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UK Power Networks
(Operations) Limited

Powerful-CB

SDRC 9.4.1: Share overall learning from the project via a stakeholder event

Contents

Glossary

Term	Description
ABB	ABB Limited, our technology partner for Method 1
BEIS	The Department for Business, Energy and Industrial Strategy
CB	Circuit Breaker – Protection device that interrupts the flow of current in an electric circuit in the event of a fault
COVID-19	Corona Virus Disease 2019
CHP	Combined Heat and Power – simultaneous generation of usable heat and power (usually electricity) in a single process; more efficient than generating heat and power separately
DG	Distributed Generation – generators that are connected to the distribution network
DNO	Distribution Network Operator
DSO	Distribution System Operator
ENA	The Energy Networks Association
EPN	Eastern Power Networks plc (one of three UK Power Networks licence areas)
FAT	Factory Acceptance Test
Fault Current	A surge of energy that flows through the network in the event of a fault. The energy comes from the momentum of rotating generators and motors connected to the network
Fault Level	The maximum fault current that could theoretically flow during a fault. "Make" fault level is the maximum fault current that could flow during the first current peak of the fault, and that a circuit breaker closing onto a fault would need to safely handle. "Break" fault level is the maximum fault current that could be flowing 100ms after the start of the fault, and that a circuit breaker clearing the fault would need to be able to interrupt.
Fault Level Headroom	The difference between fault level and fault rating at a particular substation or part of the network; corresponding to the amount of generation that can be connected to the network without exceeding its fault rating
FCL	Fault Current Limiter – a FLMT that attenuates fault current by increasing its impedance (only) during a fault.
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
FLMT	Fault Level Mitigation Technology – a technical solution that reduces fault levels on the network
FSP	The Powerful-CB Full Submission Proforma - http://bit.ly/Powerful CB-fsp
GB	Great Britain
HAZID	Hazard Identification
Inhibit Scheme	A hard-wired protection system that automatically disconnects generators from the network under pre-defined conditions, typically in the event of a transformer outage or other abnormal network configuration that causes elevated fault levels.
IPR	Intellectual Property Rights

Term	Description
I_s-limiter	Commercial product offered by ABB which limits the short-circuit current during the first rise (https://new.abb.com/medium-voltage/apparatus/fault-current-limiters/current-limiter)
L1/L2/L3	Line 1, Line 2, Line 3 of a three-phase power network
LPN	London Power Networks plc (one of three UK Power Networks licence areas)
M1	Method 1 – Installation of a FLCB at a substation
M2	Method 2 – Installation of a FLCB at a customer's premises (de-scoped from project following Ofgem approval of change request)
MCB	Motorised Circuit Breaker
NIC	Network Innovation Competition
Ofgem	Office of Gas and Electricity Markets, the regulator for gas and electricity markets in Great Britain
PPR	Project Progress Report
RIIO-ED1	The current electricity distribution regulatory period, running from 2015 to 2023
QR6	Fault Current Detector from the I_s limiter and FC-protector that detects faults and issues a trip signal to the FLCB
RMS	Voltage (V rms) or Current (A rms) Root-Mean-Squared
Rotating DG	A generator that converts mechanical energy to electrical energy using a synchronous AC rotating alternator, e.g. CHP and diesel standby generators. These types of generators have a much larger impact on fault levels than inverter-connected generators e.g. solar PV.
SCADA	Supervisory Control and Data Acquisition
SDRC	Successful Delivery Reward Criteria
SPN	South Eastern Power Networks plc (one of three UK Power Networks licence areas)
TRL	Technology Readiness Level
UKPN	UK Power Networks
UPS	Uninterruptable Power Supply
VCB	Vacuum Circuit Breaker

1 Executive Summary

1.1 Background and Project Motivation

The Powerful-CB project aims to demonstrate that Fault-Limiting Circuit Breakers (FLCBs) can enable us to connect more distributed generation (DG) to fault-constrained 11 kV distribution networks without the need for network reinforcement.

