SIF Discovery Round 2 Project Registration

Date of Submission

Apr 2023

Project Reference Number

10061608

Project Registration

Project Title

Carnot Gas Plant

Project Reference Number

10061608

Project Licensee(s)

SGN

Project Start

Apr 2023

Project Duration

2 Months

Nominated Project Contact(s)

stuart.sherlock@sgn.co.uk

Project Budget

£104,793.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£93,952.00

Strategy Theme

Net zero and the energy system transition

Challenge Area

Accelerating decarbonisation of major energy demands.

Lead Sector

Gas Distribution

Other Related Sectors

Funding Licensees

Lead Funding Licensee

SGN - Southern England (inc South London)

Collaborating Networks

SGN

Technology Areas

Energy Storage, Green Gas

Equality, Diversity And InclusionSurvey

Yes

Project Summary

Project

The project is to develop the technical design and commercial modelling for large scale energy storage and high efficiency gas use via a Carnot Gas Plant ("CGP"), this will be integrated into a heat network to provide cross vector flexibility. This will meet the aims of Innovation Challenge 4 by integrating heat networks for wider energy network management.

Aims

The aim is to increase the energy efficiency and decarbonise flexible export via a novel CGP coupled with a heat network. Flexibility provided by multiple modes of operation and improved efficiency helps reduce costs of connecting and operating decarbonised heat.

Innovation

The innovation is a CGP which can provide flexibility services to the gas and electricity networks through several modes of operation which can be optimised based on market conditions.

The CGP can either:

*Convert electricity into stored heat and cryogenic air

*Discharge stored heat in a heat network

*Efficiently use gas to heat the stored air and Gas can be used to boost the electrical output with heat recovery via a heat network

The use of Gas Turbines for flexible power production and heat recovery is established, but a significant proportion of the gas input is used to drive the compressor. The CGP has a significantly increased efficiency as a result of removing the compressor load from the point of generation.

Users

User benefits:

*Gas peaking owner operators -- The innovation provides equivalent flexibility function as existing gas turbine peaking plant, but at reduced gas consumption volumes.

*Heat network owner operators / consumers -- The innovation reduces the cost associated with providing decarbonised heat to consumers.

*DNO/ESO -- The innovation provides for various needs such as inertia provision which is not provided by flexible assets (e.g. batteries), balancing services such as frequency response and also black start capability.

Partners

SGN are the lead partner, bringing expertise in gas and hydrogen as well as numerous sites in urban areas.

Vital Energi are the heat network provider. They are UK market leader in district heating schemes with 83,000 homes connected.

Imperial College London will be the academic partner, having developed an integrated whole energy systems (IWES) model.

University of Birmingham (UoB) will be an academic partner specialising in phase change material.

Glasgow City Council and West Dunbartonshire Council will be Local Government partners.

Project Description

The project is to develop the technical design and commercial modelling for large scale energy storage and high efficiency gas use via a Carnot Gas Plant, this will be integrated into a heat network to provide cross vector flexibility.

The aim is to increase the energy efficiency and decarbonise flexible export via a novel Carnot battery coupled with a heat network. Flexibility provided by multiple modes of operation and improved efficiency helps reduce costs of connecting and operating decarbonised heat.

The technology will support the wider grid by increasing the amount of flexibility by importing and exporting power depending on the requirements of the grid.

Nominated Contact Email Address(es)

sgn.innovation@sgn.co.uk

Project Description And Benefits

Applicants Location (not scored)

Southern Gas Networks St Lawrence House, Station Approach, Horley, England, RH6 9HJ

Vital Energi Solutions Limited Century House, Roman Rd, Blackburn BB1 2LD

Imperial College London Exhibition Rd, South Kensington, London SW7 2BX

Glasgow City Council 82 George Square, Glasgow G2 1DU

West Dunbartonshire Council 16 Church St, Dumbarton G82 1QL

University of Birmingham Edgbaston, Birmingham, B15 2TT

Project Short Description (not scored)

The project is to develop a Carnot Gas Plant integrated with a heat network to provide efficiency improvements and cross-vector flexibility.

Video description

https://youtu.be/iPH4RStzFm0

Innovation justification

Problem

As we progress to net zero there is an established requirement for:

- Heat networks with flexibility
- Import/Export flexibility within the electrical network e.g. batteries
- Gas fired peaking plants with low operating hours for periods of extended low renewable generation.
- Demand side only flexibility as hours of excess generation increases

The above activities are important individually however if they are considered in isolation this will lead to:

- Increased CO2 production from flexibility
- Increase in the amount of transmission and distribution infrastructure of power and gas
- Increased timescales in connecting all flexible assets including heat networks
- Single function assets which may cease operating if market factors negatively impact their business case

The innovation provides the requirements described efficiently from a single thus overcoming the problems.

