SIF Round 3 Project Registration

Date of Submission

May 2024

Project Reference Number

NPG_SIF_012

Initial Project Details

Project Title

Cross Vector Energy Hub

Project Contact

Chris Goodhand

Challenge Area

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

Strategy Theme

Whole energy systems

Lead Sector

Electricity Distribution

Other Related Sectors

Electricity Distribution

Electricity Transmission

Gas Distribution

Gas Transmission

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

NPg - Northern Powergrid (Northeast) Limited

Funding Licensee(s)

NPg - Northern Powergrid (Northeast) Limited

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

Northern Powergrid

Technology Areas

Active Network Management

Low Carbon Generation

Modelling

Demand Side Management

Distributed Generation

Electricity Transmission Networks

Energy Storage and Demand Response

Storage

Gas Distribution Networks

Gas Transmission Networks

Project Summary

This project will design and implement a Multi-Vector (Gas+ Electricity) Energy Hub that optimises devices across a truly whole system solution to increase network resilience, operating efficiency, and hosting capability by coordinating:

*renewable generation,

*battery storage,

*power to gas and gas to power, through a hydrogen electrolyser and peaking plant,

*gas storage,

This builds on the academic theory of Energy Hubs through detailed design and simulation, and when progressed to beta stage, will deliver a solution for holistic whole energy system planning & operation that has been calibrated and validated against a real-world demonstration.

Add Third Party Collaborator(s)

Smarter Grid Solutions

Project Budget

£131,350.00

SIF Funding

£117,305.00

Project Approaches and Desired Outcomes

Problem statement

Innovation projects to date have explored advanced optimisation and control of assets on the electricity network to deliver resilience and grid capacity release, improving the availability of supply and import/export capability when the electricity network is under outage or periods of stress.

Electricity and gas networks are traditionally planned and operated separately, with energy conversion between vectors occurring primarily at the domestic level. This results in inefficient planning and operational decisions because the cross vector visibility is very low. The energy transition drives greater inter-dependencies and enhances opportunity for gas and electricity networks to support each other.

There is a potential benefits case for co-optimisation of the grids, utilising long duration gas storage and gas's ability to provide invaluable fast responding and highly dispatchable peaking services to the electricity grid.

However, there is a very limited body of evidence related to real-world trials looking to quantify the impacts of one system upon the other when operated holistically and so the benefits available are poorly understood. This lack of understanding represents a lost opportunity to customers in the form of higher network costs and unnecessary emissions of greenhouse gasses.

Coordination of energy resources and conversion technologies across the electricity and gas grids can play an important role in the balancing of local electricity grids, further enhancing hosting capacity and providing additional grid resiliency.

In this project vision, information on the gas and electricity grid will be used by Smarter Grid Solutions to build a tool that allows network models to be integrated and for the impacts of actions on one network upon the other to be simulated. This meets focus theme 1.

Validating these tools by being able to calibrate the predicted simulations against the real-world outcomes of the next-phase trial and demonstration will ensure that

the tools are tested and validated, providing crucial confidence in their ability to predict the benefits of other energy hubs being rolled out at sites that are found to present the right value for money to consumers. This meets innovation challenge aim 1.

This project builds on learning from projects that demonstrate resilience for the system, including e Microresilience, RaaS, and ReFLEX as well as those that look at hydrogen use cases and its ability to support the network, such as SCOTclue and Cumbrian Hydrogen vision, as detailed in the project plan spreadsheet.

Video Description

https://www.youtube.com/watch?v=5-eZyqlvo

Innovation justification

The concept of Multi-Vector Energy Hubs has been presented previously at a conceptual level, however the challenge is that the concept is undemonstrated with enabling technologies and suitable application cases are difficult to identify. Therefore, the scale of the benefits that could be realised is unproven.

Many of the individual components of the proposed project are at a mature stage of TRL; electrolysers, batteries, and fuel cells have all been demonstrated individually, however, there is no instance of these technologies being fully integrated and operated as a single multi-vector optimised system, or had implementation models validated through combined modelling and demonstration.

This project concept (from Discovery to Beta) will address this gap, initially studying the feasibility, value and modelling requirements of Multi-Vector Energy Hubs, through to testing, detailed modelling, and then full network demonstration of the value that can be unlocked for consumers. The full value case of these concepts are yet to be defined, therefore progression of the concept within a BaU environment introduces significant risk to any ONO.

The project requires the gas and electricity networks to be considered as a single system and demonstration the coordination of new technology for the benefit of the whole system. Such an approach does not fit within the existing price control

programmes and requires novel commercial arrangements to facilitate cross vector flexibility and support across the networks.

The project outcomes are highly relevant to Ofgem's Regional Energy Strategic Planners and the Future System Operator, both of which will have responsibilities for holistic energy system planning.

