SIF Discovery Round 2 Project Registration

Date of Submission

Jun 2023

Project Reference Number

SIF_WWU_2_3

Project Registration

Project Title

NextGen Electrolysis - Wastewater to Green Hydrogen

Project Reference Number

SIF_WWU_2_3

Project Licensee(s)

Wales & West Utilities

Project Start

Apr 2023

Project Duration

2 Months

Nominated Project Contact(s)

Mark Evans

Project Budget

£90,470.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£81,422.00

Strategy Theme

Net zero and the energy system transition

Challenge Area

Improving energy system resilience and robustness

Lead Sector

Gas Distribution

Other Related Sectors

Electricity Distribution

Funding Licensees

Lead Funding Licensee

WWU - Wales and South West England

Collaborating Networks

National Grid Electricity Distribution, Wales & West Utilities

Technology Areas

Carbon Emission Reduction Technologies, Green Gas, Hydrogen

Equality, Diversity And InclusionSurvey

Yes

Project Summary

Green Hydrogen is essential to decarbonise the gas network, but with current PEM technologies requiring up to 153,300,000 litres of highly purified waterannually for a 10MW system this poses a significant threat to water reserves, particularly in communities without substantial water mains infrastructure. This means that rural communities are less likely to benefit from hydrogen usage, which will often focus on highly populated areas.

This project targets the issues of high-water demand and difficulty of supplying low carbon energy to isolated communities by developing Next Generation electrolyser systems which can run off wastewater sources such as rain, well or river water, dramatically reducing demand for precious mains water, increasing resilience of green hydrogen production. The NextGen electrolysers can substantially reduce operational water demands since, unlike PEM electrolysers, they do not require purified water from reverse osmosis, providing agility in the production process.

NextGen electrolysers will integrate with fluctuating renewable electricity production alongside using wastewater, adding resilience to hydrogen production and effectively supporting the SIF challenge aims of providing robust, agile and resilient energy systems, whilst accelerating decarbonisation of major energy demands.

The large numbers of different end usage cases experienced by HydroStar pairs with the extensive operational knowledge of WWU as the lead network and NGED as a project partner acting in an advisory capacity to ensure whole system representation, to deliver the project successfully and realise the benefits of the innovation.

- WWU---regulated gas distributor at the forefront of the transition to net-zero, currently managing 412 GWh green-gas across its network. Recognising thecomplexity of the subject, WWU will support through an experienced projectmanager.
- HydroStar---cutting-edge developer of membraneless electrolysers that uniquely run off any wastewater source, creating dramatic water resource savings of up 86%, simultaneously slashing CAPEX.

There are a number of different use cases for the innovation, however, this project will initially analyse high gas demand industrial businesses for proof-of-concept,from which knowledge can be applied throughout the gas network. The needs of the innovation users are common across the board with a resilient, decarbonised and sustainable gas supply required for industrial and domestic users alike.

HydroStar are working with Yeo Valley, Burt's Crisps and Muller on commercial decarbonisation strategies, along with Exeter-City-Council and Devon-County-Council on public sector strategies (Letters-of-support available on request).

Project Description

Next Gen Electrolysis -- Wastewater to Green Hydrogen will look to reduce the cost of hydrogen production by tackling the real-world operational constraints ofelectrolytic production, specifically the need for high purity water, by utilising lesspure/wastewater sources to reduce demand on pure mains water, passing costsavings to end consumers.

Nominated Contact Email Address(es)

innovation@wwutilities.co.uk

Project Description And Benefits

Applicants Location (not scored)

Wales & West Utilities
Wales & West House
Spooner Close
Celtic Springs
Coedkernew
Newport
NP10 8FZ

Project Short Description (not scored)

Wales & West Utilities are working with Hydrostar to look at features required within a low carbon electrolyser system, primarily the use of low-quality water, enabling cost reductions that can be passed on to end customers.

