBs are not energised.

However risk R43 materialised in this period, which has resulted in the project being unable to commission the auto-close scheme and fault recording relays due to a cable fault associated with grid transformer 1 (GT1) at the trial site. The cable fault cannot be resolved until a sinkhole in close proximity to where the excavation is required is repaired. To mitigate this, the project team has agreed to progress with energisation of the device, and commission these later to limit delays due to the uncertainty of when the sinkhole will be fixed. The team will rely on the fault recording within the FLCB in the interim and the auto-close scheme is not required in the trial until running arrangement 3 (the final running arrangement to be trialled) is demonstrated around Q3 2020.

Figure 1 FLCB positioned into place and installation

Workstream 3 – Understanding Customers' Requirements

During this reporting period, the project team agreed in principle with Ofgem for the removal of M2 from the project. Ofgem is expected to provide formal confirmation regarding the change request in the following reporting period, upon which the project team will inform all interested stakeholders involved, including the project mailing list about the removal of M2. Following the removal of M2 from the project, SDRC 9.3.2 – *Assess the (commercial) business case based on the technical and customer findings, focusing on investment decision criteria and trade-offs, such as cost, time to connect, space and impact on security of supply*, will no longer be produced and published.

UK Power Networks still intends to build upon the learnings generated from our engagements with customers willing to participate in such a trial, and continue to see real value in the customer placed FLCB. As such we exploring partnering with Western Power Distribution on an NIA project called EDGE-FCLi (Embedded Distributed Generation Electronic – Fault Current Limiter interrupter). The scope is similar to that of M2 and although a different supplier is being used, we aim to deliver similar benefits to customers once the project is complete. The project is unique as the technology readiness level (TRL) of the device being developed is lower than what was originally proposed with AMAT in M2 and hence provides a great opportunity for the project to increase choice in the market for customers.

Workstream 4 – Knowledge Dissemination

SDRC 9.1.1 was submitted to Ofgem in October 2019 and published on UK Power Networks' innovation website, https://innovation.ukpowernetworks.co.uk/projects/powerful-cb/.

In addition to this learning report, the project was also presented at the Low Carbon and Network Innovation (LCNI) Conference in Glasgow in October 2019. The project was presented in main auditorium under the 'Transition to a Low Carbon Future' session. The conference provided a great opportunity to raise awareness of the project to the wider community as well as share key learnings from the development of the FLCB.

Four internal workshops were also held with internal stakeholders during the period to ensure the FLCB meets the operational requirements, the business understands the benefits, and operational staff are provided an opportunity to familiarise themselves with the FLCB; setting the device up for a successful transition to business as usual (BAU).

1.3 Risks and issues

The project continues to apply robust risk management procedures to reduce the probability and impact of risks materialising. The full risk register and status of each can be found in section 11. Several risks have materialised and are impacting certain project activities or have a medium likelihood of materialising. The project team have taken mitigating actions to reduce the impact of issues and are closely managing high risk items. Further detail is provided below:

Ref	Issue	Impact	Mitigation
R15	Project partners unable to deliver on commitments on time because of lack of resources and/or other commitments	Delay in commissioning and energisation of the FLCB	ABB have some resource availability limitations for commissioning of the FLCB for December. Some resources are unavailable as the original committed dates changed due to delays in type testing completion (R41)
R17	UK Power Networks not able to deliver on commitments because of operational resource constraints	We have engaged the relevant business units within UK Power Networks to confirm their support of the project, and will confirm resourcing commitments during project mobilisation Impact has been a two month delay in completion of installation activities	This risk did materialise and to mitigate some of the delay to project team agreed for some overtime work to be completed. Some resources are unavailable as the original committed dates changed due to delays in type testing completion (R41)
R42	Delay in energisation and commencement of trial period (due to defect identified in QF switchgear (retrofit circuit breakers))	A defect was discovered with a batch of retrofit VOR-M CBs of the same type as the ones being used for the trial site. The defect caused capacitor failures due to a defective batch and they form part of the magnetic actuator mechanism. Failure of the capacitor would	Project team have identified that the retrofit CBs procured for the project are not part of the defective batch of capacitors so the risk of failure is low UKPN has proposed that in the unlikely event of a DC power supply failure of the substation a portable power pack should be developed by ABB so that the CB can be operated. Asset Management have

Ref	Issue	Impact	Mitigation
		prevent the CB from opening/tripping	requested that energisation of these CBs does not take place until this is received from the manufacturer
R43	GT1 cable fault at trial site cannot be repaired until sinkhole near where excavation is required is fixed first	Trial site has three transformers in total and the impact of GT1 being out of service is that GT2 and GT3 cannot also been taken out of service as two must be in service. The result of this is that both the auto-close scheme and the fault recording relays cannot be fully commissioned	Return at a later date to commission auto-close scheme and fault recorders to mitigate delay in energisation. Auto-close scheme is required for running arrangement 3 and the FLCB has its own fault recording devices Have been in contact with London Borough of Tower Hamlets to discuss when the sinkhole will be fixed

In the previous PPR, risk R41, "Delay in testing and/or FAT of FLCB device" was impacting the project but is now closed as the FLCB has been delivered to site. The impact of this materialised risk was approximately 3-4 months delay, which was initially associated with a failure of the generator at the high power test laboratory and then due to the failure of the first internal arc fault (IAC) test.

1.4 Outlook for next reporting period

During the next reporting period, the project will transition from prototype development of the FLCB and installation stage to the commencement of the network demonstration period. During the next period the project will trial the FLCB in two running arrangements. The first running arrangement will see the FLCB sit on the network for a soak test and the second running arrangement the FLCB will be operated as a transformer incomer circuit breaker (CB) The project team will also begin evaluating the FLCB performance and working on the fourth SDRC of the project, SDRC 9.2.1.

Building on the publication of the preliminary safety case report in 2018, Phase 2 of the safety case will be on-going for the duration of the project. Phase 2 will include updating the preliminary safety case with any lessons learned and additional safety requirements identified during the preparation, installation, commissioning of the FLCB and any design changes during the trial. Although it will not occur in the next reporting period, Phase 2 will also see another hazard identification (HAZID) and risk assessment workshop take place for any changes or learnings from the above.

The project team intends to keep recipients on the project mailing list (which constitutes of all interested stakeholders) informed about how M1 is progressing as it transitions from the development phase to the network demonstration phase of the project.

The project team are expecting close out the change request submitted to Ofgem to remove M2 from the project in the following period.

Knowledge dissemination planned for the next reporting period includes engaging with internal and external stakeholders to share knowledge gained from the installation work and commissioning. The project will be presented at UK Power Networks led external event, Better Networks Forum and any other opportunities that arise.

2. Project Manager's report

The project made good progress during this reporting period (July-December 2019), focusing on the following areas:

- Ongoing project planning;
- Type testing and factory acceptance testing (FATs) of the FLCB;
- Completing electrical installation works to extend the existing switchgear at the network demonstration site;
- Completing electrical installation works for protection panels, SCADA panels, multicores, etc.;
- Delivery of FLCB to the network demonstration site;
- Completing installation of the FLCB;
- Completing commissioning of the existing switchgear extension;
- Completing commissioning of the FLCB;
- Completing energisation (planned for late December);
- Publishing learning report SDRC 9.1.1, development of a FLCB for substations, to UK Power Networks' innovation website; and
- Finalising change request submitted to Ofgem for the removal of Method 2 (M2) from the scope of the project.

