Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Nov 2024

Project Reference Number

NIA_WWU_02_67

Project Registration

Project Title

Hydrogen Storage in Aquifers

Project Reference Number

NIA_WWU_02_67

Project Licensee(s)

Wales & West Utilities

Project Start

December 2024

Project Duration

0 years and 6 months

Nominated Project Contact(s)

Robert James Pugh

Project Budget

£306,723.00

Summary

The development of large-scale storage of hydrogen is widely accepted to be a critical element of the transition to a future net zero energy system. Most focus at present is on the development of depleted gas fields as hydrogen stores. This project will advance the alternative of development of aquifer structures for hydrogen storage. As a lower cost option, this clearly offers a lower cost integrated energy system to the benefit of all system participants. Aquifers are also significantly more accessible than depleted gas fields, with some regions not having access close to them: e.g. South Wales or the Southwest of England.

The objective of this project is to extend the earlier concept work undertaken for the Hydrogen Storage in Aquifers SIF Round 3 Discovery (SIF_WWU_3_1) project into a pre-feasibility study relating to a small number of specific structures.

Preceding Projects

SIF_WWU_3_1 - Hydrogen Storage in Aquifers

Third Party Collaborators

Progressive Energy Limited

British Geological Survey

Cambridge University

Nominated Contact Email Address(es)

innovation@wwutilities.co.uk

Problem Being Solved

Large volumes of hydrogen will be required to be stored to support dispatchable low-carbon power generation in a UK energy system in which intermittent renewable power generation plays a dominant role. Hydrogen storage is technically possible, in increasing volumes, in line pack, in salt caverns and in porous geological formations.

Studies by (among others) the Royal Society showed that the storage volumes would significantly exceed the potential capacity of line pack and salt caverns. Depleted gas fields are widely considered to be the obvious option as porous geological formations for such large-scale storage (as they have previously demonstrated the capacity to store mobile gases at scale over long periods). To date the use of aquifers for hydrogen storage has not been addressed in detail.

An initial feasibility study was undertaken utilising SIF Round 3 funding (SIF_WWU_3_1) and found that aquifers may offer better value than use of depleted gas fields for large scale hydrogen storage, as the “net present cost” of hydrogen lost permanently in storing in aquifer formations compared favourably with the net present cost of cushion gas in depleted gas fields.

It is currently not clear how the storage of hydrogen (in either aquifers or depleted gas fields) will be supported by DESNZ business models, which are being developed and implemented to support net zero activities across the value chain. This project will see Progressive engage with industry stakeholders, including DEZNZ, directly to share their recommendations for a business model detailing the option for aquifer storage of hydrogen.

Method(s)

The development of large-scale storage of hydrogen is widely accepted to be a critical element of the transition to a future net zero energy system. Most focus at present is on the development of depleted gas fields as hydrogen stores. This project will advance the alternative of development of aquifer structures for hydrogen storage. As a lower cost option, this clearly offers a lower cost integrated energy system to the benefit of all system participants. Aquifers are also significantly more accessible than depleted gas fields, with some regions not having access close to them e.g. South Wales or the Southwest of England. The benefits to consumers would arise from the development and use of lower-cost bulk hydrogen storage options than currently under consideration.

The project is comprised of ten work packages. The roles of BGS (British Geological Survey) and CUIEEF (Cambridge University Insitute of Energy and Environmental Flows) fall within defined technical remits, and Progressive’s role will be to ensure that these subcontractors can deliver their objectives, while undertaking their own technical work.

BGS will lead on the first three work packages, wherein they will map priority closures of aquifers and develop structure maps of shortlisted structures and develop the basis for reservoir modelling. A review of data on reservoir materials and properties will be undertaken to inform the development of the models. The reservoir models will be developed in an appropriate software package in order to assess flow rates and pressure behaviours of the reservoirs. Concurrently, Progressive will determine the required injection and production rates for aquifer storage and thereby assess the numbers of wells and geological storage structures required to meet storage needs.

CUIEEF will undertake laboratory studies to determine the effect of reservoir heterogeneity on storage performance. Progressive will develop an outline of storage facilities for the aquifer structures, including pipeline sizing and routing, injection and production facilities, compression requirements, and high-level indicative costing of such facilities.

BGS will then undertake reservoir modelling to develop understanding of reservoir pressures behaviour in response to flow rates required, applying assessed injection and production rates to the models supplied by Progressive.

Progressive will engage with industrial and regulatory stakeholders, such as the North Sea Transition Authority (NSTA) to inform them of the option for aquifer storage of hydrogen. They will also develop academic papers based on the results of the project and submit them for publication. Project findings will be presented at appropriate industry conferences, and the Department of Energy Security and Net Zero (DESNZ) will be engaged to inform them of the option for aquifer storage of hydrogen.

