SIF Discovery Round 2 Project Registration

Date of Submission

Aug 2023

Project Reference Number

NGET/SCOHL/SIFIESRR/Rd2_Discovery

Project Registration

Project Title

SCOHL

Project Reference Number

NGET/SCOHL/SIFIESRR/Rd2_Discovery

Project Licensee(s)

National Grid Electricity Transmission

Project Start

Apr 2023

Project Duration

3 Months

Nominated Project Contact(s)

Sean Coleman

Project Budget

£153,846.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£132,507.00

Strategy Theme

Net zero and the energy system transition

Challenge Area

Improving energy system resilience and robustness

Lead Sector

Electricity Transmission

Other Related Sectors

Electricity Distribution, Electricity Transmission

Funding Licensees

Lead Funding Licensee

NGET - National Grid Electricity Transmission

Collaborating Networks

National Grid Electricity Transmission

Technology Areas

Conductors, Electricity Transmission Networks, High Voltage Technology, Overhead Lines

Equality, Diversity And InclusionSurvey

Yes

Project Summary

This project aims to assess the potential for implementing novel high-temperature superconductor (HTS) technology on National Grid's overhead line (OHL) assets. Meeting Net Zero goals requires £21.7 billion for 94 onshore network reinforcement projects by 2030, with additional build-out by 2050 (NOA 2021/22 Refresh). However, the required pace of network expansion is unprecedented and regulatory processes and public resistance can slow deployment, especially for new OHL routes which have high visual impact.

Overhead superconducting technology could improve system robustness by increasing the power transfer capability of existing transmission corridors, reducing network constraints and allowing for significantly increased flexibility in our energy mix and ability to meet demand from all available generation sources. The ability to rebuild or add lines within existing corridors and transmit more power in smaller corridors shortens the time to construct and energize new transmission capacity. Expediting the upgrading and expansion of the network in this way offers greater certainty about connection timeframes and development costs and quickens our ability to cut carbon emissions through the ability to connect more renewable generation and limit its curtailment due to network constraints. The resulting guarantee of the unconstrained availability of generated power significantly increases network resilience and robustness.

SCOHLs are currently at TRL 4 as the novel cryogenic cooling system with superconducting conductors have been operated as a raised overhead system in a lab environment and detailed simulation models of the system and its components have been verified. A SIF-funded project provides an opportunity to increase this TRL; in the discovery phase, an appropriate methodology for increasing the TRL will be developed through scanning for potential applications on NGET's assets, investigating technical limitations and financial benefits and identifying an adoption into BAU roadmap. The alpha and beta phases will subsequently progress towards to use of prototype demonstrators at live testing sites.

Project partners:

*National Grid Electricity Transmission (NGET) as a transmission network owner and transmission licensee with access to required testing facilities and OHL assets

*VEIR as the developers of the cooling technology that will enable SCOHL rollout

*University of Strathclyde as experts in power system analysis

HTS-enabled SCOHLs could be used by TNOs and DNOs across GB and potentially beyond. This project will identify the specific benefits and abilities of SCOHLs, where they can be used successfully, and their operational limitations so that users can be guided on the optimal route for adoption into BAU.

Project Description

The SCOHL project, led by National Grid Electricity Transmission (NGET), will explore the opportunity for deploying high-capacity, superconducting overhead lines in the UK, gauge technical and economic limitations, and roadmap a means to scale adoption for customer benefit.

Third Party Collaborators

University of Strathclyde

VEIR

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Project Description And Benefits

Applicants Location (not scored)

The National Grid team is located at:

National Grid Electricity Transmission PLC

National Grid House,

Warwick Technology Park, Gallows Hill,

Warwick

CV34 6DA

The VEIR team is based out of Woburn, Massachusetts in the USA. University of Strathclyde team members will participate from Glasgow.