UK Power Networks are establishing a Distribution System Operator (DSO)[1] to respond to the needs of our customers, both now and in the future, and working with the wider industry to help deliver decarbonisation of the electricity system at the lowest cost. The Government's Carbon Plan and the Department of Energy & Climate Change (now known as BEIS) Community Energy Strategy report[2] highlight the importance of Combined Heat and Power (CHP) in achieving the UK's carbon targets. In addition to this, the Mayor of London's target[3] is to generate 25% of London's heat and power requirements locally by 2025. We expect this to encourage CHP and district heating for new developments.

To date we have over 750 MW of DG including 300 MW of CHP connected to our London network but the ability to connect more may be limited as a result of fault level constraints. The traditional solutions to fault level constraints are an inhibit agreement (therefore restricting output,; connection at a higher voltage level and network reinforcement with the latter two resulting in a connection cost which may make generation projects economically unviable.

A FLCB is a solid-state circuit breaker that operates 20 times faster than existing Vacuum Circuit Breakers (VCB). This high-speed operation can mitigate fault level contributions from distributed generation, allowing us to connect more generating sites (including CHP) to fault-level constrained networks in dense urban areas. This will help facilitate the decarbonisation of heat, which is a key element of the Government's Carbon Plan. Connecting more decentralised renewable generation also helps in achieving Net Zero and contributes to the transition to a DSO model.

We have been working with technology partner and equipment manufacturer ABB Ltd (ABB), who have developed a FLCB for use at a 11 kV primary substation in an urban location. This was the world's first demonstration of a FLCB with a fast commutating switch.

Throughout the duration of the Powerful-CB project, the team has been and will continue to share key learnings with the industry. The project is delivering a number of Successful Delivery Reward Criteria (SDRCs) reports – which capture learnings from various stages of the project. The value of innovation is playing a major part in ensuring Distribution Network Operators (DNOs) can support a low carbon future. UK Power Networks recognises the importance of sharing learning from its projects to ensure DNOs in Great Britain (GB) can work collaboratively such that successful solutions can be adopted faster by other networks for the benefit of customers and to facilitate Net Zero.

1.2 Purpose and Structure of This Report

The project team hosted a project closedown event on 18 August 2022 where overall learning from the project was shared with a range of stakeholders including customers, regulators, other utilities, other manufacturers, consultants, developers, engineers and the academia. It was decided to organise a webinar event instead of a face-to-face event in order to engage not only with UK professionals but also internationals interested in the trialled device and project findings. Zoom was the webinar platform selected as the project team has previous experience using it in similar past events

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1 http://futuresmart.ukpowernetworks.co.uk

2 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275163/20140126Community_Energy_Strategy.pdf

3 https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan/london-plan-chapter-five-londons-response/poli-0

where useful functionalities such as the Q&A exist (Figure 1). The agenda included sharing experiences from the design, installation and commissioning of the unit as well as its operation, maintenance and performance.

