

SIF Alpha Project Registration

Date of Submission

Sep 2022

Project Reference Number

10036946

Project Registration

Project Title

Network-DC Circuit Breakers

Project Reference Number

10036946

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

Aug 2022

Project Duration

6 Months

Nominated Project Contact(s)

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Project Budget

£491,905.00

Funding Mechanism

SIF Alpha - Round 1

SIF Funding

£423,476.00

Strategy Theme

Whole energy systems

Challenge Area

Whole system integration

Project Summary

The whole system innovation challenge requires coordination of design to reduce duplication and complexity of networks to deliver an integrated system capable of providing net-zero electricity generation. This project supports the coordination of offshore and onshore networks, with the potential to reduce infrastructure, thus improving delivery time and reducing costs, and improving network reliability. Users include offshore wind developers; National Grid ESO; and the Offshore and Onshore Transmission Owners and Operators managing the interface between DC and AC circuits. DCCBs enable broader network strategic changes, primarily the establishment of onshore HVDC hubs, which will be needed given the requirement to rapidly expand offshore wind as a clean energy supply for the UK. The goal of the project is to complete the work necessary to allow the selection of DCCBs as an option in network design.

DCCBs are developing technology with limited information available from the first implementations in China, thus there is a significant risk in adopting the technology. Given the number of stakeholders involved in these first applications, de-risking the first implementation in the UK is significantly complex. The Discovery project has evaluated the cost and critical activities of de-risking necessary to support the first implementation in the UK. Allowing this enabling technology to be available as a viable option for coordinated and efficient grid infrastructure is key to delivering secure, reliable, and clean energy to consumers at the lowest possible cost.

The Alpha Phase of the project will coordinate between networks, generators, market participants, investors, local and national policymakers. This phase will:

- refine costing and value estimation;
- identify design efficiency;
- use the results of DCCB simulation to inform the tender specification; and
- engage the supplier community around an initial UK-focused efficient specification to de-risk the first implementation.

This approach will reduce the duplication of efforts from different stakeholders by working to de-risk across the full stakeholder map in one coordinated effort, focusing on a relevant and specific use case. Learning from the use case will be disseminated to support future projects.

The work packages set out for Alpha Phase will address the areas that the users of DCCBs have identified as necessary to reduce the barrier to entry for DCCB technologies in the UK system.

Therefore, this phase will bring increased detail and reduced uncertainty to the cost-benefit case, take the early steps towards Front End Engineering Design (FEED), as defined in the Discovery Phase recommendations, and establish a case for market development for UK-ready solutions. Beta Phase will deliver FEED in preparation for DCCBs installed after 2030.

The consortium includes five of the partners from the Discovery Phase, and the addition of SuperGrid as a new partner. The partners have been selected based on their expertise and detailed understanding of stakeholders' needs concerning their work package.

- SSEN-T is a Network Owner and familiar with the design of networks and runs the National HVDC Centre, a centre of excellence for HVDC.
- National Grid ESO is accountable for the overall strategy for the design of the future network, including the integration of DC grids.
- SuperGrid bring international experience of the design and testing of DCCBs and also have capabilities testing.
- The Carbon Trust, Renewable UK and National Grid Ventures and have expertise in regulation and policy and also represent key stakeholder groups.
- National Grid Ventures is connected with stakeholder groups interested in investing in network development.
- The University of Edinburgh brings technical electrical engineering expertise and have detailed knowledge of open-source DCCB models that can be used in simulation.

