SIF Round 3 Project Registration

Date of Submission

Mar 2024

Project Reference Number

10102109

Initial Project Details

Project Title

B-Linepack+

Project Contact

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Challenge Area

Enabling power-to-gas (P2G) to provide system flexibility and energy network optimisation

Strategy Theme

Net zero and the energy system transition

Lead Sector

Gas Transmission

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

NGT - National Gas Transmission PLC

Funding Licensee(s)

SGN - Southern England (inc South London)

NGT - National Gas Transmission PLC

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

SGN

Technology Areas

Carbon Emission Reduction Technologies

Hydrogen

Gas Transmission Networks

Project Summary

The national gas transmission system currently has the ability to pack additional gas into the lines (linepack) in order to provide flexibility and more efficiently manage supply and demand across the network. The amount of energy able to bestored by linepacking in the future may potentially decrease with the addition of blended or 100% hydrogen. This project will explore the feasibility of smaller, intermediate scale storage sites (purpose built geological storage solutions with minimal geographical constraints e.g. lined shafts, engineered rock caverns,underground silos) to supplement linepack capacity and provide system flexibility and network optimisation.

Add Third Party Collaborator(s)

Gravitricity Limited

Edinburgh Innovations Ltd

Energy Reform Ltd

Revolutionary Engineering & Digital Design Ltd

Project Budget

£165,004.00

SIF Funding

£150,000.00

Project Approaches and Desired Outcomes

Problem statement

Linepack currently provides gas system resilience and network storage (~10% ofUK natural gas storage capacity) to manage shorter-term demand/supply trends. A 100% hydrogen national transmission system (HyNTS) could decrease the linepack energy storage capacity by up to 74%. While hydrogen storage is key to provide flexibility to a hydrogen transmission system, current plans predominately focus on large scale seasonal geological options (salt caverns, depleted gas fields or saline aquifers) which are geographically constrained, with long lead times to develop and uncertain supporting regulatory market frameworks to incentivise the investment required for project development.

Hydrogen storage location is understood to have a critical impact of infrastructure build out. Therefore, this project seeks to investigate the development of a flexible asset class utilising intermediate geological storage technology solutions (lined rock caverns, engineering rock caverns & underground silos) for supporting a100% hydrogen transmission system. Use cases to be considered are; Linepack supplementation, short term buffer storage, safe operational storage at compressor stations, commercial storage for localised hydrogen hub connections, blend balancing and fatigue/capacity resilience for customers.

Innovation Challenge
This project meets Challenge 4 regarding enabling power-to-gas (P2G) to provide system flexibility and energy network optimisation and Scope 2, regarding commercial and technical innovation to secure system benefits from hydrogen storage deployments.
In discovery, state of the art P2G energy system modelling utilising SPINE OptToolbox will be undertaken to understand system flexibility benefits to the gas system and understand value of Linepack vs technology deployment/rollout costs to develop an initial cost benefit analysis. Multiple flexible assets will be modelled for scenarios out to 2050 along the current gas transmission system model and compared to the counterfactual of a single large scale gas storage asset e.g.Rough. Identification of network optimisation opportunities and Linepack flexibility services will be identified.

Potential users
Potential users and needs addressed are below:
Transmission System Operators - Linepack supplementation for gas systemresilience, based on feeder Linepack decrease with hydrogen when compared to natural gas.
Gas Distribution Networks - Short term buffer storage
Gas Storage Operators - Commercial hydrogen storage
Hydrogen Hub Developers - Commercial or buffer hydrogen storage

Other public or network innovation funded work already completed that is relevant or is contributing to this Project
NIA_NGGT0203: Impact of Hydrogen & Hydrogen Blends on Linepack
NIA_NGT0223: Linepack opportunities in the current and future energy system
SIF_10062040: Beta HyNTS Compression

Video Description

https://youtu.be/_iU_P0g-W1w

Innovation justification

Core innovation aspects:

Demonstrating technical understanding and safe operability of hydrogen storage asset to be used for linepack supplementation
Geotechnical analysis and subsurface modelling of a lined rock shaft storage for hydrogen
Thermodynamic modelling of hydrogen gas cycling for lined rock shaft storage
P2G flexibility opportunity energy system modelling for a hydrogen storage asset, considering gas and electricity systems.
Energy network optimisation modelling considering N-1 constraints for technical constraints
Parametric digital design models for system optioneering across geological locations
Digitalised risk mitigation construction planning

H2FlexiStore developed by UK based Gravitricity, is developing lined rock shafts for storage of gaseous hydrogen. This is state of the art technology for hydrogen storage, with the potential to be deployed rapidly and at scale, depending on land and geological suitability, across our entire repurposed transmission system for hydrogen. The solution could provide up to 100tons of safe hydrogen storage per site.

