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NIA Project Registration and PEA Document

Date of Submission

Aug 2024

Project Reference Number

NIA_WWU_02_61

Project Registration

Project Title

NextGen Electrolysis – Producing Green Hydrogen from Contaminated Water

Project Reference Number

NIA_WWU_02_61

Project Licensee(s)

Wales & West Utilities

Project Start

August 2024

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Mark Evans

Project Budget

£432,134.00

Summary

The UK Government has committed to reducing greenhouse gas emissions to net zero by 2050. All future energy modelling identifies a key role for hydrogen in providing decarbonised energy for heat, industry and power generation. Green hydrogen production requires carbon-free electricity, purified water and relatively expensive membranes made from rare metals giving considerable barriers to efficient and cost-effective production.

This project will focus on how treatment of industrial manufacturing process wastewater containing elevated levels of contaminants (heavy metals/fibres) and microplastics, can expand water types available for electrolysis, increasing opportunities for co-location of electrolysis citing at industrial clusters and reducing risk of fast passivation of electrodes to reduce ongoing maintenance costs. The resultant water will be used in the process of electrolysis to produce green hydrogen, reducing cost and increasing availability of green hydrogen production.

Preceding Projects

NIA_WWU_2_02 - Regional Decarbonisation Pathways

SIF_WWU_2_3 - NextGen Electrolysis - Wastewater to Green Hydrogen

SIF_WWU_2_3A - NextGen Electrolysis - Wastewater to Green Hydrogen

Third Party Collaborators

HydroStar Europe

Cardiff University

Nominated Contact Email Address(es)

Problem Being Solved

Green hydrogen has the potential to replace large quantities of natural gas demands in “hard to abate” sectors like industrial heat and transport, however it currently faces certain barriers to widespread adoption. One of these is the requirement for highly purified water, with current electrolyzers requiring water which has gone through reverse osmosis, incurring high energy demands and creating large amounts of wastewater.

To address this, HydroStar and Wales and West Utilities (WWU) are working together on an OFGEM SIF project focussed on low cost, high resiliency hydrogen production using water that is less pure (tap/rain/effluent water, etc.). This reduces the barrier of water availability and quality for hydrogen production, enabling a more distributed approach to generation including onsite generation from renewables.

This project will look to expand the range of water types that can be used by the NextGen device in the electrolysis process by enabling contaminated water to be used to produce green hydrogen, which alongside the co-location opportunities available at industrial cluster sites, will expand opportunities for green hydrogen to be injected onto the gas network, supporting decarbonisation of industrial sites.

Whilst the NextGen device being developed in the SIF project uses less pure water to produce hydrogen, contaminated industrial process water is full of debris like microplastics, fibres and heavy metals and unable to be utilised to produce green hydrogen. The process of electrocoagulation and flotation being explored in this project can clump together microplastics/heavy metals/other pollutants and bring them to the water surface to aid in their removal and to remediate the worst types of water with minimal energy intensity giving the ability to recycle the contaminants properly.

This project will explore decontamination of industrial and highly polluted process water to enable the production of green hydrogen through NextGen electrolysis, which is complementary process to the device itself being explored as part of the SIF project.

Method(s)

HydroStar are partnering with WWU and Cardiff University to develop a game changing NextGen electrolysis technology within the SWIC which can directly use contaminated water for green hydrogen production on industrial sites, performing a remediation process and high efficiency hydrogen generation using the same device.

The innovation is aimed at large gas users wishing to switch to hydrogen who also have large quantities of wastewater from onsite processes, removing the need for extensive purification and water main infrastructure to produce hydrogen more sustainably.

This is achievable through electrocoagulation and particle flotation for water remediation, using bubble dynamics of electrolyser waste oxygen to bring contaminants to the surface with electrolysis of impure water achieved through bespoke membraneless electrolysis designs.