The following sections present individual workstream reports covering progress made during the reporting period, challenges encountered, lessons learned and the outlook for the next reporting period.

2.1 Project Team

In this reporting period the project team remains unchanged and the core project team continues to comprise of three dedicated roles:

Role	Status	Start Date
Project Manager	Appointed	4 February 2019
Workstream 1&2 Lead	Appointed	23 March 2018
Workstream 3&4 Lead	Appointed	3 July 2017

The Workstream 1 (WS1) and Workstream 2 (WS2) Lead remains unchanged from the period however the role of the Workstream 3 (WS3) and Workstream 4 (WS4) Lead has been reduced to WS4 only. This is due to the change request submitted to Ofgem for the removal of M2 from the scope of the project.

2.2 Project Partners

As highlighted in the December 2018 Project Progress Report (PPR) our project partner ABB has signed onto a collaboration agreement and progressing with developing the FLCB. The M2 proposed project partner, AMAT, did not sign onto a collaboration agreement and subsequently withdrew from the project. Although the change request which was submitted to Ofgem during the December 2018 reporting period has not been formalised, it has been agreed in principle that M2 will indeed be removed from the project. The removal of M2 impacts WS1, WS2 and WS3 and as such works relating to M2 will no longer be discussed in future PPRs.

The project continues to hold fortnightly Project Partner meetings to ensure successful delivery of the project. The Project Partner meeting covers a number of key points, including:

- Workstream updates – Report on progress to date, risks and issues;
- Technical discussions requiring input from all involved in the project, including internal stakeholders;
- Collaborative planning of tasks for upcoming project milestones;
- Planning for workshops and engagement with UK Power Networks' stakeholders; and
- Risks, issues and mitigation.

2.3 Workstream 1 – Development of a FLCB Device

WS1 is responsible for designing, building and testing prototype devices suitable for installation and trial and both a primary substation and customer site within London Power Networks (LPN). With the removal of M2 from the project, a device will no longer be developed for trial at a customer site. For the remainder of the project WS1 will focus on developing and delivering M1 only.

ABB are progressing their technology from TRL4 (single-phase proof-of-concept prototype) to TRL7 (three-phase field prototype), in accordance with defined specifications provided by UK Power Networks. For WS1, ABB will design a three-phase prototype, build and integrate it into modular switchgear cubicles, and perform testing to ensure the prototype complies with UK Power Networks' requirements.

The learnings from WS1 including specifying the device, prototype development and testing have been disseminated via SDRC 9.1.1. The test reports generated from WS1 are available to other Licensees and stakeholders upon request.

Progress during this reporting period

During this reporting period, WS1 focused on the following activities:

- In July, ABB finalised type testing by completing the necessary modifications to the FLCB panel in order to pass the internal arc fault (IAC) test. As highlighted in the previous PPR, initial IAC testing failed so a re-test was needed. Further details of the modifications can be found in SDRC 9.1.1 or a summary in the sub-section of this PPR 'Challenges and lessons learned';
- In August, ABB completed FATs at ABB in Ratingen, Germany in the presence of UK Power Networks. These tests ensured that the FLCB had been built, assembled and operated in accordance with the specification. This signified that the FLCB was ready to be shipped to site;
- Produced installation manual for the FLCB;
- Produced operational documentation for the engineers in the UK Power Networks control centre and to provide guidance to field and operational staff; and
- Published SDRC 9.1.1, development of a FLCB for substations, onto the UK Power Networks website and was submitted to Ofgem in October 2019.

Figure 2 FLCB panels after short time current withstand testing

Challenges and lessons learned

This section describes the main challenges and lessons learned in the workstream during this reporting period:

- After the failed IAC test ABB investigated the cause, arriving at the conclusion that an internal arc behaves different in a three-phase design compared to a single-phase design. In the case of a phase-to-earth failure like in the FLCB application, the arc is attracted to all earthed parts, which includes the complete earthing system and the sheet metal enclosure. In the first IAC test of the FLCB (25 kA for 1 second) the arc was ignited between the busbar and the earthing bar, however was forced to the rear panel immediately and burnt through as shown in Figure 3. The rear panel was not designed to withstand an arc flash on it for one second.

Figure 3 Rear of FLCB panel (left) and front of panel (right) after failed internal arc test

- After the first IAC test ABB understood in which direction the arc is forced and redesigned this part of the enclosure. The design changes are shown in Figure 4. One earthing bar (1) and a C-shaped sheet (2) was added to attract the arc, “catch” it and prevent the arc from jumping to the rear wall. Additionally, the rear wall was reinforced with an isolating sheet (3) and a metal sheet (4). As intended, the results of the second IAC showed that the arc could be controlled in the area of (1) and (2) and did not damage the rear wall.

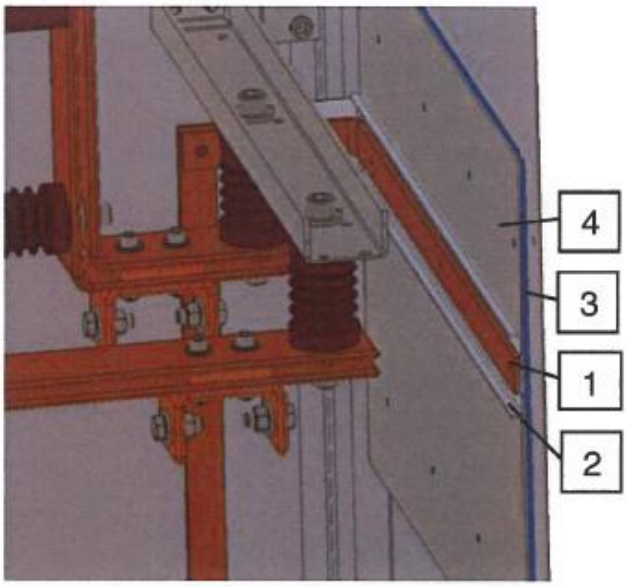

Figure 4 Design modifications made to the rear of the FLCB panel following failure of internal arc test

- One challenge encountered by the project was collating the information from the development and testing of the device which formed part of SDRC 9.1.1. The ABB generated reports from validation testing and FATs were easy to obtain upon request. However the type testing reports from KEMA Laboratories proved more challenging as they had long lead times for final test reports. In order to prevent delaying the submission of SDRC 9.1.1 we have made preliminary type test reports available in the interim. The final reports will be available Q1 2020.
- The FLCB passed all tests in the FATs with only minor issues for ABB to rectify before the device could be prepared for shipping. The issues identified were addressed by ABB and included further improvements to safety and included:
  - Addition of various warning labels and documentation;
  - Addition of timer relay to allow opening of high voltage (HV) compartment door only after certain time has passed after capacitor charging voltage has been switched off; and
  - Addition of lockable cover for manual door release and labelling it 'interlock override'.