Project Short Description (not scored)

The SCOHL project, led by National Grid Electricity Transmission (NGET), will explore the opportunity for deploying high-capacity, superconducting overhead lines in the UK, gauge technical and economic limitations, and roadmap a means to scale adoption for customer benefit.

Video description

https://youtu.be/2k-JtTo0sFg

Innovation justification

The GB network has several highly constrained boundaries which have caused two problems:

-Limited power capacity meaning power flow increase is reliant on building additional major civil infrastructure.

-Significant power system losses.

Superconductors may present a solution to these issues. However, traditional superconducting lines are buried underground and rely on heavy closed-loop, mechanical cooling systems to keep conductors below the critical temperature. Another SIF-funded project led by NGET, entitled SCADENT, focuses on these underground superconducting lines. Despite its success, mechanical cooling is a barrier to deploying superconductors in overhead applications due weight and size limitations.

A novel cooling approach can bring high-efficiency, superconducting electric transmission lines to market at scale. VEIR's technology uses an open-loop system that evaporates a portion of liquid nitrogen at points along the line. This eliminates the need for mechanical cooling and relieves constraints on locations and length. VEIR's approach also shrinks the cryostat; for the first time enabling superconducting transmission lines to deploy overhead, as with conventional lines.

Unlocking superconducting technology for broader grid application increases options for grid planners - transmission lines could be rebuilt in existing corridors to increase capacity five- to tenfold, or new, lower-voltage lines could be built under existing ones. Alternatively, new corridors could carry high amounts of power within the same rights-of-way and with smaller towers. Line retrofit capability will also be explored. Across new and existing corridors, superconducting lines could provide low-sag options that consistently carry power despite ambient temperature change -- eliminating the need to dynamically rate lines. This will become increasingly important due to climate change induced temperature increases.

However, deploying first-of-a-kind technology on the grid is challenging. To be successful, utilities and regulators need to confirm that overhead superconducting lines can be reliably and cost-effectively deployed with installation and maintenance techniques akin to those used today.

The SCOHL project will review technical limitations to deployment, operations and maintenance of overhead superconducting lines, such as the availability of equipment to integrate 3,000-5,000 amp lines or any factors limiting installation and repair practices; outline applications that most benefit grid resilience and provide customer savings; and roadmap efficient routes to market.

Funding support for these activities is critical as overhead superconducting lines have never been deployed commercially before. Though HTS technology is proven and could become a strategic tool for decarbonizing the energy system reliably, further work is needed to test and gain confidence in overhead applications.

Benefits Part 1

Environmental - carbon reduction – direct CO_2 savings per annum against a business-as-usual counterfactual
Environmental - carbon reduction – indirect CO_2 savings per annum against a business-as-usual counterfactual
Financial - cost savings per annum for users of network services
Financial - future reductions in the cost of operating the network

Benefits Part 2

The project scope includes a benefits analysis that will provide an initial estimate of direct and indirect CO_2 and financial savings as well as a summary of technical considerations for deploying overhead superconducting lines in GB. These techno-economic analyses will be based on high-level application scenarios selected based on an initial brainstorming of opportunity by team members. In particular, University of Strathclyde with support from other partners will identify high-value applications such as lines with very large predicted power flows over the coming years (e.g., Harker-Hutton 400 kV double circuit); strategically important lines facing deployment delays or constraints (e.g., the 11 reinforcement projects identified by National Grid ESO in its July 2022 Pathway to 2030 report which are required by 2030 but anticipated to be delivered late); or lines that if built with higher capacity could avoid smaller-capacity projects.