Innovation

The project is innovative because there is no technology providing the same breadth of functionality commercially available. The interface between the various components must be designed to ensure the Carnot battery and wider system operates efficiently and can provide the full functionality as described above.

Knowledge Gap

The project partners have experience in key areas of cryogenic air storage, heat storage and heat engines but are yet to design the relative capacities of the heating and storage equipment and the associated interfaces. The expertise of the partners in overcoming similar design requirements on other energy projects make them well placed to achieve success.

We also need to model how the operational regime changes with the amount of renewables on the grid and the need for flexibility changes. We will use Plexos simulation software to run a variety of scenarios to optimize the specification.

Counterfactual

The proposed counterfactual is:

A low carbon, low temperature hot water network with separately located gas peaking plants

Economic Benefits

- System can draw in electricity flexibly targeting low-cost periods
- Increased flexibility reduces operating costs of the local heat network and wider energy network
- Provides more heat from same energy source therefore reduces investment required in generation, transmission, and distribution reinforcement
- Reduces need for carbon negative technology

Sustainability Benefits

- Reduces CO2 production from flexibility
- Allows for increased penetration of renewables by improving flexibility and efficiency

Price Control

SIF funding is the only option within price control. It wouldn't attract any other type of funding as it is research led and is risky as it requires new models and control systems to be developed and proven.

Benefits Part 1

Environmental - carbon reduction – direct CO2 savings per annum against a business-as-usual counterfactual
Financial - cost savings per annum on energy bills for consumers
Financial - future reductions in the cost of operating the network

Benefits Part 2

Our project will deliver the following benefits against this counterfactual:

Financial - future reductions in the cost of operating the network

The key metric will be the volumes (MWh) of hydrogen and electricity required to provide the flexibility and the consumers heating. We will review the profile of these against the counterfactual and using Imperial's model, look at the local and national infrastructure and investment requirements to meet these demands. These savings would be achieved gradually during the transition to Net Zero.

Financial - cost savings per annum on energy bills for consumers

*We will make an estimate of how the savings on network reinforcement would translate into reduction in standing and variable charges on all gas consumer bills across various scenarios for deployment of the project.

*We will calculate the MWh of heating produced by hydrogen and electricity and will show how the heat network consumer costs will vary over several scenarios during the transition to hydrogen.

*We will demonstrate how access to flexible markets will further reduce the bills of those connected to the heat network.

Environmental - carbon reduction -- direct CO2 savings per annum against a business-as-usual counterfactual

The CO2 emissions applicable to our project will be zero from 2035. In 2017 the average household generated 2,745 kg of CO2 emissions from heating. We will identify several comparisons in the CO2 savings at various points between now and 2050 against the calculated gas and power mix.

We will compare the CO2 emissions in kg/MWh export compared to a standard peaking plant.

Project Plans And Milestones

Project Plan and Milestones

The attached Project Plant will be updated throughout the project, our team is flexible, agile, and responsive to change.

We consider the key work packages to be:

WP1 Project Support (SGN lead)

Liaising with BEIS regarding deliverables, administration of claims and supporting documentation.

WP2 Project Management (SGNCS)

The project will require a dedicated project manager (PM) to disseminate the deliverables between parties and assemble the final report.

WP3 Modelling equipment (Vital Energi lead)

We will select an actual site from our portfolio that matches the counterfactual as the base case for the design. This will provide half hourly data on the consumptions of power and heat which can be used for modelling to calculate the benefits against business as usual. The scheme will be scaled up on the basis of a 50MWe Carnot Gas Plant at the site in Provan, Glasgow. We will develop a range of sensitivities for how the market will develop over time.

VE will use Plexos simulation software to review the economic benefits of the plant and the impact of changing the relative sizing of the equipment. For example, the import and export requirements can be different and the cryogenic air and heat stores can be increased to lengthen the duration of the storage. The modelling will be used to identify an optimum size of the equipment across a range of scenarios. The intention is to identify the sizing which will give the equipment the best resilience to future changes in the energy market.

WP4 Major Component Specification (UoB Lead)

The partners will use their experience to produce an outline design for the major equipment and the associated sizing based on the outcomes of WP3. This will identify the physical sizing and a commentary will be provided on the constraints. Indicative estimates will be provided for operating and capital costs.