Project Description

To combat climate change, the UK needs clean energy. The UK is well-positioned to generate clean electricity because our coasts provide a large potential for offshore wind. We currently have an installed offshore wind capacity of 12GW and are targeting increasing the total capacity to 50GW by 2030 and more than 100GW by 2050. Given the scale of the developments proposed and their increasing distance from the onshore grid, the most efficient option is to connect these to the network using Direct Current (DC) cables, as it reduces the power lost in the transmission of the energy. The electricity used by the consumer, and what comes out of the sockets in their homes, is alternating current (AC), and there is a need to convert the DC to AC at a convertor station. This is usually positioned on the coast and connected point-to-point to the wind farm via an offshore cable. The current connection method is to connect each wind farm to an AC convertor station with an AC circuit breaker between the convertor station and the rest of the onshore AC network, to protect the electricity grid from faults on the offshore DC network. However, as the number of wind farms increases, so the number of AC convertor stations increases in a point-to-point system. This impacts coastal communities through an ever-increasing number of convertor stations and cables. It is also costly to install and maintain many converter stations, which increases the consumer cost of electricity.

The big idea is to create DC networks connecting multiple wind farms into a DC substation to connect to fewer converter stations. This approach will reduce the impact on coastal communities, reduce costs and has the potential to lower costs to consumers. It will also help us open new areas for developing windfarms. To do this, we need to use DC circuit breakers (DCCB), an innovative technology untested in the UK and European market. DCCB will allow us to bring multiple windfarms into a DC system, containing the impact of any single failure safely and securely and allowing other connected windfarms to be unaffected and continue to supply clean energy.

We will need to develop and test these DCCBs before we can create a DC network. This project will test and prove the use of DC breakers so that we can implement DC networks that can deliver safe, reliable, and cost-effective energy to the consumer.

Preceding Projects

10020383 - Network-DC Circuit Breakers

Nominated Contact Email Address(es)

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Project Approaches And Desired Outcomes

Innovation Justification

The construction of DC circuits and cables will optimise export from remote windfarms to areas of high electricity demand by reducing network losses associated with energy transmission. DC Circuit Breakers (DCCBs) are an enabler for efficient management and control of DC networks. DCCBs are untested in the UK market. This project aims to remove the barriers to the first DCCB installation in the UK.

DCCBs have never been installed in the UK or Europe. DCCBs are at a technology readiness level (TRL) of 9 in China but are at a TRL of between 6 and 7 in Europe (based on results from the €42.7m Horizon 2020 funded Progress on Meshed HVDC Offshore Transmission Networks (PROMOTioN) project). Our approach uses the state-of-the-art HVDC centre to simulate DCCBs, avoiding overreliance on live fault testing and field trials, which comes with high risk for other users of the system.

The UK currently has an installed offshore wind capacity of 12GW and is targeting increasing that capacity to 50GW by 2030 and over 100GW by 2050. Given the scale of the developments proposed and their increasing distance from the onshore grid, the most efficient option to connect these to the network is via a DC network.

Traditionally, offshore wind farms have a point-to-point (PtP) connection via a DC or AC cable with the onshore AC network using a proven AC circuit breaker (ACCB). The drawback of this network design is it results in stand-alone assets connected directly to the transmission grid, increasing the total number of required AC convertor stations. The alternative is to combine multiple dispersed wind farms to the grid in a meshed DC network to a single AC convertor station.

As explained in Q1, this project will de-risk implementation of DCCBs in an efficient manner using simulation of DCCB performance informing specifications that OEM will require to enter the market.

Based on analysis of prior relevant work and the needs of stakeholders, there are several key areas of missing knowledge that are currently preventing DCCBs from being installed in the UK system. These are:

- the operational behaviour of DCCBs;
- the protection scheme design for DCCBs;
- the best configuration and operation of the DCCB, protection and associated network;
- the likely capital and operating costs of DCCBs;
- the quantified benefits of a first DCCB implementation;
- ownership and operation models for DCCBs under current regulatory systems; and
- the level of commercial risk if they were delivered using strategic investment.

Without de-risking DCCB's for the UK market, DC networks will be

- delayed;
- less efficient in their use of resources when implemented (i.e. requirement for more connections and substations); and
- less resilient to the development of faults.

Without DCCBs, the choice in network topology supporting wind targets would be reduced, costs associated with delivering Net Zero increased, timescales lengthened, and result in less resilient networks.

