Scottish & Southern Electricity Networks
TRANSMISSION

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

May 2026

Project Reference Number

NIA_SHET_0059

Project Registration

Project Title

FAST DC

Project Reference Number

NIA_SHET_0059

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

April 2026

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Brant Wilson - Innovation Portfolio Manager

Project Budget

£435,515.00

Summary

FAST DC develops a vendor-agnostic framework to enable advanced studies of multiterminal high-voltage direct current (HVDC) grids, with a strong focus on the modelling and system-level assessment of DC circuit breakers (DCCBs). As HVDC networks evolve from point-to-point links to complex DC grids, effective and selective DC fault protection becomes a critical challenge. FAST DC builds on prior Network DC SIF work to deliver high-fidelity electromagnetic transient (EMT) models, real-time field-programmable gate array (FPGA) based simulation capabilities, and new analytical methods to evaluate advanced DCCB functionalities such as proactive interruption, current limiting, selectivity, and post-fault stabilisation. The project will produce open-source models and evidence-based guidance to improve DC grid resilience, reduce reliance on proprietary tools, and support future multiterminal HVDC hubs and interconnectors.

Preceding Projects

10067854 - Network-DC Circuit Breakers

Third Party Collaborators

University of Edinburgh

Nominated Contact Email Address(es)

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Problem Being Solved

As HVDC systems evolve from point-to-point links to multi-terminal (MT) grids, new technical challenges emerge. MT DC grids deliver improved flexibility, resilience and security, and cost efficiency, but they require effective DC fault protection. Unlike AC systems, DC networks lack natural current zero-crossings, making fault interruption significantly more complex.

DC circuit breakers (DCCBs) provide ultra-fast fault isolation and remain a developing technology, with deployment at transmission-level voltages in China but not yet in GB or Europe. These DCCBs also require "selectivity" in protection, as on the AC system, to inform which circuit breakers should act based on the fault location. However, given the speed that DCCBs need to operate, the protection methods are also still developing, as are the concepts for managing other equipment within the DC system through the fault and post-fault period of operation. Fortunately, DCCBs are capable of several advanced functions that can support these areas. While DCCBs are essential enablers for future multi-terminal DC hubs, their advanced functions remain poorly understood at the system level. Most studies still treat DCCBs as simple "open–close" devices and rely on conservative assumptions for DC reactor sizing and protection speeds. Study of advanced functions is also important to be able to approach the procurement of DCCBs in a vendor agnostic way, to be confident that the different vendors involved in DCCB technology, as opposed to HVDC converters, can be accommodated into a developing DC network.

Current understanding and approaches:

- Provide little evidence on the system value of advanced DCCB features such as proactive operation, active fault current limitation, improved selectivity of DC fault protection, and DC current and voltage stabilisation.
- Will restrict DC hub capacity.
- Lead to larger DC reactors than are likely to be necessary.

It also leaves open the potential value of dynamically adjusting breaker capability after internal failures so that, even in a degraded state, the device can still make a useful contribution to fault clearance.

Currently planners and manufacturers have little basis on which to optimise converter control, DC protection philosophy or hardware specifications for these advanced breakers, such as maximum fault-current capability, transient interruption voltage and fault-clearance energy. Cost-benefit assessments for DCCB-enabled hubs still rest on simplified models and sparse operational experience. Simulation and analysis are limited by the available modelling methods and resources.

Method(s)

System Level Assessment Framework

Studies will be carried out using detailed generic models developed from publicly available information and reviewed by experienced staff of University of Edinburgh and HVDC Centre. The review process will endeavour to ensure these models cover a wide range of hardware and control options with sufficient resolution to capture the required range of practical behaviours, with particular focus on advanced breaker functionalities.
The Network-DC electromagnetic transient (EMT) models will be extended to represent, in a consistent way, proactive interruption, active limitation of fault current, DC current and voltage-stabilising actions, and the dynamic adjustment of breaker capability following internal failures. A suite of studies will capture the sequence from fault inception, through advanced-function DCCB operation, to post-fault recovery and reconnection of offshore wind farms for a variety of DCCB hardware and control options.

Analytical Framework Development

In the latter part of the project, preliminary work will be undertaken to develop an analytical, multi-stage frequency domain framework analysis for DC fault-current specification, preventing reliance solely on full EMT studies. This will inform potential follow-on work that would enable analytical modelling of the DC fault transient in a realistic hub.
The analytical work will inform realistic protection and DC circuit breaker requirements, including DC fault current and energy specifications that reflect advanced DCCB functionalities. Testing of the analytical method will support assessment of its applicability to other aspects of DC grid behaviour with potentially wide-ranging implications.

