SIF Project Registration

Date of Submission

Apr 2022

Project Reference Number

10027503

Project Registration

Project Title

SEGIL - Sustainable Electrical Gas Insulated Lines

Project Reference Number

10027503

Project Licensee(s)

National Grid Electricity Transmission

Project Start

March 2022

Project Duration

2 Months

Nominated Project Contact(s)

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Project Budget

£133,814.00

Project Summary

A sustainable GIL solution will help to connect offshore renewables to urban centres. Our project will focus on identifying:

- The potential for GIL to provide high-capacity transmission connections over 2000MVA to increase capacity available for new offshore wind generation.
- Options to replace SF6 with alternative low carbon footprint gases as a viable means of GIL insulation.

Scope: The project meets the scope of the competition by developing and widely implementing a technology that will allow more rapid progress towards Whole System integration and decarbonisation. It will address:

1. “Current and future heat, power, and transport energy requirements”: the solution potentially offers more cost-effective, sustainable and better-performing transmission capacity delivery to support demand growth from heat and transport electrification.
2. Novel approaches to infrastructure investment to maximise efficiency in large-scale network and system investments by taking systems view across generation and demand side changes linked to decarbonisation.

Project Partners

Lead partner is National Grid Electricity Transmission (NGET). Additional project partners are:

- Ørsted as a windfarm developer and generation licence holder.
- Scottish Power Transmission (SPT) and National Grid Electricity System Operator (NGESO) as networks owners and operators.
- General Electric (GE) as the GIL technology provider.
- J. Murphy & Sons as civil construction expert and EPC.
- University of Manchester as an academic partner and expert in HV assets and SF6 replacement.
- Frazer-Nash Consultancy (FNC) as techno-economic assessment experts.

These partners bring knowledge and capabilities and have a strong interest in advancing SEGIL technology: NGET, SPT and Ørsted can deploy the solution on the respective networks, GE will design and produce innovative GIL components, University of Manchester

can expand their research in the area of sustainable gases and new assets, J. Murphy & Sons would benefit from learning how to specify, procure, install and commission GIL, while FNC would gain experience collaborating with the networks on innovative technology.

User Needs

Potential users of SEGIL technology are NGET, other transmission owners (TOs) and offshore wind developers that require connection of new offshore generation sites to the existing networks via high-capacity connections; faster and with less disruption to local communities or wildlife. Future power infrastructure investments can benefit from increasing the range of technologies available, including the replacement of existing assets reaching the end of life. The potential benefits to consumers are faster integration of renewable generation and a more cost-effective and sustainable network, with lower impact on areas of natural beauty.

Third Party Collaborators

General Electric

J Murphy & Sons Ltd

The University of Manchester

Frazer-Nash Consultancy

Orsted

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Context: The UK Government has committed to achieve Net Zero by 2050 that leads to significant changes in GB energy system:

- An increase in renewable generation with UK government's commitment to deliver 40GW of offshore wind power by 2030 by large windfarms on the East Coast where the transmission network is underdeveloped for the expected connection capacity.
- Decarbonisation through electrification of heat and transport which will significantly increase the demand for electricity, especially in heavily populated areas.

Problem: The increasing need to transmit electricity from offshore renewables to urban centres where demand is growing requires new efficient, resilient, cost-effective and rapidly deployable solutions. Without this, offshore wind energy integration and ultimately the UK's Net Zero targets may be compromised.

Despite radical grid advancements elsewhere, the core transmission technology, high-capacity high voltage (HV) overhead line (OHL) has remained largely unchanged in past decades. However, public opposition to the visual impact of OHLs and impacts on wildlife, lead to challenges with planning consents, design and build. Relying on conventional OHL lead to a risk not delivering required capacity quickly enough to accommodate fast-growing demand in cities.

Underground HV cable systems offer low visual impact and often receive consent much faster. However, they too bring challenges:

- They are more costly and require significant construction works.
- Operational challenges, as in the case of an internal fault, a circuit stays out of service for significantly longer due to identifying faults, excavation and replacement.

Solution: This project would begin early-stage R&D by exploring opportunities for a new alternative – Gas Insulated Line (GIL), in certain way similar to a gas transmission, can transmit over 3000MVA, more power than a conventional OHL, and with less construction works than a cable system for the same power rating, hence reducing the cost and time to deliver capacity. However, to develop GIL at scale as a viable alternative, two key challenges must be resolved:

- Lack of experience with long-distance GIL construction and operation. Currently, the longest operating circuit is 17 km, 420 kV inside a substation.
- Current generation GIL are filled with a sulphur hexafluoride (SF6), a potent greenhouse gas which is 23,900 times more environmentally damaging than CO2.