This project will completely disrupt the current need for electrolyzers to run off ultra-pure water sources by creating a system which can simultaneously remediate contaminated water and produce hydrogen from the remaining impure water. This will provide a resilient and flexible system which can operate in distributed locations without requiring extensive water/electrical grid infrastructure. Key innovations are;

- Combining remediation/production - Combining water treatment and hydrogen production into a single NextGen electrolysis device through advanced control systems for multi-use operations
- Coagulation/flotation of contaminants - Combining hydrophobic/hydrophilic particles which 'grip' onto contaminants and water respectively, with byproduct oxygen bubbles to float the contaminants particles to water surface where they can be removed
- Electrolysis of impure water - Using membraneless electrolysis to produce hydrogen from impure water, removing the need for water/energy intensive purification processes

To evidence the disruptive impact of a combined remediation/production system, a 5kW-scale system will be developed, using an optimised NextGen electrolyser design to enable coagulation/flotation of contaminant particles using Cardiff University's expertise in particle dynamics.

General

The following paragraphs outline how the project will meet measurement and data quality objectives, including the measurement procedures and techniques to be used against each Work Package (WP), and the mechanisms to ensure the traceability, reliability, and comparability of the measurement result. A data capture and handling framework is provided within the WP7 summary since this

is the WP which contains the most data handling, however elements from this plan will be experienced within all of WP's 5,6 and 7).

WP1 – Project Management and Reporting

WP1 involves several key tasks including establishing the baseline project management plan, risk management, and delivering reports / documentation, as well as any IP management.

The Project Management and Reporting Work-Package will require careful management of any sensitive Intellectual Property (IP) data that may be required or developed as part of this project. HydroStar employees have been trained by its Senior Management Team to know the different types of IP, including but not limited to; patents, trademarks, copyrights, and trade secrets, allowing employees to understand how each type protects different aspects of prospective creations.

Furthermore, HydroStar also work closely with their IP specialised Legal Team at Sirius IP, led by Kate Butler. Close communication with this organisation means that HydroStar regularly advised as to the best protection strategies and are kept up to date with the most contemporary changes regarding IP policy.

Finally, HydroStar Senior Management only engage with third party companies when there is a Non-Disclosure Agreement (NDA) in place or a clear Collaboration Agreement (CA) that maps the ownership of the IP.

WP2 – Exploitation and Dissemination

WP2 involves engagement with key stakeholders such as; Gas Users, Water Utilities, Local Authorities, and Councils. This will also involve approaching these organisations for potential water samples and consumption data.

Therefore, this work package requires careful management of any sensitive data that may be required as part of this project. HydroStar employees will follow the most widely accepted conditions for managing Personally Identifiable Information (PII) as laid out in the General Data Protection Regulations (GDPR) such that employees safeguard individuals' privacy. This will be ensured through the following steps:

1. All HydroStar employees have been familiarised with GDPR requirements---ensures that all employees involved with this project are up to date with the regulatory requirements, preventing the likelihood of accidental data release.
2. Data Minimisation---HydroStar employees will only collect PII data that is necessary, the team will also continually update data collection practices to avoid future unnecessary information collection.
3. Data Retention and Deletion---HydroStar have clear data retention policies, ensuring that any PII that is no longer required is deleted. This deletion utilises secure erasure practices with second-stage backup systems adhering to HydroStar deletion protocols.
4. Documentation and Accountability---HydroStar's CFO, Ian Gordon (IG), is responsible for GDPR compliance, who regularly oversees updating policies. IG also maintains a detailed record of data processing activities and risk assessment development.

WP3 – Overall system architecture and operating conditions

WP3 involves assessing the overall operating conditions that the system will need to operate within both at the initial research scale but also in a scaled case. A core component of this work package is the sampling of wastewater sources, which will be analysed officially using laboratory testing to ensure quality of data. This will include heavy metals testing, microelement tests, biology tests and also microscope tests to view the microplastics. These tests will be achieved through a mix of external laboratories and Cardiff University lab equipment.

WP4 – CARDIFF UNIVERSITY WP

To be delivered by Cardiff University.

