SIF Round 3 Project Registration

Date of Submission

Mar 2024

Project Reference Number

SIF_WWU_3_1

Initial Project Details

Project Title

Hydrogen Storage in Aquifers

Project Contact

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Challenge Area

Novel technical, process and market approaches to deliver an equitable and secure net zero power system

Strategy Theme

Net zero and the energy system transition

Lead Sector

Gas Distribution

Other Related Sectors

Gas Distribution

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

Wales & West Utilities

Funding Licensee(s)

Northern Gas Networks

Wales & West Utilities

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

Northern Gas Networks

Wales & West Utilities

Technology Areas

Hydrogen

Energy Storage

Storage

Project Summary

Presently large-scale storage of hydrogen in a net zero system is primarily in depleted gas fields. This project considers the alternative of using aquifer formations.

Aquifers offers countervailing benefits: the aquifer is at pressure at the start of storage use, so the requirement for cushion gas is reduced, and there is no risk of contamination of stored hydrogen with residual methane.

The project will assess and model the reservoir performance of known geological structures in two locations, to inform developers of hydrogen storage and identify the relative cost and performance of depleted gas fields as compared with aquifers.

Add Preceding Project(s)

NIA_WWU_2_10 - Potential for Salt cavern storage of hydrogen in and near South Wales

REF:10079341 - HyCoRe (Alpha)

Add Third Party Collaborator(s)

Progressive Energy Limited

Project Budget

£123,985.00

SIF Funding

£111,580.00

Project Approaches and Desired Outcomes

Problem statement

The seasonal variability of hydrogen demand expected in the future net zero energy system, especially if if hydrogen plays a significant role in domestic heating, is likely to drive a requirement for large scale geological storage of hydrogen. While salt caverns are an option for medium-scale (GWh scale) storage capable of managing supply/demand over days or weeks, larger seasonal scale storage (TWh scale) will be necessary in the longer term.

Redevelopment of depleted gas fields for hydrogen storage is being actively considered, but these require large volumes of cushion gas to repressurise the structures to a level at which flow rates are acceptable. As aquifer structures are not pressure depleted, there may be potential for development of these structures with significantly smaller amounts of cushion gas. This would significantly reduce the capital (setup) cost of these structures relative to depleted gas fields.

The project will assess and model the reservoir performance of known geological structures in the East Irish Sea and off North East England, to inform developers of hydrogen storage as to the relative cost and performance of depleted gas fields as compared with aquifers, and to develop a ranking for suitable structures in the East Irish Sea.

Video Description

https://youtu.be/XdtkaPMlrKM

Innovation justification

The proposed project addresses the challenge of developing novel technical and market approaches to deliver an equitable and secure net zero power system. The innovation addresses the challenges of managing peak demand and stability over longer time periods, specifically seasonal storage of hydrogen.

Innovation in the project aims to develop a specific novel operational practice -- namely, the storage of large quantities of hydrogen in porous geological aquifer structures at lower cost and at least operational equivalence with storage in depleted gas fields.

At present, most focus on large scale storage of hydrogen in a net zero energy system is on storage in depleted gas fields. This project considers the alternative strategy of using aquifer formations. Depleted gas fields offer the advantage of demonstrated storage integrity, but have a very significant requirement for cushion gas (gas required to repressurise the gas field to a level at which flow rates are viable) and produced hydrogen is likely to be contaminated with methane from the depleted reservoir.

The use of aquifers offers countervailing benefits: the aquifer is at pressure at the start of storage use, so the requirement for cushion gas is reduced, and there is no risk of contamination of stored hydrogen with residual methane. However, pressure management of the aquifer may require the drilling of pressure relief wells, and demonstration of storage integrity may be more challenging.

The innovation in the project will apply laboratory-scale experimental results already derived by Cambridge University's Institute Energy and Environmental Flows ("CUIEEF") and regional and localised geological interpretations available to the British Geological Survey to evaluate known and mapped aquifer structures in the East Irish Sea and offshore Northeast England.

BGS has detailed information on the known aquifer structures in the East Irish Sea, and will catalogue critical aspects of their geology including volume, reservoir characteristics, sealing formation thickness, integrity and faulting.

CUIEEF has already undertaken lab-scale experiments to explore how injected hydrogen interfingers with interstitial formation water and how hydrogen re-produced from a storage site is mixed with produced formation water.

Progressive will work with CUIEEF to apply learnings from these experiments with the assessment of the known structures, to develop reservoir models which will characterise the likely injection and production performance, and cushion gas requirement for these structures. These structures will be assessed and subjected to a techno-economic evaluation and ranking, against a counterfactual of hydrogen storage in a depleted gas field.

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum on energy bills for consumers

Environmental - carbon reduction – direct CO2 savings per annum

Environmental - carbon reduction – indirect CO2 savings per annum

Revenues - improved access to revenues for users of network services

Revenues - creation of new revenue streams

New to market – products

New to market – processes

New to market - services

Impacts and benefits description

Financial - The project will identify whether aquifer storage of hydrogen is lower cost than the counterfactual. This will allow network operators to select the least cost storage strategy, thereby achieving reductions in the cost of operating the network.