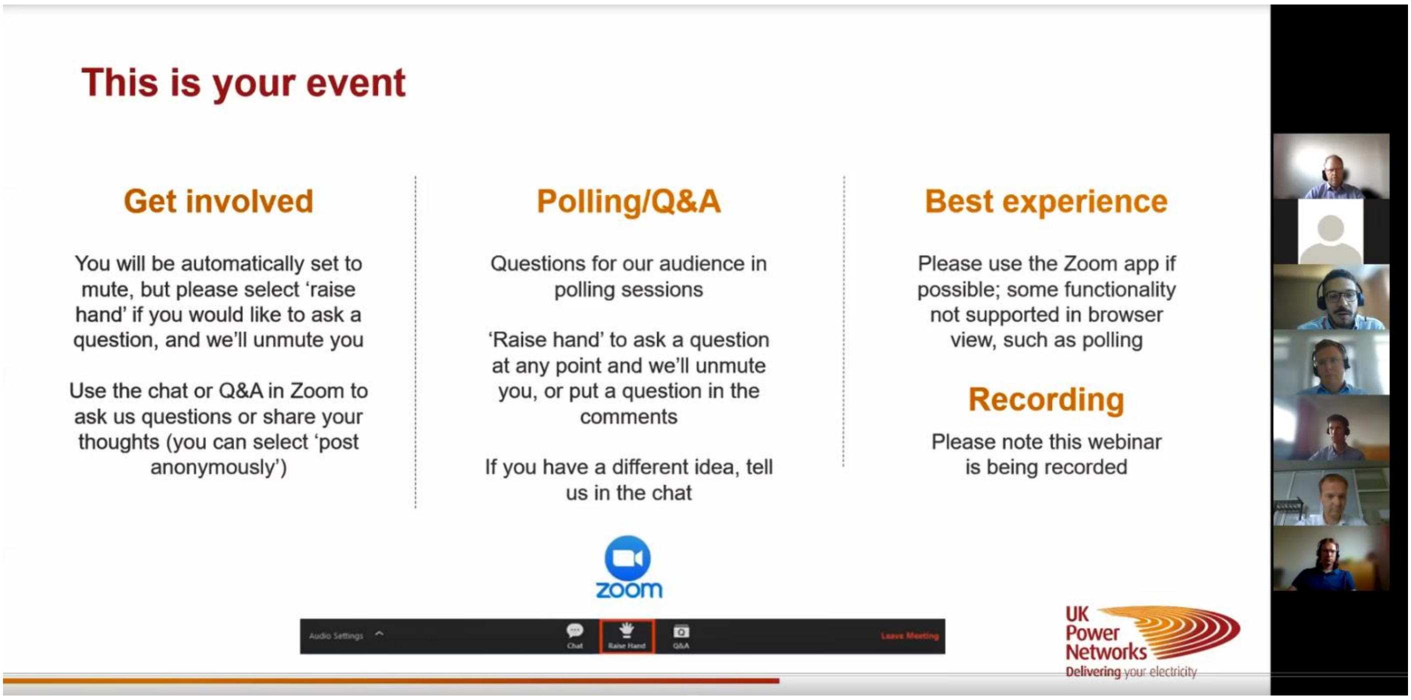

Figure 1 Webinar screenshot

In total, 100 people attended the event which was a valuable opportunity for other utilities, consultants, developers and engineers who are planning to implement similar tools to understand key risks and lessons learnt during the duration of the project. In addition, it highlighted the benefits and smart savings that FLCB units can deliver to networks with fault level constraint issues. 29% of the attendees were non-UK based participants highlighting the status of UK Power Networks innovation activities on the international stage. Valuable feedback was received from the webinar participants through the polling questions shared during the event, the scheduled Q&A session and the feedback form that they were asked to fill in following the session.

The purpose of this SDRC 9.4.1 report is to publish key materials from the stakeholder event and provide Ofgem with a list of invitees and attendees. Table 1 summarises the evidence supporting the stated deliverable for SDRC 9.4.1.

Table 1 Summary of SDRC supporting evidence in accordance with the Project Direction issued by Ofgem

Project Deliverable	Deadline	Evidence
9.4.1 Share overall learning from the project with customers, regulators, other DNOs, other manufacturers, and academia via a stakeholder event	31 August 2022 *Changed from 31 January 2022*	Publish key materials from the stakeholder event (e.g. slides), and provide Ofgem with a list of invitees and attendees.

The structure of the report can be seen in Table 2 below. The presentation slides have been added in Appendix A of the document.

Table 2 Details of each section found within this document

Section 1: Executive Summary	Summarises the background, report structure and purpose of the document
Section 2: Agenda	Describes the webinar agenda and explains its content – a link to the slides is provided in the Appendix
Section 3: List of invitees	Summarises the list of the webinar invitees
Section 4: List of attendees	Summarises the list of the webinar attendees
Section 5: Feedback	Summarises the learnings from the event polling questions, Q&A session and feedback form
Section 6: Summary	Summarises the report content and webinar outcomes

2 Agenda

This chapter highlights the webinar agenda and provides context on each of the topics that were presented and discussed with the audience:

Welcome and introduction

Introduction to the event

The intro covered an overview of the webinar agenda, some general housekeeping rules such as the Q&A session details and a presentation of the key speakers.

