national gas transmission

SIF Discovery Round 2 Project Registration

Date of Submission

Apr 2023

Project Reference Number

10060432

Project Registration

Project Title

Hybrid Storage Systems for site safety and efficiency

Project Reference Number

10060432

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

£148,507.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£133,656.00

Strategy Theme

Net zero and the energy system transition

Challenge Area

Preparing for a net zero power system

Lead Sector

Gas Transmission

Other Related Sectors

Electricity Distribution, Gas Distribution

Funding Licensees

Lead Funding Licensee

NGT - National Gas Transmission PLC

Collaborating Networks

UK Power Networks, Wales & West Utilities

Technology Areas

Asset Management, Energy Storage, Gas Distribution Networks, 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 reliant on the weather (wind/solar) and/or constraints in the electricity network. This makes it very hard to predict the alignment of production and demand of hydrogen.

Storage of hydrogen and release within relevant timescales is going to be vital to ensuring a consistent energy source and improved resilience. Compressed gas storage is a method utilized today to support green hydrogen production, however, the space requirements and safety of these systems are limited. Alternative technologies such as solid state or liquid hydrogen storage provide benefits in storage density and safety but have challenges in the release rates of the hydrogen. It is believed that a hybrid storage system of solid and gaseous storage managed by an artificially intelligent management network HyAI could provide safe and reliable opportunity.

Energy network innovation

Hydrogen is proposed to be transported within the gas networks to decarbonise the UK; the transportation of hydrogen requires ancillary systems such as compression systems that run on gas or electrical sources. Removing emissions from these ancillary systems is vital to realise a decarbonised energy system. The use of network hydrogen could be limited due to blend restrictions and in the early transitional stages, availability. Application of production and storage on local sites without restrictions due to COMAH is a game changer for the energy transition.

Partner experience and capability

GT&M and WWU are considering this opportunity for use on their operational sites, whilst UKPN are looking to understand how the electricity networks may interact with hydrogen production. Each of these networks is key to understanding the technologies application across multiple use cases in the UK.

H2GO are experts in solid state and liquid state storage systems and a private company looking to commercialise these systems and associated digital analytical systems. MTC are experts in ensuring manufacturability and reliability of systems. UoN have been researching hydrogen storage for many years and have identified novel solutions for solid state storage which could assist in the efficiency of output.

Potential users and needs

The solutions developed in this project could be utilised across the UK in both users applications and at production sites to improve resilience against the instability of green hydrogen production.

Project Description

In order to achieve the UKs Net Zero targets by 2050, the gas networks will play an important part through the delivery of net zero gases such as hydrogen and biogas to users. Hydrogen plays an important role in decarbonising operations that cannot be electrified and reducing the transition cost for the UK. Green hydrogen is produced using renewable energy sources such as wind or solar and is relatively easy to store compared to electricity, making it an attractive renewable energy carrier.

The UK government has set a target of 5GW of green hydrogen by 2030 and an end goal of moving to predominantly green hydrogen production in the future. However, there are some challenges surrounding green hydrogen production which include the intermittency of its availability. Green hydrogen will be produced during periods of high renewable electricity generation and when the electricity network is constrained; therefore, it is unlikely that hydrogen can be produced at the same rate as the users demand for hydrogen.

A storage method is required to store hydrogen for periods of low generation to provide a buffer. Currently, compressed gas storage technologies are being deployed across the UK as a relatively easy method of storing gas for medium to long durations, utilising underground geological facilities and pressurised vessels. The ease of its input/output of gas makes it a reliable method of gas storage, however, this method comes with its own challenges.

Pressurised vessels on operational sites pose safety challenges, efficiency limitations, high costs at scale associated with compression, and require large areas of land to store. Low pressure solid-state hydrogen storage provides an interesting alternative to compressed gas storage, with improvements in the energy density (up to 50-100gH2/l), safety, efficiency and cost of the system. However, the release of hydrogen from solid-state is slower than that of compressed gas storage.

The development of the hybrid storage (solid & gaseous) system and associated digital tools to analyse external factors and determine the optimum storage management will be explored in this feasibility study. Taking the best elements from each storage mechanism to provide a valuable storage mechanism for the future, the system will enable sites to manage larger volumes of gas without entering the COMAH thresholds. Modelling work done to date suggests that a hybrid solid/gaseous storage system could enable the deployment of solid-state storage in applications of high hydrogen volumes/flow requirements.