This project reduces the cost of bringing DCCBs to market by using simulation instead of live field testing to de-risk use of DCCBs. If DCCBs are then successfully installed, the cost-benefit analysis, shows a preliminary benefit of approximately £10 billion in a DCCB hub use case, compared to the counterfactual of PtP links (see Question 3). Other benefits include reduced environmental impact through lower land-use change, reduced use of materials, and reduced CO2 production (through construction savings and reduced losses).

DC networks are at an early stage of development. The TRL level means that this is too high a risk to be funded with BAU activities. The uncertainty around where the costs and benefits would sit makes it a problematic investment case for any stakeholder.

Benefits

The Cost-Benefit Analysis (CBA) considers three use cases: (1) DCCB hub design; (2) split circuit; and (3) interconnector spur. We have developed a CBA framework that considers how the project could impact the Ofgem strategic goals.

The CBA framework and qualitative analysis of benefits is shown in the attached appendix. Highlights of these benefits include:

- Lower bills for consumers. Using a DCCB hub reduces the need for AC infrastructure, which in turn reduces necessary investment and cost.
- Ensuring system security, reliability, and sustainability. DCCBs enable the isolation of faults in offshore network components more effectively than the existing PtP arrangements. As such, use of DCCBs would reduce the downtime of offshore assets, increasing system reliability and increasing the amount of clean energy supplied.
- Reduced reliance on non-UK energy. DCCBs are fundamentally an enabling technology for broader network strategic changes, primarily the establishment of a HVDC network, which could help to unlock UK offshore wind capacity in an efficient manner.
- Reduced environmental damage. The DCCB hub requires a smaller onshore footprint than multiple P2Ps, as additional converters per P2P would be needed and additional AC substations. The difference in footprint is ~52,900 sqm.

For each of the potential use cases, a cost benefit analysis has been carried out by modelling the following quantifiable characteristics of both the use case (DCCB) and counterfactual (without DCCB) options:

- Capital expenditure
- Operational expenditure
- HVDC system losses
- Ancillary services requirements
- Land acquisition requirements

We have based the CBA on the RIIO-T2 CBA template and assumed a 45-year asset life span. Given the topologies set out are theoretical and do not have a geographical location in the grid, we have not modelled the AC grid beyond the topology specified. This is reasonable at this stage of development as we are considering that each use case and counterfactual would have an equivalent surrounding AC network, so it would not result in a differential in the outcomes. Where the use case or counterfactual results in a different impact on the AC network, this is modelled as a specific implementation.

The different data collected and calculated for each option are then combined over the same project operational period, with an aligned year of commissioning, for use and counterfactual cases to determine the Net Present Value (NPV) of all options. Since the NPVs are not a full system NPV, they are to be taken as the use case relative to the counterfactual, rather than as stand-alone figures.

The early CBA carried out during Discovery Phase indicates a positive benefit for GB customers compared to current market practices of PtP HVDC links for offshore windfarm connections. All three use cases show relative improvements in NPV due to the avoided ancillary services costs enabled by the fast recovery enabled by DCCBs. 'Appendix Q3' sets out the potential benefits of a HVDC breaker relevant to Ofgem goals. Using this methodology, we have estimated a benefit of £10 billion for an individual DCCB installed in the network, against the counterfactual of securing a 4GW Offshore Wind connection with 12GVA of services.

While some engagement with OEMs and a review by National Grid ESO has been used to inform assumptions around the key areas of DCCB costs and ancillary services benefits, these are the areas that have uncertainty. This is due to the fact that existing information on DCCB implementations is very limited due to commercial considerations of the organisations involved. The next step in the Alpha phase towards a first implementation of a DCCB in the UK is to reduce these uncertainties and the risk associated with the commercial aspects of an implementation.

Risks And Issues

We have identified 22 risks and 10 assumptions that are core to the project extending over technical, political, commercial, managerial and environmental factors (see Appendix Q5). All partners have been involved in the risk and assumption assessment process.

