SIF Alpha Round 3 Project Registration

Date of Submission

Nov 2024

Project Reference Number

NPG_SIF_R3A-Cross-Vector-Hub

Initial Project Details

Project Title

Cross Vector Hub (R3A)

Project Contact

Daniel Hoare

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

Gas Distribution

Project Start Date

01/10/2024

Project Duration (Months)

6

Lead Funding Licensee

NGN - North East

NPg - Northern Powergrid (Northeast) Limited

Funding Licensee(s)

NGN - North East

NPg - Northern Powergrid (Northeast) Limited

Funding Mechanism

SIF Alpha - Round 3

Collaborating Networks

Northern Gas Networks

Technology Areas

Modelling

Demand Side Management

Network Monitoring

Gas Distribution Networks

Project Summary

Cross-Vector Energy Hubs can leverage the flexibility of both Electrical and Gas technologies to support the electricity system and release grid capacity via coordination of these parallel energy vectors. The project builds and demonstrates a planning and simulation toolset that evaluates the Cross-Vector Energy Hub, allowing both DNOs and prospective Energy Hub developers/owners to simulate the coordination of electrical and gas technology components. The toolset models the control of device portfolios as configured by user, quantifying the value of constraint-limitation and feasible device coordination (technical), which can then feed into assessment of the commercial value for such coordination (economic).

Add Preceding Project(s)

NPG_SIF_012 - Cross Vector Energy Hub

Add Third Party Collaborator(s)

Smarter Grid Solutions

Project Budget

£425,544.00

SIF Funding

£380,106.00

Project Approaches and Desired Outcomes

Animal testing (not scored)

- ○ Yes
- ⊙ No

Problem statement

It is a well established concept that operating the separate vectors of the energy networks (gas and electricity) as a single system can deliver benefits to both consumers and utility companies.

These benefits arise from the ability to optimise the energy system to meet consumer demands in a holistic fashion and for each vector to be able to support other vectors at points of peak demand. This concept is widely studied and accepted in academia but is untested and unproven in real world operations.

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.

At Discovery Phase, Cross Vector Energy Hub project demonstrated a clear benefits case for co-optimisation of the grids, utilising long duration gas storage (green hydrogen) and gas's ability to provide invaluable fast responding and highly dispatchable peaking services to the electricity grid. Further, the Discovery phase demonstrated clear evidence that the 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.

The challenge to delivering the benefits is that, without existing deployments and functional trials knowledge of how to make a Multi Vector Energy hub successful is lacking. To address this, we propose to develop advanced modelling tools that will allow assessment of the gas and electricity networks at planning stage to identify locations that offer the potential whole system cross vector management. We also intend to develop and deliver tools that allow either network operators or third parties to design an energy hub, including sizing of assets, and to optimise operation.

Validating these tools by being able to calibrate the predicted simulations against the real-world outcomes of the Beta 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

At the outset of the Discovery phase it was expected that the Network Utitilites would be the primary users of the tool set and energy hub concept. However, the demonstration of potential value through wider market participation led the project team to conclude that third party developers and those with a stake in energy planning, such as Local Councils, would benefit equally if not more from the tools developed. Developers and third parties with an interest in energy planning can use the tools for their site assessment, locating the best locations for siting an Energy Hub asset and in the design of the energy hub. Similarly many local energy planners, such as local authorities are trying to find ways to reduce their carbon while also lower their energy costs; these tools will help them to meet these objectives.

In addition to the recently-completed Discovery phase project, this Alpha phase 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 Connectrolyser, SCOTclue and Cumbrian Hydrogen vision, as detailed in the project plan spreadsheet.

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 difficult to identify. Therefore, the scale of the benefits that could be realised is unproven, the Discovery Phase CBA shows that there is good reason to expect benefits to be substantial with positive CBAs across all modelled scenarios.

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 and are being successfully operated, giving them a TRL9. 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. We consider the Energy Hub concept to be at a TRL2, this Alpha phase application aims to take this to TRL 3/4 by creating a functional design. The Beta stage demonstration would raise the Energy Hub to a TRL 8.

This project concept will address this gap, by building on the work already done 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. As there are no deployments of this concept, 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 DNO.

