SIF Alpha Round 2 Project Registration

Date of Submission

Project Reference Number

SIF_WWU_2_3A

Initial Project Details

Project Title

NextGen Electrolysis - Wastewater to Green Hydrogen

Project Contact

Mark Evans

Challenge Area

Improving energy system resilience and robustness

Strategy Theme

Net zero and the energy system transition

Lead Sector

Gas Distribution

Project Start Date

01/10/2023

Project Duration (Months)

6

Lead Funding Licensee

WWU - Wales and South West England

Funding Licensee(s)

NGED - National Grid Electricity Distribution

Funding Mechanism

SIF Alpha - Round 2

Collaborating Networks

Wales & West Utilities

National Grid Electricity Distribution

Technology Areas

Carbon Emission Reduction Technologies

Hydrogen

Low Carbon Generation

Project Summary

Wales and West Utilities are partnering with HydroStar to look at features required from an electrolyser system and the associated electrolyte that ensures resilience of hydrogen supply across the network, giving best value-for-money to WWU and its customers, along with other Gas-Distribution-Network (GDN) customers.

Current electrolysers have focussed on stack efficiency and hydrogen purity without considering real-world manufacturing and operational constraints, and the high costs associated. This project focusses on using less pure water, namely rainwater, storm overflow and industrial process wastewater as feedstock, which reduces operational constraints and costs for customers whilst enabling wide-scale uptake of low carbon hydrogen.

Add Preceding Project(s)

SIF_WWU_2_3 - NextGen Electrolysis - Wastewater to Green Hydrogen

Add Third Party Collaborator(s)

HydroStar Europe

Project Budget

£328,761.00

SIF Funding

£295,824.00

Project Approaches and Desired Outcomes

Problem statement

Current electrolysis technologies have focussed on increasing stack efficiency to high levels, but without large consideration of real-world electrolyser operation. Proton-Exchange-Membrane (PEM) electrolysers require highly purified water, which must go through a purification process with high water/electrical demands. This limits hydrogen production to specific locations which have the required infrastructure.

Within Discovery it was found that operational barriers have significantly larger environmental impacts than previously thought. Water consumption for purification alone was found to be 11.5million litres/GW installed capacity daily, with annual carbon emissions of 47.9MtCO2/GW for compression to 200bar. This equates to vast water consumption/emissions when scaled to Government 5GW electrolysis targets.

Effects on capital/operational costs were explored and were greater than previously expected, with lifetime-cost-of-hydrogen savings of up to 19% and 22% achievable from removing the need for water purification or compression respectively, and over 35% when both were integrated into a system. This is a particular consideration for small-scale systems and will be explored further for the distributed and flexible hydrogen injection strategy.

The project has evolved from Discovery by identifying further strategies and network requirements. Using industrial process wastewater could enable colocation, using process wastewater to generate hydrogen that powers the onsite process itself. This represents a more closed-loop system which can have environmental and financial benefits. Developing smart injection strategies that benefit sensitive users, be that hydrogen or natural gas users, is also a key evolution for Alpha.

Alpha will focus on increasing network resilience through the strategies above along with experimental development of innovative membraneless electrolysers and environmentally friendly, noncorrosive electrolyte. These facilitate using wastewater sources like rain or river water as feedstock, whilst matching to fluctuating renewable sources and removing purification requirements entirely. These factors greatly reduce operational barriers by removing current dependencies on electrical grid and water mains infrastructure.

This enables a more distributed generation strategy to be pursued, injecting hydrogen at strategically beneficial nodes along the gas network to enable networks to control the pressure tier at which hydrogen is injected. Having distributed generation will allow GDNs to target areas of the network and early adopters of hydrogen blends while also avoiding sensitive users if required. Capital and operational costs are also reduced, with the distributed injection approach reducing requirements for compression or tube trailer transportation, which currently has high energy and financial costs.

The benefits above all contribute to increasing network resilience and robustness. Using wastewater and fluctuating renewables as feedstock and generation enables more locations for hydrogen generation, not limited to areas of high infrastructure. This means that rural communities can benefit alongside more built-up environments, and reduces risks associated with single points of failure as is experienced in large scale single location generation.