National Grid ESO and Renewable UK reviewed the political and commercial assumptions. From the Discovery phase, of the 22 risks identified, 7 remain as High Impact post-mitigation, of those 4 are technical, 2 commercial and 1 managerial. Risk mitigations are underway for over half of the risks.

Technical

- There is a limited study of onshore system impact from use of DCCBs conducted to date informing specific operational risks. Mitigation: based on advice from National Grid ESO, National HVDC centre to deliver tailored simulation cases.
- Whole system impacts need to be assessed in a model sufficiently large to be informative, but not so large as to be impractical. Mitigation: Early discussions between National Grid ESO and HVDC Centre to agree the extent of test network.
- Publications and developments during the lifetime of the project render the intervention unnecessary. Mitigation: Up-to-date literature review carried out in Discovery. Involvement of industry experts with OEM experience during Discovery. Update/re-review of literature included before end-of-Alpha stage gate.
- The proposed Beta phase (which develops a specification based on Hardware in the Loop testing and addresses - should it be found relevant from Alpha work - further requirements for lab tests) creates a specification that cannot be achieved by existing technology. Mitigation: Involve sufficient equipment from vendors as Hardware in the Loop in Beta phase and seek supplier feedback on requirements for lab test in Alpha phase.

Commercial

- Manufacturers are insufficiently motivated to develop the equipment due to lack of commercial incentives. Mitigation: Responses received from nine OEMs expressing interest in participation in the Alpha and/or Beta stage. Early engagement with manufacturers in Alpha to follow-up, gather cost information and assess this risk further.
- None of the limited number of manufacturers which carried out laboratory tests of DCCB are willing to participate in Alpha and Beta. Mitigation: Responses received from nine OEMs expressing interest in participation Alpha and/or Beta stage with relevant products and tests. Early engagement with manufacturers in Alpha. Also available are simulation models from HVDC centre and academia tuned and refined based on results from laboratory tests.

Managerial

- A suitable transient model of GB network cannot be made available by NG ESO due to other commitments. Mitigation: use of existing models available to and developed by the National HVDC centre of the GB system, suitably modified to reflect ESO needs.

Intellectual Property

- We do not anticipate any significant Intellectual Property risks, and the approach to IP is set out in more detail in Question 9.

Risk Management

Following our mitigation actions in Discovery Phase, the most significant risks remain commercial risks associated with securing participation from at least one of the manufacturers which has already successfully carried out laboratory tests to characterise an HVDC Circuit Breaker. Mitigations and resulting risks are set out the attached appendix.

In structuring Alpha's project organisation and work breakdown structure, we have ensured that no Work Breakdown Structure (WBS) (at Level Two) owns more than 25% of the risks and assumptions. This enables partners to focus on the risks they own and are best placed to address, rather than leaving all risk management with a single organisation.

In order to monitor these risks going forward and identify any new risks arising, SSEN-T will be responsible for the regular review and update of the risk register and engaging the project partners to ensure a holistic view of the project risks.

Project Plans And Milestones

Project Plans And Milestones

The Alpha Phase project plan defines the comprehensive arrangements to deliver the project by organising the work in a logical structure that will be used to manage the delivery of the project scope to meet time, cost and quality requirements. The submitted plan is summarised below and developed using an agile framework with Work-Breakdown-Structure (WBS) that resolves individual work packages delivered as project sprints (Appendix Q4-1). The work packages have been assigned to individual owners with defined accountabilities (see WBS in Appendix Q4-1). Deliverables in the WBS have defined success criteria measured on a SMART basis (specific, measurable, achievable, and relevant goals).