Financial - By adopting least cost hydrogen storage, users of network services can expect to share in the lower costs delivered by the network operators, and we would expect these to be passed on to customers.

Environmental - direct and indirect CO2 savings per annum. The techno-economic evaluation will include an assessment of the direct and indirect CO2 emissions impacts of large scale storage of hydrogen in aquifers against the counterfactual of depleted gas field storage. Combining cost and emissions assessments from each storage strategy, the preferred strategy from both cost and emissions perspectives will be assessed.

Revenues - The availability of large scale storage will provide network service users with security of supply of hydrogen, through the year, and independent of short term supply disruption (which may arise from low wind output impacting green hydrogen output or restricted natural gas feedstock availability reducing blue hydrogen output). This will give them improved access to existing revenue streams.

Revenues - Users of network services may be able to use low cost large scale storage of hydrogen to develop revenue-generative services and products. For example, network users may be able to offer hydrogen supply contracts underwritten by secure hydrogen supply from storage, providing customers with secure supply at a known cost.

New to market --The availability of low cost large scale hydrogen storage will enable the development of new products, processes and services. Large scale storage permits the development of different hydrogen supply offers, and this project will identify the least cost strategy for such large scale storage. The requirement for low carbon dispatchable power in a net zero energy system, to meet demand when renewables output is low for an extended period, is critical to the operation of that system.

Teams and resources

The project team will comprise Progressive Energy, British Geological Survey and CUIEEF, together with advisory input from the network operators sponsoring the project.

Progressive Energy is an innovative low carbon project developer, with interests in hydrogen production ("blue" and "green") and CCUS. It has undertaken many innovative projects relating to the use of geological features for CO2 and hydrogen storage, most specifically for Wales & West Utilities (for which it assessed geological storage potential for hydrogen in and around South Wales), at HyNet and Morecambe Net Zero Cluster (involving work assessing the CO2 storage potential of geological horizons in the Irish Sea) and for the North Sea Transition Authority (for which it undertook a concept study which led to the Bacton Energy Hub project and a number of subsequent cluster projects including Eni's Bacton Thames Net zero (in which it is a participant)).

The British Geological Survey is the UK's premier provider of objective and authoritative geoscientific data. It is recognised as a world-leading geological survey and global geoscience organisation. Progressive Energy has previously worked with the BGS and has found it to live up to its vision of being a leading and trusted provider of geological data and knowledge to meet the societal need for a sustainable future.

CUIEEF is an interdisciplinary research institute focussed on fluid flows in the environment. It has active research interests in hydrogen and carbon storage and has previously undertaken work with Progressive Energy on hydrogen storage.

Progressive will lead the project, undertaking the techno-economic review of storage options, based on detailed geological information of the selected structures provided by BGS and findings from CUIEEF on hydrogen storage performance. Progressive has the resources and expertise required to undertake this aspect of the project.

BGS will provide data on the selected geological structures, including size, reservoir geology and integrity. BGS has this data readily available, and will require no special resources or equipment.

CUIEEF will undertake further bench-scale experiments on storage of hydrogen in porous formations, to provide critical input on cushion gas requirements for aquifer and gas field storage. CUIEEF has the required equipment and resources to undertake this work.

Advisory board input will be sought from the network operators participating in the project, ensuring that the project is aligned with their needs. Appropriate relationships with other entities working in this field will be developed to maximise alignment of effort and value for money.

Project Plans and Milestones

Project management and delivery

Progressive Energy is experienced at successfully managing projects of this kind with UKRI. We have agreed scopes and deliverables for the partners, and will monitor progress of these against pre-agreed timelines and the risk register.

Work is planned into work packages:

WP1: BGS review of aquifer structures in study area: cataloguing known aquifer structures in terms of volume, location, number of wells, reservoir quality, pressure, aquifer composition, storage capacity. Deliverable: catalogue of aquifer storage candidates, ranked by attractiveness. Milestone: delivery of report end of Month 1.

WP2: CUIEEF lab scale modelling of storage of hydrogen in aquifers: comprising bench top experiments assessing cushion gas requirements, factors driving losses of working gas. Deliverable: report and assessment on key factors driving losses in aquifer storage. Milestone: delivery of report at end of Month 1.

WP3: Progressive Energy techno-economic assessment of aquifers. Cost and performance data gathering, techno-economic modelling to assess aquifers and depleted gas fields. Milestone: delivery of report at end of Month 1.

WP4: Progressive Energy integration of WP1, 2 and 3 to deliver ranked catalogue of aquifer storage structures. Milestone: delivery of report at end of Month 2.

WP5: Progressive Energy, with BGS and CUIEEF, develop work scope for alpha phase. Milestone: delivery of final project report at end of Month 2 or early Month 3.