Outlook for next reporting period

The next period will see minimal progress in WS1 as the FLCB has been tested and installed on-site. The remaining activities include:

- Collating additional evidence documents required for the ongoing updates of the safety case (note that this has overlap with WS2).

2.4 Workstream 2 – Network Demonstration

WS2 is responsible for the following activities:

- Designing the interface between the FLCB and the existing network;
- Installation and commissioning of switchgear including the FLCB and ancillary equipment;
- Conducting the network demonstration;
- Collecting adequate data to prove the FLCB is safe and effective; and
- Updating the preliminary safety case.

Within WS2, UK Power Networks will continue to collaborate with ABB, and our safety case expert to develop the engineering knowledge necessary to safely and effectively demonstrate FLCBs on GB networks. We will investigate issues such as:

- Use cases for FLCBs – for example in parallel with a bus section/coupler or in series with a transformer;
- Protection and control philosophy – FLCB trip settings, reclosing scheme, coordination and discrimination and how to handle failure of the FLCB; and
- The safety case which will be developed in parallel with the engineering investigations to ensure that safety is considered in every aspect of the business as usual (BAU) solution.

Where appropriate we will seek to engage with the Health and Safety Executive (HSE), the Energy Networks Association (ENA), and other Licensees, especially Electricity North West (ENWL) and Western Power Distribution (WPD) who have investigated similar issues with the Respond and FlexDGrid projects respectively. The learning from this phase will be captured in engineering policies, standards, and procedures and shared via learning dissemination.

Progress during this reporting period

During this reporting period, WS2 focused on the following activities:

- Extending the existing switchboard including the addition of the retrofitted circuit breakers. This work was completed in November;
- Installing new unit protection panels, fault recording relays, SCADA panel and all the wiring for signalling;

Figure 5 Protection panels installed at network demonstration site

- Delivery of FLCB to site 5 November following a delay due to site being inaccessible which is explained further in the next sub-section ‘Challenges and lessons learned’;

Figure 6 Delivery of FLCB to the network demonstration site

- Installing steelworks in the basement for power cables;
- Installing the FLCB and multicores;
- Installing power cables from the busbar to the FLCB and back including terminations;
- Commissioning the busbar extension including the retrofit circuit breakers;
- Commissioning the FLCB;
- Energisation (planned for end of December); and
- In parallel with completing type testing and site works, a number of documents were created including:
    - FLCB installation manual;
    - Commissioning plan; and
    - Resource plan for the network demonstration period.

The above listed documents along with those outlined in Section 2.3 also form part of the supporting evidence documents required for the safety case of the FLCB.

Figure 7 Training of staff during commissioning of the FLCB

Challenges and lessons learned

This section describes the main challenges and lessons learned in the workstream during this reporting period.

- Similar to the previous PPR, June 2019, a valuable lesson learned was to ensure critical, scarce resources are secured for installation. This is critical when working in aged substations where there are limited skilled resources to carry out the work. This was highlighted by the project where UK Power Networks had limited skilled resources, as did external parties, to complete the busbar extension. These skilled internal resources are also used in many network reinforcement projects which can at times take precedence over innovation projects and to attend to unforeseen faults on the network. This occurred a number of times during the period where the skilled resources had to attend other sites to complete work and rectify faults. Though the project team tried to mitigate the impact by working outside of shift, it still resulted in delays in completing and commissioning the switchgear extension;

Figure 8 Progress of busbar extension with retrofit circuit breakers to still be added

- During the installation works, a defect was discovered with a batch of retrofit VOR-M CBs of the same type as the ones being used for the trial site. The defect caused capacitor failures and form part of the magnetic actuator mechanism. Failure of the capacitor would prevent the CB from opening/tripping. The project team engaged with the appropriate Asset Engineers and Network Operations staff, and with their assistance, contacted the manufacturer who confirmed that the capacitors in the retrofit CBs procured for the project trial are not part of the defective batch. Although the risk of failure of the CB is very low, UK Power Networks has requested the development of a portable power pack from the manufacturer that would enable the CB to be opened in the event of a loss of DC supply to the CBs. Until this has been produced, Asset Management have requested that these retrofit CBs are not energised;

Figure 9 Retrofit circuit breakers prior to being installed into busbar extension

- On 15 October 2019 an attempt was made to deliver the FLCB on site. This was unsuccessful as the road to access the substation is narrow and some parked vehicles prevented the lorry entering the site. The parking suspension requirements were not communicated from ABB UK to the delivery company and as such the delivery had to be rescheduled for 5 November 2019. This communication problem occurred due to the number of parties involved in the delivery and assumptions on who was responsible for organising parking suspensions. Even though ABB UK had visited and surveyed they site, when communicating specific needs to the delivery company, parking suspension was not requested. The useful learning for us is to ensure contractually that delivery plans, routes, traffic management and permits are the responsibility of the supplier and/or any delivery sub-contractor of the supplier.;

Figure 10 Parked vehicles impeding first delivery attempt of FLCB

- Due to large excavations in the construction site behind the network demonstration site, a sinkhole, as seen in Figure 12, developed in the footway and carriageway adjacent to the construction site, approximately 45 m away from a UK Power Networks excavation. This excavation was for a cable fault for transformer, GT1, at the demonstration site. The London Borough of Tower Hamlets closed the road and diverted traffic as a result of the sinkhole. To minimise the impact on local traffic by having two sets of traffic management in close proximity, the council requested UK Power Networks backfill and reinstate our excavation. This cable fault will not be resolved and hence GT1 cannot be put back in service until after the sinkhole has been repaired by the council;

Figure 11 Construction site behind the trial substation site

- The trial substation has three transformers in total and the impact of GT1 being out of service is that GT2 and GT3 cannot also been taken out of service as two must be in service. The result of this is that both the auto-close scheme and the fault recording relays cannot be fully commissioned. To mitigate delays in commencement of the trial period, due to the uncertainty of when the sinkhole will be repaired, the team has agreed to energise the FLCB without commissioning the auto-close scheme as it is only required during third trial running arrangement planned for Q3 2020.

Figure 12 Large sinkhole that has developed adjacent to construction site, blocking one half of the road

Outlook for next reporting period

The next period will see the completion of several key milestones for WS2 and these include:

- Energisation of the FLCB and thus commencement of the trial period;
- Monitoring of FLCB performance data;
- Complete commissioning of auto-close scheme and fault recorders (likely to be after energisation due to GT1 fault/sinkhole issue);
- Commence work on publishing SDRC 9.2.1; and
- Phase 2 of the safety case will be on-going for the remainder of the project. Phase 2 will include updating the preliminary safety with any lessons learned and additional safety requirements identified during the preparation, installation, commissioning of the FLCB and design changes through the trial period. Although it will not occur in the next reporting period, Phase 2 will also see another HAZID and risk assessment workshop take place for any changes or learnings.

2.5 Workstream 3 – Understanding Customers' Requirements

WS3 is responsible for understanding our customers' needs, ensuring that we design the solutions to meet our customers' needs and to recruit a trial participant for the M2 demonstration.

