Electricity Network Innovation Competition Screening Submission Pro-forma

Notes on completion
Before completing this form, please refer to the Electricity Network Innovation Competition (NIC) Governance Document. **Please use the default font (Verdana size 10) in your submission, the text entry areas are predetermined and should not be changed. The full-completed submission should not exceed 10 pages in total.** **Ofgem will publish all the information contained within the Screening Submission.**
Funding Licensee
London Power Networks plc – part of UK Power Networks (LPN and UKPN in this document)
Network Licence Project Partners
Funding Licensee area
LPN
Project title
POWERFL-CB (POWER-electronic Fault-Limiting Circuit Breaker)
Project Summary
The Licensee must provide an approximate Project start and end date.
Smart solutions to fault level constraints are a key enabler for continued growth of distributed generation (DG) and district heating in dense urban areas such as London. This project will develop a new smart solution for fault level constraints on 11kV distribution networks: an **11kV fault-limiting circuit breaker (FLCB).** A FLCB uses power electronics to interrupt fault current before its first peak, which limits the let-through energy and fault level contribution to a fraction of their unrestrained levels. This approach has advantages over other existing smart solutions: for example, it can eliminate (not just reduce) a circuit's contribution to fault levels. FLCBs could unlock additional benefits if integrated with ENWL's Respond methods. We intend to partner with ABB to develop this technology. ABB have already developed the technology to TRL4 (technology readiness level 4, i.e. working lab prototype). We have sought, and have not yet found, any other suitable technology partners. **The project will run for four years from January 2017 to December 2020.** This comprises two years to develop, test, and industrialise the technology, followed by two years to install and operate a trial unit on our network. Upon project completion, ABB will decide, based on the technical and business outcomes of the project, whether an 11kV FLCB product will be made available for Network Licensees to purchase.

Estimated Project funding			
The Licensee must provide an approximate figure of the total cost of the project and the NIC funding it is applying for.			
Total cost of Project	£4.0m	**NIC funding requested**	£3.3m
Cross Sector Projects only: requested funding from Gas NIC, NIA or second tier LCN Fund?	*If yes, please specify*		

Problem

The Licensee must provide a narrative which explains the Problem(s) which the Project is seeking to address.

In response to the Carbon Plan and DECC's Community Energy Strategy, the Mayor of London has set a target to generate 25% of London's heat and power requirements locally by 2025, which is encouraging CHP and district heating for new developments. In parallel, the demand for flexibility (driven by decarbonisation of GB's generation mix) is encouraging customers to connect their existing standby generators for long-term-parallel (LTP) operation. This has pushed fault levels at many LPN substations close to their limits. (CHP and standby generation typically comprise rotating machines, whose momentum adds significant energy to nearby faults.) Where fault level headroom is only available in normal network conditions, DG has been allowed to connect on a curtailable basis – but this headroom is quickly being exhausted. In other words, **fault level constraints are quickly becoming the main barrier to connection of new distribution generation in London.** Similar scenarios are occurring elsewhere in GB – WPD's FlexDGrid project and ENWL's Respond project are both also addressing fault level constraints caused by the uptake of low-carbon heating and electricity.

Fault level constraints are traditionally relieved when 11kV switchgear or primary transformers are replaced due to load or health drivers. (Modern switchgear has higher fault ratings, and new transformers can be specified with higher impedance.) In theory, new generation customers could pay for these schemes to be brought forward, or avoid the fault level constraint by connecting at 132kV. But these options rarely make economic sense. **In practice, most customers opt to reduce the size of their generator connections.**

Smart solutions are becoming available, but they are far from ideal. GB DNOs have trialled several types of fault current limiters (FCLs), and some, including the GridON FCL that UKPN trialled at Newhaven, are mature enough for BAU deployment. However: they are expensive, most types consume significant auxiliary power, and all types require a lot of physical space – which is scarce in dense urban environments. ENWL is trialling active network management techniques that use fault level monitoring, adaptive protection settings, and fast disconnection of customers' motors and generators; but these techniques can only mitigate break current (not make current) constraints. ENWL is also developing the safety case for DNOs to use ABB's Is-limiter – which is compact enough to integrate into an 11kV switchboard, and can mitigate break and make current constraints, but requires replacement after interrupting a fault.

Method(s)

The Licensee must describe the Method(s) which are being demonstrated or developed. It must also outline how the Method(s) could solve the Problem. The type of Method should be identified where possible eg technical, commercial etc.