Third Party Collaborators

Manufacturing Technology Centre

H2GO Power

University of Nottingham

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Project Description And Benefits

Applicants Location (not scored)

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

H2GO Power LTD (H2GO) - London, London, City Of, United Kingdom, W12 0BZ

The Manufacturing Technology Centre Limited (MTC) - Coventry, Warwickshire, England, CV7 9JU

University of Nottingham (UoN) - Nottingham, NG7 2RD, United Kingdom

Wales & West Gas Networks Limited (WWU) - Newport, NP10 8FZ

UK Power Networks (Operations) Limited - London, SE1 6NP

Project Short Description (not scored)

The Hybrid Storage System will enable safe and efficient storage of hydrogen on operational sites using an optimised approach to hydrogens physical state against production and demand profiles.

Video description

https://youtu.be/8Y9qkbs0Sfk

Innovation justification

Problem

Storage is required to manage the intermittency of hydrogen production and resolve constraints in electricity energy storage. The deployment of storage systems on operational sites has limitations in space, safety and efficiency. Solid state storage has opportunities over liquid and gaseous storage solutions utilised today but are limited in their release of hydrogen. A recent modelling activity identified that a hybrid storage system of solid and gaseous storage would enable optimisation of storage both in cost and efficiency.

Innovation

This project is innovative in its approach by hybridising solid and gaseous storage to resolve the limitations of the different hydrogen storage systems. The proposed solid state hydrogen storage technology stores hydrogen more efficiently, safely and at a lower cost than compressed gas. The system includes an innovative machine learning platform (HyAI) using reliable algorithms which predict energy generation/storage /demand to optimise operations across the value chain.

Whilst the solid-state storage system provides benefits over other storage systems, the release rate for high flow applications needs focus. This project will consider the opportunity to expand the scale of the solid-state system and utilise novel methods to improve release rates alongside the use of gaseous storage. Academic research in this space has been undertaken but focussed on aerospace and automotive applications which are limited by space and weight.

Knowledge gaps

Prior work has not considered how the system would be designed and the different elements work together. This project focusses on concluding the system design, optimisation and providing insight into cost and output. Combining solid-state storage and compressed gas storage can minimise the scale of compressed gas storage but enable fast release of hydrogen when required. This system will need close management using data analytics to determine the optimum storage method at any one point in time, determination of how this system will work across the hybrid storage elements will be concluded in this phase of the project.

Economic and sustainability value

The use of the proven, ground-breaking solid-state modular reactors, linked to high flow storage systems and innovative AI systems that manage generation, storage and demand will provide value to the UK energy system in providing energy storage at a cheaper more efficient rate.

Funding options

The development of the system through other funding mechanisms has been considered but SIF funding is being progressed due to level of risk remaining in developing the system and the scale of demonstration required.

Benefits Part 1

Environmental - carbon reduction – direct CO2 savings per annum against a business-as-usual counterfactual
Environmental - carbon reduction – indirect CO2 savings per annum against a business-as-usual counterfactual
Financial - cost savings per annum for users of network services
Financial - cost savings per annum on energy bills for consumers
Financial - future reductions in the cost of operating the network
New to market – products, processes, and services

Benefits Part 2

In order to quantify the Financial benefits of a hybrid storage system the baseline of a compressed gas storage system will be compared against the novel design. Consideration for the gas turbine emissions reduction when utilising hydrogen will also be considered and will drive the storage requirements.

The following elements will be developed to enable calculation of the benefits:

Define the blend utilised by the gas turbine to determine the amount of hydrogen required. (Multiple blend scenarios will be considered in the model)
Annual profile of demand to be created
Define the demand requirements for other use cases as appropriate
Identify the reduction in emissions in utilising this blend in the gas turbine and CO2 equivalent per year (Environmental - direct carbon reduction)
Convert the CO2 saving to an annual net saving, utilising a base carbon cost
Consider the electrolyser size required for the use-case and associated capital cost / running cost
Annual profile for production to be created
Identify demand and production profile alignment over the year and potential deficits
Consider the renewable energy (wind farm) capacity for the use-case and associated capital cost / running cost
Identify hydrogen storage size required both as compressed and hybrid across an annual period
Determine storage capital cost and any running costs
Determine any other site upgrades and costs associated (COMAH requirements)
Financial