Distributed production also enables specific gas network locations to be reinforced with production or upgraded in line with technical requirements/constraints being faced, along with facilitating targeted hydrogen injection.

Knowledge of sensitive network users has evolved to the point of designing strategies to deliver their requirements. Users can be sensitive if their plants require either pure hydrogen or pure natural gas. By using a targeted injection strategy injecting at beneficial locations, customers wishing to decarbonise who cannot be electrified can be delivered high quantities of hydrogen, whilst existing users with sensitive requirements can still be fed pure natural gas.

Alongside this project, WWU has used Network-Innovation-Allowance (NIA) to assess regulations and billing changes required to account for the different chemical characteristics of hydrogen and natural gas at South Cornelly (NIA_WWU_02_15). This will be essential for large-scale uptake and customer contracts and will be embedded in Alpha within WP5 analyses of targeted injection locations and customers.

Innovation justification

INNOVATIONS

This project will improve energy system resilience and robustness by developing novel technologies to lower current operational barriers of Green Hydrogen production, namely water purity requirements, electrical grid constraints and hydrogen compression/transportation. This not only reduces future costs of hydrogen for network customers, but reduces single points of failure within the system and enables a distributed injection approach that can reach rural and urban communities alike. The key innovations are;

NextGeneration membraneless electrolyser which can use wastewater as feedstock instead of highly purified water
Total removal of rare metals within the electrolyser design
Green and non-corrosive electrolyte which can adjust based on specific wastewater feedstocks
Efficient matching of electrolysers to fluctuating renewables
Each innovation address real-world constraints, enabling hydrogen generation which is not limited by requirements for high infrastructure. This means that rural communities can benefit alongside more built-up environments, and reduces risks associated with single points of failure as is experienced in large-scale single location generation.

Discovery phase found that 1 litre of purified water requires 6 litres of tap water for purification alone. This represents 50million litres daily at Government 5GW target levels, posing threats to water availability in locations with constrained water infrastructure or annual shortages. Techno-economic modelling found that a 2MW solar/1MW electrolyser system consumed 91% of generated renewable electricity, and 99.5% from a 1MW turbine/1MW electrolyser setup. These systems produce an estimated 37,324 and 82,497kg of hydrogen respectively, reducing an estimated 205 and 454 tonnes CO_2 when replacing natural-gas.

Alpha focusses on experimental development of the innovative membraneless electrolyser and green noncorrosive electrolyte, enabling wastewater feedstock and matching to fluctuating renewables. This builds on Discovery feasibility studies, which confirmed technological viability whilst quantifying the benefits of removing water purification entirely.

A counterfactual approach focussed on electrolysers with scope to operate efficiently off unpurified mains water but not wastewater. This addresses purification issues but greatly reduces production ability at locations without mains infrastructure, and does not reduce future demands on this infrastructure.

STAKEHOLDER MANAGEMENT

South-West-Water have been engaged from a wastewater perspective, with process wastewater identified as a potential further innovation, along with NGED for potential electrical demands at different regional sites and electricity network capacities available. A very strong relationship is held with Exeter-City-Council, with discussions on hydrogen production on city industrial estates underway. Further GDNs (Northern-Gas-Networks/National-Gas-Transmission) have been engaged regarding key similarities/collaboration potential in future projects, with both networks supportive of project focusses.

High gas demand customers, some with process wastewater, have been engaged about hydrogen offtakes (see-Section-10), with the potential to investigate colocation strategies which use onsite wastewater to produce hydrogen, then consuming hydrogen/byproduct oxygen onsite.

As a 6-month timescale with electrolyser/electrolyte experimental development, the project scale supports SIF objectives, providing vital insights into wastewater usage required to develop large-scale systems in Beta phase and during mass infrastructure development. Alpha uses insights gained during Discovery to guide key tasks and greatly increase TRL.

READINESS LEVELS

Commercial

Current---5/6. Expected---6/7. Financial models will be validated, with focusses on exploitation through customer integration and agreements, and innovation protection through patenting

Technology

Current---4/5. Expected---6. Technology validation/demonstration will be achieved during tests with electrolyte/electrolyser, and output analyses

Integration

Current---3. Expected---4/5. Experimental development of electrolysers/electrolyte will enable termination/management methods between the two technologies based on changing inputs

FUNDING

The project cannot be funded elsewhere or considered as business-as-usual because of the early-stage nature of the innovation. HydroStar has considered private equity investment, with Hydrogen One and Investec expressing interest in funding innovative hydrogen projects, however early-stage innovation risks are outside their investment scope. HydroStar will be considered within investment scope once the technology has been demonstrated at scale.