This project proposes to develop and trial an 11kV fault-limiting circuit breaker (FLCB), which combines the best characteristics of other fault-level solutions: it can mitigate break and make current constraints, it is compact enough to integrate into an 11kV switchboard/switchroom, it does not require replacement or maintenance after operation, and it consumes negligible auxiliary power.

The fault-limiting principle is the same as for ABB's Is-limiter: it interrupts fault current before the first peak, which limits the let-through energy and fault-level contribution to a fraction of their unrestrained levels. This is not possible with conventional vacuum or SF6 interrupter technologies. During normal operation, load current is carried by an ultra-fast low-resistance bypass switch. Upon detecting a fault, the bypass switch opens and commutates the fault current to a power-electronic switch, which interrupts the fault current. ABB has demonstrated a single-phase prototype in their laboratory – i.e. the technology is currently at TRL4.

Method(s) continued

A FLCB is different to a fault current limiter (FCL) such as those used in FlexDGrid: unlike a FCL, a FLCB can limit and interrupt a fault. A FLCB is also different to, and in fact complements, ENWL's Respond methods: FLCBs have all the same benefits as Is-limiters, but can also rapidly reclose, to restore the network to its normal (secure) running arrangement as soon as the fault has been cleared. If installed at a customer's premises in front of a large motor/generator, a FLCB would allow the Respond FCL service to eliminate that customer's contribution to both break and make fault levels.

Phase 1 - Develop three-phase device: ABB will build, test, optimise, and industrialise a three-phase device. UKPN and ABB will work together to specify the functional, performance, and safety requirements. This phase is expected to take two years.

Phase 2 - Trial FLCB at DNO substation: UKPN will install and trial the FLCB on a live 11kV network. UKPN and ABB will work together to select the trial site, run power system studies, design the necessary modifications to the network/substation, and complete the installation and commissioning. This phase is expected to last another two years, but we expect to gain (and disseminate) significant early learning within the first year of trial operation.

Funding commentary
The Licensee must provide a commentary on the accuracy of its funding estimate. If the Project has phases, the Licensee must identify the approximate cost of each phase. OFTOs should indicate potential bid costs expenses.

ABB's costs of £3.0m are based on a bottom-up estimate of labour and material costs.

UKPN's costs of of £1.0m are based on bottom-up estimate of labour and construction costs, and previous experience from the ETI/GridON FCL trial at Newhaven.

The amount of NIC funding requested is net of a £400k contribution from UKPN (10% of the total project cost), and a further £300k in-kind contribution from ABB.

Specific Requirements (please tick which of the specific requirements this project fulfils)	
A specific piece of new (ie unproven in GB) equipment (including control and/or communications systems and/or software)	✓
A specific novel arrangement or application of existing electricity transmission equipment (including control and communications systems software)	
A specific novel operational practice directly related to the operation of the electricity transmission system	
A specific novel commercial arrangement	

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

The Licensee must demonstrate that the Solution has the potential to accelerate the development of the low carbon energy sector in GB and/or deliver wider environmental benefits to GB customers. The Licensee must demonstrate the potential to deliver net financial benefits to existing and/or future customers.

As discussed previously, CHP and other rotating DG connections in central London (and the associated financial and low-carbon benefits) are likely to be limited because of fault level constraints. The following case studies will illustrate how FLCBs could help mitigate these constraints, enabling faster/cheaper/larger connections of CHP and long-term-parallel (LTP) standby generation. These are typical scenarios for Central London.

Case Study 1: CHP in new development
We recently investigated the feasibility of connecting 40MW of CHP as part of a new development in central London. We found that, due to fault level constraints:
- **10MW connection cost ≈ £150k (£15k/MW)** – maximum possible at 11kV without reinforcement. CHP can only operate when network is running in normal arrangement.
- **16MW connection cost ≈ £300k (£19k/MW)** – maximum possible at 33kV
- **40MW connection cost ≈ £4,000k (£100k/MW) –** must be connected at 132kV
- In the absence of any smart solutions, it is clear that the maximum feasible CHP size is 16MW. A FLCB installed at either UKPN's substation or the customer's premises would likely allow 40MW of CHP to connect at 11kV. We don't yet have accurate estimates of long-run FLCB purchase/installation costs; but if we assume that CHP is feasible at a connection cost of £19k/MW, and assume that 11kV cables and (other) switchgear cost about £250k, this allows about £500k for the cost of the FLCB – which we believe is achievable. Therefore, in this case**, a FLCB could enable connection of an additional 24MW of low-carbon generation and heating at this development.**