University of Strathclyde, with support from VEIR and National Grid, will review the application of VEIR's product and identify any technical challenges with integrating the technology. The team will also confirm an approach to estimating potential benefits of reduced losses. Frazer-Nash will help National Grid provide a range of CO_2 savings estimates using the initial loss estimates and a blended average emissions rate. National Grid will also work with Frazer-Nash to estimate first-order material and civil works savings, with the counterfactual being the resources used to deploy a conventional line. The University of Strathclyde will review VEIR's estimates for capacity in a given installation and estimate first-order total congestion reduction with added capacity. For a given application type, National Grid, with Frazer-Nash, will estimate a range of potential congestion and electrical loss cost reductions. For example, if the "Leading the Way" FES is followed up to 2030/31, losses in the particularly heavily loaded Harker-Hutton and Legacy-Shrewsbury/Ironbridge 400 kV double circuits could reach a combined value of 516 TWh per year. If resistance in these lines was reduced by half, this would save consumers £12.9m annually at £50/MWh, for a total of £258m over a 20-year asset lifespan. Similarly, in the 12 months from 01/04/21 to 31/03/22, 3850 TWh of energy were constrained due to thermal constraints in the GB network at an average cost of £341/MWh for a total cost of more than £1bn. These are only indicative numbers, with true savings dependent on the results of the more detailed analyses which will take place in the discovery phase.

Project Plans And Milestones

Project Plan and Milestones

The SCOHL project will be structured as detailed below:

• WP1: Technology applications and considerations

o Lead resources: University of Strathclyde.

o Support: VEIR, NGET, FNC, University of Manchester.

o Success criteria: Identification of the scenarios that represent technically feasible, high opportunity applications; a review of TRLs of overhead applications of superconducting technologies; and a summary of potential future technical considerations.

▪ Task 1.1: High-level benefits opportunity assessment and prioritization of brainstormed scenarios for further assessment.

▪ Task 1.2: Review of technology considerations for installing VEIR's technology on the GB grid, given outputs of 1.1, including the identification of relevant standards and requirement and any notable current engineering standards, technical installation, operation or maintenance barriers/limitations.

▪ Task 1.3: Summary of technical limitations for implementation and an estimate of technology readiness.

o Deliverable 1: Summary of the above work, including technical considerations for applications of high value for SCOHLs.

• WP2: Benefits Assessment

o Lead resources: FNC, University of Strathclyde.

o Support: NGET, VEIR.

o Success criteria: High-level benefits estimates, including CO2 reduction and financial savings of SCOHLs for scenarios outlined in WP1

▪ Task 2.1: High-level benefits assessment of WP1 scenarios, including estimated financial savings and CO2 savings.

o Deliverable 2: Report on high-level benefits analysis of the use cases, compared to other conventional options.

• WP3: Technology Roadmapping

o Lead resources: FNC, VEIR.

o Support: NGET, University of Strathclyde, University of Manchester.

o Success criteria: This work package shall deliver a roadmap for adoption of the SCOHL technologies.

▪ Task 3.1: Define methods to overcome technology considerations identified in WP1 for high-benefit applications identified in WP2.

▪ Task 3.2: Identify methods to scale, including key areas to standardise, such as development of engineering standards, installation or maintenance practices, or modified planning approaches that account for technology benefits.

o Deliverable 3: Report summarizing hurdles to adoption, approaches to overcome hurdles and an adoption roadmap for SCOHLs.

Regulatory Barriers (not scored)

None, we have not identified any regulatory barriers that affect the project or technology adoption. The proposed solution is a technology to address a core DNO and TNO business requirement, to increase the network capacity in a cost-effective manner and with lowest disruption to both high demand centres and local consumer communities.

Commercials

Route To Market

Like all new electric grid technologies, the biggest barrier is a justified aversion to risk. Bringing respected industry experts into the Discovery Phase to conduct techno-economic assessments of potential applications and developing a commercialization roadmap will be a key first step to identifying and teeing up successful trials.

Discovery Phase: The project will create a structured milestone-based roadmap, defining how the technology readiness level will mature the technology into business as usual on both an organisational and sector-wide basis.

Alpha Phase: The project team intend to investigate innovation opportunities to improve technology readiness level as well as draft standardised designs for upto 400kV applications that can be adopted for all GB transmission and distribution voltage systems.