As highlighted in the December 2018 and June 2019 PPRs following the removal of M2 from the project, SDRC 9.3.2 will no longer be produced and published. Further details of this SDRC can be found in section 7.

Progress during this reporting period

During this reporting period, the project team received a draft decision from Ofgem for the removal of M2 from the project. Once final confirmation is received, the project team will inform all interested stakeholders involved about the removal of M2.

Although WS3 will cease to exist following the final decision, UK Power Networks still intends to build upon the learnings generated from our engagements with customers willing to participate in such a trial, and continue to see real value in the customer placed FLCB. As such we are exploring partnering with Western Power Distribution for a NIA project called EDGE-FCLi (Embedded Distributed Generation Electronic – Fault Current Limiter interrupter). The scope is similar to that of M2 and we aim to deliver similar benefits to the customers once the project is complete and proved to be successful. The technology readiness level (TRL) of the device being developed is lower than what was originally proposed with AMAT in M2 which provides a great opportunity to increase choice for customers.

Challenges and lessons learned

The project team experienced no challenges under WS3.

Outlook for next reporting period

During the next reporting period the project team intends to keep recipients on the project mailing list (which constitutes all interested stakeholders) informed about how M1 is progressing as it transitions from the development phase to the network demonstration phase of the project.

2.6 Workstream 4 – Knowledge Dissemination

WS4 oversees the dissemination and activities for learnings generated throughout the project. These are critical aspects of the project and will ensure that DNOs across GB can build on Powerful-CB learning, avoiding unnecessary duplication of work. Internal stakeholder engagement activities also play an important role in guiding the development and deployment of the new FLCB within the business and support the successful transition into BAU.

Progress during this reporting period

Key learning report, SDRC 9.1.1 was submitted to Ofgem and published on UK Power Networks innovation website, https://innovation.ukpowernetworks.co.uk/projects/powerful-cb/. SDRC 9.1.1 is the third SDRC for Powerful-CB that has been submitted over the course of the project, as described in the Project Direction. This learning report includes recommendations for specifying a substation-based FLCB, results and learning from type tests (including a short circuit test) conducted at an accredited high power laboratory, requirements for integrating FLCBs into existing networks and ensuring safety.

The project was also presented at the Low Carbon Networks & Innovation Conference (LCNI) held in Glasgow this year in October. The project was presented in main auditorium under the 'Transition to a Low Carbon Future' session. In addition to the main presentation, ABB also had a stand which had a side dedicated to the project. The conference provided a great opportunity to raise awareness of the project to the wider community as well as share key learnings from the development of the FLCB.

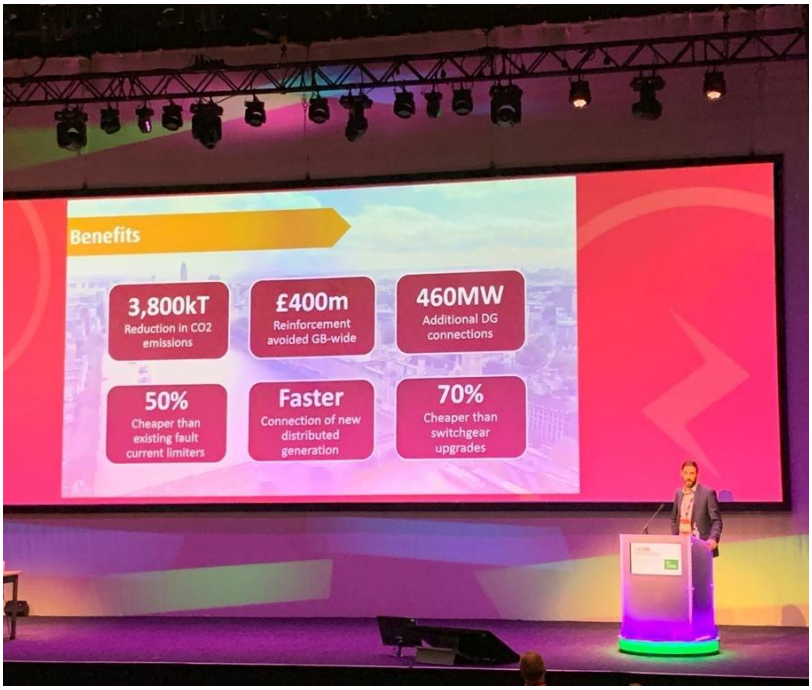

Figure 13 Powerful-CB being presented at LCNI Conference 2019

UK Power Networks was also present at Utility Week Live where members of the project team discussed progress to date with interested stakeholders.

In addition to the industry-facing knowledge dissemination activities above, valuable engagement with UK Power Networks' internal stakeholders has been ongoing during the period to ensure the FLCB meets the operational requirements, the business understands the benefits and sets the device up for a successful BAU transition.

A number of workshops have been held with control engineers and presentations made to the LPN commissioning team. These were opportunities to explain how the FLCB operates, the different network arrangements the FLCB will be trialled and an explanation of alarms. Feedback and considerations for the project team were also provided through these workshops and presentations.

A press release was prepared during the reporting period to inform the industry and general public to raise general awareness about this smart solution, and more specifically to share the project progress including that of FLCB installation at the trial site.

Challenges and lessons learned

No challenges were encountered with respect to WS4 during the reporting period.

Outlook for next reporting period

The following activities are planned for the next reporting period:

- The project is planning to feature in other UK Power Networks led external events such as Better Networks Forum;
- Complete training session for maintenance of the FLCB for operational staff and commissioners;
- Inform project mailing list of key milestones such as the start of the trial period; and
- Continued updating of the project website.

3. Business case update

We have not discovered any new information that affects the business case; thus the business case remains consistent with our FSP. As previously highlighted in the December 2018 and June 2019 PPRs, a change request has been submitted to request the removal of M2 from the project. Based on this, the project assumes 100% deployment of M1 across GB and the delivery of committed benefits of up to £403m by 2050.

4. Progress against plan

This section summarises the project's progress in the period July to December 2019. It describes issues we faced and how we managed them, key achievements, notable events, key planned activities for the next reporting period and any issues we expect in the next reporting period.

4.1 Summary of changes since the last Project Progress Report

Since the last reporting period, the following notable changes have been made to the project plan:

- For WS1, the completion of the FLCB and readiness to be shipped to site was delayed due to the failed IAC test in the last reporting period. ABB had to modify the panel and completed a re-test in July. This was linked to risk R41 and resulted in approximately a further two months delay in completion of type testing in addition to the delay reported in the previous PPR due to the generator fault at the high-power test laboratory. The FLCB was delivered to site in November, however a combination of both these issues resulted in a delay of 3-4 months against the plan;
- For WS2 we identified in the previous reporting period that resourcing for the electrical site works was open to risk R17. For the busbar extension works, this risk did materialise as the specialist resource was required to work at alternative sites on both network projects and network faults. In order to recover some of the delay in completion it was agreed by the project team for some overtime worked to be completed.