We have identified eight key deliverables with success criteria:

1. NDAs are secured with DCCB manufacturers. Success Criteria: NDA with three or more Manufacturers that have experience designing HVDC Circuit Breakers. End month 1.
2. DCCB Models collated for use in simulation. Success Criteria: Models represent a range of different types of DCCB already used in China designs. Models are developed in such a way they can be adapted to the needs identified in our subsequent simulation phase. End month 1.
3. Use case and site selected. Success Criteria: Use case has agreement from both the regional Transmission Owner and NG ESO. Voltage levels, ratings, topology, AC/DC converter types, plant and circuit parameters have been-collated and agreed on. End month 2.
4. Revision of the Discovery Phase CapEx estimate for DCCBs agreed with manufacturers. Success Criteria: A higher standard of accuracy compared to the Discovery phase. End month 2.
5. Publication of draft commercial model(s) and associated regulatory recommendations. Success Criteria: Confirmation that the regulatory, political, and commercial environment does not impact the business case, and a review of mitigations if required. End Month 4.
6. Validated network models and simulation results. Success Criteria: Simulation environment uses sufficient models of HVDC CBs and of the network to be effective. End of Month 5.
7. Revised Cost-Benefit Analysis. Success Criteria: Revision of the CBA to support a robust end-of-Alpha stage gate process incorporating project specifics of revised CapEx estimate, use case and site. End Month 5.
8. Draft ITT issued to manufacturers for Beta for feedback. Success Criteria: ITT specifies the scope of work, draft technical specification and collaboration arrangements (including confidentiality and IPR) with evidence of engagement through Letters of Support. Initial supplier feedback collected. End month 6.

Unique skills and capabilities of each of the partners and support for the work packages:

- SSEN-T: Project management and development of the counterfactual case based on experience and knowledge of the current transmission network.
- National Grid ESO: Knowledge of the current transmission network, constraint markets and responsible for developing the strategic direction for the future network that will inform the relevance of DCCBs.
- SSEN-T, National Centre HVDC: Deep expertise of HVDC and resources for the simulation and testing of DCCBs in real-time.
- National Grid Ventures: Experience with network models and validation of models providing a peer check on complex simulation models.
- Edinburgh University: Experience with open-source models and Simulink providing a richer dataset for potential OEM suppliers with suitable equipment.
- SuperGrid are a new partner who can provide linkage to European networks and research and expertise in efficient DC architecture and design.

- Carbon Trust and Renewable UK provide expertise in the policy and regulatory environment, identifying risks and enablers to the implementation of DCCBs.

We expect to involve OEM's in Alpha Phase and non-disclosure agreements are currently in progress.

Payment milestones: We would require 50% of funding at the start of the project and 50% at the halfway point, end of Month 3, a more detailed schedule and a payment plan will be developed before the start of the project (1st of August).

Regulatory Barriers (Not scored)

The key regulatory uncertainty is the lack of commercial arrangements for wind developers to share hubs and common points of connection. For the DCCB hub use case to be credible, this would need to be developed by Ofgem outside of the project. Clarity of roles around the ownership and operation of shared connections (in this case DCCB hubs) are required. Ofgem's progress on this front may influence the commercial benefit perceived by Offshore Transmission Operators and wind farm developers in the Beta Phase. The forwarding looking commercial arrangement would also impact the calculated CBA.

To address this barrier, The Carbon Trust and RenewableUK will develop potential commercial models for consideration and recommendations for the regulatory changes that would be required to unlock these opportunities. This work package will engage relevant stakeholders to understand their concerns around the current commercial arrangements and the key points that will be required to be defined by Ofgem, versus those that could reasonably be left to the market to define on a case-by-case basis.

Other influences of regulation on the project are associated with regulatory assumptions. These will be monitored throughout the project and will be assessed for their impact on the project. These are not currently barriers to the project outcomes. These assumptions are:

- Amendment of largest infrequent loss of infeed in the SQSS to 1800MW;
- Amendment of UK engineering standards appropriate for the design and use of DCCBs;
- Offshore HVDC links remain part of the main Interconnected Transmission System; and
- Outcome of Offshore Transmission Network Review does not prefer a model within which it would be challenging to implement DCCBs.