Detailed DCCB Model Development

In parallel with system-level modelling, there will be further development of the detailed DCCB models produced in Network-DC. Existing models for use in real-time simulation studies are often very simplified models, such as a switched resistance, which cannot capture the advanced DCCB functionalities such as current-limiting and active oscillation damping.
There is also the need for operations such as failed breaking and reclosing to be accurately captured to properly assess transient interruption voltage magnitudes and backup protection strategies in DCCB-enabled hubs.

Real-Time Simulation

To enable real-time network studies, we will develop real-time models of DCCBs that can be implemented in low-cost real-time simulator platforms at small time-steps. To enable the low simulation time-steps required to model advanced functionalities, this will be performed on FPGA.
The FPGA-based real-time "DC Breaker Box" will be interfaced with existing Real Time Digital Simulators (RTDS) at the HVDC

Centre over fibre‐optic links, enabling systems with multiple detailed DCCB models to be implemented, with DCCB topology and performance
adjustable within real‐time system studies. Demonstration of this approach will inform the design of future real‐time simulation platforms and test environments.

Data Quality Statement (DQS):
The project will be delivered under the NIA framework in line with OFGEM, ENA and SSEN Transmission internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the
best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring access control, backup, and version management. Deliverables will be shared with other network licensees through the closedown reports on the Smarter Networks Portal.

Measurement Quality Statement (MQS):
The methodology used in this project will be subject to supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

In line with ENA's Energy Networks Innovation Process (ENIP) document, the cumulative risk score is scored as 5 = LOW from the sum of the risk thresholds below:

TRL Steps – 1 TRL Steps – Low (Score 1)
Cost – <£1m – Low (Score 1)
Number of suppliers – 2 – Low (Score 1)
Data – Defined assumptions and principles – Medium (Score 2)

Scope

The FAST DC project aims to develop a framework for advanced studies of multi-terminal DC grids, focusing on the modelling and assessment of DCCBs with advanced functionalities to improve grid resilience and protection.

Objective(s)

- Open-source, generic EMT model package for advanced-function DCCBs
- A detailed system-level assessment report and supporting study archive that compares advanced-function DCCBs with alternative implementation
- Expanded FPGA models of the Hybrid DCCB model with advanced functions
- Validation of real-time HVDC operation using open-source FPGA-based DCCB models, demonstrated on RTDS system at the National HVDC Centre.

Consumer Vulnerability Impact Assessment

An assessment of distributional impacts (technical, financial, and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative, or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register. This project has been assessed as having a neutral impact, meaning that it does not have any effect on customers in vulnerable situations. This is because it is a Transmission project.

Success Criteria

The project will be deemed as successful if all items in the scope, objectives and learnings are met which can be used to increase the understanding the impact of DCCB's will have on the GB network.

Project Partners and External Funding

The project will be undertaken using NIA funding by Scottish Hydro Electric Transmission supported by Contractors. -

National HVDC Centre
The National HVDC Centre will provide subject matter expertise in HVDC design and simulation. The Centre has state-of-the-art computer cluster equipment that is unavailable elsewhere.

University of Edinburgh

The University of Edinburgh will be contracted and bring technical electrical engineering expertise and detailed knowledge of opensource DCCB models that can be used in the simulation.

Potential for New Learning

Build on the modelling foundations created by the Network DC SIF project, the FAST DC project will develop learning in the following areas:

- Enhanced, vendor agnostic EMT and real time models of DCCBs.
- A comprehensive system level assessment framework for advanced breaker functionalities.
- A suite of studies capturing full DC system behaviour from fault inception to post-fault recovery.
- Analytical methods to complement EMT studies and better specify protection and breaker requirements.

Realtime FPGA based DCCB models ("DC Breaker Box") enabling detailed real time simulation and benchmarking.

Learnings from the project will be disseminated via internal and external stakeholder events which will be conducted during, and following the completion of the project. The learnings will also be shared within the annual project report and at relevant dissemination events such as the Energy Innovation Summit Conference.

Scale of Project

The FAST DC project has a duration of 12 months and is deliberately scoped to deliver maximum learning and system insight at proportionate cost. The project scale is sufficient to enable rigorous system-level assessment of advanced DC circuit breaker functionalities without extending into costly physical deployment or live network trials.