Video description

https://youtu.be/ejADgL2llul

Innovation justification

At present, electrolysers use extensively purified water, wasting significant amounts of drinking water within the purification process and requiring expensive plant to be co-located onsite. Additionally, electrolysers are only widely operated from constant energy profiles from the grid. These are costly and inflexible processes, consuming vast quantities of water and only achievable at certain locations.
The problem this project aims to solve are current knowledge gaps, primarily effects of different wastewater types on Green-Hydrogen production and the associated efficiency levels, along with electrolyser operation with fluctuating renewable sources.
The two key focus areas are the use of wastewater sources such as rain (harvested), well or river water instead of highly purified to create Green-Hydrogen, and by using low-cost Next-Generation electrolysers matched to renewable generation to produce Hydrogen at below £4/kg.
The novel and innovative approach uses Bio-Ionic electrolytes (green/non-caustic) to enable NextGen electrolysers to use harvested rain, well or river water for electrolysis. Particular emphasis is placed on biological aspects and removal of microplastics. The project will address these gaps by creating a testing rig to test different water types and operation from fluctuating production, exposing thesystem to multiple operating conditions and analysing the response. NextGen electrolysers use disruptive membraneless electrolysis, removing the need for expensive membranes or cryogenic separation. The electrolysers have already been modelled, with calculations verified by the National-Physics-Laboratory in a funded A4I-project. This project aims to discover how real-world operation compares to modelled production.
Economic and environmental sustainability are at the heart of the innovations. The ability to use wastewater can vastly reduce water consumption compared to alternative electrolysers in the market, e.g---PEM, which consumes 7 litres of drinking water to produce 1 litre of Green-Hydrogen feedstock. When scaled to a hydrogen economy, billions of litres could be saved. Economic benefits are reduced resource usage, carbon savings from reduced natural-gas usage (augmented with Hydrogen) and low-cost manufacturing of NextGen electrolysers with Stainless-Steel electrodes rather than Platinum coated Titanium, lowering CAPEX and environmental impacts.
The early TRL of NextGen electrolysers means that high levels of risk are inherent and therefore not considered part of BAU activities as per regular price control mechanisms. Therefore, government funding is required to reduce the associated risk to acceptable levels. Other funding mechanisms e.g---NIA, were considered, but this project is very applicable to the SIF, with the ability to move with agility through the three SIF stages to a demonstrator solution.

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

Benefits Part 2

Financial - Cost savings

Green Hydrogen from Next Generation electrolysers facilitates direct financial benefits to network customers. Key issues of energy security and stability of prices have been highlighted within the last year. NextGen electrolysers running off renewable energy can facilitate this, meaning customers do not experience stressful and crippling energy bill increases. Furthermore, reduced CAPEX costs of NextGen electrolysers results in lower prices per unit of hydrogen compared to current sources.

Substantially reduced water demand of NextGen electrolysers, enhanced by the ability to use wastewater, reduces stress on local water systems. This means new infrastructure investment which would pass on costs to customers are avoided.

In this phase, metrics will be modelled instead of measured. The following metrics will be modelled to quantify Green-Hydrogen cost savings;

1. Water usage and source (litres of rainwater, well water, mains water) allowing quantification of water savings.
2. Electricity usage(kWh) tracking renewable energy consumption of electrolyser allowing quantification of reduction in wasted curtailed power.
3. Green Hydrogen production (kilograms) Allowing quantification of carbon savings from natural gas replacement, calculating electrical efficiency of electrolyser
   Tracking of benefits will occur during the physical demonstration and emulation stages, planned to be by the end of Year 2 where Beta Phase infrastructure would be operational.

Environmental - Direct/Indirect CO2

Gas CO2 savings

CO2 savings are calculated per kWh of natural gas replaced. Calculations take into account direct emissions along with indirect Well-to-Tank emissions (WTT---anaverage of all GHG emissions from production, processing and delivery) for natural gas. A Life Cycle Analysis (LCA---methodology for assessing environmental impacts associated with all the stages of a commercial product) providing CO2 footprint of Green-Hydrogen from solar. All calculations use Government-Conversion-Factors.

Natural gas---0.184kgCO2e/kWh

WTT---0.03446kgCO2e/kWh

Total emissions---0.21846kgCO2e/kWh

1kgH2---33.33kWh

Hydrogen emissions from solar--- 1kgCO2e/kg

Therefore---0.03kgCO2e/kWh

REDUCTION = 0.21846 -- 0.03 = 0.18846kgCO2e/kWh (86%)

10MW system at 100% capacity produces 1,460,000kgH2/annum, removing 9,170,803kgCO2e.

Water CO2 savings

Water---0.149kgCO2/m3

NextGen demand -- 15l/kg

PEM demand -- 105l/kg

From above, 10MW system produces 1,460,00kgH2/annum. Resulting waterdemands are;

- 21,900,000 litres from Next Generation (if from mains) = 3,263kgCO2e
- 21,900,000 litres from Next Generation (if not from mains) = 0kgCO2e
- 153,300,000 litres from PEM electrolyser = 22,842kgCO2e

Reductions

- 22,842 -- 3,263 = 19,579 (86% from mains)
- Wastewater---100%

Carbon savings are an important metric, however water demand reduction is potentially even more significant, since the quantity demanded for a hydrogen economy are infeasible to provide through the mains, especially during water shortages.