During the reporting period two risks, namely R42 and R43 materialised and have impacted the project plan. A summary is as follows:

- R42 (delay in energisation and commencement of trial period (due to defect identified in QF switchgear (retrofit circuit breakers)) deals with the risk that energisation may be delayed due to a defect identified with the retrofit CBs being used for the project as discussed in Section 2.4. The project team were able to mitigate this risk by identifying that the CBs nominated for the project were not part of the defective batch of capacitors. Secondly a portable power pack is being developed by the manufacturer to be used in the unlikely event of a DC power supply failure at the substation. In discussion with both Asset Management and Network Operations it has been requested that the retrofit CBs cannot be energised until the portable power pack has been received; and
- R43 identified that the auto-close scheme and fault recording relays could not be commissioned due to an existing cable fault of GT1 at the trial site. The cable fault cannot be rectified due to a sinkhole in close proximity to where the excavation is required. To mitigate this, the project team have agreed to progress with energisation and commission these later to limit delays due to the uncertainty of when the sinkhole will be fixed. The team will rely on the fault recording within the FLCB in the interim and the auto-close scheme is not required in the trial until running arrangement 3 (the final running arrangement to be trialled) of the demonstration phase.

4.2 Detailed progress in the reporting period

The project has made significant progress during this reporting period, as shown below:

Task description	Workstream	Status at start of period	Status at end of period
Testing and validation of FLCB	1	In progress	Complete
Type Testing of FLCB	1	Started in period	Complete
Completion of SDRC 9.1.1	1	In progress	Complete
Detailed design (civil, mechanical, electrical)	2	In progress	Complete
Detailed design (SCADA)	2	Started in period	Complete
Site works (civil)	2	In progress	Complete
Site works (small lighting and power)	2	Started in period	Complete
Procurement of relays	2	Started in period	Complete
Retrofit of CBs	2	In progress	Complete
CT end boxes upgrade	2	Started in period	Complete
Procurement of SCADA panel	2	Started in period	Complete
Engage with UK Power Networks' internal stakeholders in design phase	1 and 2	In progress	Complete
Busbar extension including retrofit circuit breakers	2	In progress	Complete
Installation of protection relays, SCADA panel, multicores, etc.	2	In progress	Complete
Installation of HV power cables	2	Started in period	Complete
Delivery and installation of FLCB	1 and 2	Started in period	Complete
Commissioning of busbar extension, unit protection, etc.	2	Started in period	Complete
Commissioning of FLCB	2	Started in period	Complete
Energisation	2	Started in period	In progress

4.3 Identification and management of issues

The project team recognises the importance of robust risk management methodologies for any project, but more specifically for complex innovation projects. Due to the nature of complex innovation projects, it is likely that certain risks will impact the overall project activities in some form. A full list of project risks identified for the project is provided in Section 11. However, during this period it can be reported that three risks: R15; R17; and R43, have begun to impact the schedule of specific project activities.

In addition to the issues outlined below, we reported that in the previous PPR, risk R41, "Delay in testing and/or FAT of FLCB device" was active but is now closed as the FLCB has been delivered to site. The total delay caused by this risk was approximately 3-4 months and is attributed to initially a failure of the generator at the high power test lab and secondly by failure of the first internal arc fault (IAC) test.

The following issues have been reported in the workstream reports and are also captured below:

Ref	Issue	Impact	Mitigation
R15	Project partners unable to deliver on commitments on time because of lack of resources and/or other commitments	Delay in commissioning and energisation of the FLCB	ABB have some resource availability limitations for commissioning of the FLCB for December. Some resources are unavailable as the original committed dates changed due to delays in type testing completion (R41)
R17	UK Power Networks not able to deliver on commitments because of operational resource constraints	We have engaged the relevant business units within UK Power Networks to confirm their support of the project, and will confirm resourcing commitments during project mobilisation Impact has been a two month delay in completion of installation activities	This risk did materialise and to mitigate some of the delay to project team agreed for some overtime work to be completed. Some resources are unavailable as the original committed dates changed due to delays in type testing completion (R41)
R42	Delay in energisation and commencement of trial period (due to defect identified in QF switchgear (retrofit circuit breakers))	A defect was discovered with a batch of retrofit VOR-M CBs of the same type as the ones being used for the trial site. The defect caused capacitor failures due to a defective batch and they form part of the magnetic actuator mechanism. Failure of the capacitor would prevent the CB from opening/tripping	Project team have identified that the retrofit CBs procured for the project are not part of the defective batch of capacitors so the risk of failure is low UKPN has proposed that in the unlikely event of a DC power supply failure of the substation a portable power pack should be developed by ABB so that the CB can be operated. Asset Management have requested that energisation of these CBs does not take place until this is received from the manufacturer
R43	GT1 cable fault at trial site cannot be repaired until sinkhole near where excavation is required is fixed first	Trial site has three transformers in total and the impact of GT1 being out of service is that GT2 and GT3 cannot also been taken out of service as two must be in service. The result of this is	Return at a later date to commission auto-close scheme and fault recorders to mitigate delay in energisation. Auto-close scheme is required for running arrangement 3 and the FLCB has its own fault recording devices

Ref	Issue	Impact	Mitigation
		that both the auto-close scheme and the fault recording relays cannot be fully commissioned	Have been in contact with London Borough of Tower Hamlets to discuss when the sinkhole will be fixed

4.4 Key achievements and notable events

Key achievements and notable events in the reporting period are shown below:

- Successful completion of type testing of FLCB device;
- Published SDRC 9.1.1;
- Presented the project at LCNI Conference 2019;
- Completion of installation works of busbar extension, protection panels, SCADA panels, multicores and cabling;
- Installation of the FLCB;
- Commissioning of all switchgear, equipment and FLCB with the exception of the auto-close scheme and the fault recording relays; and
- Planned energisation for late December of the FLCB.

4.5 Look-ahead to next reporting period

The following major tasks and milestones are planned for the next reporting period:

- Commence network demonstration period (WS2);
- Complete Phase 2 of the safety case (WS1 and WS2);
- Commence work on SDRC 9.2.1 (WS2);
- Present at UK Power Networks hosted event (WS4); and
- Finalisation of the change request to remove M2 from the project and treat the funds to be returned as per the revised Project Direction.

5. Progress against budget

This section is provided in the Confidential Appendix A.

6. Project bank account

This section is provided in the Confidential Appendix A.

7. Successful Delivery Reward Criteria (SDRCs)

This section provides a brief narrative against each of the SDRCs set out in the Project Direction. The narrative describes progress towards the SDRCs and any challenges we may face in the next reporting period. We have struck-through the SDRCs that we have requested to be removed as part of the change request.