It is currently not clear how the storage of hydrogen (in either aquifers or depleted gas fields) will be supported by DESNZ business models which are being developed and implemented to support net zero activities across the value chain. As such, Progressive’s penultimate work package will see them undertake a review of existing business models on gas storage (natural gas, carbon dioxide, and more) and assess these models for features and benefits, then consider and recommend business models for aquifer storage of hydrogen; Progressive will share these recommendations with DESNZ as part of the project. Progressive’s final work package will see them produce a report encompassing the project’s findings, as well as plans for further work on a feasibility study to address consenting, permitting, acreage acquisition, lobbying and securing of financial support, all in turn leading to FEED and FID. This will form the basis of a future demonstration project, or an application into a SIF Beta phase.

Data Quality and Measurement Quality Statement

General

The project as a whole will be undertaken under the governance of Progressive Energy's Quality Policy.

IP rights are governed by the contractual relationships between Progressive Energy and its subcontractors BGS and the University of Cambridge Institute of Energy and Environmental Flows.

No data controlled under GDPR is involved in the project.

Progressive-led WPs (WP4,6,8,9,10)

Progressive will be developing new data and analyses relating to required flow rates into and out of storage, scoping of facilities for hydrogen storage and available business models. Where new data and analyses arise through Progressive-led work, source data and analysis methods will be documented, allowing for third party review and providing a secure foundation for further work. Progressive Energy has developed a reputation over more than 20 years of delivering high quality, robust and supportable data and analysis.

BGS-led WPs (WP1,2,3,7)

BGS will be reviewing existing data which it holds and for which it is responsible. This data will be generated, maintained and analysed under its own quality policies. BGS has operated in this manner for many decades and is the leading custodian of subsurface data for the UK.

University of Cambridge Institute of Energy and Environmental Flows -led WP (WP5) UoCIEEF will be undertaking new experiments which will generate new findings and data. These experiments will be documented in detail, to allow other researchers to reproduce results and extend their findings. The data will be generated, maintained and analysed under its own quality policies. The University of Cambridge has an enviable reputation for high quality research and publication.

The project is rated low in the common assessment framework detailed in the ENIP document after assessing the total project value, the progression through the TRL levels, the number of project delivery partners and the high level of data assumptions. No additional peer review is required for this project.

Scope

WP1 – Mapping of priority closures

The main objective of this work package is to develop structure maps of shortlisted structures and to develop a basis for reservoir modelling. The key deliverables are:

- Mapping of priority closures
- Validation of selected structures
- Development of static/property models for selected closures for WP3

WP2 – Detailed reservoir assessments on specified structures

The main objective of this work package is to review data on reservoir materials and properties to inform the development of reservoir models. The key deliverables are:

- Review of BGS materials databases to develop detailed catalogue of borehole data
- Petrophysical analysis of logs to reservoir properties for modelling
- Petrographic descriptions of up to 4 reservoir samples

WP3 – Reservoir model development, petrographic description, based on detailed data review on selected structures

The main objective of this work package is to develop reservoir models in an appropriate software package for assessment of flow rate and reservoir pressure behaviour in WP7. The key deliverables are:

- Develop reservoir model East Irish Sea structure model

WP4 – Assessment of required injection and production rates

The main objective of this work package is to determine the required injection and production rates for aquifer storage, and thereby

assess the number of wells and geostorage structures required to meet storage needs. The key deliverables are:

- Modelling of gas storage requirements (hourly, daily, seasonal) and interactions with storage options (linepack, salt cavern, geostorage)
- Assessment of required aggregate injection and production rates into/out of storage
- Assessment of realistic numbers of wells/geostorage structures required and per-well injection/production rates required

WP5 – Laboratory studies on reservoir heterogeneity and other factors

The main objective of this work package is to determine the effect of reservoir heterogeneity on storage performance. The key deliverables are:

- Lab studies on reservoir heterogeneity, addressing:
  - Reservoir layering
  - Baffles in porous reservoir (impermeable formations/lenses)
- Potential for the use of inert cushion gas
- Well placement and gas coning

WP6 – Scoping facilities storage sites

The main objective of this work package is to develop an outline of facilities and pipeline sizing and outing. The key deliverables are:

- An outline of storage facilities for structures, including:
  - Pipeline sizing and outline routing to preferred structures
  - Assessment of injection/production facilities and compression requirements
  - High-level indicative costing of storage facilities