Project Plans And Milestones

Project Plan and Milestones

A comprehensive project plan has been developed, using the extensive knowledge and experience of WWU and HydroStar in gas network operation and hydrogen production respectively, de-risking the project. Work Packages are shown below, with overviews, milestones, deliverables and success criteria. Key tasks are shown within the Gantt-Chart;

WP1 -- Project Management & Reporting

- Lead---HydroStar
- Costs---£8,681
- Overview -- Project Management Planning activities and risk management

Milestones

- End-of-project report reviewed---Reports reviewed and analysed

Deliverables

- End-of-project report---Final report produced

WP2 -- Exploitation and Dissemination

- Lead---HydroStar
- Costs---£8,323
- Overview -- Dissemination activities and end-of-life assessments

Milestones

- Exploitation and Dissemination activities completed---Completion of dissemination activities

WP3 -- Scope definition and project planning

- Lead---HydroStar
- Costs---£18,109
- Overview -- Consideration of all potential Green-Hydrogen production concepts using wastewater sources to identify project goals and tasks

Milestones

- Scope comprehensively defined---Project goals identified

Deliverables

- Project goals---Project goals document

WP4 -- Feasibility research

- Lead---HydroStar
- Costs---£31,913
- Overview -- Technical studies into hydrogen demand, delivery methods, wastewater sources and renewables integration. Economic and regulatory studies providing key market information

Milestones

- Technical feasibility studies completed---Technical research completed and comprehensive
- Economic and regulatory studies completed---Economic and regulatory research finished and comprehensive

Deliverables

- Technical report---Initial reporting on technical feasibility completed

- Economic and regulatory report---Initial reporting on economic and regulatory feasibility completed

WP5 -- Reporting and Phase 2 planning

- Lead---HydroStar
- Costs---£14,396
- Overview -- Summarising project findings into reports, with analysis to determine action plans for further stages

Milestones

- Report on concept feasibility submitted---Report completed and analysed
- Phase 2 work packages identified and plan developed---Initial Phase 2 plan completed

Deliverables

- Project report---End-of-project report completed

The risk-management approach is to mitigate effects of uncontrollable circumstances and reducing their severity, whilst de-risking the project where possible before inception. Key risks and mitigation measures are shown below, detailed further within the risk-register.

Operational

Covid-19 resurgence---Ensure WFH where possible

Key staff leaving---Succession Planning Strategy for key individuals

Scheduling

Unrealistic work package completion dates---Frequent project monitoring,review meetings and status reviews

Managerial

Deviations between plan lead to failure to meet objectives---Experienced PM, regular review process and appropriate resourcing

Project costs overrun---Regular project monitoring and review meetings

Regulation of 0.1% hydrogen blending into the gas-network is a potential constraint, however investigation into 20% blends is being undertaken. Electrolyser TRL represents technical and commercial constraints. This project will refine technical aspects to achieve a TRL for commercial scale application.

Regulatory Barriers (not scored)

It is anticipated that there will be very few barriers to the Alpha or Beta phases of the Next Gen Electrolysis -- Wastewater to Green Hydrogen project. Regulatory barriers will be experienced in varying amounts within the physical demonstration phase of the project depending upon the outputs and trajectory of the enabling phases.
At present, hydrogen is treated as a "gas" under the Gas Act 1995. This means that the production of hydrogen must be within the longstanding gas production regulations, within which WWU bare their operating licence, and does not require any further regulation. This represents a low regulatory risk to the project.
More significant barriers will be experienced if the project develops such that hydrogen will be introduced into the existing network. This is currently limited to 0.1% blending into the natural gas network under the Gas Safety (Management) Regulations 1996.
In this case, an exemption will be required for the physical demonstration stage of the project. There are a number of separately funded projects that are exploring the regulatory barriers to the injection of up to 20% hydrogen into the gas network.These projects are due to conclude ahead of the Beta phase and should therefore not pose any significant risks.
This project will aim to influence regulatory decision making by proving the viability of hydrogen injection into the grid as well as the safety of doing so through a proof-of-concept demonstration.
Clarity on the anticipated 2023 policy decision on blending into the gas network, and 2026 policy decision on hydrogen for heat will de-risk the physical demonstration phase of the project.