Impact and benefits (not scored)

Financial - cost savings per annum on energy bills for consumers

Environmental - carbon reduction – direct CO2 savings per annum

Environmental - carbon reduction – indirect CO2 savings per annum

New to market – products

New to market – processes

New to market - services

Impacts and benefits description

Impacts and benefits descriptionThe Environmental and Financial benefits realised during Discovery Phase are quantified below. The New-to-Market benefits have been expanded during Discovery to refine their focusses.

Environmental---carbon reduction---direct CO2 savings per-annum

Natural gas produces 0.18254kgCO2/kWh of gas consumed, and 0.0311kgCO2/kWh as Well-to-Tank emissions (Government-Conversion-Factors). This equals a total of 0.21364kgCO2/kWh for the current position.

Lifecycle analyses of Green Hydrogen indicate a carbon footprint of 1.7kgCO2/kg (Royal-Society-of-Chemistry). The calorific value of hydrogen is 33.33kWh/kg, therefore the assumed carbon footprint of Green Hydrogen is 0.051kgCO2/kWh, with this value to fall further as the supply chain develops.

This represents a 76% reduction compared to natural gas.

WWU distributes 60.5TWh of natural gas annually, equivalent to 1,815Mt of hydrogen and with a carbon footprint of 3,086MtCO2. Therefore, annual direct carbon savings of 2,345MtCO2 are possible by using Green Hydrogen over natural gas as BAU.

Environmental---carbon reduction---indirect CO2 savings per-annum

Discovery phase calculations have shown significant carbon emissions associated with water purification to reach the required standard of ultrapure water that current electrolysis technology requires.

Purification processes require 6 litres of tap water to create 1 litre of highly purified water, or 6,000litres/m3, with electricity consumption of 3kWh/m3. UK tap water has a carbon footprint of 0.149kgCO2/m3 and 2022 UK electricity a footprint of 0.19338kgCO2/kWh. Therefore total carbon emissions of delivering the current position of highly purified water for electrolysis is 1.47414kgCO2/m3.

Direct water consumption of electrolysers is 10l/kgH2. To deliver the equivalent 1,815Mt of hydrogen which would be distributed by WWU annually, 18.15million m3 of water is required for purification alone. This represents a carbon footprint of 26,755,641kgCO2 which could be saved indirectly from using water which does not require a purification process.

Financial---cost savings per-annum on energy bills for consumers

Techno economic modelling within Discovery phase found that the LCOH (Lifetime-cost-of-hydrogen) from a 2MW solar/1MW electrolyser system using wastewater sources as feedstock instead of highly purified water was 19% cheaper, at £5.98 instead of £7.41 at an electricity cost of £80/MWh. A similar reduction was found from removing the need for compression through distributed injection into the network, reducing costs from £7.12 to £5.97.

Further modelling investigated wind energy for hydrogen generation, showing a 1MW turbine/1MW electrolyser could generate at a LCOH of £2.13 if all plant/generation were owned, representing a significant reduction in price compared to the current Green Hydrogen prices of between £7 and £10/kg.

New to market---Products

Electrolysers which can operate from wastewater feedstock without the need for highly purified water, using membraneless technology to also reduce the capital costs of electrolysis systems.
An electrolyte which facilitates the process and can handle the different ions present in wastewater sources without limiting the electrolysis process or creating dangerous byproducts, and can be changed slightly to account for changing ion concentrations
New to market---Processes

Production of Green Hydrogen from wastewater or less pure water, helping to achieve the 2030 Government 5GW electrolysis targets by lowering operational barriers and site requirements for electrolysis production.

This enables a distributed generation strategy, injecting hydrogen at strategically beneficial network locations to enable operators to control/track hydrogen more easily, delivering specific concentrations to locations dependant on user requirements. Capital/operational costs are reduced, with distributed injection reducing the need for compression or transportation, which currently has high energy/financial costs associated.