This project aims to be a world first in demonstrating lined rock shaft storage of hydrogen for Linepack supplementation in a 100% hydrogen transmission network to improve system resilience and enable energy ecosystem optimisation opportunities across both electricity and gas networks.

Beyond incremental innovation

This project builds on existing research into intermediate geological storage options done by the University of Edinburgh and SGN in the Storage Upscale project (currently ongoing) with the aim to accelerate the development of a demonstrator for gaseous hydrogen stored in lined rock shafts.

This project will go beyond incremental innovation by developing digital design solutions to accelerate potential rollout, increasing the opportunity for emerging hydrogen hubs and electrolysers to connect to a transmission system, understanding cross-energy vector system optimisation opportunities and developing a pressure regulation strategy to better manage Linepack swing thanconventional methods.

Readiness levels
TRL - 5 -\> 7
IRL - 1 -\> 2
CRL - 1 -\> 3

Size and scale
Estimated size of demonstrator will contain 1-2 tons of hydrogen in a lined rockshaft at 30-80m deep. This will provide a good demonstration of how the technology could be used to bolster linepack.

Business-as-usual
Hydrogen projects can not be funded under BAU funding as hydrogen is not included in the RIIO-2 business plan.

Counterfactuals
Large scale seasonal hydrogen scenario - seasonal scale hydrogen storage facility to hydrogen connected to 'Project Union' phase complementing existing compressor stations capability
Increased hydrogen network length for storage
Gravitricity supplying localised energy storage

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

Financial - cost savings per annum for users of network services

Environmental - carbon reduction – direct CO2 savings per annum

Environmental - carbon reduction – indirect CO2 savings per annum

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

Pre-Innovation Baseline

Compressors are critical assets on the NTS, providing pressures and flows to meet demand for gas and provide flexibility on the network. 64 of 72 compressor units are driven by gas turbines, Compressor stations can be used to manage linepacking (more molecules packed in same volume) capability, acting as network storage for gas system resilience based on supply/demand trends.
100% gaseous hydrogen transmission is a potential solution which can be utilised as a fuel gas in most of the gas turbines to reduce emissions, however, linepacking capability could decrease significantly (~74%) due to the lower volumetric energy density on hydrogen. Therefore, storage and additional pressure regulation strategies may be required for 100% hydrogen.
One commercial B-Linepack+ system, if demonstrated, could be the equivalent to the linepack capability in 14km of 36" diameter NTS pipeline. Extrapolating further, if rolled out along Project Union (~2000km), the system may need \>100 units to provide a pressure regulation strategy and flexible storage asset for system resilience and security of supply.

Forecast Benefits
The discovery phase will develop the business case and the cost benefit analysisfor this project. The benefits that we propose to track are as follows:

Financial - HyNTS linepack supplementation (-/+) & commercial storage potential
Understanding the value of linepacking zones with a hydrogen transmission system and need for pressure regulation strategies with good distribution of injection points across the repurposed transmission system. Additionally, commercial storage value could be preliminary reviewed either being connected to the electricity or gas systems. A CBA will be developed considering counterfactual scenarios.

Environmental - System Emissions
The opportunity to utilise existing pipelines for renewable energy storage through hydrogen is invaluable in supporting the 2050 Net Zero Target. Linepack increases the volume of storage that in turn reduces our dependency on fossil fuels. Whilst this option has some environmental impact in its construction, the long term environmental impact of deploying below ground storage is beneficial over the use of solid/battery storage or the deployment of above ground solutions. Emissions from underground storage are greatly decreased in comparison to above ground options.

Benefit Synergies
A broader understanding of the wider system benefits will be achieved through this project and demonstration of the H2flexiStore technology.

Teams and resources

National Gas Transmission
-- Own, manage and operate the national transmission system (NTS) for natural gas, aiming to enable the energy transition by repurposing the network for hydrogen. Subject matter expertise includes role and value of linepack, compressor operation and gas network & system control.