WP7 – Reservoir modelling to assess pressure behaviour and flow rates

The main objective of this work package is to undertake reservoir modelling to develop an understanding of reservoir pressures behaviour in response to the flow rates required. The key deliverables are:

- Application of assessed injection and production rates to reservoir models from WP4
- Run the reservoir models to assess pressure behaviour and flow rates in models
- Iteration of modelling results to find optimal well numbers

WP8 – Engagement with stakeholders, particularly the NTSA

The main objective of this work package is to engage with regulators and other stakeholders. The key deliverables are:

- To engage with the NTSA to inform them of the option for aquifer storage of hydrogen
- To develop academic papers based on results and submit these for publication
- To present project findings at appropriate industry fora, conferences, etc.
- To engage with DESNZ to inform them of the option for aquifer storage of hydrogen

WP9 – Business model review

The main objective of this work package is to review business models and engage DESNZ for aquifer storage of hydrogen. The key deliverables are:

- A review of relevant business models covering gas storage (natural gas, CO2 and other)
- An assessment of business model features and benefits
- Consideration and recommendation of business models for hydrogen storage in geological structures
- Engagement with DESNZ to share recommendations on business models

WP10 – Project management

The main objective of this work package is to ensure that project participants deliver the agreed deliverables. The work package will be ongoing throughout the project.

The development of large-scale storage of hydrogen is widely-accepted to be a critical element of the transition to the future net zero energy system. Most focus at present is on the development of depleted gas fields as hydrogen stores. The earlier work found that

aquifer storage of hydrogen offered significant cost advantages over depleted gas field storage. This study will advance these findings with specific reference to a number of potential storage sites which could be developed and used by WWU on behalf of its customers. As a lower cost option than that of depleted gas field storage, the project clearly offers benefits to consumers. For WWU and its customers, aquifers are significantly more accessible than depleted gas fields, none of which are close to South Wales or the Southwest of England. The benefits to consumers would arise from the development and use of lower cost bulk hydrogen storage options than currently under consideration.

Objective(s)

The objective of this project is to extend the earlier concept work undertaken for the Hydrogen Storage in Aquifers SIF Round 3 Discovery (SIF_WWU_3_1) project into a pre-feasibility study relating to a small number of specific structures. This pre-feasibility study will address key questions to enable further development into feasibility studies to address consenting, permitting, acreage acquisition, lobbying and securing of financial support, which if successful and with additional funding, would lead to Front End Engineering Design (FEED) and Final Investment Decision (FID) projects. As part of this project, we have 8 key objectives that are aligned to their retrospective work packages detailed within the scope, these are:

- Develop structure maps of shortlisted structures and develop basis for reservoir modelling
- Review of data on reservoir materials and properties to inform development of reservoir models
- Develop reservoir models in appropriate software package for assessment of flow rate and reservoir pressure behaviour (in WP7)
- Determine required injection and production rates for aquifer storage, and thereby assess numbers of wells and geological storage structures required to meet storage needs
- Laboratory studies to determine effect of reservoir heterogeneity on storage performance
- Develop outline of facilities and pipeline sizing and routing
- Undertake reservoir modelling to develop understanding of reservoir pressures behaviour in response to flow rates required
- Engage with DESNZ, Ofgem and other key stakeholders

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having a neutral impact on customers in vulnerable situations, as it will focus on research only at present, and not deliver any immediate impacts on consumer or the network. Customers will not be affected directly or indirectly.

Success Criteria

A successful project will build on the findings of the previous SIF Round 3 Discovery project to provide evidence for the economic and technical viability of hydrogen storage in aquifers, as well as providing recommendations for business models for aquifer storage of hydrogen and engaging industry stakeholders/DESNZ with these findings.

Project Partners and External Funding

The project partner is Progressive Energy, who will be working with the British Geological Survey and Cambridge University as subcontracted partners. The project is wholly funded via NIA. WWU are acting as lead network and NGN are partnering with a 50/50 external cost split.

Potential for New Learning

Every pre-feasibility study makes new learnings, about the specific challenges of developing a particular project in a specific location.

This project will deliver a pre-feasibility study specifically relevant to the shortlisted aquifer structures in the East Irish Sea, but it will also deliver findings relevant to the development of aquifer storage facilities for hydrogen at other locations.

These may include learnings regarding the effects and management of reservoir heterogeneity, flow rates and pressure management of structures, utility requirements, as well as informing the development of appropriate business models in support of this application.

Scale of Project

The project is designed to involve the minimal spend required to derisk the concept of storage of hydrogen in geological aquifer structures, and building on earlier work. This earlier work found that aquifer storage of hydrogen had the potential to be lower cost than the principal counterfactual of storage in depleted gas fields.

