SIF Round 3 Project Registration

Date of Submission

Apr 2024

Project Reference Number

10103531;NGET/HIRE/SIFWSPFAR/Rd3_Discovery

Initial Project Details

Project Title

HIRE - Hybrid Network Improvement and Reliability Enhancement

Project Contact

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Challenge Area

Whole system network planning and utilisation to facilitate faster and cheaper network transformation and asset rollout

Strategy Theme

Data and digitalisation

Lead Sector

Electricity Transmission

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

NGET - National Grid Electricity Transmission

Funding Licensee(s)

NGET - National Grid Electricity Transmission

SSEN - Scottish Hydro Electric Transmission

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

Scottish and Southern Electricity Networks Transmission

Technology Areas

Asset Management

High Voltage Technology

HVDC

Maintenance & Inspections

Condition Monitoring

Measurement

Network Monitoring

Digital Network

Electricity Transmission Networks

Project Summary

Offshore wind energy is pivotal for the UK's net zero grid ambitions, increasingly, cable failures pose financial and reliability challenges for new and existing projects. New, innovative condition monitoring can improve the commissioning and operation of offshore cables to mitigate the risk of failure and overcome the limitations of existing techniques (e.g. maximum cable length). In this project, we will research state-of-the-art monitoring techniques, including for temperature, vibration and integrity of electrical insulation. The aim is to create an integrated monitoring system, aiding network operators in decision-making for a more flexible grid and robust commissioning practices.

Add Third Party Collaborator(s)

The University of Manchester

DNV

High Voltage Partial Discharge Limited

Project Budget

£151,059.00

SIF Funding

£135,082.00

Project Approaches and Desired Outcomes

Problem statement

Offshore wind energy is central to the UK's ambition net zero electricity grid ambitions. Offshore wind developers have experienced an increasing number of cable failures well ahead of the anticipated cable life expectancy. In 2021, cable failures at a developer resulted in a forecasted impact of £351 million for replacing faulty inter-array cables. The commissioning and operation of offshore transmission networks is therefore vital to ensure that connecting cables are reliable and used to their full capacity.

The increasing growth of offshore power generation has elevated the voltage of array cable networks from 33kV to 132kV, thus requiring greater reliability from the connecting power cables. The typical cost of an offshore cable installation is more than £220 million for a 1GW wind farm, with installation vessels costing ~£90k/day. In light of these costs, cable commissioning testing is an important tool to ensure integrity and identify damage during installation.

Existing approaches to condition monitoring are less viable for the longer cable lengths typical of new installations of AC/DC cables. The increased voltage levels and cable lengths used in offshore networks and the space and weight constraints in offshore platforms have led to the desire to investigate new testing technologies.

In addition, the utilisation of techniques such as dynamic thermal rating systems is part of a larger suite of smart grid technologies that require improved cable monitoring. Although substantial studies have been performed on overhead lines and cables, there are fewer studies on potential risks posed to interfaces within cable joints and how to monitor for these risks.

An investigation is needed to review potential approaches to monitor temperature, vibrations and the integrity of electrical insulation. The aim is to develop representative testing methods and establish the thermal, mechanical and electrical limits for interfaces within existing cable systems. Other electrical testing techniques will be explored, including time and frequency domain reflectometry. The knowledge generated will aid network operators in their decision-making for a more flexible grid operation instead of relying on costly uprating of existing infrastructure. While also facilitating the development of robust commissioning programs for cable construction and replacements to prove the integrity of installations.

This project addresses Innovation Challenge 1. In particular, in developing an integrated monitoring system that improves the prognostics of future generations of hybrid AC/DC electricity networks, we will minimise outages and maximise the use of renewable energy for UK plc to maximise existing network capacity.

Video Description

https://www.youtube.com/watch?v=RNWeDBHbm4Q

Innovation justification

In the UK, there is currently a total offshore wind pipeline of around 77 GW across 80 projects that are either in construction, consented, in development and planned in future seabed leasing auctions. In addition to newly built wind farms, there are planned cable replacements in the offshore wind industry due to known issues with the undersea cable protection system.

International standards and industry guidance are often not aligned with commercially available equipment, leading to various approaches for high-voltage DC testing at cable commissioning. The safety and operational implications from a measurement perspective are also not well understood when projects are specified, leading to inferior field measurements that offer little value to asset owners.

Offshore wind farm operators make critical decisions on the test voltage waveform to use during commissioning testing based on technology available on the market, cost of equipment, and space at the wind turbines or offshore substations. To target the offshore commissioning testing market, the ability to work with all test voltage waveforms is key and is a core innovative aspect of the project that will be an essential part of any testing techniques developed.

This project complements and builds upon previous innovation projects related to condition monitoring. Previous projects have tended to explore individual electrical testing techniques. A novel aspect of this project is the consideration of multiple techniques, including partial discharge and time and frequency domain reflectometry (current TRL 2-5). An integrated solution could help to overcome issues around certain techniques not being suitable for longer cable lengths and to filter out reflections that are not from the cable itself during operation.