Over the course of the project, targeted modelling, analytical development and real-time simulation activities will generate transferable knowledge that advances industry understanding of multi-terminal HVDC grid protection and resilience. The scale allows comprehensive exploration of fault behaviour, protection selectivity, and post-fault recovery across representative DC hub configurations, while remaining focused on evidence generation rather than asset delivery.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project will be undertaken at the University of Edinburgh, and the National HVDC Centre in Cumbernauld.

Revenue Allowed for the RIIO Settlement

No allowance has been made for this type of development within the RIIO-T3 settlement. No savings are expected during project implementation; future savings may be possible depending on the outcomes of the project and the future adoption of the learnings.

Indicative Total NIA Project Expenditure

The total expenditure for the project is expected to be £435,515. 90% of which £391,964 is allowable NIA expenditure.

Project Eligibility Assessment Part 1

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

The FAST DC project facilitates the energy system transition by addressing a critical technical barrier to the development of future electricity networks: the protection, resilience and operability of multiterminal HVDC (MTDC) grids, which are essential to integrating large volumes of low carbon generation and interconnection.

The transition to a net zero energy system requires increased deployment of offshore wind, multipurpose interconnectors and DC hubs, all of which rely on scalable and resilient HVDC infrastructure. While MTDC grids offer significant flexibility and efficiency benefits compared to point to point HVDC links, their deployment is currently constrained by uncertainty around DC fault protection and DC circuit breaker (DCCB) performance. FAST DC directly addresses this constraint by developing system level understanding and modelling capability for advanced DCCB functionalities, enabling confident progression toward more complex DC networks.

By delivering vendor agnostic, open-source EMT and real time models, the project reduces reliance on proprietary OEM tools and enables consistent, transparent assessment of alternative DC grid architectures and protection philosophies. This supports faster and lower risk decision making for future HVDC projects that are fundamental to decarbonisation, including offshore wind integration and cross border electricity trading.

The project also facilitates the energy system transition by enabling more efficient and resilient network designs. Improved understanding of advanced DCCB functionalities, such as proactive interruption, active fault current limitation, selectivity support and postfault stabilisation allowing for a more realistic specification of breaker capability and DC reactor sizing. This reduces overengineering, lowers whole system costs and improves network availability, all of which are essential to delivering affordable low carbon electricity to consumers at scale.

Furthermore, the development of FPGA based real time simulation capability provides a practical and cost-effective platform for testing future HVDC protection concepts under realistic operating and fault conditions. This accelerates learning, derisks future innovation and supports timely deployment of new technologies required for the transition to a smarter, more flexible electricity system.

How the Project has potential to benefit consumer in vulnerable situations:

Not applicable

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved

n/a

Please provide a calculation and/or description of the expected benefits of the solution

The FAST DC project provides qualitative benefits that support both the business and the wider energy system. Although primarily focusing on research, FAST DC offers several meaningful value pathways that reduce long-term system costs, enhance reliability, and support strategic decision-making for future HVDC investments.

1. Avoided Over-Engineering and More Cost-Effective Specifications
By improving the modelling and understanding of advanced DCCB functionalities, the project helps avoid overly conservative design assumptions, such as unnecessarily high reactor sizing or excessive breaker capability, leading to more efficient, evidence-based

specifications. This reduces future capital expenditure for DCCB-enabled HVDC hubs and multipurpose interconnectors.

2. Lower Bills for Consumers

Better-informed specifications, reduced technology lock-in risk, and more efficient protection designs ultimately support lower network development costs, which feed through to reduced consumer bills over time.

3. Strengthened System Security and Reliability

Realistic, system-level breaker modelling and real-time simulation capability improve understanding of how DC grids behave through faults and recovery. This enhances security of supply for offshore wind integration, interconnectors, and future DC hubs, reducing operational risk and improving network resilience.

4. Better Quality of Service

Delivery of open-source EMT and real-time DCCB models reduces dependence on proprietary OEM tools, improving transparency, flexibility, and the quality of planning decisions. This leads to more robust control and protection strategies before assets are deployed.

5. Broader Real-Time Simulation Capability

The FPGA-based DC Breaker Box strengthens SSEN's real-time testing capabilities and can be adapted for other technologies, creating future cost savings and enabling more effective validation of network innovations.

6. Societal and Strategic Benefits

FAST DC accelerates progress toward Net Zero by enabling scalable, flexible DC grids capable of integrating large volumes of offshore wind. Its open-source outputs also support wider industry learning and future standards development, delivering value far beyond the immediate project partners

Please provide an estimate of how replicable the Method is across GB

The learnings are not limited to Scottish Hydro Electric Transmission, all transmission and distribution network operators across GB could benefit from this research work.