As with all project development pathways, the scale of commitment (both financial and personnel) at each stage is matched to the quantum of risk removed from the project. This pre-feasibility study is targeted at addressing and resolving the key technical and developmental risks associated with development of aquifer stores for hydrogen, focussing on a very limited number of structures which were identified in the earlier work. Findings will be directly relevant to the potential development of these structures, and also more generally to other aquifer storage opportunities for hydrogen in the UK and around the world.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The project itself is a desktop study. This project will deliver a pre-feasibility study specifically relevant to the shortlisted aquifer structures in the East Irish Sea, but it will also deliver findings relevant to the development of aquifer storage facilities for hydrogen at other locations.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

External

- WWU: £119,667
- NGN: £119,667

Internal

- WWU: £39,889
- NGN: £27,500

Total

- WWU: £159,556
- NGN: £147,167
- Grand total: £306,723

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

As referenced in the UK Hydrogen Strategy, hydrogen's ability to store energy for long periods of time and in large quantities is an important part of its strategic value to a fully decarbonised energy system, of which they envisage hydrogen storage being a key part of future network infrastructure. Most focus at present is on the development of depleted gas fields as hydrogen stores. This project will advance the alternative – which earlier work suggested offers a lower cost option – of development of aquifer structures for hydrogen storage. As a lower cost option, this clearly offers a lower cost integrated energy system to the benefit of all system participants.

How the Project has potential to benefit consumer in vulnerable situations:

N/A

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

N/A

Please provide a calculation of the expected benefits the Solution

The earlier work found that aquifer storage of hydrogen offered significant cost advantages over depleted gas field storage. This study will advance these findings with specific reference to a number of potential storage sites which could be developed and used by WWU on behalf of its customers. As a lower cost option than that of depleted gas field storage, the project clearly offers benefits to consumers. For WWU and its customers, aquifers are significantly more accessible than depleted gas fields, none of which are close to South Wales or the Southwest of England. The benefits to consumers would arise from the development and use of lower cost bulk hydrogen storage options than currently under consideration.

Please provide an estimate of how replicable the Method is across GB

Other Network Licensees are expected to have these general learnings made available to them, with NGN (who participated in the earlier SIF-supported study), Cadent (whose network is geographically close to the shortlisted structures) and National Gas Transmission being the most obviously interested parties. Suitable aquifers structures may also be found in the Central and Northern North Sea, and these structures may be of interest to SGN.

Please provide an outline of the costs of rolling out the Method across GB.

There are no rollout costs at present, this is a research project.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☑ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

This project will deliver a pre-feasibility study specifically relevant to the shortlisted aquifer structures in the East Irish Sea, but it will also deliver findings relevant to the development of aquifer storage facilities for hydrogen at other locations.

These may include learnings regarding the effects and management of reservoir heterogeneity, flow rates and pressure management of structures, utility requirements, as well as informing the development of appropriate business models in support of this application.

Other Network Licensees are expected to have these general learnings made available to them, with NGN (which participated in the earlier SIF-supported study), Cadent (whose network is geographically close to the shortlisted structures) and National Gas Transmission being the most obviously interested parties. Suitable aquifers structures may also be found in the Central and Northern North Sea, and these structures may be of interest to SGN.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

N/A

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

All networks have been made aware of this project and no concerns of duplication have been raised.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

The business risk is clear, as the counterfactual approach of storing hydrogen in depleted gas fields has reached the status of “conventional wisdom”. Additionally, it is currently not clear how the storage of hydrogen (in either aquifers or depleted gas fields) will be supported by DESNZ business models which are being developed and implemented to support net zero activities across the value chain.

Relevant Foreground IPR

The foreground IP generated will be the final report and other deliverables.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click ‘Contact Lead Network’. WWU already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website here
- Via our managed mailbox innovation@wwutilities.co.uk
- Details on the terms on which such data will be made available by Wales & West Utilities can be found in our publicly available “Data sharing policy relating to NIC/NIA projects” here

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

It is currently not clear how the storage of hydrogen (in either aquifers or depleted gas fields) will be supported by DESNZ business models which are being developed and implemented to support net zero activities across the value chain. This project seeks to explore the technical and economic feasibility of large-scale hydrogen storage in aquifers. This not a BAU activity for networks.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

The project would only be undertaken with support from NIA funding, it is in the interests of gas customers, the regulator and the UK government and the realisation of any benefits are outside the control of the gas networks. There is no allowance in BAU business plans for this type of research and development work.

This project has been approved by a senior member of staff

☑ Yes