Our project is well aligned with the SIF objectives and, in particular, the sequence of the SIF stages. Following a successful Discovery Phase, in Alpha, we intend to conduct laboratory-scale testing on a rig at Deeside Innovation Centre to test the feasibility of new methods for assessing cable health and increase the TRL. This testing will provide data to inform the predictive abilities of the integrated monitoring solution and increase the knowledge about the costs and benefits of the novel condition monitoring system. The Beta Phase will then be a large-scale demonstration of the novel condition monitoring methods, for instance, by installing it on an in-situ section of the network to understand performance in a live operating environment.

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum for users of network services

Environmental - carbon reduction – indirect CO2 savings per annum

Revenues - improved access to revenues for users of network services

New to market – products

New to market – processes

New to market - services

Impacts and benefits description

Future reductions in the cost of operating the network

Improved monitoring methods will allow earlier identification of damage to cables to ensure networks are safe and reliable, avoiding dangerous and costly, unplanned outages. These methods allow networks to carry out preventative maintenance, which lowers costs compared to isolating an area of the network with a failure and waiting for the next planned outage to carry out the repair.

Cost savings per annum on energy bills for consumers

Interconnectors give the UK access to cheaper electricity from abroad. National Grid estimates that hitting the UK government’s ambition of 18 GW of interconnector capacity by 2030 would save UK consumers up to £20 billion between now and 2045. This estimated benefit is only plausible if we can ensure that DC interconnectors are reliable and do not suffer from premature failure. Additional repair costs elevate the costs of insurance premiums, as seen recently for the BritNed interconnector after multiple cable faults caused outages of up to 90 days.

Indirect CO2 savings per annum

By 2030, National Grid estimates that 90% of the electricity we import from mainland Europe via National Grid interconnectors will be from zero-carbon sources. The interconnectors will help Britain prevent over 100 million tonnes of carbon emissions before 2030. By effectively monitoring the condition of these interconnectors during both commissioning and operation, we can ensure they are reliable and deliver their intended environmental benefits.

Improved access to revenues for users of network services

Offshore wind developers and OFTOs will also benefit from the earlier identification of damage from improved condition monitoring, particularly in light of the high cable replacement costs. Export and array cables can take up to 6 and 2 months, respectively, and cost between £25-50 million per export cable and £4-5 million per array cable. In 2016-2017, the DolWin 2 offshore grid connection project saw a £375 million loss of revenue due to defective cable joints onshore.

Products, processes and services

The development of new electrical and mechanical-based monitoring instruments promises to detect earlier signs of insulation degradation. This project will determine the suitability of frequency and time domain reflectometry or line impedance monitoring for this application. Following the project's successful conclusion, Monitra could look to offer new commissioning and operational testing techniques for DC cables to TOs that help evaluate cable health over long distances and identify signs of progressively deteriorating conditions.

Teams and resources

Our Project team comprises transmission owners, academia, techno-economic assessment experts and HV asset monitoring specialists.

The lead partner is National Grid Electricity Transmission (NGET) which brings significant existing knowledge of Transmission network assets and the management of HV transmission assets, in particular cables and methods related to cable monitoring. The Deeside Centre for Innovation, owned by NGET, also offers an opportunity for testing in future project phases. NGET will be supporting all work packages and providing oversight and control over the project as a whole.

SSEN Transmission offers the perspective of a second transmission licensee. SSEN will provide support and input across all work packages.

The University of Manchester (UoM) is the sole academic partner of this project. They have world renowned capability in high-voltage testing and hosts the UK’s largest academic high-voltage laboratory that test up to 600kV DC, 800kV AC, and 2MV impulse, well above the anticipated voltage of this facility. The UoM also plays an integral role as part of the Research Centre for Non Destructive Evaluation. These established expertise make the UoM team suitable in leading WP1 and supporting WP2-3.

DNV will act as overall project manager and techno-economic assessment experts on the project. DNV are experts in providing strategic conceptual, implementation and operational advice on design, economics and regulation of energy markets, as well as advise on integration of new technologies into existing commercial environments. DNV have expertise in live cable monitoring methods. DNV will lead work package 3 and support WP2 and WP3.

Monitra is an expert in HV asset condition monitoring having developed and brought to market technology for on-line partial discharge of a range of high voltage assets including power cables, switchgear and rotating machines. Monitra’s role will be pivotal for new TDR related methods. They are best placed in the consortium to understand the practical side of RF measurements, having complimentary experience from partial discharge testing on power cables. The company has capability in digital tools and techniques (as required by SIF). Monitra will be leading Work Package 2 and supporting WP1 and WP3.

In subsequent stages of the project, we will look to bring on board offshore transmission owners (OFTOs) and offshore wind developers as organisations with existing and proposed supply connections. We will also look to bring on board additional OEMs with specialisms in different types of measurements such as pressure and temperature.