New to market---Services

Colocation services for water treatment and onsite gas demand production, reducing overall energy/fiscal costs and with potential to supply oxygen demands for any onsite processes as an electrolyser byproduct
Nodal hydrogen injection services into specific locations on gas networks to increase hydrogen quantities or concentrations required at these locations, improving security-of-supply for both network users and operators

Teams and resources

PROJECT TEAM

Core project partners remain the same for Alpha, except the addition of University-of-Exeter (UoE) and Welsh Water as subcontractors. HydroStar will lead technical electrolyser and electrolyte development, utilising wastewater as feedstock and designing methods for achieving low-cost Green Hydrogen at £4/kg.

WWU will lead from project governance/network operator perspectives, ensuring SIF compliance and delivering long-term benefits for both network operators/users.

UoE will be responsible for modelling/simulating the electrolyte across wastewater sources with changing concentrations of ions. HydroStar has strong existing relationships with UoE, having worked with Professor Li on previous projects. UoE are vital to achieving Alpha outputs for their ability to simulate and handle vast datasets on water analyses/electrolyte compositions.

Welsh Water will provide advisory services on potential wastewater/discharge sources, along with basic analyes of Welsh Water sites which could be integrated into colocation strategies.

HYDROSTAR TEAM

The HydroStar team have extensive experience in R&D across hydrogen production, electrolyte usage, hydrogen storage/strategy, along with wider engineering and AI control systems. Specific roles are;

Ian Gordon---Project Manager---10 years extensive experience in R&D Project Management, specific to hydrogen
Gary Nicholson---Project Director---Ex-Rolls-Royce Director-of-Advanced-Controls, worked with US-Department-of-Energy developing low-cost green electrolysers
Domanique Bridglalsingh---Chief Scientist---Masters in Molecular-Cell-Biology/Biochemistry, leading HydroStar's Green-Electrolyte team with 5 related patents
Charlie Newbold---Modelling Lead---MEng Mechanical-Engineering, with significant knowledge of modelling hybrid renewable energy systems
Matthew Morley-Jacob---Technical Engineer---MsC Global-Sustainability-Solutions, with skillsets in emissions reduction/health effects
Asma Akhter---Technical Engineer---Masters in Robotics/AI, with strong control engineering background for systems integration

Meenakshy Sunil---Programme Manager---Masters in Business Management, with experience in risk management and documentation compilation

WWU TEAM

WWU are experts in gas network infrastructure operation, with team members having wide experience in hands-on engineering, project and risk management. Specific roles are;

Mark Evans---Technical lead---14+ years of Mechanical engineering/project-management experience within Aviation/Medical&Gas
Darren Cushen---Technical support---Chartered engineer with 8 year's experience in the Gas Industry/Net-Zero project management
Lydia Whatley---Innovation Project Lead---6 years' experience in project management with a focus on Net Zero and Sustainability across Insurance/Finance/Agile Web Development/Higher Education/Gas Industry
Geraint Herbert---Innovation Project Support---14+ years' experience in the Gas Industry with 6 years experience of Innovation project management

NGED TEAM

Peter White---System Development Engineer---20+ years in Power Systems, with global business knowledge of developing infrastructure in the Middle-East

UoE TEAM

Professor Xiaohong Li---Professor and Chair-of-Energy-Conversion---Focus on membraneless electrolysers for hydrogen production/nanoscale materials for electrocatalysis
Professor Edward Keedwell---Professor of Artificial-Intelligence---Focus on machine learning/AI-based simulation, and their application to engineering problems

WELSH WATER TEAM

Andrew Dixon---Head of Energy Efficiency---10+ years of experience in water/renewable electricity systems, focussing on Hydro power and maintaining water infrastructure
ADVISORY BOARD

Sam Blackadder---CEO Elvin Renewables---Extensive experience installing and operating renewable energy infrastructure/raising funding
Blake Putney---Systems Director---Ex-NASA---Designed hydrogen-based rocket engines with particular focus on risk analysis
Kareem Hassan---Exeter-City-Council/CEO---Focussed on delivering Exeter's vision for a healthy and sustainable city, working with private/public sector to ensure institutions pull together

RESOURCES/EQUIPMENT/FACILITIES

This project seeks to perform initial experimental development activities using 3 small 2kW electrolyser testing units and simulation software for modelling the electrolyte.