SGN --
Gas distribution network for Scotland and South England regions, they will provide additional opportunities to the use of this novel storage solution.

University of Edinburgh
-- Subsurface geological academia research expertise. They will provide peer review into the technologies reviewed and proposals for future project phases.

Gravitricity
-- Technology developer for flexible hydrogen storage using lined rock shaft type solutions. They will lead the technical appraisal of their solution in coordination with the UK gas networks. Gravitricity was founded in 2011 by Peter Fraenkel MBE and Martin Wright, the innovators behind the successful tidal stream energy company Marine Current Turbines. The concept of using gravity to store energy is not new -- pumped hydro storage (PHS) systems can be found all around the world. However, such systems are reliant on specific topography and can only be found at significant scale.

Energy Reform Consulting

-- Expertise in stochastic and energy planning P2G modelling for investment decisions. They will provide modelling of the energy network and storage systems. Energy Reform engages in research and consultancy in the international energy sector and has specialist expertise in developing and applying state of the art power system and energy systemmodelling techniques in support of the energy transition.

Revolutionary Engineering & Digital Design
-- Provide a unique perspectiveto optioneering & digital design of structural systems. They will support the design activities both physical and digital. REDD are a company specialising in Structural Engineering, Design Software, APIs, Digital tools Consulting & Training.

The discovery phase will be predominately desktop based at local facilities. We will be setting up a base to enable Alpha and Beta demonstration, therefore planning and consents development will be commenced in Discovery.

Stakeholders across the energy system will be engaged to share learning from this project that could benefit local energy solutions as well as the wider network.

Project Plans and Milestones

Project management and delivery

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.

There are four milestones that are common across the 6 work packages:
M1 - Project Kick Off (01/04/2024) Contracts in place and project partners set tocommence project
M2 - Mid Point Review (01/05/2024) Status update based on deliverables
M3 - End of Technical Activity (31/05/2024) Core deliverables provided toapplication team
M4 - Alpha Application (31/06/2024)

1. Project Management
- This work package will ensure the project meets itsprojected timing, risk and cost through the Discovery period and will develop theplan for the Alpha phase project.
2. Business Case & Requirements Development
- This work package willdevelop the key requirements for the system and develop the business caseand CBA for the system to be deployed
3. Geological & Structural Requirements
- This work package will refine thestorage system requirements and begin the design work to determine how these solutions could link to the gas network.
4. Engineering, Construction & Automation
- This work package will developdigitalised construction planning methods for sub-surface geological storage systems for rapid rollout.
5. Energy System Modelling
- This work package applies preliminary P2Genergy system modelling using existing electricity and gas models
6. System Demonstration & Stakeholder Engagement
- This work package develops the concept system design bringing together the key elements from each work package into a concept for the alpha phase to develop further. It will also develop a commercial storage developer stakeholder engagement andsocial license to operate plan for Alpha.

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 flexibility application toa 100% hydrogen transmission system that takes advantage of P2G opportunitieswith an uncertain future energy system design. 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.

Key outputs and dissemination

What you want to achieve by the end of your Project's Discovery Phase

This project will determine the opportunity to use smaller scale medium term storage for support of linepack across the UK gas network at a lower cost and improved efficiency than the larger seasonal storage currently being investigated. The discovery phase will determine through modelling and detailed design whether this opportunity should be investigated further and demonstrated in the UK energy system.

Who within the Project team will be responsible for each key output and planned dissemination activity

1. Project Management - National Gas will be responsible for the delivery of the projects and the 4 milestones. This will be supported by the other projectpartners.
2. Business Case & Requirements - National Gas will be responsible for supplying the customer requirements and key data to enable delivery of the other workpackages, benchmarking and ultimately the business case
3. Geological & Structural Requirements - Gravitricity will develop the requirements for the storage system and its interaction with

the network including any modelling on the system design
4. Engineering, Construction & Automation Requirements - Revolutionary Engineering and Digital Design will model the design of the system and enable optioneering and construction planning
5. Energy System Modelling - Energy Reform Consulting will deliver the model ofthe energy network and how the storage options could support a robust resilient network
6. Stakeholder Engagement and System Demonstration Plan - National Gas will take a lead on stakeholder engagement and developing the demonstrationopportunity for the Beta phase.