Project Deliverable	Deadline	Evidence	Progress
9.1 Work with industry to advance new FLMTs based on FLCB technology			
9.1.1 Prototype and lab test a substation-based solution (Method 1)	31 May 2019	**Publish Learning Report – Development of a FLCB for substations**, which will include: recommendations for specifying a substation-based FLCB; results and learning from type tests (including a short circuit test) conducted at an accredited high power laboratory; and requirements for integrating FLCBs into existing networks and ensuring safety.	Complete
~~9.1.2 Prototype and lab test a customer-based solution (Method 2)~~	~~31 August 2019~~	~~**Publish Learning Report – Development of a FLCB for customers**, which will include: recommendations for specifying a customer-based FLCB; results and learning from type tests (including a short circuit test) conducted at an accredited high power laboratory; and requirements for integrating FLCBs into existing networks and ensuring safety.~~	Removed from project
9.1.3 Independent review of safety case	31 May 2018	**Issue preliminary safety case to relevant ENA panel(s) for independent review** which will include: Definition and justification of acceptable levels of risk; analysis of failure modes and effects; details of proposed mitigations; and claims, arguments, and evidence to demonstrate that the proposed mitigations reduce the overall level of risk to an acceptably low level.	Complete
9.1.4 Safety case for FLCB installation without back-up	31 May 2018	**Publish preliminary safety case** which will include the technological and operational safety case to the time when the trial equipment could be deployed as BAU without the FLCBs being installed in series with a back-up circuit breaker.	Complete
9.2 Trial the technical suitability of these two technologies including effectiveness and safety considerations for relieving fault level constraints for 11kV networks			
9.2.1 Install and commission solution at an 11kV substation (Method 1)	31 July 2020	**Publish Interim Learning Report – Demonstration of a FLCB for substations**, which will include results and learning from installation, commissioning, and operation to date of a FLCB at a substation.	On schedule
~~9.2.2 Install and commission~~	~~31 July 2020~~	~~**Publish Interim Learning Report – Demonstration of a FLCB for customers**, which~~	Removed from project

Project Deliverable	Deadline	Evidence	Progress
~~solution at a customer's premises (Method 2)~~		~~will include results and learning from installation, commissioning, and operation to date of a FLCB at a customer's premises.~~	
9.2.3 Demonstration of solution at an 11kV substation (Method 1)	30 June 2021	**Publish Final Learning Report – Demonstration of a FLCB for substations**, which will include results and learning from operating and maintaining a substation containing a FLCB, and technical performance of the FLCB and overall solution under real network conditions.	On schedule
~~9.2.4 Demonstration of solution at a customer's premises (Method 2)~~	~~30 June 2021~~	~~**Publish Final Learning Report – Demonstration of a FLCB for customers**, which will include results and learning from operating and maintaining a FLCB at a customer's premises, and technical performance of the FLCB and overall solution under real network conditions.~~	Removed from project
9.3 Assess the suitability of the solutions against customers' needs			
9.3.1 Review the customer needs for these two FLCBs technologies on behalf of DNOs and DG stakeholders	31 October 2017	**Publish Learning report – Understanding customers' requirements**, which will describe our findings from customer dialogue sessions, i.e. understanding their requirements and concerns about FLCBs, and customer feedback.	Complete
~~9.3.2 Assess the (commercial) business case based on the technical and customer findings, focusing on investment decision criteria and trade-offs, such as cost, time to connect, space~~	~~31 March 2020~~	~~**Publish Learning report – Suitability of FLCBs**, which will inform generation customers of the solutions, answer frequently-asked questions, and provide enough information for customers to assess whether the solution meets their requirements (e.g. cost, time to connect, space required, operational impacts, etc.).~~	Removed from project

Project Deliverable	Deadline	Evidence	Progress
~~and impact on security of supply~~			
9.4 Share the learning throughout the project with the wider utility industry			
9.4.1 Share overall learning from the project with customers, regulators, other DNOs, other manufacturers, and academia via a stakeholder event	30 September 2021	Publish key materials from the stakeholder event (e.g. slides), and provide Ofgem with a list of invitees and attendees.	On schedule

8. Data access details

To view the full Innovation Data Sharing Policy, please visit UK Power Networks' website here: https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2019/11/UKPN-Innovation-Data-Sharing-Policy-7-Nov-19.pdf

UK Power Networks recognises that innovation projects may produce network and consumption data, and that this data may be useful to others. This data may be shared with interested parties whenever it is practicable and legal to do so and it is in the interest of GB electricity customers. In accordance with the Innovation Data Sharing Policy, published in 2019, UK Power Networks aims to make available all non-personal, non-confidential/non-sensitive data on request, so that interested parties can benefit from this data.

9. Learning outcomes

The project team recognises the importance of learning and dissemination. Specific lessons learned in each of the workstreams are captured in the workstream progress reports in Section 2 of this progress report. In addition to this PPR, the learning report SDRC 9.1.1 was submitted to Ofgem on 24 October 2019 and published on our innovation website, https://innovation.ukpowernetworks.co.uk/projects/powerful-cb/. Included in this SDRC is an appendix with a list of test reports that are available upon request. Previous learning reports are also available through this website.

During the next reporting period, the project team will commence work on SDRC 9.2.1 as previous discussed and this will be published on the Powerful-CB website. In addition, UK Power Networks is expecting to host an external dissemination event where the project team will disseminate initial progress and learnings at this event to all peer DNOs and industry stakeholders.

10. Intellectual Property Rights (IPR)

This section lists any relevant IPR that has been generated or registered during the reporting period along with details of who owns the IPR and any royalties which have resulted, and any relevant IPR that is forecast to be registered in the next reporting period.

IPR generated this period (July – December 2019)

IPR Description	Owner(s)	Type	Royalties
SDRC 9.1.1 including test reports	UK Power Networks	Relevant Foreground IPR	Nil
FLCB installation manual	ABB	Relevant Foreground IPR	Nil
FLCB commissioning plan	ABB UK Power Networks	Relevant Foreground IPR	Nil
Panel modifications to correct internal arc performance	ABB	Foreground IPR	Nil

IPR forecast next period (January – June 2020)

IPR Description	Owner(s)	Type	Royalties
Data and performance of FLCB during network demonstration	ABB UK Power Networks	Relevant Foreground IPR	Nil

11. Risk management

This section lists the risks highlighted in the FSP plus any other risks that have arisen in the reporting period. We have described how we are managing the risks we have highlighted and what we have learned. Risks 1-36 are captured in the FSP although some have been updated. Risks 37-39 were identified during the progress of the project. The project continues to monitor risks and issues on a monthly basis where risk impacts and mitigation plans are updated.