Opening address

ABB's Tobias Hintzen, a Local Product Group Manager for Indoor Apparatus in ABB, welcomed the audience and discussed his involvement in the project since the very beginning.

Project overview

An overview of the Powerful-CB project was demonstrated under this section. The speaker introduced the problem statement to highlight the business drivers and motivation behind the project. The principles of FLCB devices were discussed to showcase why these units are suitable solutions to the UK Power Network challenges. The characteristics and limitations of the FLCB units already available in the market were analysed to illustrate why they are not fit for purpose for our DNO network. The project objectives were also defined to explain what the project is planning to achieve in a local as well as GB scale following its delivery. Lastly, a timeline of Powerful-CB was presented to indicate the content and timing of the different stages of the whole project lifetime from the design development until the trial completion.

What we did

Experience from design and testing

This part of the presentation started with a thorough explanation of how the pilot FLCB device operates, its hybrid technology concept, the different physical compartments that it consists of and the interruption sequence logic during its operation.

To describe the design process, the speaker presented the experiences and learnings from past projects that were the starting point for Powerful-CB. They followed up with the design requirements agreed with UK Power Networks, the reliability considerations and limitations for the tested device. Significant lessons learnt from the development of the design from a technology readiness (TRL) 4 to a TRL 7 were covered under this section.

Special reference was also made to the novel monitoring and control system specifically prepared for Powerful-CB project in order to enable ABB to remotely collect and analyse the FLCB data outside of the UK Power Networks premises.

During the whole process, different types of validation, type and FAT testing from component level to full device testing were undertaken to ensure that it meets the relevant industry and UK Power Network standards. The details of the testing were discussed with the audience.

Trial arrangements & site selection

This chapter covered the selection criteria for the project installation site and the three different trial arrangements under which the device was tested during the trial. These were set in order to ensure that the device could be appropriately demonstrated in the network to maximise learning for business as usual (BAU) installation, commissioning and operation. The description of each trial arrangement as well as their benefits and rationale behind their selection were analysed.

Installation & Commissioning

The substation preparation works for the installation of the FLCB unit and the electrical works associated with its integration into the network were highlighted by the speaker. Details from the ABB site visits to install, then test and commission the FLCB to ensure full functionality with UK Power Networks' systems have also been introduced. Access to site and travelling were prohibited for a period of time in 2020 due to COVID-19 restrictions, thus the impact to the project was discussed.

The results and next steps

Trial & Performance

The results and lessons learned from the trial since the energisation of the FLCB unit in August 2020 were presented under this section. Information about ongoing testing (i.e. monthly confidence switching) and maintenance of the device were shared. The operation and performance of the FLCB during faults was one of the main project highlights to demonstrate its suitability for similar applications in DNO networks across the UK. Finally, any challenges and experiences identified during the trial were communicated by the project team.

Commercial suitability

Details for future commercialisation of the unit for any interested parties with information such as the unit improvements, indicative costs etc. were provided. Possibilities for further trials and more pilots with different characteristics were also discussed with the audience to get an indication of the appetite for the unit deployment in the future.

Summary and close

This section summarised everything discussed during the webinar and highlighted the key points that the audience should take from the project delivery and its findings. It also provided the project team contact details for anyone interested to learn more about the trial and opened the Q&A section for the attendees.

3 List of invitees

The list of invitees can be found in the confidential appendix of the report.

4 List of attendees

A diverse mix of professionals and customers from multiple industries varying from manufacturers and engineers to consultants, developers etc. attended the session. The total number of participants was 100 and a detailed list can be found in the confidential appendix of the report.

