SIF Discovery Round 2 Project Registration

Date of Submission

Apr 2023

Project Reference Number

10052878

Project Registration

Project Title

Electrolyser Improvements driven by Waste Heat Recovery

Project Reference Number

10052878

Project Licensee(s)

National Gas Transmission PLC

Project Start

Apr 2023

Project Duration

2 Months

Nominated Project Contact(s)

box.gt.innovation@nationalgrid.com

Project Budget

£106,349.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£95,714.00

Strategy Theme

Whole energy systems

Challenge Area

Preparing for a net zero power system

Lead Sector

Gas Transmission

Other Related Sectors

Electricity Distribution

Funding Licensees

Lead Funding Licensee

NGT - National Gas Transmission PLC

Collaborating Networks

UK Power Networks

Technology Areas

Asset Management, Distributed Generation, Gas Transmission Networks, Hydrogen, LV & 11kV Networks

Equality, Diversity And InclusionSurvey

Yes

Project Summary

SIF Innovation Challenge

This project looks to address the challenge of preparing for net zero power systems using novel ways to reliably support low stability systems. Green hydrogen production is a low stability system in that the production is reliable on the weather (wind/solar) and/or constraints in the electricity network. This makes it very hard to predict the alignment of production and use of hydrogen.

Improvements in the efficiency of hydrogen production will maximise the hydrogen created within periods of high renewable energy availability.

Energy Network Innovation

Hydrogen is looking to be transported within the gas networks to decarbonise the UK, hydrogen production is currently focussed on the industrial clusters and there will be limited access to hydrogen during the transition to decarbonise operational sites, especially those not situated on the hydrogen backbone. On the NTS many compression systems are planned to be replaced to enable them to meet emissions targets, an alternative approach is to capture emissions whilst we transition them to utilise hydrogen at a lower cost. This is required sooner than the full network transition to hydrogen and therefore onsite production could assist. In order to supply hydrogen to these sites in an economical manner renewably powered electrolysers are being considered.

Partner Experience and Capability

National Grid Gas (GT&M) and UKPN are considering the opportunity of electrolyser interactions with the energy networks. GT&M are also managing the integration of the systems into operational sites. Anglian Water are a key stakeholder in the production of hydrogen from electrolysis and it is key to understand the impact on their network as well as our own.

Ceres are experts in solid-oxide electrolyser systems and Alfa Laval have many years of experience in deploying heat recovery solutions, these are the two critical technologies for our system development. Cardiff University have expertise in gas turbine development and digital systems, their role will be to provide insight into optimising the system through data and support our understanding of the likely emissions of burning hydrogen and hydrogen blends, this is important when designing emissions capture systems. HydroGenus are supporting the project on the commercial implications of the proposed system.

Potential Users and Needs

The focus of this work is on the gas transmission system but the solutions developed in this project could be utilised across the UK where waste heat is available to improve the efficiency of hydrogen production.

Project Description

The UK government has identified the opportunity for the use of hydrogen as a NetZero energy source, replacing the use of natural gas as a fuel. Subsequently, the networks have identified the opportunity to decarbonise the fuel at operational sites, replacing natural gas with hydrogen to fuel compressors and other site equipment.

The challenges surrounding NetZero energy sources include the intermittency of its availability, it is therefore vital that we ensure we are maximising the efficiency of green hydrogen production (electrolysis) to make the most of the electricity available at any one point in time. Green hydrogen is likely to be produced during periods of high renewable electricity generation to prevent the need to curtail electricity production, however this means that hydrogen production is very reliant on the weather.

The National Transmission System (NTS) transports natural gas around the UK today supported by 24 compressor sites and approx. 70 compressor units. The majority of the compression systems are driven by gas turbines which burn natural gas; ongoing projects are looking at the opportunity to transition these gas turbines to utilise hydrogen as their fuel gas, which is looking promising. Many of the NTS sites are located near renewable electricity generation or have enough surrounding land to consider the application of renewable generation to provide hydrogen to power the compression systems, rather than drawing from the gas network.

Proton Exchange Membrane (PEM) electrolysers are the most commonly available system today for green hydrogen production, efficiency of these systems is set to reach 82/86%. Solid Oxide Electrolysers (SOE) can reach efficiencies as high as 93% but require heat to drive the hydrogen production system.