The project requires the gas and electricity networks to be considered as a single system and demonstrates the coordination of new technology for the benefit of the whole system. They will also be able to assess other energy vectors such as heat systems as demands that interact with the 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. These novel arrangements were explored as part of the Discovery phase, such as the potential development of a flexibility market on the gas networks. The outcomes of this project will help to demonstrate what is possible through a whole system approach, this evidence will help to inform future policy development, improving the efficient and economic running of a coordinated system and delivering benefits through improved price control outcomes.

The project outcomes are highly relevant to Ofgem's Regional Energy Strategic Planners and the National Energy System Operator , both of which will have responsibilities for holistic energy system planning covering electricity, natural gas and future hydrogen gas. Similarly, the tools and learning that will come from this project can help support local authorities through the LEAP process, to make more efficient energy plans, especially where other energy demands such as heating might be met by district heating schemes.

This stage of the project fits directly into the structure of the SIF challenge. At this Alpha stage we will develop the multi-vector, whole system modelling methods that will allow network companies, third party developers, and future local planning authorities, to identify sites for co-optimisation and to minimise network costs by doing so. The Beta 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.

Impact and benefits (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum on energy bills for consumers

Financial - cost savings per annum for users of network services

Environmental - carbon reduction – direct CO2 savings per annum

Environmental - carbon reduction – indirect CO2 savings per annum

New to market - services

Others that are not SIF specific

Impacts and benefits description

The Discovery phase demonstrates how Renewable Energy Source electricity export that would be curtailed by the DSO could be converted to green hydrogen within a Cross Vector Energy Hub and used to support the gas distribution network operation or as hydrogen fuel for other use cases such as transport or heating. Curtailment is avoided by managing demand from the hydrogen electrolyser. The Hub supports the following benefits to network operators and customers.

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

The Cross Vector Energy Hub solution reduces curtailment levels and effectively allows other RES to connect. The Discovery Phase considered Energy Hub export curtailment avoidance of up to 15% of annual electricity export for a 100kW peak demand site where peak curtailment avoided was 160kW, 98MWh per year. Using a value of £300/kWh for flexible services this translates to a present value of avoided investment in networks of £496k over 25 years and £29k in CO2 reduction by allowing another 160kW of renewable generation to connect. Scaling this up to the equivalent of 50 x 160kW Cross vector Energy Hub sites (8MW) would see these benefits i

Financial - future reductions in the cost of operating the gas network. The potential to inject hydrogen into the gas networks could possibly benefit gas network operators and gas customers by avoiding gas network upgrades.

Financial - cost savings per annum on energy bills for consumers. The Discovery phase showed that 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. It also demonstrated the potential for reduction of energy lost via curtailment, this is expected to improve renewable generation business cases and could lower the prices they need to charge to recover their investments due to less MWh's lost.

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%.

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 networks. 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. The CBA carried out at Discovery phase strongly supports this conclusion and shows that in addition to operating as an Energy Hub the assets can access broader markets, such as ESO markets or local constraint markets.

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 was demonstrated at Discovery Phase.

Teams and resources

The Alpha phase project will be delivered by Smarter Grid Solutions (SGS), Northern Powergrid (NPg), and Northern Gas Networks building on learning from the discovery phase 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 and NGN who are well-versed in the development and demonstration of innovation concepts across their respective 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's existing experience in modelling and in digital tool creation means that we do not require access to equipment or facilities. We do require access to planning and operational information for the relevant utility networks, this will be provided by our project partners.

Northern Powergrid is responsible for project management and electrical networks data acquisition within the project, ensuring that all project outputs and learning outcomes are relevant, feasible and tailored for distribution licensees to derive value from. They will also provide planning and operational information and support the development of the solutions tools and modelling applications.

Northern Gas Networks will provide planning and operational information for the development of the solution tools and modelling applications. They will also provide expert steering and review project deliverables to ensure that they are relevant and usable for gas utility licensees.

The alpha phase will provide continuity with the discovery phase, with the core delivery being done by the existing team from SGS and NPg from the Discovery phase, with NGN joining as a new partner. There will be additional expertise from SGS on network modelling and software development for the tool design and delivery.

Project Plans and Milestones

Project management and delivery

The proposed governance arrangements, including key roles and responsibilities, are like those successfully deployed in previous projects including the Discovery phase project.