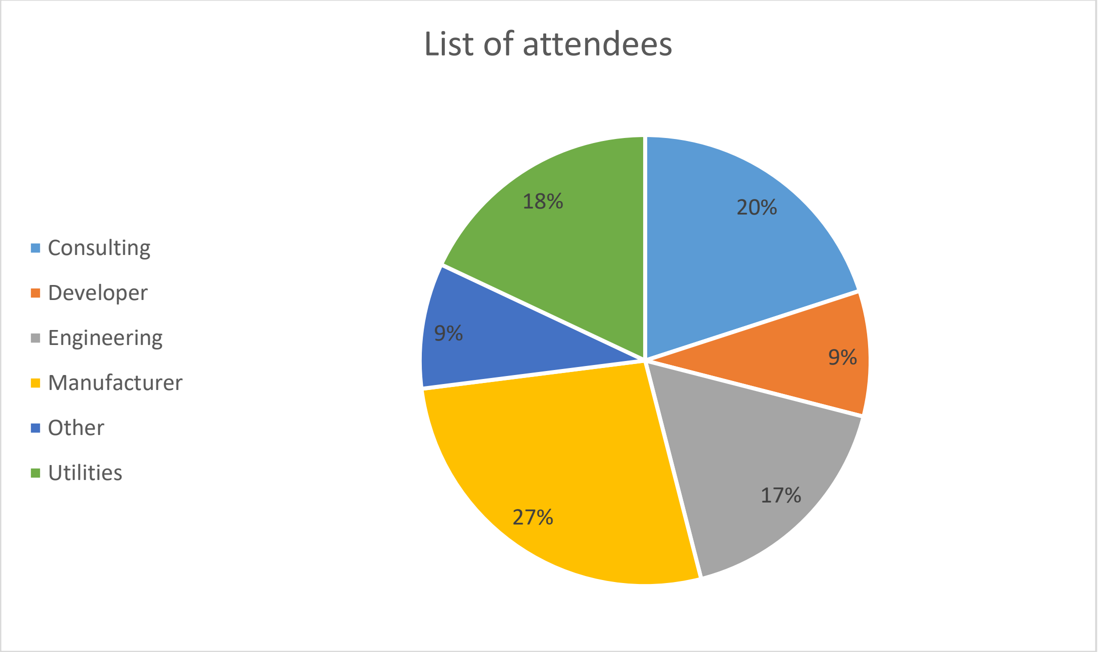

Figure 2 Webinar attendees breakdown

Figure 2 showcases the split of the industries that the webinar attendees were representing. The biggest share of attendees (27%) were employees from manufacturing companies. The main benefit for these participants was the learnings from the trial of a pilot device that could potentially be commercialised in the coming years. This was an opportunity for them to learn more about an electrical equipment that could be developed further and also launched by other manufacturers than ABB. Energy and utilities consultants were also keen on the webinar as the FLCB pilot could be incorporated into their available tools for network design which could assist them in sizing electrical infrastructure and offer solutions to existing network issues. A large number of utility companies (18%) also attended the event, the majority of which were DNOs and IDNOs as well as water utilities. The FLCB pilot is a device tested in an actual distribution network, thus it was of direct interest to these parties to understand more about the benefits the device can offer as it could be utilised in the networks that they own and operate.

Utilities Engineering companies were the next in numbers (17%) to attend the event. Apart from Independent Connection Providers (ICPs), there were also participants from other companies offering engineering, procurement and construction and transport solutions. Furthermore, developers from solar, storage and other renewable industries showed particular interest on the project findings. They approached the project team during and after the session to comprehend whether such a solution could be introduced in their activities and discuss the availability of pilots at different ratings. Finally, a mix of other attendees ranging from academia, local authorities to energy suppliers and renewables investment companies participated in the Powerful-CB webinar. Information on up-to-date research activities on electrical equipment as well understanding more about the facilitation of Net Zero in existing and future schemes were some of the learnings that these groups gained from the event.