To achieve WP3 electrolyser work outputs (see-PMT), 2kW units will be purchased and assembled, accessed through HydroStar's supply-chain partners from previous projects and local precision-engineering companies for steel. Testing will occur in University-of-Exeter laboratories within the subcontract, which contain all relevant safety equipment. Specific components are;

Stainless Steel---316L rings/plates
Stainless Steel---316L Busbar posts
Safety release valves
Power leads/Valves/Auxiliary Parts
Furthermore, to achieve WP4 electrolyte outputs (see-PMT), simulation software is required. This will again be accessed through the UoE subcontract rather than HydroStar purchasing all required software at high expensive. The substances required for

electrolyte composition will be purchased from Fisher Scientific, a UK based supply company for scientific test equipment.

Project Plans and Milestones

Project management and delivery

How will you manage your Project effectively?The project management approach adopts a mix of running Work Packages (WPs) concurrently with a traditional waterfall model for tasks within individual WPs dependent on prior tasks being completed. Alpha WPs have been constructed to achieve technology innovation goals whilst designing long-term commercial development plans. Project WP's are;

WP1---Project Management & Reporting

WP2---Exploitation and Dissemination

WP3---Electrolyser system development

WP4---Electrolyte development

WP5---Gas network technical analyses

WP6---IP and patenting

WP7---Project analysis and next steps

Key dependencies are held between WP3 and WP4 (See-Gantt), with T3.6/7 tests requiring electrolyte preparation for different wastewater sources from T4.6. Furthermore, WP5 analyses are dependent on colocation designs within T3.8.

Inter WP dependencies exist, such as water composition analyses in T4.5 relying sample collection in T4.4, shown visually in the Gantt. Understanding task/WP interactions enables identification of critical paths, essential for electrolyser development since lead times/late orders could cause delays.

WWU will manage project governance and SIF compliance, coordinating project partners HydroStar and NGED. HydroStar's reporting fill flow through Ian Gordon(PM), with close contact from team members/advisory board.

Risk management begins with identifying and fully understanding effects of risks across key areas listed below, with a full risk-register provided within the PMT;

TECHNICAL

Separation of byproduct gases from wastewater electrolysis. Mitigation---Operate electrolyser at specific power levels and collect gases from earliest source possible. Use purification equipment where required
OPERATIONAL

Ambitious project timeline, with potential for delays. Mitigation---Analysis of critical path to track which activities cannot slip, ensuring wider project-team is aware
COMMERCIAL

System cost too high for wide-scale uptake. Mitigation---Use widely recyclable materials for electrolyser, lower in cost than current rare metals used
ENVIRONMENTAL

Fugitive hydrogen emissions. Mitigation---Fugitive emissions report compiled identifying key areas emissions can occur (process venting/seals/connections). Reduction methods prepared for each source
LEGAL/POLICY

Regulation barriers from blending. Mitigation---Work with WWU regulation specialists/wider stakeholders to track the decision, whilst designing systems to modulate flow
SAFETY

Unpredictable gases made from wastewater mixtures. Mitigation---Use extraction fan whilst running tests, and ensure specific

power level required for hydrogen production reactions is calculated before experiment begins to reduce potential for unpredictable gases
Pre-project mitigations are designed to reduce likelihood of occurrence/impacts. Contingency actions have been identified in case the risk still occurs, enabling fast responses to mitigate effects. Risks will be monitored throughout to track changing likelihoods/effects, with mitigation strategies designed in response.

A Stage Gate will be held in Week 6 before T3.3 (Order-hardware for 2kW-testing-unit) after final designs have been prepared and before capital is spent on components. By holding the stage gate, assurance that designs are of highest quality is achieved and there is low-risk of equipment failure in testing phases.

Since Alpha focusses on test-rig scale experimental development, there will be no supply interruptions. During large scale roll-out, interruptions could be experienced during construction and operation from grid injection point connections. To mitigate this, wider plant construction would be managed separately to injection point construction, ensuring no dependencies which could cause delays. During operation, the distributed approach enables multiple suppliers to deliver hydrogen to a user, reducing the impact of one plant going offline.