Baseline - costs to deploy compressed gas storage

Method - costs to deploy hybrid storage system

Benefits - Baseline - Method

Other benefits include safety by not storing large quantities of compressed gas on an operational site and impact on the consumer by removing our compression based emissions and the cost this will incur in the future. Quantification of these benefits is difficult to define and qualitive assessment may be required. 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 4 work packages, utilising agile methodologies to enable us to make the most of the three months in the discovery phase. We will look to run activities in parallel and bring these together in the later sprints of the project to conclude feasibility of the system proposed.

Project Management led by GT&M
Ensures the project meets its projected timing, risk and cost and will develop the plan for the Alpha phase.
Milestone 5 (M5) - Alpha Application
Success Criteria (C5) - the final report or/and application the Alpha is complete and submitted for assessment
Business Case & Requirements Development led by GT&M
Will develop the key requirements for the system and develop the business case and CBA for the system to be deployed
M1 - Requirements defined and shared with all partners
SC1 - requirements defined and shared with all partners to enable continued project development
M5 - Alpha application
Hybrid Solid State Storage System led by H2GO
Reviews the feasibility of the hybrid storage system and continues to develop the simulation associated (HyAI), the work package will consider alternative options and improvements in the efficiency of the system
M2 - Hybrid system model (HyAI)
SC2 - revised HyAI model to provide further insight into the system aligned to the user cases
M3 - Concept design for the hybrid storage system
SC3 - early concept design for how the hybrid storage system will integrate
System Demonstration led by MTC
Determines the concept system design bringing together the key elements from each work package into a concept for the alpha phase to develop further.
M4 - Onsite system application and demonstration proposal
SC4 - concept design of the hybrid system applied to site and interactions with other key site elements
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 interaction with the use cases. 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 manged 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

BAU adoption

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 storage mechanisms vs the hybrid 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 "Electrolyser Improvements driven by Waste Heat Recovery" enabling an alternative more efficient electrolyser route than PEM options utilising NTS 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 manage 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 Owner

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-state storage system will be available through H2GO Power and models for integration with sites will be available for customers to utilise and apply to their applications.

Primary customer segment

The hybrid storage solution could be considered in any application requiring storage of hydrogen, this is not limited to gas network applications. The optimisation of hydrogen release from the solid-state storage system and the interactions with the HyAI tool will enable a greater landscape of applications for solid-state storage whilst the integration of gaseous storage further improves the cost effectiveness of the system.

Customer value

The customer value is in the ability to deploy large volumes of hydrogen storage at a lower cost and with improved safety, this can be applied to many applications.

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 £150,506 including £2000 in kind contribution and we are requesting £133,656 of funding. The funds are split as follows:

The split of finances shows that the majority of activity will be led and undertaken by H2GO and MTC to develop the hybrid system design supported by the other partners to ensure it meets the energy system requirements.

In the quest to reach Net Zero, GT&M and WWU's key requirements will be to safely transport hydrogen between production facilities and its end users, whilst ensuring the running of the networks is done sustainably. Operational sites will need to transition to hydrogen along with the network itself.

The variability in hydrogen production vs demand requires methods for ensuring hydrogen can be produced when it is most cost effective and utilised when it is needed. Hydrogen storage is key to enabling this but traditional methods can have difficulties with efficiency, cost and safety. This project will provide an alternative solution that will resolve these issues and therefore reduce the costs consumers see in deploying such systems.

This project demonstrates value for money as the benefits of developing a safe efficient storage method for high volume, high flow hydrogen storage for above ground applications could provide value to all networks both gas and electricity alongside a wide range of other energy system users. Enabling flexible efficient and safe energy storage is key to the energy transition and will inevitably provide value to the consumer.

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:

H2GO SIF one pager.pdf

Hybrid Storage Systems Application Nov22 (1).pdf

SIF Discovery Round 2 Project Registration 2023-04-12 9_23

SIF Hybrid Storage Systems for Site Safety and Efficiency - Discovery Show and Tell.pdf

This project has been approved by a senior member of staff

☑ Yes