How and where you intend to disseminate your key outputs and lessons learned

The project will be shared via the Energy Networks Association Smart Networks Portal, Discovery Show & Tells, Social Media (LinkedIn) and specific stakeholderwebinars and sessions.

How your Project will not undermine the development of competitive markets

Whilst this project will demonstrate the opportunity of this alternative storage option for the UK energy system, deployment across the network will be undertaken through competitive tender. The data from the project will demonstrate the opportunity and capability of these systems for future business plans to robustly utilise.

Commercials

Intellectual Property Rights (IPR) (not scored)

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. On creation of Foreground IPR the creator of the IPR will notify the projectpartners to enable it to be recorded and ownership agreed in line with the contract terms.

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.

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.

Clarification

National Gas will look to consider the following inclusion in the Discovery contract. Contract negotiations will follow the application submission. This would be a slight change to the default arrangement, but is not foreseen to cause difficulty at this stage, further work is required to determine the impact on consumer value. Inclusion will be subject to all parties agreement.

Any improvements, modifications or enhancements made to background IP, will be owned by the party owning the background IP from which it was developed, regardless of which project party created it.

Reasoning: During the duration of the project, Gravitricity expect to develop and enhance the technology they are providing. The foundation of the design and the know-how lies with Gravitricity. Enhancements, modifications and improvements of the design willbe based upon the IP that Gravitricity have developed and without this, enhancements, modifications and improvements could not be made. As a result, the ownership of the any improvements, modifications or enhancements should lie with Gravitricity.

Value for money

Project Cost, SIF Funding & Contributions

The project will cost £165,004, which is split between the project partners based on the level of activity in the discovery phase of the project. The project partners are contributing a total of £15,004 to the project, and we are therefore requesting funding of £150,000

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The costs are split as follows:

National Gas: £28,376 . The costs include the project management of theproject, stakeholder engagement and development of the demonstrationapproach. Gas Transmission and Metering are contributing £15,004 to projectcosts.

SGN: £1,388 to provide insight into alternative opportunities for this technology to be deployed across the UK gas networks.

University of Edinburgh: £25,000 to provide benchmarking and peer review of the technologies being considered.

Gravitricity: £50,000 to provide technical knowledge on the intermediate storage technologies, determine requirements and develop the storage concept designs.

Energy Reform Consulting: £35,240 to provide design support on optioneering, digital systems and construction.

Revolutionary Engineering & Digital Design: £25,000 to provide modelling of the storage opportunity and its link to the UK energy system.

The project provides value for money for the consumer through the delivery of storage for renewable energy produced when electricity is abundant and unable to be consumed by the electricity grid. The consortium brought together are experts in this field and will determine to optimum cost effective route to delivering this option for the future. This option could enable us to prevent the need to constrain electricity production in the future, maximising the utilisation of energy and eliminating the large costs associated.

There are no subcontractors in this phase of project, we will however be engaging directly with several UK Energy System stakeholders. There is no additional funding from other innovation funds.

There are no other business-as-usual (BAU) financial mechanisms to cover these costs outside of further Network Innovation Allowance (NIA) process funding. Hydrogen based activities are not able to be funded through the RIIO-2 business plan and have not been confirmed for RIIO-3. This makes projects associated to this topic high risk and requiring incentive funding to drive the opportunity for thefuture.

Commercialisation of this technology will be through deployment on the future hydrogen gas networks, this technology could also further support users of hydrogen in local applications. Work will be undertaken in Discovery to further define this and determine the approach to Beta demonstration activities

Supporting documents

File Upload

System Demonstration.pdf - 4.1 MB
B_Linepack_D5_review on past geological storage options.pdf - 7.7 MB
B-linepack Work Package 5 ER.pdf - 1.2 MB
B-Linepack_D7_WorldwideHydrogenStorageProjects (1).pdf - 1.2 MB
B-Linepack_D21 Digital Delivery Plan.pdf - 3.3 MB
B-Linepack_D20 Optioneering Review.pdf - 1.3 MB
B-Linepack+ Show N' Tell.pdf - 2.1 MB
SIF Round 3 Project Registration 2024-03-27 7_00 - 94.2 KB
B-Linepack+ Application - Innovation Funding Service.pdf - 332.6 KB

Documents uploaded where applicable?

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