The gas turbines that drive the compression systems on the network currently release emissions and heat to atmosphere, heat recovery and emissions capture is vital to support the transition to net zero. The heat released from each turbine can be in the range of

450degC which could be utilised to drive the SOE system which typically run at 500degC. This project will determine the feasibility and opportunity to enable this opportunity to prevent harmful emissions and improve the efficiency of hydrogen production. This project will consider both gas turbines powered by natural gas and hydrogen/blends.

Third Party Collaborators

Ceres Power Limited

Anglian Water

Alfa Laval Aalborg Oy

Hydrogenus

Cardiff University

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Project Description And Benefits

Applicants Location (not scored)

National Grid Gas PLC (GT&M) - 02006000
1-3 Strand, London, WC2N 5EH

Ceres Power Holdings PLC (Ceres) - 05174075
Viking House, Foundry Lane, Horsham, West Sussex, RH13 5PX

Alfa Laval Aalborg Oy (Alfa Laval)
Kaivopuistontie 33, Rauma, Finland, 26200

Cardiff University (CU) - RC000089
Cardiff University, School of Engineering, Cardiff, Wales, CF24 3AA, UK

Hydrogenus ltd - 13687696
Chapel Farm Chapel Lane, Thornham Parva, Eye, England, IP23 8EX

Anglian Water Services Limited (AWG) - 02366656
Lancaster House Lancaster Way, Ermine Business Park, Huntingdon, Cambridgeshire, United Kingdom, PE29 6XU

UK Power Networks (Operations) Limited - 03870728
Newington House, 237 Southwark Bridge Road, London, SE1 6NP

Project Short Description (not scored)

The Electrolyser Improvements driven by Waste Heat Recovery project looks to demonstrate efficiency improvements in hydrogen production through the use of waste heat produced in the transportation of network gases.

Video description

https://youtu.be/ztng1jwXeKM

Innovation justification

Problem

This project looks to improve the efficiency of green hydrogen production utilising waste heat produced by the high-pressure gas network which is not currently utilised. Green hydrogen production can be expensive and inefficient leading to criticism of its capability against electrification; however, it is a far more efficient method for storing renewable energy. In improving the efficiency of green hydrogen production, we can maximise the conversion of electricity to hydrogen and greatly improve the business case and costs of hydrogen.

Innovation

The application of waste heat recovery on the national transmission system (NTS) gas turbine systems has not previously been undertaken and its integration with solid-oxide electrolysis systems has not been considered; but could provide an optimised hydrogen source for many applications. The Ceres solid-oxide electrolysers are relatively new systems which are looking to demonstrate capability in 2023 alongside the Discovery and Alpha phase of this project, to enable full demonstration of the system in 2024.

Knowledge Gaps

Little work has been undertaken on the use of gas turbine waste heat for electrolysis and therefore there are many knowledge gaps to fill, requiring a cross functional team of experts: our partners. We will need to consider not only the equipment but the integration to an operational site and optimisation through data. The work packages described in Discovery enable us to quickly determine the suitability of this proposal.

Economic and Sustainability Value

The alternative solution to this project is to deploy PEM electrolyser systems which are less efficient than their solid-oxide counterparts, leading to less hydrogen for every unit of electricity utilised and increasing the cost of the produced energy source. At present the waste heat from the onsite compression systems is not utilised and therefore development of this capability could also provide energy for other applications such as hydrogen storage.

Funding Options

The system proposed is novel in its approach and relatively low in technology readiness levels therefore it is not ready to be deployed as business-as-usual (BAU). The BAU alternative available for deployment is limited by efficiency and therefore the business case for deployment is harder to justify. SIF funding will enable this technology to be accelerated into use in connection with our 24 compressor stations. In the case that hydrogen is not utilised in the compression system this solution will enable capture of emissions and heat whilst providing hydrogen for other users in the local area.

Benefits Part 1

Environmental - carbon reduction – direct CO2 savings per annum against a business-as-usual counterfactual
Financial - future reductions in the cost of operating the network
New to market – products, processes, and services
Revenues - creation of new revenue streams

Benefits Part 2

The Discovery phase will develop the business case and the cost/benefit analysis for this project. The benefits that we propose to track are as follows:

Financial - Electrolyser efficiency vs alternative on market PEM system
This will consider the energy input into the electrolyser and the output hydrogen. Consideration will be made for periods throughout the year when waste heat may not be available and the impact of this on the efficiency of the overall system.