Case Study 2: Customer seeking LTP operation of standby generators
We recently received a request to allow operation for 17.5MW of standby generation in a new development. The generators comprised seven units of 2.5MW each. We found that, due to fault level constraints:
- Without significant reinforcement, only three of the seven generators (7.5MW) can be LTP connected at a time, and only when the network is running in normal arrangement.
- The customer would need to modify the arrangement of their 11kV generator switchboard to enable the generators to be segregated into groups of three. This would increase the switchboard's cost by up to £50k, and was only feasible because the switchboard had not yet been procured. If this had been an established site, the modifications would have been much more costly and/or technically unfeasible.
- In either case (new or existing site), a FLCB would likely allow the other four units (10MW) to also operate LTP, and hence contribute to security of supply by participating in flexibility and/or capacity markets. Therefore, in this case, **a FLCB would allow 10MW of high-carbon baseload generation to be replaced with an equivalent amount of low-carbon intermittent generation.**

Case Study 3: Upgrade the entire 11kV network to fault rating of 25kA
90% of LPN's 11kV network is limited to a fault level of 13.1kA, mainly due to fault ratings of 11kV CBs/RMUs. We estimate that to upgrade the entire network to 25kA (by replacing all CBs/RMUs rated <25kA) would release significant fault level headroom and cost about £380m. However, considering that our RIIO-ED1 settlement only allows £31m worth of condition-based RMU/CB replacements, it is very unlikely that £380m worth could be delivered within a useful timeframe. By comparison, installing a FLCB at each of LPN's 211 11kV buses could release the same amount of headroom, but (tentatively assuming £500k/FLCB) could cost as little as £106m – a theoretical **saving of £274m;** and **could plausibly be completed by the end of RIIO-ED2.**

Delivers value for money for electricity customers

The Licensee must demonstrate that the Method(s) being trialled can derive benefits and resulting learning that can be attributed to or are applicable to the electricity transmission system.

Deployment of the FLCB will provide DNOs with an alternative tool to be utilised during the lifecycle of network design, delivery and operation. DNOs will have the ability to improve switching capability and manage fault levels at primary substations without the need to replace and uprate existing assets or install space consuming FCL type plant. This novel circuit breaker will be the first of its kind seen on GB distribution networks and could provide a breakthrough in switching technology, reducing technical losses and increasing the sustainable use of existing assets to provide better value to customers.

The cost of the learning is expected to enhance the development of a new product that will become commercially available to DNOs, providing competition to other FCL type plant at a more reasonable cost. An industrialised product would be significantly smaller then alternative FCL plant, and remove the need for additional plant, as it would replace an existing circuit breaker on a bus tie or a customer's feeder.

UKPN will employ a robust governance process with the technology partner to ensure the cost of the project remains competitive.

The project provides an immediate and significant proportion of benefits to the distribution system. However, the further learning could lead to developments at transmission voltages. HVDC hybrid breakers using similar technology are commercially available for HVDC transmission.

Demonstrates the Project generates knowledge that can be shared amongst all Network Licensees

The Licensee must explain the learning which it expects the Method(s) it is trialling to deliver. The Licensee must demonstrate that it has a robust methodology in place to capture the learning from the Trial(s).

The project aims to develop an 11kV FLCB from TRL4 to TRL8, i.e. ready for BAU deployment. Upon project completion, ABB will decide, based on the technical and business outcomes of the project, whether an 11kV FLCB product will be made available for Network Licensees to purchase.

The project will also seek to answer questions such as:

- How could FLCBs change the way Network Licensees design and operate their networks?
- What are the risks and opportunities associated with deploying FLCBs?
- Do FLCBs offer other benefits besides fault level mitigation? (e.g. voltage stability due to faster fault clearance and/or reclosing; more flexible network interconnection)
- In what scenarios does a FLCB provide a better outcome than other smart or traditional solutions?
- Where should FLCBs be rolled out?
- What skills and knowledge do DNOs need to deploy/operate/maintain FLCBs?
- What are the health, safety, and environmental implications of deploying FLCBs?

The project's results will be captured and disseminated using the best-practice methods available amongst the LCNF/NIC community.

Please tick if the project conforms to the default IPR arrangements set out in the NIC Governance Document?	✓

If the Licensee wishes to deviate from the default requirement for IPR then it must demonstrate how the learning will be disseminated to other Licensees and how value for money will be ensured. The Licensee must also outline the proposed alternative arrangements and justify why the arrangements are more suitable than the default arrangements.

ABB have confirmed that they are able to work within the default IPR arrangements.