Project Plans and Milestones

Project management and delivery

The project will be delivered in three work packages (WPs):

WP1 Review of Existing Monitoring Techniques, Systems and Repair Techniques

We will conduct a review of existing condition monitoring systems and fault detection techniques in a DC cable setting (e.g. partial discharge, distributed temperature sensing). This will include a description of their technical requirements and also consider limitations such as space/weight, voltage levels and maximum cables length.

We will use a combination of desk-based research, workshops and interviews to determine how and where these existing techniques are currently applied by networks.

Lead - University of Manchester (UoM)

Support from NGET, SSEN Transmission, Monitra, DNV

WP2 Identify Review of Infrastructure and Equipment Requirements for Future Monitoring Systems

We will review future infrastructure and equipment requirements for future monitoring. This work package includes a feasibility of the state-of-the-art condition monitoring techniques including the potential of partial discharge and time and frequency domain reflectometry (TDR and FDR). We will also investigate how temperature monitoring and vibration can be monitored and used to establish the thermal, mechanism and electrical limits for interfaces within cable systems (e.g. joints).

The objective is to develop a draft set of testing requirements needed for future DC cable connections that will help to define a high-level outline for a potential new integrated monitoring system.

Lead - Monitra

Support from NGET, SSEN Transmission, DNV, UoM

WP3 Techno-economic Analysis

We will develop the business case for improved condition monitoring by conducting a techno-economic analysis to evaluate its benefit from the reductions in renewable energy curtailment and the higher utilisation of assets. To develop this model, we will identify future scenarios against which improved condition monitoring will be assessed, under which we will carry out a high-level estimate of the costs and benefits.

Lead - DNV

Support from NGET, SSEN Transmission, UoM, Monitra

The project will be managed by DNV, who has extensive experience in delivering innovation, research and development projects through network funding mechanisms, including strategic change, technology policy and systems roadmap development. As Lead Partner, NGET will provide regular control and support to the day-to-day project management that DNV will deliver.

Key outputs and dissemination

The key outputs by the end of the Discovery Phase will be a:

· Feasibility study that reviews the state of the art on condition monitoring techniques

· Draft set of testing requirements needed for future DC cable connections and cable monitoring evaluation criteria (e.g. identifying vibration as a key measure)

Overall reporting to the UKRI of the project's progress at the midpoint review and end of phase, along with all other ongoing reporting will be done by NGET and the project manager in collaboration. The successful completion of the Discovery phase will result in a greater understanding of the requirements for cable monitoring methods and equipment, leading to a greater understanding of any laboratory-scale testing in the next phases of the project. There will also be quantification of the costs and benefits of improved methods for assessing cable health.

We plan to showcase the findings of the Discovery phase of our project at various energy conferences and at a Cigre webinar to engage with more stakeholders. The outcomes will also be shared as part of the end-of-phase reporting, including the "Show and Tell" event, and will inform future proposals for the Alpha phase. Finally, the project team plans to conduct a "Lessons Learned" session at the end of the project phase to share their experience and insights.

Commercials

Intellectual Property Rights (IPR) (not scored)

The Discovery phase will primarily be a desk-based exercise to understand the problem in more detail ahead of laboratory-scale testing in the Alpha phase. Confidential details of IPR will not be disclosed, however sufficient information will be provided to enable other licensees to understand the technology being developed and its applicability to their own networks. This is in the interests of all project partners as it is hoped that the solutions can be demonstrated to be technically and commercially viable so wider licensee understanding of the new technology could lead to additional network development activity and economic benefits for the supply chain, including project partners from industry.

Partners commit to the fair distribution of IP developed in the project. IP arrangements will be reviewed following the successful completion of the Discovery Phase before moving into Alpha.

Project compliance with the IPR arrangements, as defined in Chapter 9 of the SIF governance document, will be assured via the contractual arrangements which will be put in place between NGET and each of the project partners.

Value for money

The total costs of the project amount to £151,059, with partner's contribution of £15,977 leaving the requested funding sum of £135,082.

NGET will receive £17,157 of the requested funding as the leading partner providing project direction. NGET will be contributing £15,106 equivalent to 10% of the overall project cost.

SSEN will receive £7,000 of the requested funding complementing the TO experience. SSEN will contribute an additional £871 to the project.

University of Manchester will receive £41,000 of the requested funding. The team brings power system assets research and testing expertise.

DNV will receive £51,925. DNV is experiences in techno-economic assessments and project management.

Monitra will receive £18,000 of the requested funding.

Supporting documents

File Upload

Discovery End of Phase Report - HIRE.pdf - 418.1 KB
2024-06-05 SIF Discovery Show and Tell HIRE PDF.pdf - 1.0 MB
SIF Round 3 Project Registration 2024-04-25 5_11 - 58.8 KB

Documents uploaded where applicable?

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