Further to this a consideration for the approximate cost of the equipment and operation of the facility will be made against that of a more traditional electrolyser. The cost of the system vs the efficiency will then be considered over a set period of time to ensure that the system cost does not override any efficiency benefits seen. In order to ensure this calculation is as realistic as possible hydrogen production periods will utilise an example year of weather in the demonstration location and the same year of compressor utilisation. Working with UKPN and the innovative electrolyser connection project we will ensure alignment between the benefits cases.

The calculation will be as follows for both the baseline and method:

(Cost of electricity in per annum + system cost + ongoing cost per annum*) / Volume of hydrogen produced per annum = relative hydrogen cost

*Ongoing cost per annum - this could include maintenance, water, land requirements etc...

Environmental - System Emissions
This will consider the potential reduction in emissions in deploying this system and quantify this against current emissions. Consideration of this against emissions targets and the potential to deploy this system instead of replacing assets will be made. Benefits could be seen during the beta phase, once the demonstration is operational, however most benefits will occur once the system has been deployed across multiple operational sites. We believe this could be through the Project Union timeline of between 2026 and the early 2030s for the gas transmission network.

Project Plans And Milestones

Project Plan and Milestones

The project will be undertaken through 6 work packages, utilising agile methodologies to enable us to make the most of the two month phase. We will look to run activities in parallel and bring these together in the later sprints of the project to conclude the feasibility study.

Project Management led by GT&M - £12,474
This work package will ensure the project meets its projected timing, risk and cost through the Discovery period and will develop the plan for the Alpha phase project.
Milestone 6 - Alpha application
Business Case & Requirements Development led by GT&M - £11,739
This work package will develop the key requirements for the system and develop the business case and CBA for the system to be deployed
Milestone 1 - Requirements defined and shared with all partners
Milestone 6 - Alpha application
Waste Heat Recovery led by Alfa Laval - £24,695
This work package reviews the feasibility of waste heat recovery on NTS compression systems and determines cost and approach
Milestone 2 - Waste heat recovery system proposal and outputs
Solid Oxide Electrolyser (SOE) led by Ceres - £23,512
This work package determines the feasibility of utilising SOE alongside waste heat recovery on compression facilities.
Milestone 3 - SOE system proposal
Emissions Capture led by Cardiff University and supported by Alfa Laval - £16,145
This work package reviews the waste heat recovery system and looks to integrate waste heat recovery whilst considering methods for carbon transportation, storage and use.
Milestone 4 - Emissions management system proposal
System Demonstration led by GT&M - £7149
This work package determines the concept system design bringing together the key elements from each work package into a concept for the alpha phase to develop further.
Milestone 5 - Delivery of the concept design for site integration of the system
Risks will be managed through the project as depicted in the risk-register. The project meetings will take stock of progress against the project plan and the risks associated. The key risks for the project are in the systems application to operational sites and the alignment of hydrogen production and waste heat recovery. The discovery phase is vital to providing insight into these key risks and mitigating/eliminating them prior to the Alpha phase development. There are several risks associated to project management and meeting the SIF requirements that will be managed by the project team through the project set up and delivery.

Regulatory Barriers (not scored)

Project regulatory barriers
There are no regulatory barriers that prevent the delivery of the project through Discovery or Alpha. In Beta we are looking to deploy on an operational site which will require permits, early engagement to ensure these are attained will be required. Uncertainty in the RIIO-2 funding mechanisms requirements and timelines could lead to projects not progressing in the assumed funding route or timescales proposed, however, discussions are ongoing to ensure we are approaching the activities in the correct manner with Ofgem and BEIS to reduce this risk.

Longer-term regulatory barriers and policy requirements
The deployment of hydrogen on gas networks in the UK has not yet been finalised however many exploratory demonstrations have been sanctioned across the UK. As we progress past Beta we will need to ensure that the opportunity to duplicate the demonstration is available for other sites.

There are several policy and regulatory systems in review around the introduction of hydrogen considering both 100% hydrogen and blended hydrogen. Primary and secondary legislation will need to be updated to enable blends of hydrogen within the network and allow for the development of a 100% hydrogen NTS. Alongside this, rules will need to be agreed, such as the uniform network code (UNC) and Gas Safety Management Regulation (GSMR) to incorporate hydrogen blending and if required adapted for hydrogen transportation.

Evidence creation to influence future policy and regulations
The project will look to create evidence for the HSE and relevant stakeholders on the deployment of these systems, the format of which

will look to follow that utilised by the NSIB working group. All current NIA and SIF project are engaged in providing evidence for the transition of the gas networks to hydrogen.