How is the project innovative and with an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness?

Demonstrate why the Licensee has not previously used this Solution (including where the Solution involves commercial arrangements) and why NIC funding is required to undertake it. This must include why the Licensee would not run the trial as part of its normal course of business and why the Solution is not Research.

The requirement for novel solutions to manage fault levels on networks is becoming more critical. The FLCB will be the first time power electronics paralleled with a commutative switch will be used to interrupt current and manage the fault level on the HV distribution network. Similar technologies are being trialled by UKPN and others at low voltage, but these do not scale effectively to 11kV.

ABB has only recently been able to develop their patented technology to TRL4. In the absence of NIC funding, they have no immediate plans to develop the technology further because of the lack of a proven business case.

The concept would not proceed as business as usual due to a number of risks:
Demonstration of withstand tests: New equipment needs to demonstrate that it can pass or "withstand" extreme conditions on the network. This requires structured tests in a controlled environment, and as their name suggests, the tests carry a degree of uncertainty because they push equipment to its limits.
Early life issues and reliability issues: All new concepts have a higher-than-usual risk of reliability issues, particularly early life issues, which can only be discovered via extended use.
Manufactured cost: The manufactured cost, and hence the long-run price, are dependent on the detailed design stage. This technology is not yet mature enough to be procured traditionally, and the design stage needs to be jointly explored.

Project Partners and external resourcing/funding

The Licensee must provide evidence of how Project Partners have been identified and selected, including details of the process that has been followed and the rationale for selecting participants and ideas for the project.

The Licensee should provide details of any Project Partners who will be actively involved in the Project and are prepared to devote time, resources and/or funding to the Project. If the Licensee has not identified any specific Project Partners, it should provide details of the type of Project Partners it wishes to attract to the Project.

At the outset of this year's NIC, we began discussions with National Grid about potential projects which tackled joint transmission and distribution issues; and separately began to look at issues within distribution networks only.

We consulted with internal and external stakeholders to compile an initial list of 12 project ideas relevant to distribution companies. We shortlisted ideas based on NIC eligibility, technical feasibility, and relevancy to challenges in RIIO-ED1. As we reviewed the shortlist, we worked with a number of manufacturers to understand the status of their products.

We selected the FLCB idea because:
- Of all the ideas, it had the most support from our internal stakeholders, particularly from the frontline engineering teams developing the network;
- It addresses an issue that is expected to be a major barrier to LCT uptake within RIIO-ED1;
- It complements other fault-level-mitigation solutions currently being developed; and
- It will be a world first.

We intend to partner with ABB to develop this technology. At this early stage, we have not been able to identify any other suitable technology partners. (We contacted four other technology vendors, consulted a power electronics expert from academia, and conducted a thorough literature search, but we could not find any other party who has developed a working 11kV FLCB prototype to TRL4.) We will publish an open expression of interest before our NIC full submission, to ensure that we have exhausted all options for potential technology partners.

We are conscious that we may require additional expertise to fully understand the safety implications of this technology, and how it will affect the behaviour and operation of our network. We will seek other project partners/suppliers to provide this expertise if necessary.

Derogations or exemptions

The Licensee should outline if it considers that the Project will require any derogations, exemptions or changes to the regulatory arrangements.

At this early stage of the project, we are not aware of any issues that might require any derogations, exemptions, or changes to regulatory arrangements.

Customer impact

The Licensee should outline any planned interaction with customers or customers' premises as part of the Project, and any other direct customer impact (such as amended contractual or charging arrangements, or supply interruptions).

At this early stage, we don't expect this project to have any direct impact on customers.

Details of cross sector aspects

The Licensee should complete this box only if this Project forms part of a larger cross sector Project that is seeking funding from multiple competitions (Electricity NIC, Gas NIC or LCN Fund). The Licensee must explain about the Project it will be collaborating with, how it all fits together, and must also add a justification for the funding split.

N/A

Any further detail the Licensee feels may support its submission
Our Innovation Strategy states that as part of the development of network innovation project proposals, we include risk assessment and identification of mitigating provisions. Our governance framework for innovation projects also ensures that we continuously assess and monitor our innovation work with respect to health and safety, thus ensuring that such risks are actively assessed and addressed in a manner commensurate with our commitment to health, safety and sustainability. We plan to provide other licensees with the opportunity to be a part of the FLCB project by allowing them to provide input into the development of the device, and provide guidance on how it can be utilised in the future management and operation of distribution networks. This will ensure that the project's outputs are useful to all Network Licensees.
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