Ref	WS	Status	Description	Mitigation/Planned Action	Current Status	RAG
R1	WS1	Closed	ABB's costs increase because of exchange rate movements due to Brexit developments.	ABB has agreed to hold their quoted price in GBP until the project commences. Once the project has commenced, we will agree the ABB contract price in GBP, or agree the price in EUR and take steps to hedge the exchange rate risk.	Now the contract has been agreed and signed in GBP, this risk is mitigated.	G
R2	WS3	Closed	Unable to find a suitable site / willing customer for customer trial.	We will engage with customers to understand their motivations for participating in the trial, so that we can design the trial and recruitment campaign to provide the right incentives and target the right customers. We will also consider relevant customer research and learning from ENWL's FCL Service trial.	We identified a potential customer and a location for trials.	G
R3	-	-	NOT USED.	NOT USED.	NOT USED.	-
R4	WS1	Closed	Delay and/or cost overrun – prototype development.	ABB and AMAT have agreed to take all risk of cost overruns within their control. UK Power Networks will use our existing change control procedures to minimise the risk of changes that cause additional costs for ABB and AMAT.	We have negotiated and signed the collaboration agreement with ABB to minimise the risk of cost overruns. The risk of delay in prototype development is still present. See risk R41 for more specific risk. FLCB was delivered to site 5 November 2019	R
R5	WS1	Closed	Delay and/or cost overrun - safety case (due to unforeseeable requirements).	We have allowed specific contingency for the safety case, based on FNC's experience of required effort in the event of unforeseen requirements.	FNC delivered the preliminary safety case within the given timescales. SDRC 9.1.3 and SDRC 9.1.4 are complete.	G
R6	WS1	Closed	Prototype as delivered is not fit for purpose.	UK Power Networks, ABB, AMAT, FNC to collaborate to develop the FLCB specifications; Safety consultant to develop safety case in parallel; engage with other HSE, ENA, and other DNOs.	Regular meetings and ad-hoc communications between ABB, FNC, and UK Power Networks technical experts has meant successful collaboration on the FLCB specification and safety case. The preliminary safety case is complete. The FLCB has undergone type testing and FATs	G
R7	WS1	Open	Solution does not deliver the necessary reliability and/or redundancy to be able to prove the safety case.	Safety case feasibility study completed before full submission. Safety case to be developed in close collaboration with FLCB designers and engineering standards.	All key stakeholders, including ABB and UK Power Networks technical experts, attended the safety case workshops. The preliminary safety case is complete. Phase 2 of safety case to be completed during demonstration period.	G
R8	WS1	Open	Solution is not suitable for general population of GB sites due to operational or physical space constraints.	We will engage with other DNOs to understand any operational or physical space constraints that are unique to their networks.	N/A this period.	G
R9	WS2	Open	Trial site does not experience enough HV network faults to prove that the solution is safe and reliable.	We will use history of HV network faults as a criterion when selecting trial sites. We will use the safety case to determine how much data is required to prove that the FLCB is safe. Additionally a 24 month trial period will be completed.	We have used historic fault data when looking at potential sites – recognising that fault history is not necessarily an indicator of future faults. The trial period has been reduced due to delays but still sufficiently long enough to experience a number of faults.	G
R10	WS2	Open	Trial fails to capture the data necessary to prove that the solution is safe and reliable.	We will ensure that our data capture solution has adequate reliability and redundancy so that we don't miss any opportunities to capture data from real network faults.	N/A this period.	G

Ref	WS	Status	Description	Mitigation/Planned Action	Current Status	RAG
R11	WS2	Open	Solution fails to operate correctly during field trial (i.e. fails to limit fault current).	We will not allow fault levels to exceed equipment ratings until the FLCB has been proven safe and reliable. This minimises the risk of an unsafe situation if the FLCB fails to operate correctly.	N/A this period.	G
R12	WS2	Closed	Customer trial has adverse impacts on customer.	We will identify the potential impacts on the customer and work with them to ensure the risks are well managed.	M2 (customer site trials) will no longer be pursued as part of this project.	R
R13	WS4	Open	ABB decides not to offer a commercial product.	ABB have confirmed that if they are unable to offer their foreground IPR to Licensees in the form of a commercial FLCB product, they are willing, in principle, to licence any relevant foreground/background IPR to a third party for the purpose of developing a commercial FLCB product.	N/A this period.	G
R14	WS4	Open	Solution is not accepted by other DNOs.	We will engage with other DNOs at key stages of the design and specification processes to ensure that their requirements and concerns are addressed.	N/A this period.	G
R15	WS1	Open	Project partners unable to deliver on commitments on time because of lack of resources and/or other commitments.	We will agree heads of terms and scopes for collaboration agreements with all project partners in advance of project kick-off.	ABB have experienced issues with the high power test laboratory used for the type tests. An alternative laboratory will be used for the test. FLCB was delivered to site 5 November 2019. ABB commissioning resources were available ABB have some resource availability limitations for commissioning of the FLCB for December	G
R16	PM	Open	UK Power Networks not able to deliver on commitments because project delivery team is under-resourced.	We will secure resources for the core project delivery team in advance of project kick-off, and ensure adequate succession planning to manage the risk of staff movements.	No issues in this period.	G
R17	PM	Issue	UK Power Networks not able to deliver on commitments because other teams supporting the project have operational resource constraints.	We have engaged the relevant business units within UK Power Networks to confirm their support of the project, and will confirm resourcing commitments during project mobilisation.	We are working with the relevant business units to secure resourcing. Specialist resources requirement for busbar extension works increasing the risk of a delay to the start of the network demonstration period. Preliminary external engagement for skilled resource has not helped as the parties approached do not have the necessary skills to complete the work. This risk did cause delays in completion of the busbar extension works due to attendance to rectify network fault. Overtime work was completed to help minimise completion of the busbar extension	A
R18	PM	Open	Partner withdraws from project for financial, commercial, or technical reasons.	If one technology partner withdraws from the project, we will consider using the same technology at both substation and customer sites, or if this would not provide value for customers' money, we would de-scope the project to only trial one method. If FNC withdraw from the project, we will seek an alternative partner who can provide the necessary safety case expertise.	AMAT did not sign the collaboration agreement and have withdrawn from the project. Following this change, we engaged with the market to find an alternative partner for M2. However when no suitable replacement could be found, the project team decided to request a change from Ofgem to remove M2 from the project.	R
R19	WS2	Closed	Customer (trial participant) withdraws from the project because the trial is impacting their business activities.	To minimise probability, we will only consider customers where the risk of adverse impact on their business activities is minimal or can be managed.	Risk no longer valid. M2 (customer site trials) will no longer be pursued as part of this project. Change request submitted to remove M2 from the project.	R
R20	PM	Open	Breach of data protection regulations.	We will ensure that all customer's details are handled and stored in accordance with our data protection procedures.	N/A this period.	G
R21	WS2	Open	Solution has adverse impacts on protection grading, causing unacceptable fault clearance times.	We will complete a protection coordination study to ensure that the solution does not have any adverse effects on protection coordination.	We have engaged with the protection team and they have not indicated any initial issues.	G
R22	WS2	Open	Solution fails, causing unplanned outages.	We will install additional circuit breakers that enable the FLCB to be remotely bypassed and isolated to minimise the risk of unplanned outages in the event that it fails.	N/A this period.	G