WP5 Gas use and Hydrogen Conversion (SGN lead)

Review the annual gas usage based on the scenarios from WP2 and comparison of gas and CO2 savings against equivalent sized peaking plant. Review the options for conversion to hydrogen and the options for import and storage of hydrogen.

WP6 Review of impact (Imperial College lead)

Using their advanced integrated whole energy system (IWES) model to analyse the impact of the project on the energy system in 2050. This will look at the impact of the concept depending on different levels of deployment.

Regulatory Barriers (not scored)

At present SGN and the project team, are confident the proposed concept would not provoke any regulatory barriers that could affect or hinder delivery of either the Alpha or Beta phases.

Heat Network contractors are not yet eligible for 'statutory undertaker' status, although this has been proposed. Lack of this status limits the obligations of contractors to respond in the instance of a fault with the heat network, which can negatively impact on quality of service, system KPIs, and acts as a regulatory barrier. There have been proposals for this status to be extended to the heat network sector in order to encourage development but details are not currently available.

As the utility industry aims to build a shared net-zero future by accelerating decarbonised energy solutions and minimising our environmental impact.

The project team will also be working closely with internal stakeholders including Operations, Network Planning and Policy, to help consider any policy and procedural impact. As the project develops through the different phases, we will also be making use of a

suitable accredited Technical Consultant to help add further industry understanding.

Commercials

Route To Market

Business As Usual

SGN is already considering how heat network infrastructure can be included in the on-going infrastructure works, both to accommodate hydrogen and the distribution of heat. This is expected to become business as usual across SGN's networks by the end of the decade.

SGN have secured 50MWe grid connections on 5 former gas holder sites which are near high density residential and suitable locations for the innovation. Of these sites one in Provan, Glasgow has been selected for this project, once proven we expect these types of projects to become common place.

Competitive Market

The market required for decarbonised heating is huge. To accomplish the ambitious requirements of Net Zero many companies will be required to offer solutions, but all will require power and/or gas and associate infrastructure. By increasing the efficiency, the product will maximise infrastructure and resources as such this will increase the rate at which the decarbonised heating market grows.

Implementation

SGN is in a Joint Venture with Vital Energi to deliver heat networks. The JV will be responsible for the implementation of the innovation incorporating it into the delivery of future heat networks starting with the Provan site if the project is successful.

Customers

The tangible innovation delivered will be an innovative Carnot battery which increases the efficiency of gas usage for peaking integrating with a heat network to provide cross vector improvements in flexibility and efficiency. The primary customer for this product would be heat network providers and flexible asset operators. The business model is to be established but one option would be to licence the base products which could be adapted by the user to fit their project specifics. This would be as suitable to international heat network providers as it would domestic.

Customer Value

The innovation can reduce the cost of owning and operating a both flexible assets and heat network allowing more customers to be supplied from the same infrastructure. This will allow for both the fixed and variable costs elements of customers to be lowered.

Funding

Adoption of the primary innovation should reduce the cost and timescales of installing heat networks. The intention to introduce heat network zones has increased investor interested and SGN have already had discussions with investors who would be interested in investing in further development and implementation of the product once it has been proven in situ.

Intellectual property rights (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.

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

Total Project Cost: £101,466

Private Funding: Our partners will fund ineligible costs and the none supported eligible costs of this project via retained earnings, these will be significantly in excess of 10% of the project cost.

SIF Funding:

The SIF funding will be split between the partners as follows:

SGN -- £1

SGN CS - £18,490

Vital Energi -- £38,700

Imperial College -- £19,360

GCC - £1500

WDC - £1

Subcontractors:

In the Discovery Phase we have not identified any requirement for subcontractor assistance.

Value for Money:

The aim is to increase the energy efficiency and decarbonise flexible export via a novel Carnot Gas Plant coupled with a heat network. These systems will lead to a reduction in load on both the gas network and the electrical network and reduce requirements for reinforcement costs to increase network capacity. This should lead to a reduction in charges on customers' bills and make savings far beyond to costs of the SIF investment.

In addition, the results of this discovery phase will feed back into our business as usual, allowing us to focus on other areas if the project results in alternatives that deliver more value at lower cost.

Document Upload

Documents Uploaded Where Applicable

Yes

Documents:

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Carnot Gas Plant - Show and Tell v1.pptx

This project has been approved by a senior member of staff

☑ Yes