Commercials

Route To Market

The route to commercialisation and the Next Generation electrolysers becoming a business-as-usual production technology within the network is a mixture of non-domestic and domestic strategies.

HydroStar is already in contact with multiple high gas demand businesses in the South-West who are very interested in reducing their carbon emissions and achieving energy security and price stability, representing the initial routes to market in the non-domestic market. Examples of these are Yeo Valley, Muller, Burts Crisps and Exeter Airport. Furthermore, HydroStar have had extensive discussions with Exeter-City-Council and Devon-County-Council, both of whom are in full support of the project. This represents strong routes to market for the public sector and domestic market.

Both strategies support the identified benefits, most significantly carbon and water savings. Particularly at initial nondomestic sites, rainwater harvesting can be employed at large scales on site building roofs. The Green-Hydrogen produced can then be injected directly to the usage source such as a boiler or into the wider network, where it can be used to deliver the financial benefits of reduced per unit cost and stable prices to consumers in isolated communities.

To ensure benefits can be realised, steps will be taken from both HydroStar and WWU. HydroStar will focus on providing a proof of concept and developing the NextGen electrolyser technology to a commercially scalable level. WWU will investigate the infrastructure requirements to facilitate large-scale injection, enabling all produced hydrogen to be delivered to network users.

Primary customers will be network users in remote locations, however businesses as earlier identified will also be customers. The operational side of the system will be focussed on microgrid communities within the more remote locations, however current gas producers will also be potential avenues also. The diversified usage cases of the electrolysers, along with the benefits and strategies, are actively beneficial in creating competitive markets and achieving low prices.

Following successful grant funding, both internal and external investment to develop key sites and production capacity will be used. Ongoing costs will be largely electricity costs for electrolysis, which will be de-risked through Power-Purchase-Agreements (PPA). HydroStar has received significant interest from a Swiss private equity firm, who could provide funding for the expansion of the technology.

Project Director Gary Nicholson is leading the innovation implementation. Having managed over £30m in R&D grant funding, he has extensive operational knowledge and the ability to drive the innovative process to achieve full technological exploitation.

Intellectual property rights (not scored)

Appropriate management of Intellectual Property Rights (IPR) is of central importance to the delivery of the Next Gen Electrolysis -- Wastewater to Green Hydrogen project.

All project Partners, and any tools or technologies that are developed during the delivery process, will adhere to the default Intellectual Property Rights (IPR) arrangements as set out within Chapter 9 of the SIF Governance Document. As part of their selection criteria, any consultants and suppliers working within the project structure will be required to comply with the same IPR arrangements.

In addition to complying with the default IPR arrangements, any data generated during the project will be shared and made openly available through knowledge dissemination to allow other parties to continue to benefit from the outputs.

Prior to starting the Discovery phase, each project Partner will make a declaration of background IP for the consortium agreement that will clearly define the background IP they bring to the project.

An IP Register will be created as part of the project kick-off process and will be developed and maintained throughout the project. Any restrictions on freedom to operate from individual components or know-how used in the NextGen Electrolysis -- Wastewater to Green Hydrogen project will be evaluated as part of the project delivery.

Specific IP issues arising during project delivery will be addressed by the project Steering Group.

Costs and value for money

The total project costs are £90,470.

This represents costs of £10,092 from WWU, £75,962 from HydroStar and £4,416 from NGED.

There are no subcontractor costs associated with this project.

The 10% of self-funding for the project will be provided through members within the team undertaking additional work within the project above that which is listed in the labour costs within the Costs breakdown. From each individual partner, the irrespective contributions are listed below;

- WWU -- Contribution of £1,010
- HydroStar -- Contribution of £7,596
- NGED -- Contribution of £442
- Total contributions across partners = £9,048 (10% of total project cost)

The project delivers strong value for money by leveraging the extensive knowledge of each respective partner within the project in their particular fields. This is gas network operation for WWU, overall electricity grid operation for NGED and Green Hydrogen production, applications and technologies for HydroStar. Costs have been minimised through the use of an agile project schedule, which enables different workstreams within the project to run concurrently whilst still being delivered to the highest standard.

Furthermore, to increase value for money, competitive market rates have been used for each individual involved within the project from all partners, along with existing equipment and facilities being used wherever possible.

Document Upload

Documents Uploaded Where Applicable

Yes

Documents:

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NextGen Electrolysis Show and Tell.pptx

SIF Discovery report.pdf

This project has been approved by a senior member of staff

☑ Yes