This early stage of the project fits directly into the structure of the SIF challenge, with the initial feasibility and design stage being deliverable within the 3-month timeframe. Further phases will include the development (and trial validation) of multi-vector modelling methods that will allow network companies, and future local planning authorities, to identify sites for co-optimisation and to minimise network costs by doing so (Alpha phase). The final phase offers the unique opportunity to calibrate and validate the models through a functional energy hub deployed with collaboration between Northern Powergrid and Northern Gas Networks. This demonstration will provide invaluable knowledge on the technological capabilities required by utility companies for a future in which the energy transition creates fundamentally more interconnected and interdependent systems.

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 – direct CO2 savings per annum

Revenues - improved access to revenues for users of network services

Revenues - creation of new revenue streams

Impacts and benefits description

Financial - future reductions in the cost of operating the network.

Existing academic literature on Energy hubs strongly supports the expectation that they allow a reduction in costs by increasing the efficiency of both networks, reducing infrastructure and management costs. Introducing flexibility through new vectors can introduce additional scope for network optimisation and new sources of flexibility for grid balancing.

Financial - cost savings per annum on energy bills for consumers

In addition to the reduction in the need for infrastructural build arising from more efficient networks the use of hydrogen as a storage vector can significantly reduce the requirements for battery storage, (an expensive form of energy storage per MWh). Long duration storage is presently still a significant challenge in the transition to renewable forms of electricity increasing the benefits of converting excess electricity into hydrogen to be used either directly or stored until needed.

Environmental - carbon reduction – direct CO2 savings per annum
Many proponents of fossil fuels point to the continued need for the use of natural gas in combined cycle gas turbines as a way of stabilising the electricity grid because of its highly controllable and dispatchable nature. Hydrogen can perform the same role within a system generating electricity from gas in a dispatchable way with no or low carbon emissions. A typical CCGT can return efficiencies of around 50% while a hydrogen fuel cell efficiency is quoted at between 40 and 60% efficiency with some demonstrations reaching as high as 68%.

Recent development of hydrogen and fuel cell technologies: A review - ScienceDirect
(https://www.sciencedirect.com/science/article/pii/S2352484721006053)

Revenues - improved access to revenues for users of network services
Hydrogen electrolysers have already been demonstrated successfully as a way of minimising curtailment to renewable generations when co-located in constrained network. An electrolyser is also a dispatchable form of demand that can contribute to grid stabilising services. Minimising curtailment allows generation users to maximise return on their investments (as well as maximizing low-carbon energy) and avoids the loss of that generation potential.

Revenues - creation of new revenue streams
Energy hubs will allow flexibility service providers to access the opportunity to arbitrage between different vectors, the value case for this will be defined and quantified as part of the Discovery phase of the project.

Teams and resources

The Discovery project will be delivered by Smarter Grid Solutions (SGS) and Northern Powergrid (NPg), building on learning from the previous successful collaboration on the MicroResilience project. The project team offers a best-in class collaboration between the Consultants at SGS, bringing expertise in the modelling of DER optimisation and design of innovative network control solutions, and the Innovation Engineers at NPg who are well-versed in the development and demonstration of innovation concepts across their distribution network.

SGS are a UK-based vendor of DER Management System (DERMS) software that provides monitoring, optimisation and dispatch functionality to distribution utilities and DER owner/operators. In addition to teams dedicated to the design and development of innovative control solutions, SGS has a team of consultants that deliver novel modelling and analysis studies that explore the impact and value case of new control solutions. SGS has been a key delivery partner in the demonstration of network innovations (through Ofgem RPZ, LCNF and NIA/NIC) that have transitioned to BaU deployment, including the Accelerating Renewable Connections (SPEN) and Flexible Plug and Play (UKPN). Their experience in developing and applying novel system modelling/analysis methods within innovation projects, alongside the demonstrated heritage of deploying innovations through live network trials ensures that SGS are the best partner to lead the development of this concept from the Discovery phase through to the intended Beta phase of network demonstration.

SGS will lead all project activities in the Discovery Phase, including Project Management.

Northern Powergrid is responsible for expert steering and review roles within the project, ensuring that all project outputs and learning outcomes are relevant, feasible and tailored for distribution licensees to derive value from.

The discovery phase consists solely of desk-based research, design, and analysis activities, therefore there is no requirement for bespoke or non-standard resources, equipment, or facilities to be funded through this project.

Whilst not a formal project partner, Northern Gas Networks is committed to demonstrating Innovation and are engaged with Northern Powergrid and Smarter Grid Solutions as the MicroResilience project is deploying technology to the Low Thornley site. This stakeholder will provide supporting information for the development of the solution concept, value modelling and cost assessments. It is expected that if decision is made to progress to trial or network demonstration, Northern Gas Networks will become a formal project partner.

Project Plans and Milestones

Project management and delivery

SGS project delivery follows an ISO9001 certified management system with a series of standard stages and output review process. The project will have a dedicated Project Manager (from SGS) that will maintain a project plan via MS Project. A Gantt Chart detailing a high-level project plan is presented in the attached spreadsheet, where Project Management effort is incorporated within all phases. Key Project roles are presented in the Gantt Chart included in the attached Project Management spreadsheet.