The key aim of this Discovery project is to evaluate these challenges and propose solutions to develop a viable, efficient long-distance

GIL for high-capacity lines for the GB network.

Project Approaches And Desired Outcomes

The Big Idea

Aim: The project will explore the feasibility of developing new solutions that would allow the implementation of GIL to connect offshore renewable generation to the urban centres where the power demand growth will be the highest.

The project delivers on two key aims set out in the competition scope:

- Decarbonise electric energy transmission networks and benefit consumers. It will be achieved through enabling faster, less environmentally damaging methods of connecting renewables to consumers.
- Improve coordination between networks and other system participants. It will do this by developing a whole system approach that connects energy generation to distribution and consumers.

Project Focus: GIL is a potential solution to connect consumers to renewables. However, our assessment of current state of the art TRL has identified five key areas of focus:

- Current GIL technology has only been utilised for shorter distances. At present, the longest GIL is associated to a substation in Saudi Arabia has a total length of 17 km. Our Discovery Project will determine whether a GIL length of 30-40 km is possible to achieve at the end of the Beta project phase a 400 or 550 kV up to 4,000MVA rated system, such that network upgrades can be performed going forward to meet increasing demand.
- Current GIL technology relies on environmentally damaging SF6 for insulation. The project will investigate the potential to replace SF6 with a more sustainable and environmentally friendly gas mix.
- Current GIL technology requires refinement to achieve “business as usual” (BAU) implementation. Our project will consider dimensional changes to pipes and the impact of using different insulating media.
- Implementation: Our study will establish a checklist of basic factors to assess a route suitable for GIL application.
- Cost-benefits: A cost-benefit analysis will compare evidence for the performance of GIL and the equivalent cable system. It will consider rating, cost, ease/speed of installation, impact/footprint on land routes, and ease of repairing failures/maintaining the assets. This will help to develop a competitive target price for a GIL system, specifically compared to equivalent 2000 MVA cable systems. Cost reduction opportunities will also be identified by implementing any lessons learned from existing non-SF6 Gas Insulated Busbars (GIB) technologies.

Innovation Justification

Current high-capacity power solutions are unlikely to be able to provide the capacity that widescale electrification will require to meet anticipated demand from consumers (particularly for heat and transport in urban centres). Innovation is therefore required to develop higher capacity transmission alternatives at comparable prices to existing solutions. This requirement is driven by the number of grid-edge renewable generation projects planned, and the UK Government’s commitment to deliver 40GW of wind power by 2030. Future power circuits may require higher capacity than buried cable solutions can provide, in the same time avoiding prolong consent, as often the case for OHL, hence the development of a GIL alternative with a higher performance is necessary to build an efficient network.

Connecting generation to demand centres is currently achieved through construction of OHLs or buried cables. GIL could provide a higher ratings capability than a cable circuit, whilst also mitigating the public and regulatory opposition often encountered with OHL solutions. Deployment of any new high-capacity transmission assets in the UK is considered challenging because of the dense physical and human geography, highly constrained environmentally sensitive areas, and strict planning legislation.

A long-distance GIL (over 20 km) is not a mature technology, with an assessed technology readiness level 6 (TRL). Long-distance GIL has not been demonstrated in the UK or internationally. Currently the applications are limited to interconnection inside substations or in tunnels to overcome natural obstacles like rivers. Information about similar projects can be found in the attached Appendix 1.

Low carbon alternative to SF6 gas mixes have already been developed for certain applications by the supply chain, and demonstrated, e.g. in Sellindge substation in the UK. Much shorter sections of GIB with alternative gases are becoming business as usual for 400kV substations and these advancements can be successfully transferred to GIL applications.

Using GIL in the UK has often been considered very challenging because the UK has many physical obstacles, dense population centres, highly constrained environmentally sensitive areas and planning legislation to satisfy. Therefore, creative thinking and innovative methods are particularly important for GIL projects. These challenges have already been addressed by gas networks that utilise buried high pressure gas lines. Gas industry demonstrates that the routeing of buried tubes through rural and urban environments is practically possible. This project will learn from existing best practice in the gas industry to develop innovative methods

for GIL projects to enhance capacity in the electricity network.