SGS will take the lead on Project Management. SGS's 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 (DNO focus and expert review).

*Project Engineer (NGN) --Project Delivery (Gas focus and expert review).

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

In addition to the core project team, there will be a project sponsor from each of the project partners:

SGS (Robert MacDonald -- Executive Vice President)

NPg (Bart de Leeuw -- Head of Innovation)

NGN (Richard Hynes-Cooper -- Head of Innovation)

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

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

Key outputs and dissemination

The Alpha trial will establish the models and digital toolsets required to support the future role out of Energy Hubs. The Tools referred to in this application are a set of software applications, with suitable user interfaces, that can be used to simulate the cross vector energy hub operation including the coordination of different devices, allowing the user to evaluate their value case through time series analysis.

These digital tools will allow the user to the energy networks for appropriate Energy Hub sites and model the final design specification for an energy hub.

The project will deliver two separate toolsets, one targeted for Network utilities and one for third party stakeholders such as Developers, Local Energy planners, and local councils.

To deliver these tools we will break down our engagement and consultations in the following way:

1.Tools designed to support DNOs in planning and assessments of their networks, allowing them to sign post parts of the network where the flexibility provided by energy hubs would be of most benefit, particularly in supporting the release of capacity. -- These tools will be disseminated to other network operators via webinars, ENA working groups and knowledge sharing events that NPg and NGN will be responsible for leading, with support from SGS for tool demonstration where required.

Tools that allow third parties, such as DER developers or local councils to asses the network allowing them to simulate the coordination of different technology types, configure different assets, and design their Energy Hub. The tools will also support the quantification of the value case for the development and deployment of an energy hub in a certain location. To ensure that the tools meet user needs we will engage with developers and local authorities, facilitated by NPg and NGN through their LEAP teams, to test functions and gather feedback. To ensure that the tools are accessible and understandable and that the tools are intuitive for users who do not have network planning backgrounds, we will test an alpha stage version of the tool with the third parties, SGS will support these meetings with a User Interface/User Experience design specialist. -- These tools, once validated, will be disseminated to third parties via webinars led by NPg and NGN, with SGS support for demonstrations. The tools will also be published on NPg and NGN's respective websites alongside explanations of how to use them.
The tools designed through the Alpha phase will be used to design the Energy Hub for the demonstration trial at Low Thornley, proposed as the live trial deployment at Beta stage. This will then validate the developed tools, and they will be available for use by the energy utilities and third parties.

Because the tools will be available for third parties the tools aim to help to develop access and revenue generation within existing competitive markets, and will not undermine their operation in any way.

Commercials

Intellectual property rights, procurement and contracting (not scored)

We are using the default agreement for IPR.

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 their DERMS product.

Commercialisation, route to market and business as usual

The outputs of the Alpha Phase directly support the commercialisation of Energy Hubs by providing tools for network utilities and third parties to assess the economic and operational viability of Energy hubs at different sites on the energy networks. In addition to these fully functional tools (modelling and simulation software applications), the project team will deliver a fully described functional specification for the tools, allowing others to build and develop on the toolsets to customize them or adapt them to new use cases.

The component assessment completed in Work package 1 of the Discovery Phase showed each individual component of an Energy Hub is already well established and available as an off the shelf asset, e.g. battery storage, hydrogen electrolyser, renewable generation assets. The key output of this project is to demonstrate their commercial viability when operated in an optimised and coordinated fashion for the benefit of the energy networks.

SGS have proven track record of delivering bespoke tools and modelling services to both network utilities and third party developers and their consultancy team has a wealth of experience in supporting developers in looking for grid connections and in delivering curtailment reports. In support will be provided by NPg and NGN in the for of expert advice and design parameters for the electricity and gas distribution networks. At the Alpha stage there is not requirement for investment in technological resources to deliver the project outcomes.

If taken through Beta phase live trial deployment the tools that have been developed through this Alpha phase can be validated. The intention is for third parties to develop, deploy, and operate Energy hubs which will be supported by the dissemination of these validated tools and by the demonstration of commercial viability achieved through the demonstration site. NPg and NGN will support other network utilities to adopt the tools. They will also support developers looking to deploy Energy Hubs on their respective networks where the tools show a benefit to network resilience, capacity hosting, and efficiency.