Ref	WS	Status	Description	Mitigation/Planned Action	Current Status	RAG
R23	WS2	Open	Solution is not suitable for general population of UK Power Networks sites due to operational or physical space constraints.	We have already completed a preliminary feasibility study on a sample of LPN sites, and will complete a feasibility study on a sample of LPN, EPN, and SPN sites as part of the project.	N/A this period.	G
R24	WS3, WS4	Open	BAU method cost is higher than expected.	If we discover any issues that could increase the BAU method cost to the point where the project business case is no longer viable, we will assess whether the project should be halted or de-scoped.	N/A this period.	G
R25	WS1	Closed	Equipment fails to pass high power type tests.	ABB and AMAT have both allowed adequate contingency to build another prototype, in the event that the device intended for the field trials fails catastrophically during type testing and cannot be salvaged.	4 of 5 type tests passed. Internal arc withstand will be re-tested. Re-test of IAC test completed in July 2019	G
R26	WS2	Closed	Unable to find a suitable site for substation trial.	If we are unable to find a suitable site in LPN (e.g. there are sites that would be suitable for a BAU deployment but not suitable for a trial for business/commercial/safety reasons), we will also consider sites in SPN or EPN that have similar operational and/or physical constraints as typical LPN sites.	This risk is closed as a trial site has been selected within LPN.	G
R27	WS4	Open	Learning from the project is not disseminated effectively to the DNO community.	We will benchmark our knowledge dissemination strategy against other projects and other DNOs to ensure its effectiveness.	N/A this period.	G
R28	WS4	Open	Solution is not approved by UK Power Networks.	We will involve key UK Power Networks stakeholders to champion the design and specification of the solution to ensure that it is accepted.	Key UK Power Networks stakeholders (i.e. technical experts) are forming an internal working group to discuss issues that may arise in the BAU adoption of FLCB technology.	G
R29	WS3	Closed	Solution is not accepted by customers.	We will engage with customers to understand their requirements and motivations, and ensure the solution is designed to meet their needs.	The customer based solution for M2 was removed from the scope of the project.	G
R30	WS2	Closed	Delay and/or cost overrun – civil works.	We will leverage the expertise of our in-house capital delivery teams to ensure that all site works are well managed.	Civil works completed this period	G
R31	WS2	Closed	Delay and/or cost overrun – electrical installation works.	We will leverage the expertise of our in-house capital delivery teams to ensure that all site works are well managed.	See R17 for the delay in electrical installation works.	A
R32	WS1	Closed	Project kick-off delayed by negotiations with project partners.	We have agreed heads of terms and scopes for collaboration agreements with all project partners before full submission.	AMAT withdrew from the project and ABB have signed the collaboration agreement.	R
R33	WS1, WS2	Open	Project delivery team lacks necessary technical expertise.	We have engaged technical experts within the business to serve as the project design authority. We will also engage an expert on power electronics to provide assurance on ABB designs and specifications.	We are working closely with any relevant business units where necessary.	G
R34	WS2	Open	Delay and/or cost overrun – commissioning.	We will leverage the expertise of our in-house capital delivery teams to ensure that all site works are well managed.	Commissioning team is engaged with the project and resources assigned. The required time might be longer than initially planned.	A
R35	WS3	Closed	Delay and/or cost overrun – customer engagement/recruitment.	We will leverage the expertise of our in-house capital delivery teams to ensure that all site works are well managed.	WS3 was removed from scope of project as it was related to M2.	G
R36	WS2	Closed	ABB-provided (conventional) circuit breakers do not comply with UK Power Network's requirements.	We have allowed adequate contingency for UK Power Networks to supply approved circuit breakers, which would be connected to the FLCB by joggle panels[1].	The CBs used in the project are retrofitted from existing ones and we have used the same supplier for the retrofit before.	G
R37	WS3	Closed	Delay in contract phase with the customer.	Shortlist a number of potential customers should the customer withdraw from the project. Engage with the customer and legal team early to allow sufficient time for contracts to be drawn up.	WS3 was removed from scope of project as it was related to M2.	G
R38	WS1	Closed	Unable to sign contract with Method 2 supplier.	Find an alternative supplier. Efforts were made to find an alternative supplier but were unsuccessful. The decision was made to remove Method 2 from the project and a change request was submitted to Ofgem. We	Method 2 is removed from the project.	R

[1] Joggling is a metalworking technique to attach two metal sheets together. It is an offset bending process in which the two opposite bends are each less than 90°, and are separated by a neutral web so that the offset (in the usual case where the opposite bends are equal in angle) is less than five work piece thicknesses. Often the offset will be one work piece thickness, in order to allow a lap joint, which is smooth on the 'show-face'.

Ref	WS	Status	Description	Mitigation/Planned Action	Current Status	RAG
				are awaiting official response from Ofgem but has been agreed in principle.		
R39	WS2	Closed	Delay in delivery of retrofitted CBs.	We have allowed adequate time contingency for ABB UK to supply approved circuit breakers.	The CB retrofit is complete and ready to be delivered to site. The CB retrofit were delivered to site	G
R40	WS2	Closed	Delay in completion of electrical design (CPP).	Close support of the electrical design team from the project team. Monitoring of progress and assistance from the supplier.	Electrical design completed in this period. The risk remains open for any changes that might be identified during commissioning.	G
R41	WS1	Closed	Delay in testing and/or FAT of FLCB device.	Change order of type tests depending on what is causing the delay.	This risk has become an issue due to the original high power test laboratory having a fault with the generator required for the type testing. Due to the long lead time (3-4 months) for repair of the generator, an alternate high power test laboratory has be booked. This will minimise the impact on the readiness of the FLCB for delivery to site. The FLCB failed the first IAC test so an investigation and panel modification were made. The re-test was completed in July 2019 but this did impact the delivery to site	R
R42	WS2	Issue	A defect was discovered with a batch of retrofit VOR-M CBs of the same type as the ones being used for the trial site. The defect caused capacitor failures due to a defective batch and they form part of the magnetic actuator mechanism. Failure of the capacitor would prevent the CB from opening/tripping	Project team have identified that the retrofit CBs procured for the project are not part of the defective batch of capacitors so the risk of failure is low UKPN has proposed that in the unlikely event of a DC power supply failure of the substation a portable power pack should be developed by ABB so that the CB can be operated	ABB to design and produce portable power pack. Asset management have requested that the energisation of these CBs does not take place until this has been received.	A
R43	WS2	Issue	GT1 cable fault cannot be repaired until sinkhole near where excavation is required is fixed first. Trial site has three transformers in total and the impact of GT1 being out of service is that GT2 and GT3 cannot also been taken out of service as two must be in service. The result of this is that both the auto-close scheme and the fault recording relays can't be fully commissioned.	Comeback at a later date to commission auto-close scheme and fault recorders to mitigate delay in energisation. Auto-close scheme is required for running arrangement 3 and the FLCB has its own fault recording devices	Have been in contact with London Borough of Tower Hamlets to discuss when the sinkhole will be fixed	A

12. Material change information

No material changes have been encountered during this reporting period and none are foreseen for the next reporting period.

13. Other information

Currently there is no other information to report to Ofgem.

14. Accuracy assurance statement

The project has implemented a project governance structure as outlined in our innovation policies and procedures that effectively and efficiently manages the project and all its products. All information produced and held by the project is reviewed and updated when required to ensure quality and accuracy. This report has gone through an internal project review and a further review within UK Power Networks to ensure the accuracy of information.

We hereby confirm that this report represents a true, complete and accurate statement on the progress of the Powerful-CB project in its sixth six-month reporting period and an accurate view of our understanding of the activities for the next reporting period.

Signed 

Date 13/12/2019

Suleman Alli
Director of Safety, Strategy & Support Services
UK Power Networks