Progressive' s demonstrated project management capability ensure timely delivery of these work packages. Parallel WPs 1-3 allow for accelerated findings, while WP4 can respond to the findings of these earlier work packages. WP5 will be developed in parallel with all of the other WPs, as set out in the PMT.

Risk management is provided by the separated nature of the early WPs and the known capability and capacity of the project participants. BGS is known to have the data, capability and capacity to deliver this with a high confidence. CUIEEF has already demonstrated its ability to deliver modelling results, and has ensured capacity for the project.

Progressive Energy has also ensured that it will have capacity to deliver this project, which does not present any significant technical risks.

The project is not dependent on any specific policy or regulatory questions: the need for large scale hydrogen storage is widely accepted, and this study is independent of policy questions around funding and support.

As a long term project, no near term impacts on services to energy consumers can arise in this phase of the project.

Key outputs and dissemination

The principal outputs of the discovery phase will be a ranking of aquifers potentially available for hydrogen storage in the study area, together with a techno-economic assessment of them compared to the counterfactual of hydrogen storage in a depleted gas field. An additional output will be the development of generalised evaluation approach for potential hydrogen storage sites, applicable across the UK and further afield.

This approach and findings will be disseminated through industry for a, by application with potential developers of hydrogen stores and through academic publications and conference and other presentations.

Progressive Energy holds the prime responsibility for delivery of all project deliverables and will lead public dissemination efforts. Progressive is a leading participant in the HyNet cluster, Peak Cluster, Bacton Thames Net Zero and the South Wales Industrial Cluster and will disseminate these results into these groupings. Additionally Progressive's relationships with Spirit Energy and Sumitomo Energy Evolution Limited, as well as other offshore operators and participants, will enable it to share these findings and potentially begin the application for and development of large scale hydrogen stores.

The North Sea Transition Authority has prime responsibility for licensing of the subsurface for energy uses, including hydrocarbon exploration and production, and gas and CO2 storage. At present, it does not licence structures for hydrogen storage. A critical aspect of the dissemination will be to engage with NSTA to share results, to inform them in seeking additional licensing powers for hydrogen storage. Progressive has a good relationship with NSTA and will lead on this engagement and dissemination.

CUEEF and BGS are engaged in the project as partners, with specific areas of work as detailed above. Each of these organisations will wish to, and be permitted to, disseminate non-commercially-sensitive findings from their aspects of the project. It is expected that the principal channel for such specialist and focussed dissemination with be trough academic publication and presentation.

John Aldersey-Williams is leading this project for Progressive Energy, and will have primary responsibility for dissemination as well as liaison with project partners, stakeholders and UKRI.

The development of a systematic and rational techno-economic evaluation methodology for large scale hydrogen storage will benefit the development of a competitive market for this critical future technology, and Progressive Energy is well positioned to disseminate this methodology and its findings.

Commercials

Intellectual Property Rights (IPR) (not scored)

The project partners accept the standard Intellectual Property rights as specified in the UKRI specification document.

Value for money

The discovery phase is budgeted at £110,000 plus the costs of sponsoring networks, Wales & West Utilities and Northern Gas Networks. As noted above, the project will develop a generalised methodology for assessing the techno-economic costs, features and benefits of large scale hydrogen storage alternatives in geological structures. SIF funding is sought for the full amount, with £110,000 directed to Progressive Energy, of which £60,000 will be deployed in subcontracts with BGS and CUIEEF.

Application of this methodology will enable developers of such storage sites to make early, informed assessments of development candidates, limiting money spent on early option development and accelerating project development.

The project represents value for money for all energy network users, as it will minimise abortive development spend on unsuitable storage structures, and advance development of the most attractive (and low cost) candidates.

The 10% minimum contribution to project costs will be met by Wales & West Utilities and Northern Gas Networks from their private funds.

Progressive Energy's costs under the projects will be funded as working capital, prior to being paid by the network sponsors following their receipt of SIF funding.

The subcontractors, BGS and CUIEEF, have unique skills, access to data and facilities, and a demonstrated track record in work of this kind with Progressive Energy. The project would not be possible without BGS' access to data, and CUIEEF's expertise in modelling gas and liquid flows in subsurface systems.

This project is self-standing, and will not receive any additional funding from other innovation funds.

BGS already has the necessary data, CUIEEF has the necessary laboratory facilities for the study.

Progressive and its subcontractors plan to publish the findings of this work, and to use it to advance identified large scale hydrogen storage development candidates. Additionally, by informing the North Sea Transition Authority of the opportunity for aquifer storage of hydrogen, the project will help to put in a place a licensing regime for this technology, enabling developers across the UK to pursue the concept.

Supporting documents

File Upload

SIF_WWU_3_1 SIF Discovery Round 3 Closedown Report 2025-08-05 10_45.pdf - 52.7 KB
SIF Hydrogen Storage in Aquifers Final Report.pdf - 14.7 MB
SIF Aquifer presentation_ Show and tell.pptx - 8.7 MB
SIF Round 3 Project Registration 2024-03-01 12_29 - 57.2 KB

Documents uploaded where applicable?

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