To Date, NPg and SGS's project sponsors have been directly involved in the project, including in the review of project outputs and the decision to carry this project forward to Alpha stage on the strength of the CBA showing positive economic outcomes for all scenarios assessed.

Policy, standards and regulations (not scored)

The project does not require derogations or exemptions in order to proceed at Alpha stage, it is also not expected that any derogations or exemptions would be required for a successful Beta stage demonstration.

From the Discovery stage the following regulatory considerations were identified, however these would be for consideration at the stage of BaU roll out and do not prevent Developers form successfully deploying the solution.

Electricity Regulation

Assuming Cross Vector Energy Hub applications would involve private networks not owned by a DNO or IDNO then a number of license exemptions would be applicable that would allow an energy hub owner to generate electricity, distribute this within the private network and supply industrial and commercial customers, but there would be a limit on supply to domestic customers up to a level of 1MW.

Gas Regulation

In terms of the Cross Vector Energy Hub proposition a key element is access to trade hydrogen gas in the Wholesale gas market. This requires physical access to the gas distribution network to inject hydrogen gas into the network and compliance with regulations associated with this.

In terms of regulated access to gas wholesale markets for hydrogen produced via electrolysis, there is little information on blending policies and regulations. A policy decision on this topic is due to be released this year. The expected arrangements would likely limit the permitted level of hydrogen blending to be below 20% by volume across the GB gas distribution networks in practice. How this would translate into regulated rules for access to the gas distribution network, to inject hydrogen and access Wholesale gas market trading, is not known at this stage.

Value for money

The full Alpha phase, as described in this submission, will be delivered with a funding budget request of £380,106 from SIF. In delivering the project, the overall cost to project partners will be £422,341. The SIF funding request reflects a 10% contribution from all project partners, where the contribution is reflected via a 10% discounting in the day-rate cost. Given the nature of this project, where engineering effort is the key cost in achieving project deliverables, we feel this is an appropriate means of implementing partner contribution (as opposed to technology or license costs, which do not exist in this project).

The project follows on from the successful Discovery Phase project, where at close-down it was confirmed that once delivered effort was built into the consideration then the overall contribution from project partners (SGS and NPG) was higher than the initially-forecasted 10%.

The cost of partner contributions will be spread out within the project and borne out by each partner reflecting their relevant area of industrial and technical expertise. This does not reflect any reduction in effort/labour to deliver the project. There are no subcontractors involved in project delivery, and thus not to be considered in the context of project value for money. There is no additional funding from other innovation funds that will support this Alpha Phase project.

The project team consists of subject matter experts in the Smart Grid electrical/gas domain, in particular the team of Smart Grid Consultants at Smarter Grid Solutions, for whom the delivery of bespoke modelling of innovative grid technologies is a common requirement. The SGS team brings extensive experience in the development of bespoke modelling and analysis environments. Existing time-series simulation templates that are held by the team will be applied, ensure fast ramp-up of the tool development activities and delivering further value-for-money via the experienced team and our existing toolsets. For information: existing time-series toolsets are used for electrical-only modelling of constraint management schemes where the time-series simulation of smart network control schemes is required.

The Discovery phase demonstrates how Renewable Energy Source electricity export that would potentially be curtailed by the DSO could be converted to green hydrogen within a Cross Vector Energy Hub and used to support the gas distribution network operation, or as hydrogen fuel for other use cases such as transport or heating. Curtailment is avoided by managing demand from the hydrogen electrolyser. The Hub supports the following benefits to network operators and customers; future reductions in the cost of operating the electricity and gas networks. Cost savings per annum on energy bills for gas and electricity consumers. Carbon reduction -- direct CO2 savings per annum. The creation of new revenue streams, as well as improved access to revenues for users of network services.

Costs of the project are generally allocated to SGS. NPG and NGN have relatively small allocations reflecting their roles as reviewers of outputs and providers of project and network relevant information and data.

Associated Innovation Projects

- (●) Yes (Please remember to upload all required documentation)
- ( ) No (please upload your approved ANIP form as an appendix)

Supporting documents

File Upload

SIF Alpha Round 3 Project Registration 2024-11-25 3_22 - 71.8 KB

Documents uploaded where applicable?

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