Beta Phase: The approved designs will be developed into prototypes to be trialled within tester live sites. As standard practice prior to technology roll-out, parallel trials and first deployment trials need to be considered (as stated in National Grid policy PS(T)013).

Further factors include:

-Training requirements: The new technology will have new operational requirements. Training will need to be rolled out to the workforce. This incurs costs and time.

-Spares holdings: Spares need to be available.

-Anticipated asset life and expected population: Defining the design life of the new asset will be required and written into to company policies and technical specifications.

-Failure mode, effect analysis (FMEA): The new technology's failure modes will need to be understood so that new assets can be managed, suitable maintenance routines developed, and appropriate health & safety protocols established.

-Technology impacts: Impacts on business processes, systems and data need to be determined during the innovation phase, before implementing the new technology as "business as usual".

-Resilience: Avoidance of long term, single supplier dependency; manufacturing assurance and capability. The supply chain will need to be evaluated and deemed competitive with a range of providers.

-Warranties: Warranties will need to be arranged to support investor confidence.

-Post-delivery support agreements: PDSA and system/asset recovery will need to be established for the new technology.

-Decommissioning decisions: Grey spares, disposal, forensics, and recycling all require full consideration for "whole life" asset management. Once the Beta phase of the project is successfully delivered the technology could become a regular option for network reinforcement, meaning standardised procurement procedures and processes could be used for future projects with minimal modifications. This would de-risk industry investment, reduce costs, and ultimately facilitate the wider adoption of the technology.

Intellectual property rights (not scored)

VEIR has been awarded two patents:

1.17/524,262: Systems and Methods for Cooling of Superconducting Power Transmission Lines

2.17/524,267: Conductor Systems for Suspended or Underground Transmission Lines

A third patent application, "17/524,261: Suspended Superconducting Transmission Lines," has received a Notice of Allowance.

The above patents pave the way for the commercialisation of VEIR superconducting electric transmission lines. However, should the project result in new inventions, the appropriate inventors would apply for additional patents. VEIR does not anticipate needing to license its technology to other project participants for the purposes of this work.

Costs and value for money

The proposed total project cost is £153,846, with £132507 in funding sought from through SIF and £21339 in contributions from private funds.

*NGET's total cost is £105406, with £94866 sought from SIF and £10540 in its own contribution.

*NGET has a subcontracting cost of £84700, with £74700 going to Frazer-Nash Consultancy for Project Management, Use Case identification and benefits studies, and an adoption roadmap, and £10000 going to University of Manchester for a Technical assessment of standards within WP1 & a Technical assessment of roadmap to meet standards within WP3

*University of Strathclyde's total cost is £37640, with all £37640 sought from SIF

*VEIR's total cost is £10800, with most of this in private contributions and the minimum of £1 sought from SIF

The scoping work of the Discovery phase would enable the project team to identify applications for VEIR's technology that maximize value to customers and have high potential for initial deployment. The project provides value to customers by exploring and then targeting the opportunity of overhead superconducting lines for the GB grid. It also kick-starts further investment to successfully develop and deploy overhead superconducting lines in GB, something not possible without innovation grant funding today. Without this initial investment, the potential savings on the order of 100s of millions of pounds to the consumer which could be yielded with a full implementation of SCOHLs into BAU may either be significantly more difficult to achieve or be severely delayed due to a lack of funding from other sources in such innovative potential solutions. This represents value for money for the consumers.

Document Upload

Documents Uploaded Where Applicable

Yes

Documents:

10061159 - SCOHL SuperConductor Overhead Lines - Discovery Project Brief.pdf

10061159 SCOHL - Expert Assessor Feedback.pdf

SCOHL Discovery Phase Application - Submitted 22-11-22.pdf

SCOHL Project Management - Discovery Application.pdf

SCOHL - discovery show and Tell presentation V1.3.pptx

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This project has been approved by a senior member of staff

☑ Yes