Business As Usual

The use case for DCCBs in the UK depends on the overall policy strategy for the UK future network (being reviewed by NGESO in the Network Planning Review). However, it is reasonable to assume that DC networks will be required to allow efficient transmission of electricity from remote wind farm areas to areas of high demand.

In more recently released Government documents, BEIS has recognised the potential for Multi-Purpose interconnection (MPI) in realising the renewable energy target [1] [2]:

'The deployment of both cross-border interconnection and offshore wind is important in reaching net zero emissions by 2050, both for the UK and for our North Sea neighbours. By combining the functions of offshore transmission and cross-border interconnection, MPIs have further potential benefits when compared to the counterfactual (conventional interconnection deployment).'

'These potential benefits include reducing the number of landfall points of onshore grid connections, and therefore the environmental and local community impacts, reducing the capital and operational costs, alongside reducing the curtailment of wind with associated benefits of higher infrastructure utilisation rates.'

The deployment of DCCBs will be a critical part of creating flexible MPIs whilst ensuring system stability. This project aims to offer an option for DCCBs to become BAU as a feasible option in the design of the UK networks by:

1. developing a supply chain of multiple vendors able to supply DCCBs;
2. ensuring that existing DDCB designs are practical or can be adapted to address GB network conditions;
3. determining the cost of DCCBs and the associated equipment;
4. validating the ability of equipment to isolate faulted sections in response to the majority of credible faults without relying on conventional, slower back-up protection; and

5. ensuring that there is no significant integration issues with current design conventions which wind developers, Transmission Owners, Offshore Transmission Operators (OFTOs) and interconnectors are familiar with; and that there is no significant regulatory or commercial barriers to the development of onshore HVDC hubs.

To facilitate DCCBs becoming BAU, this project brings together expertise in HVDC, including the cross-industry funded National HVDC Centre. We are also introducing European experience and insights with SuperGrid becoming a partner. NGESO will provide UK national strategic insights on the future network. Carbon Trust and Renewable UK will help identify policy and regulatory challenges and enablers. Edinburgh University will bring broader international experience and knowledge of open source DCCB models. The project will engage with the supply chain and NDAs are now in progress so that OEMs can participate in the Alpha and Beta phases.

The fastest route to market is demonstrating the suitability of DCCBs through real-time simulation in the HVDC centre and working with OEMs and National Grid ESO to agree on standards and specifications for DCCBs. This partnership is likely to set the standard for the development of future offshore and onshore grids using DCCBs to help secure safe and reliable MPs.

The adoption of DCCB's in BAU depends on the direction of grid design topology, but in discovery we have identified that DC is very likely to be a component of this topology. National Grid ESO are of a view that the most likely opportunity window is between 2030 and 2040 for the implementation and the construction of DCCBs. However, for DCCBs to become an optional element in planning the future grid, this project must prove the use case and set the standards so the supply chain can develop the capability to service any future UK market for DCCBs.

Commercials

Commercialisation

To maintain a competitive market, the Alpha phase of this project will work to engage multiple suppliers to obtain balanced market views. This approach will help support a supplier-agnostic development of the specification for DCCBs during Alpha Phase and Beta Phase, which would be suitable for the GB system, keeping supplier options as open as possible for implementation and avoiding vendor lock-in. Engaging suppliers as collaborators rather than project partners allows their input to inform the project whilst preventing the approach from being locked into a specific supplier's solution, thereby maintaining competition.

The primary benefits of implementation of DCCBs to wind farm developers, networks owners/operators and consumers have been set out in the Cost Benefit Analysis summarised in Section 3. DCCBs will facilitate efficient and reliable connection of renewable energy and would be considered a critical part of the overall network design

The value to the consumer includes:

- cost reduction,
- increased security of supply and
- reduced environmental impact.