Please provide an outline of the costs of rolling out the Method across GB.

This research project is at low TRL level, consequently the costs for rolling out the method across GB network are not fully defined. If this project is proven, then there is the potential to use the outputs of the project for other TO's to conduct further tests. The costs would be dependent on the proven solution and on-site requirements.

Requirement 3 / 1

Involve Research, Development or Demonstration

Projects must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

Involve Research, Development or Demonstration - Please select all that apply

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☑ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☑ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

The FAST DC project will generate learning that can be directly used by GB electricity transmission and distribution Network Licensees to support planning and design of future HVDC-enabled networks.

The project will deliver vendor-agnostic, open-source EMT and real-time models and system-level evidence on advanced DC circuit breaker (DCCB) functionality. This learning can be applied by Network Licensees to improve DC protection philosophy, inform realistic
specification of breaker capability and DC reactor sizing, and reduce reliance on proprietary OEM tools when assessing future multi-terminal HVDC schemes.

By improving understanding of DC fault behaviour, protection selectivity and post-fault recovery at a system level, the project supports more resilient, cost-effective HVDC network designs. The learning will also inform future technical standards, specifications and planning guidance, enabling consistent application across the GB electricity transmission system as DC infrastructure is deployed at scale to support decarbonisation.

n/a

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed. Networks must explicitly mention similar projects that they have considered and how these differ.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

No project similar to the one being proposed here is currently being conducted, nor are there any currently being planned.
The Network DC SIF project has explored performance and specifications for DCCB design and integration. The goal was to produce functional specifications and supporting information that will support NESO and Transmission Owners (TO) in GB being able to recommend and procure DCCBs in future network designs. However, the Beta phase of the project was halted before this work could be completed.
The FAST DC NIA project will complete the outstanding work on advanced DCCB modelling led by the University of Edinburgh in the Network DC project. The SIF Network DC project will have completed prior to the FAST DC NIA project beginning.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

Not applicable.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

The FAST DC project is innovative because it goes beyond business-as-usual HVDC studies by developing vendor-agnostic, system-level models and analytical methods to assess advanced DC circuit breaker (DCCB) functionality in multi-terminal DC grids—an area that is not yet proven or standard practice in GB. It introduces new modelling, analytical and real-time simulation approaches, including functional representations of advanced breaker behaviour and FPGA-based real-time evaluation, to address a key technical uncertainty that currently limits the deployment of resilient, cost-effective DC networks. By generating evidence where operational experience is limited and the business case is unproven, the project de-risks future HVDC investment decisions and enables learning that cannot be obtained through routine network planning activities.

Relevant Foreground IPR

Any foreground IP created, and any background IP used will remain property of the creating party. IP arrangements are as required of the NIA Governance.

Data Access Details

For information on how to request data gathered in the course of this project, see Strategic Innovation Fund (SIF) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://www.ssen-transmission.co.uk/about-us/innovation/.

Additionally, data from this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the Strategic Innovation Fund (SIF) can be found or requested in the ways listed below:

- Via the Smarter Networks Portal at: https://smarter.energynetworks.org. To contact select a project and click 'Contact Lead Network'. SSEN Transmission already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at: Innovation - SSEN Transmission (ssen-transmission.co.uk)
- Via our managed mailbox: transmissioninnovation@sse.com

Please identify why the Network Licensees will not fund the project as a part of it's business and usual activities

NIA has been deemed the best method of supporting the delivery of this project. Development projects funded by NIA give suitable financial support to investigate areas for potential development that could not be funded by business-as-usual as no allowance was made in the RIIOT2/3 settlement.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks (e.g. commercial, technical, operational or regulatory) associated with the project

The FAST DC project can only be undertaken with NIA support because it is speculative in nature, with an unproven business case and no guaranteed short-term commercial return. The project focuses on developing and validating new modelling, analytical and real-time
simulation approaches for advanced DC circuit breaker (DCCB) functionality in multi-terminal HVDC grids, an area where there is limited operational experience and no established industry practice.

The project carries significant technical risk, as advanced DCCB functionalities and their system-level impacts are not yet proven and may not deliver the expected benefits. It also carries commercial risk, as the outputs are learning, tools and evidence rather than deployable assets, with benefits accruing to the wider GB electricity system rather than a single Network Licensee.

Given the uncertainty, lack of immediate financial return and the fact that the work goes beyond business-as-usual network planning activities, the project would not proceed without NIA funding. NIA support is therefore essential to enable this learning to be generated and shared for the benefit of consumers and the wider industry.

This project has been approved by a senior member of staff

☑ Yes