Project Plans And Milestones

Project Plan And Milestones

The Discovery Phase will consist of three work packages (WP).

WP1 – SEGIL technology readiness assessment

Lead: University of Manchester.

Support: GE and J. Murphy&Sons.

This will include:

Task 1.1 - Collate existing and available information from ongoing R&D

Task 1.2 - A review of options for alternative gases to SF6, considering the required dimensional requirements for insulation and the corresponding GIL tube sizes.

Task 1.3 - Evaluation of the supply chain to design and build GIL systems and associated components, including alternative gases.

Task 1.4 - A review of potential sites where GIL could be used, both in terms of the general terrain in parts of the UK and within the existing network where circuits may need to be replaced in the future.

Deliverable 1: SEGIL technology readiness assessment report.

Expected result: Recent advancements in GIL solutions will be reviewed. Technical readiness assessment will demonstrate key obstacles and innovation opportunities to fully develop a SEGIL solution.

WP2 – Cost-benefit analysis of SEGIL applications

Lead: Frazer-Nash Consultancy,

Support: GE and J. Murphy&Sons, Networks

Task 2.1 - Determine GIL component, installation and operation costs

Task 2.2 - Develop an investment case for a GIL solution on a selected route

Deliverable 2: SEGIL investment case and cost benefit analysis

Expected result: Development of an investment case for a >2000MVA GIL solution will determine the solution lifecycle cost and identify opportunities to make it competitive against the buried cable equivalent.

WP3 – Future Technology Roadmap

Lead: Frazer-Nash Consultancy.

Support: University of Manchester, GE, J. Murphy & Sons and Networks.

Task 3.1 - Identify recent/planned developments in the UK and internationally

Task 3.2 - Identify key technical challenges and improvement opportunities

Task 3.3 - Consider how to progress to the next technology readiness level

Deliverable 3: Technology roadmap and implementation strategy

Expected result: The roadmap will propose solutions to address identified key technical and financial challenges, improvement opportunities, potential future work in the Alpha and Beta Phases and further to BAU.

Deliverable 4: Final report detailing all findings.

Route To Market

Partner roles: This project already involves a wide range of significant transmission network owners and operators (NGET, NGESO, SPT and Ørsted), along with engineering, technology, consultancy, and academic partners. The level of industry engagement in this project gives us the reach to provide a clear route to market.

Discovery Phase: The project team will evaluate the supply chain capacity and ability to deliver SEGIL systems. This will include a detailed look into current suppliers of GIL components and their manufacturing capability and capacity.

Alpha and Beta Phases: In future phases of the SIF funding, the intention is to develop a demonstrator to prove the technology in order to de-risk future BAU investments. We will also create a roadmap for implementing the innovation into business as usual on both an organisational and sector-wide basis.

Roadmap: A key deliverable of the Discovery Phase will be a technology roadmap identifying a clear route forward and drafting an investment case, to adopt GIL technology as part of BAU. This roadmap will consider:

- Technology impacts on business processes/systems and data: Impacts will be determined during the innovation phase, before implementing the new technology as BAU.
- Anticipated asset life and expected population: Defining the design life of the new assets will be required and included in company policies and technical specifications.
- Suppliers: The supply chain will need to be evaluated and deemed competitive with a range of providers. This will prevent long term, single supplier dependency.
- Warranties: Warranties will need to be arranged.
- Post-delivery support agreements: PDSA and system/asset recovery will need to be established for the new technology.
- Whole life asset management: Consideration of decommissioning decisions (grey spares, disposal, forensics, recycling).
- Trials: The programme implications of offline trials, parallel trials and first deployment trials will also be considered (in line with the National Grid Transmission Policy Statement).
- Training requirements: The new technology will have operational requirements that operatives will need to become familiar with.
- Spares holdings: The new technology will require spare parts to be available. The range and number of parts required is yet to be determined.
- Failure mode and effects analysis (FMEA): Failure modes of the new technology will need to be understood such that new assets can be managed and suitable maintenance routines can be developed.

Dissemination: To enable a route to wider markets, consideration will be given to how the intellectual property developed is shared to other GB networks.

Costs

Total Project Costs

133814

SIF Funding

133814

This project has been approved by a senior member of staff

☑ Yes