To ensure sensitive consumers retain access to services post roll-out, hydrogen injection quantities will be modulated, supplying high hydrogen demand users where required whilst not affecting natural-gas users. Furthermore, using wastewater/off grid renewables means no other services are affected, unlike other hydrogen methodologies which rely on mains water/electricity grid. Regarding additional infrastructure external to gas networks, Welsh-Water are in support of the project (see-Letter-of-Support---Gantt-appendix) and are being consulted throughout Alpha for colocation of electrolysers on wastewater plants, feeding into the gas network and potentially delivering byproduct oxygen to further wastewater processes.

Key outputs and dissemination

EXPECTED OUTPUTS

Key outputs for Alpha support technical, commercial and strategic growth of the technology and project, whilst enabling effective dissemination of findings.

Key technical outputs will be 3x2kW electrolyser testing rigs and the simulation model for electrolyte response to changing wastewater sources. These enable initial operability and proof-of-concept testing to be undertaken, with results on the purity of hydrogen being recorded and analysed to guide Beta phase development. Initial experimental development will also prove the effects of power levels on reactions which occur, the theoretical calculations for which will be done at the start of Alpha.

Key commercial outputs will be submission of patent filings for protection of IP, and more accurate financial models which calculate system economics and the key value of lifetime cost of hydrogen, since this will be a key driver for customer uptake. The focus on patent protection means that HydroStar and WWU have freedom-to-operate and can grant licenses to other businesses to increase the technology deployment rate.

From a strategy perspective, key outputs will be having models of large sensitive gas user requirements and the respective hydrogen flows and injection locations within the network to supply these demands. The costs and potential return on investment will also be calculated at each location, with the two analyses combining to form part of the exploitation plan to increase resiliency across the network.

A further definite output is a project report detailing key findings, along with all SIF governance documentation. This will ensure that the project meets all compliance requirements and tracks the progress over the project lifespan effectively.

PROJECT OUTPUT RESPONSIBILITIES

For project outputs, Gary Nicholson will be responsible for compilation of patent filings and specific claims, whilst Charlie Newbold will be responsible for the financial model, economic analyses of sites and long-term financial forecasts.

From a technical perspective, Domanique Bridglalsingh will be responsible for electrolyte response calculations, whilst University-of-Exeter will be responsible for compiling results into an interactive model which can change relative to wastewater input and ion concentrations. Ian Gordon will be responsible for purchasing of all components required for the 3x2kW electrolyser testing units, and the assembly upon delivery.

For the strategy component, Mark Evans and Darren Cushen will be responsible from WWU for focussing the project on key network resilience and upgrade plans, along with access to relevant information on network operations and technical considerations. Charlie Newbold will be responsible from HydroStar to conduct detailed analyses of potential sites from technical and economic perspectives, and to begin detailed work on the most suitable locations.

For all SIF governance compliance, Lydia Whatley will be responsible for managing the submission of required documentation, interaction of Next Gen Electrolysis with other SIF projects as part of project requirements, interaction with key stakeholders and managing timescales throughout.

DISSEMINATION

The dissemination strategy will use a combination of virtual and physical approaches. Presentations will be given at business events run by the South-West LEP and other partnerships, whilst social media will be leveraged to spread findings to wider audiences. Meetings will be held with local councils to develop technology implementation strategies to reduce city emissions. HydroStar has a strong relationship with Exeter-City-Council, who are keen to investigate emissions reduction strategies to improve air quality/carbon footprint. Product demonstrations of the micro electrolyser testing rig and electrolyte model will be used in the short-term to show key customers and parties mentioned above the technology in operation, with larger scale demonstrations given during Beta phase.

From HydroStar, Ian Gordon will be responsible for dissemination activities in line with WP2 of the Gantt Chart (see_Section_7), with Geraint Herbert being responsible from WWU.

Commercials

Intellectual property rights, procurement and contracting (not scored)

Intellectual Property Rights, procurement and contractingIntellectual Property Rights will be granted in line with the default arrangements in the SIF document, with HydroStar owning the generated IP and granting a perpetual license to WWU without charge as detailed in Appendix Section 9---IP Arrangement.