The core project team consists of the following roles -

*Project Manager (SGS) -- Project Management role;

*Principal Consultant (SGS) - Technical Authority and Project Delivery role;

*Regulation Consultant (SGS) -- Regulation SME role;

*Consultant (SGS) -- Project Delivery (modelling/simulation) role;

*Consultant (SGS) -- Project Delivery (solution definition and assessment) role, and

*Project Engineer (NPg) -- Project Delivery (ONO focus and site assessment support).

Where required, other Subject Matter Experts at NPg and SGS may be asked to contribute to the project.

In addition to the core project team, there will be a project sponsor from both SGS and NPg to oversee project direction.

Regular project meetings will be held on a fortnightly basis, attended by the core project team. On a monthly basis, project sponsors from NPg and SGS will attend an extended project meeting to review progress and provide steering.

Risks are managed via a Risk Register, maintained by Project Manager. which is reviewed during project meetings.

As the discovery phase is desktop-based study and design, there is no site works in the project, and therefore no expectation of unplanned supply interruptions for customers.

Key outputs and dissemination

Key Learning & Deliverables:

1. Solution Definition: Presentation of the Technology Components (vendor agnostic) that can deliver multi-vector Use Cases via coordination of electrical (BESS, renewables, smart controls) and electricity/gas (hydrogen peaking plant, electrolyser) technologies.

2. Defined use cases for energy hubs in the GB energy system, detailing the functional steps required to deliver desired outputs in each case.

WP 2 -- Energy Hub Modelling Approach
Key Learning & Deliverables:

1. Modelling Methods: set out the design and methodology required for the modelling of Multi-Vector Energy Hub use cases, detailing the required datasources and technology models

2. Set out a roadmap for the continued development of enhanced modelling tools to support feasibility, testing and scheme design, setting a path of future development for the analysis tool required for at-scale deployment.

WP 3 -- Regulation and commercial review
Key Learning & Deliverables:

1. Illustration of the regulatory landscape for Multi-Vector solutions and highlight the key challenges that can act as barrier or slow-down future BaU adoption of solution. Identify key areas of commercialization or regulation that must be addressed to achieve full adoption outside of Innovation project.

WP 4 -Value case
Key Learning & Deliverables:

1. Presentation and quantification of the Energy Hub key value drivers as applied to the Low Thornley study case. Delivery of value case to full Cost-Benefit Analysis highlights potential value of solution when rolled-out at scale.

WP 5 -- Trial Design
Key Learning & Deliverables:

1. Share the trial priorities and key areas for demonstration/testing as informed by previous phases of the project. Trial priorities are fed into a trial design activity which will present a proposition for follow-on phases for prospective ONO and Technology partners to review.

Project dissemination will primarily be via published reports written by SGS and reviewed by NPg.

In addition, NPg has existing channels for informing stakeholders about innovation learnings and outcomes, including newsletters, publications, and stakeholder forums.

SGS originated in academic research and has maintained a strong tradition of contributing to industry specific academic publications including presenting papers from previous innovation funded projects at international events such as CIGRE and CIRED.

Commercials

Intellectual Property Rights (IPR) (not scored)

IPR ownership will be treated in line with SIF Governance. All partners acknowledge the requirements to make methods, approaches, and design outputs available in-line with the SIF governance. Transparency in the solution components, implemented design and any underlying commercial evaluation are all critical to successful BaU implementation across all DNOs, hence underlying the importance of ensuring that all project learning is available to all DNOs.

Smarter Grid Solutions will retain the rights to background IP derived through internally-funded development of our DERMS product.

Value for money

The total Discovery Phase project cost is £131,350.

The total SIF funding requested is £117,305 reflecting a 11% contribution from project partners.

The discovery phase is designed with full transition to alpha phase (trial and detailed modelling) and beta phase (full network demonstration and commercial/market design) which is required for the successful transition of this highly novel and ambitious (with high value to consumers) concept to BaU. Full exploration of required market/commercial considerations will occur following initial confirmation of the technical feasibility and concept value at Discovery phase.

Funding of the Discovery Phase offers full value to consumers as this is a crucial assessment stage for validation of the proposed Multi-Vector Energy Hub concept. Delivery of a desktop-based evaluation and design phase (discovery) will significantly de-risk the next phases of trial and network demonstration by avoiding costly misdirection of scope and focus.

The key delivery partner, Smarter Grid Solutions, has offered discounted rates as contribution, and offers a highly skilled team that ensures the ambitious project outcomes can be achieved in the tight delivery timescales of a discovery phase project.

Supporting documents

File Upload

Close down Report - Cross Vector Energy Hub - Final.pdf - 1.7 MB
SIF Round 3 Project Registration 2024-05-15 10_24 - 58.9 KB

Documents uploaded where applicable?

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