The government's offshore wind generation capacity targets cannot be achieved without the development of DC networks. In any DC network topology, DCCBs will be essential for ensuring a safe, reliable, and resilient supply of clean wind energy while also minimising the overall size of the network and limiting capital expenditure, thus guaranteeing the best value for the consumer.

While the technology is still novel, there are several different supplier commercial models. These need to be monitored and considered during the Alpha and Beta stages of development. While some suppliers offer a complete solution for HVDC systems, others are limited to a DCCB equipment supply option only. There are also questions about compatibility between different supplier DCCBs and more expansive HVDC systems. To maximise the market options available for any implementation and encourage competition, we would anticipate that smaller DCCB-specific suppliers would look to collaborate with larger HVDC system suppliers to ensure compatibility between different suppliers and flexibility in solutions.

With commercial models for implementation to be explored in the Alpha phase, it will be important to understand the regulatory and commercial possibilities for delivering the first implementation. The CBA indicates that most benefits are achieved at a system operation level through reduced requirements for ancillary services. The current system of OFTOs would imply that the investment decision for DCCBs could sit with developers, who are not incentivised by the benefits.

The UK has a foothold in HVDC manufacturing and testing. Whether through joint project experience with DCCB suppliers, go-to-market arrangements with DCCB suppliers, technology licensing, or acquisitions, growth in contract wins will create new jobs. As a result, setting a specification and enabling the first implementation of a DCCB in the UK would open up opportunities for all suppliers,

including those in the UK.

Intellectual Property Rights (Not scored)

We will set out the IP management in the project collaboration agreement, consistent with the SIF Project governance document issued by Ofgem. All partners will sign the collaboration agreement and therefore IP will be agreed prior to the start of the project. This follows the practice that was used in the Discovery Phase.

- We will maintain an IP register throughout the project and monitor, identify and record any IP issues.
- SSEN will employ well-developed IP management processes implemented extensively on multiple NIA/NIC and other collaborative R&D projects.
- The IP register will be used to record background and foreground IP at the beginning and end of the Alpha phase.
- All IP issues will be formalised in a Collaboration Agreement (CA) that deals with all aspects of ownership and use of IP and the management arrangements for the project. A final CA that comprehensively addresses the IP issues will be agreed upon by all consortium members before the commencement of the project.
- IP issues associated with background IP of any OEM remain background IP and will be managed through appropriate legal agreements, in the first instance non-disclosure agreements.
- All project results will be owned by the partner organisations.
- Based on the collective experience of the partners and the background knowledge/IPR they possess, we are confident that we can effectively protect and exploit the project results.

The design, development, and installation of DCCBs are expected to operate under normal market competition, assuming that the development of the future network creates demand. Therefore the design and operation of DCCBs would be considered to be 'background IP' belonging to the OEMs.

This project is designed to demonstrate the feasibility of using DCCBs and through testing, de-risk their use in the UK market by advising technical and regulatory standards that would need to be in place to stimulate market demand for DCCBs. This will give OEMs confidence to invest in further development. Demonstration of feasibility and resulting technical standards are considered to be foreground IP and will be disseminated in publicly available reports. All the partners are aligned on this approach. OEM primary interest will be the protection of DCCB design and operation software, considered background IP. OEM will be supportive of the dissemination of technical standards that derisk deployment of DCCBs as it will support the development of a commercial market for DCCBs in the UK.

Therefore this project complies with IPR as set out in Chapter 9 of the SIF governance document:

- Background IP:
 - o DCCBs would be available to purchase on a competitive market basis.
 - o Relevant black-box models would be made available by OEMs allowing design of HVDC circuits that include DCCBs.
- Foreground IP
 - o Relevant foreground IP relating to testing, feasibility, and proof of concept, including all simulation results, will be made freely available to interested UK parties and reports will be made available to UK transmission operators (current and future).
 - o Information and methods, results and insights developed from this project will be available for publication by the academic project partners, and the project partners would encourage such publication
 - o Other than DCCBs available for purchase on a competitive market basis, we do not anticipate that this project will create IP that creates revenue from a license, since the main purpose of this project is to stimulate the market to allow OEM to invest in commercial DCCBs