HydroStar will be subcontracting part of WP4 Electrolyte Development (See Section 7---Gantt) to the University of Exeter at a value of £35,000. The subcontract will utilise the modelling skills of the University to develop the simulation model which calculates the changing requirement of the electrolyte relative to the wastewater input source. The subcontract will also cover the use of facilities for electrolyser and electrolyte testing, representing a far greater value for money than specialist test equipment having to be bought within Material costs.

The University of Exeter have been chosen as the subcontractor because of HydroStar's prior relationship with Professor Li (See Section 6---Team and resources) who specialises in electrolysis research and the use of water within the process. Therefore, an RFP process is not required for procurement of university services. An RFI has been issued to the University of Exeter on Monday 12th June in line with HydroStar's project development process, to attain written documentation of the ability of the University to deliver the project specific tasks. This sets a precedent for the expected deliverables and as such protects HydroStar in the event work is not delivered to the expected standard or timelines.

Commercialisation, route to market and business as usual

ROUTE-TO-MARKET

The commercialisation plan pairs WWU strategic network upgrade intentions to supply both natural gas and hydrogen to sensitive users with the onsite innovation/energy partnership model employed by HydroStar. Together these focusses enable fast deployment of Next-Generation electrolysers in key locations, forming the foundation for business-as-usual technology usage.

From WWU's perspective, identification of strategic network nodes for supplying hydrogen to specific customers/areas is a key focus. Knowledge gained in WP5 (See_Section_7---Gantt), specifically on high demand users and predicted hydrogen flows, will help to identify these locations. Once identified, grid injection points can be designed and constructed, with generation companies like HydroStar worked with to develop/install generation capacity.

HydroStar is focussed on delivering innovative and tailored systems to businesses, working with customers as an energy partner to achieve their financial and environmental goals simultaneously by modelling onsite energy usage, identifying colocation potential for waste-heat/oxygen usage, then designing low-cost systems to supply the demands. The required knowledge and technological advancements are addressed in WP3/4 (See_Section_7---Gantt), developing an initial small-scale testing rig.

HydroStar has a strong existing client base across the South-West of customers wishing to reduce carbon footprints whilst controlling energy costs. These customers are primarily food processing (Yeo-Valley, Burts-Snacks), transport (Exeter-Airport, Gregory-Distribution) and industry (Coastal-Recycling), however farms feeding Burts and Yeo-Valley are also being engaged through collaboration with the National-Farmers-Union. HydroStar has a particularly strong relationship with Yeo-Valley, who's CEO Karl Tucker is head of the South-West LEP (Local-Enterprise-Partnership) and is very keen to install a 1MW demonstration unit of 1MW on the Cannington site. This represents the primary route-to-market through Yeo-Valley and other engaged clients, gaining operational and installation knowledge at each site.

HydroStar will work alongside WWU to supply further high demand users under different potential models;

Supply contract---HydroStar owns/operates the electrolyser plant, selling hydrogen to clients
JV arrangement---HydroStar enters a Joint-Venture with the client to split capital spend, with hydrogen pricing mechanisms being determined case-by-case
Client purchasing---Client purchases hardware and HydroStar acts as consultant/O&M provider
Once IP protection is secured through patenting, HydroStar will grant licenses to further businesses to install/operate the technology, thereby increasing the technology roll-out rate. The model of supplying hydrogen to existing clients whilst injecting at specific nodes is very scalable across further networks as a distributed production model.

COMMERCIAL READINESS

WWU are at high commercial readiness as network operator for Wales and the South-West of England. WWU will finance network upgrades and exploratory studies from internal funds, investing £400m between 2021 and 2026 to deliver a Net-Zero ready gas network by 2035, while looking after the most vulnerable in communities. The company currently has 20 green gas sites connected, injecting enough decarbonised gas to power approximately 180,000 homes.

As a small company, HydroStar does not have internal funding to invest in all potential sites, however the company has strong commercial knowledge and experience, with CEO Gary Nicholson having been Director of Rolls-Royce Advanced Controls, managing large M&A/sales deals. Funding mechanisms to facilitate commercial roll-out have been and continue to be explored. HydroStar have interest from Investec and Hydrogen One for provision of capital and equity investment into the business or as project funding. However, this is contingent on successful technology demonstration since current risk profiles do not meet their investment criteria. Debt funding will be explored where possible and when consistent with business financial requirements.