We continue to support Government and Ofgem in gathering the evidence required to deliver policy and regulation that will enable the energy transition through working groups such as Hydrogen Grid Research and Development (HGR&D) and Gas Goes Green (GGG). Evidence of our networks capability to support the transition is beginning the be reviewed by the HSE and development of approaches to blending both commercial and technical are underway through these collaborative working groups.

Commercials

Route To Market

Projects transition to BAU

An implementation plan is due to be developed in work package 2 of the Discovery phase, considering the costs associated with deployment and providing a comparison of traditional electrolyser systems and the solid oxide solution proposed. The plan will also consider a selection of potential applications across the UK. The proposed demonstration site for Beta has industrial applications for hydrogen in the local vicinity who have been engaged in developing hydrogen as an energy source for their systems. There are two additional projects that will be considered in the final beta demonstration: UKPN led "Connectrolyser" determining the optimum route for electrolyser interactions with the electricity network ensuring the use of renewable and constrained and GT&M led "Hybrid Storage System for Site Safety and Efficiency" enabling an alternative more efficient electrolyser route than existing options utilising network waste heat.

Competitive Markets

The deployment of network connected PEM with compressed gas storage is something that could be deployed as BAU today but has limitations in efficiency and cost that make the business case hard to justify. These project elements will enable a refined, safe and cost-effective solution for sites to produce and utilise hydrogen. They do not however prevent a competitive market as the end solution could be provided by several suppliers in the future.

Implementation Ownership

Deployment of the end system across the network will be done through investment programmes and the spend justified through our price control business plan proposals. The solid-oxide and heat recovery systems will be available through Ceres and Alfa Laval and models for integration with sites will be available for customers to utilise and apply to their applications.

Primary customer segment

Customers for the solid oxide and gas turbine waste heat combined system could range from global transmission networks to power stations.

Customer value

The customer value is in improving the efficiency of hydrogen production and maximising the hydrogen that can be produced from the electricity supplied, this should in turn reduce the cost of the hydrogen for the end user. Initially we are considering the hydrogen being utilised by site equipment but in the future this system could inject into the network for all consumers.

Funding strategy for Deployment

The Beta demonstration will enable a blueprint for future deployment of the hybrid storage system for operational sites and continued deployment will be built into future business plans if successful.

Intellectual property rights (not scored)

What are the Intellectual Property Rights (IPR) arrangements for your project?

For SIF projects, each Project Partner shall own all Foreground IPR that it independently creates as part of the Project, or where it is created jointly then it shall be owned in shares that are in proportion to the work done in its creation. The exact allocation of Foreground IPR ownership will be determined during the contractual negotiations with the Project Partners on the agreement for the project.

Also if the party appoints a sub-contractor, the agreement with that sub-contractor should have similar IP provisions to those in this agreement and which at least achieve the same aims as the agreement regarding IP.

Once the Project is completed, Relevant Background IPR will be licensed for use by the Project Partners in connection with another Project Partners' Foreground IPR solely to the extent necessary to use that Foreground IPR, upon terms to be agreed.

Describe how each Project Partners complies with Chapter 9 SIF Governance Document.

We intend to ensure each Project Partner will comply with Chapter 9 SIF Governance Document through the contractual terms governing the project. However, precisely how this is done will be subject to contractual negotiations with the Project Partners on the agreement for the project.

Costs and value for money

The total discovery project cost is £110,347 including £4,000 in kind contribution and we are requesting £95,714 of funding. The funds are split as follows:

£14,635 of contribution is to be provided to the project which includes the 10% financial contribution required.

The split of finances shows that the majority of activity will be led and undertaken by Alfa Laval, Ceres and Cardiff University to develop the integrated waste heat recovery and electrolyser system supported by the other partners to ensure it meets the energy system requirements.

This project demonstrates value for money as the benefits of developing a more efficient method for producing hydrogen utilising current waste could provide value in reducing the cost of hydrogen for the end user. Eliminating emissions from our compressors could accelerate our move to net zero and enable the life extension of assets reducing the cost for the consumers in the short term.

Bringing all these partners together to develop a common solution is difficult to do outside of funded projects and demonstrates the value of innovation funding for enabling high risk opportunities to be realised.

Document Upload

Documents Uploaded Where Applicable

Yes

Documents:

Electrolyser Improvements Application Nov22 (1).pdf

Infographic.pdf

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SIF Electrolyser Efficiency Improvements Driven by Waste Heat Recovery - Discovery Show and Tell.pdf

This project has been approved by a senior member of staff

☑ Yes