The invitation was open to international companies which are non-UK based as the pilot in principle could be utilised in other countries considering it meets the local standards and regulations. In fact, 29% of the attendees were non-UK based from multiple countries across the globe including India, Germany, United Arab Emirates, South Africa. highlighting UK Power Networks' status on the international innovation stage.

5 Feedback

In order to make the webinar interactive with the attendees and get their feedback from the presentation, polling questions were posed between the speakers and a Q&A session took place towards the end of the event. Following the webinar, the participants were also asked to fill in a feedback form. Overall, the project team received useful insights from the audience and the event contributed to the continuous engagement with the wider public which was one of the key project objectives.

5.1 Polling questions

Three different polling questions were asked to the audience to get their view on how they are currently dealing with similar problems that we face in our network and their views regarding the pilot FLCB device. The majority of the webinar attendees responded to all questions as their feedback is key to the project continuous improvement and development.

The first question was to understand how the participants are currently dealing with fault constrained sites either during design or operation of the network. It was not surprising to see that the majority of participants voted for the “Split bar & Auto Reclose scheme” and “Upgrade the infrastructure” options, given that both are the options that UK Power Networks historically chooses to resolve fault level issues (Figure 3a). The option of “Install other fault current limiter devices” gathered 18% of the votes which was higher than expected as it is a solution not commonly found in existing networks.

The second question (Figure 3b) was relevant to the parameter that the audience would identify as key for such an FLCB device. The top selected option was the “Fast operation” of the unit which is one of the key reasons why the project was initiated in the beginning of 2017. The fact that the pilot is a “Multiple operations device” was also one of the top characteristics followed by the fact that “No active cooling is required for the pilot”.

The third question asked was “What is the biggest barrier for adopting the product?” (Figure 3c) in order to understand what the audience’s main concerns about the pilot were. Just over half of the voters (51%) selected the “Cost” option as the biggest barrier with the “Availability” and “Rating” of the device being the next on the list. Only 9% voted for the “Space” option which was unexpected to see since this is one of the key constraints towards the future deployment of the device in our network.