Costs and Value for Money

The total eligible costs for the project phase is £491,905. We are requesting £423,473 of funding. A total 14% contribution will be met by the partners investment in the project from in kind contributions sanctioned by each partner's internal governance process. SSEN

are contributing £28,715. If this project is not funded by SIF, SSEN would spend money on incremental BAU activities that would have a less significant impact on benefits to consumer compared to this project.

SSEN-T are requesting £258,439 of funding to lead this project and manage the delivery of work. Of this amount, £88.5k will be allocated to consultants for coordinating design parameterisation for DCCBs, and ensure that basic rating parameters are discussed and agreed with partners. They will also update of the Cost-Benefit Analysis, including revised CAPEX, CBA calculations and produce a CBA report.

The remaining funding requested of £165,035 will be spread across 6 of the project partners. National Grid Ventures and RenewableUK will provide their costs in-kind (£18,170 and £7,850, respectively). These partners' role will be to support Mott MacDonald in developing and delivering the two work packages, the preparation for ITT and the CBA, and providing expert insight to enable the final analysis.

The Network-DC project proposal is developed to complement and be additional to SSEN-T BaU activity. The BaU approach to transporting high voltage electricity from the point of offshore connection has evolved to support the design of the current network. However, DCCB will provide additional value by refining the existing system design providing greater capacity recognising the potential for HVDC transmission to deliver energy security at a much-reduced cost to the consumer.

Mott MacDonald as subcontractor will support the CBA. The CBA requires inputs of up-to-date costs from across the industry and our abilities to reach this detail effectively within the Alpha project timeline will be challenging. Also, the development of the route map requires specialism in understanding the technical aspects and the economic components of the end-to-end solution. Experience from past projects has proven it practical to utilise consultancies as a supporting function in developing unique business cases. Mott MacDonald has access to a broad range of expertise and can produce high-quality work within specific deadlines.

Our procurement strategy is developed from an extensive review of procurement process that supported the T2 business plan and was approved by Ofgem. Using this process, we have chosen Mott MacDonald to deliver both the CBA and the route map of FEED. Mott Macdonald are a global engineering, management, and development consultancy with a dedicated HVDC team with extensive experience in this field. This can be seen through the work they supported on SSEN-T's Caithness-Moray project. They also have experience in delivering CBA on regulated innovation programmes, where they supported SSEN in the development of the TRANSITION Network Innovation Competition project.

The work includes use of the National HVDC centre, including advanced simulation equipment. We estimate that the commercial value of using the HVDC centre is £357,000. This type of work cannot be duplicated elsewhere in the UK. Edinburgh University and SuperGrid provide specialist expertise. Edinburgh will give support to simulation with the development of Open-Source DC Circuit Breaker Models. SuperGrid will add value by providing an experience in protection system design and techno-economic evaluation of the DC network switching station for the GB use case.

The costs submitted in the budget are in full accordance with the terms set out in the UKRI costs guidance. Therefore, these are cost rates without profit and offer more competitive rates than standard industry rates that the partners apply for commercial work.

Supporting Documents

Documents Uploaded Where Applicable

Yes

Documents:

Appendix Q3 - Network-DC Cost Benefit Analysis.pdf

Appendix Q4-1 - Network-DC Project Plan.pdf

Appendix Q4-3 - Network-DC organogram.pdf

SIF Alpha Project Registration 2022-09-30 1_14

UKRI 10035946 Networ-DC (DC Breakers) Summary Report (public).pdf

SIF Alpha Project Registration 2023-03-29 11_12

10036946 SIF Alpha Close Down Report 2023-03-29 11_12

SIF Alpha Project Registration 2024-02-15 3_26

This project has been approved by a senior member of staff

Yes