SPONSORSHIP

The project has sponsorship and sign-off from WWU's Net-Zero & Sustainability Steering Group, which includes the majority of WWU Executives/senior representatives from around the business. This demonstrates the intention of WWU to expand the technology at scale upon successful concept demonstration and project completion of Alpha/Beta phases.

Policy, standards and regulations (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 Beta 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 and the accompanying HSE standards. 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 in a business-as-usual manner. 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 (Beta). There are several 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.

The requirements and steps to be put in place will be addressed within WP5 (See-Gantt), and the 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. There are no stage gates required for the upcoming phase, however stage gates will be needed within the Beta phase of the project for regulatory bodies to process the request.

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.

Value for money

The total project costs being requested from SIF are £295,824. This is split between partners WWU, HydroStar and NGED at £18,348, £269,064 and £8,412 respectively. This is considered a fair proportionate split of costs, with WWU managing governance and overseeing the project, HydroStar conducting most of the technical development and project delivery, and NGED acting in an advisory capacity.

A total 10% contribution of £32,937 is contributed by the partners at values of £2,049, £29,952 and £936 from WWU, HydroStar and NGED respectively. This 10% contribution to the project will be achieved through labour costs of project team members in kind from WWU and NGED, and at 10% contribution of all labour, materials, subcontract and travel & subsistence costs from HydroStar (See Finances Section for specific costs).

The project has a subcontract to University of Exeter. This will entail technical research on the electrolyte composition and then simulation modelling of the electrolyte response to changing ion concentrations in wastewater sources. This is a vital cost for the project because understanding the compositions of electrolyte needed for integration with wastewater sources is essential to enabling Green Hydrogen production from these sources. Using University of Exeter as a subcontractor also gives access to expensive software to simulate the electrolyte compositions and conduct initial testing on the micro unit. This represents strong value for money because otherwise additional costs would have to be incurred to purchase software and hire additional facilities for testing.

The project also has a subcontract to Welsh Water. This will entail consulting with members of the Welsh Water team, in particular Andrew Dixon (See Team-and-Resources) regarding energy production on their sites and the different types of wastewater that Welsh Water treats. This can then be built into the wider network analyses and colocation strategies, by using the wastewater onsite to generate hydrogen which can be used in close proximity to site or injected into the gas grid, with potential for the byproduct oxygen to also be used at the wastewater plant.

A breakdown of WWU total costs is given below:

Labour---£18,348
A breakdown of HydroStar total costs is given below:

Labour---£142,344
Materials---£79,740
Subcontracting---£40,500
Travel and subsistence---£6,480
A breakdown of NGED total costs is given below:

Labour---£8,412
WWU, HydroStar and NGED will both finance the remaining contribution to the project in kind through time spent on the project by the team (See Team and Resources).

There is no additional funding coming from other innovation funds.

USE OF PRE-EXISTING FACILITIES

Within the experimental testing component of Alpha, components for a 2kW unit will be purchased and assembled to conduct initial testing with wastewater sources. HydroStar already owns hydrogen and oxygen gas analysis equipment, therefore the material cost for the project is less than it would have been if the full gas analysis setup needed to be purchased. This represents strong value for money by reusing existing equipment.

WWU already have many tools for gas network analysis, including GIS models to view specific injection points, directional gas flows and other network characteristics. This removes the need for these tools to be built or large quantities of time to be spent analysing data, reducing overall labour cost.

Furthermore, facilities for testing will be encompassed within the subcontract to University-of-Exeter, which already have all the required safety equipment, benches, power supplies etc. This represents a substantial reduction in project cost since the required testing and safety equipment is very expensive, and would otherwise have to be listed within the project material costs. Instead a rate is paid for use of the facilities for a number of days within the subcontract, greatly reducing total cost.

Associated Innovation Projects

- [ ] Yes (Please remember to upload all required documentation)
- [x] No

Supporting documents

File Upload

NextGen Electrolysis_ Alpha Show and Tell.pptx - 28.1 MB
SIF Alpha Gantt.pdf - 449.0 KB

Documents uploaded where applicable?

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