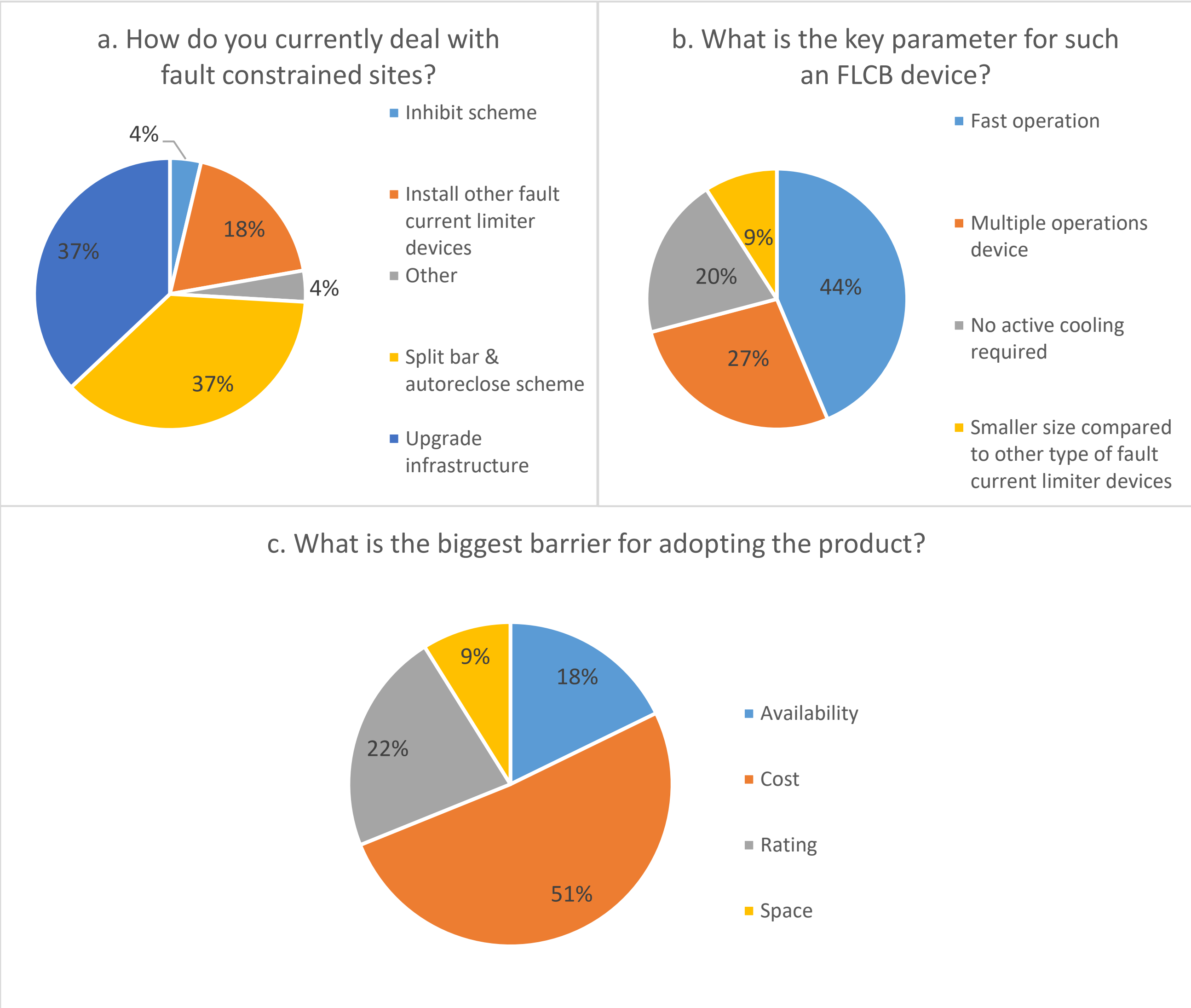

Figure 3 Polling questions

5.2 Q&A Session

A Q&A session followed the overall presentation where the audience asked questions to the project team's panel. 26 questions were posed to the speakers where some were answered live and others in writing in the Q&A functionality of the Zoom application. The questions were mainly technical and some examples can be found below:

"Has scalability for higher voltages been considered or is the scale needed at 66-132kV etc a break point and reinforcements are deemed more economic?"

"Do the mechanical switches require any lubrication during maintenance?"

There were also questions that combined technical with commercial and future planning elements such as the below:

"What are the fail-safe mechanisms of the unit were the power electronics to fail or malfunction? Is this a stop-gap approach to long term system reinforcement as the amount of generation expected to come online past 2030 is enormous?"

"What happens now with the FLCB on the UKPN network, will it remain in service?

5.3 Feedback form

A feedback form was provided to the participants at the end of session. The overall score for the event as rated by the webinar attendees was 8.28/10. The sections of the webinar which received the most positive feedback was the development of the unit from an R&D to a BAU product, the technical benefits that it can add to the network and information about the trial results. Particular interest was shown on the equipment pricing and availability as well as the project team's enabling works for the pilot installation. Following the session, the participants were encouraged to get in touch with the project team to answer any further questions and discuss additional topics that would be of interest to them.

6 Summary

The project has successfully delivered on the requirements of SDRC 9.4.1. The agenda covered information over the whole lifetime of the project and provided a good overview of each stage of the project as well as its findings. In total 100 stakeholders joined the webinar, including a diverse mix of professionals and customers from different industries ranging from manufacturers, utilities and engineers to consultants and developers. 29% of the attendants were non-UK based from multiple countries across the world, showcasing their interest not only in the device but also in UK Power Networks' innovation activities. The feedback from the attendants was valuable for the project team, thus polling questions were posed and a Q&A session took place during the session. Finally, the webinar attendees were also requested to provide their feedback at the end of the session and the event received an 8.28/10 rating.

Appendix A – Presentation slides

The presentation slides have been uploaded on the project's innovation website.