WP5 – Electrolyte analysis and pollutant capture systems

Within WP5, the electrolyte composition will be modelled and calculated to ensure efficient operation of the system. The data used for this will be largely gained through HydroStar's current patented electrolyte (B9TM and Bi-IonicTM). This provides the characteristics of the electrolyte, from which further development can be achieved.

Alongside this, pollutant capture systems will be designed. A full literature review will be undertaken to ensure deep understanding of current systems is present. This will involve research papers, commercial systems and patent analyses, to ensure that the most effective solution can be utilised within the project but crucially without affecting any licenses or freedom to operate.

WP6 – Testing rig designs and manufacture

Within WP6 the testing rig will be designed and manufactured, using core information from previous work packages. The data generated will be from initial safety tests, which will be achieved through data logging systems to track temperatures within the device and also pressure, along with visual assessments. Visual recordings will be made to ensure data from this perspective is also present.

WP7 – Full testing procedure and performance analysis

WP7 involves full testing and performance analysis of the electrolyser and pollutant skimming system. Therefore the data gained will be purely from the project, and as such high quality research data. The data from the system can be compared to market data, which will be achieved through conducting a literature review as well as some product analysis to determine the efficiency and resiliency associated with different electrolysers, including Solid Oxide, Proton Exchange Membrane, and Alkaline Electrolysers.

A full data management and processing plan is being developed, consisting of the following elements;

- Data Capture
 - Instrumentation and Devices
 - Data Entry and Collection
 - Metadata Capture
 - Validation and Quality Control
- Data Storage and Management
 - Data Storage Solutions
 - Data Organisation
 - Data Security
- Data Processing and Analysis
 - Data Cleaning
 - Data Integration
 - Analytical Tools and Techniques (R, Python, SPSS)
- Data Sharing and Reporting
 - Data Accessibility
 - Data Documentation
 - Publication and Dissemination
- Data Archiving and Preservation
 - Long-term Storage Solutions
 - Data Preservation
 - Retention Policies
- Compliance and Ethical Considerations
 - Ethical Approval and Consent
 - Data Protection Regulations

WP8 – IP and patenting

The Project Management and Reporting Work-Package will require careful management of any sensitive Intellectual Property (IP) data that may be required or developed as part of this project. HydroStar employees have been trained by its Senior Management Team to know the different types of IP, including but not limited to; patents, trademarks, copyrights, and trade secrets, allowing employees to understand how each type protects different aspects of prospective creations.

Furthermore, HydroStar also work closely with their IP specialised Legal Team at Sirius IP, led by Kate Butler. Close communication with this organisation means that HydroStar regularly advised as to the best protection strategies and are kept up to date with the most contemporary changes regarding IP policy.

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

Scope

The project scope adopts a mix of running Work Packages (WPs) concurrently with a traditional waterfall model for specific work packages dependent on prior tasks being completed. The project consists of eight inter-linked work packages

WP1 - Project Management/Reporting

- Coordination of project and reporting using established PRINCE-2 techniques, assessing progress against milestones/deliverables, and periodically updating the risk register

WP2 - Exploitation/Dissemination

- WWU/HydroStar liaise with further clients/stakeholders to ensure outputs are commercially relevant and that broader dissemination of information occurs in further market verticals

WP3 - Overall system architecture/operating conditions

- Whole system architecture, defining specific wastewater considerations and resultant electrolyser operating conditions

WP4 - Electrode designs/simulations

- Designs/simulation for electrode configurations which can facilitate flocculation/coagulation of pollutants, then electrolysis with remaining wastewater. Dependency from WP3

WP5 - Electrolyte analysis and pollutant capture systems

- Designing electrolyte from specific wastewater ions/pollutants present, and physical/chemical 'skimming' methods for pollutant clump removals. Dependency from WP3

WP6 - Testing rig designs/manufacture

- Design/manufacture testing rig which can simultaneously test flocculation/coagulation/electrolysis. Dependency from WP4/5

WP7 - Full testing procedure and performance analysis

- Testing electrolysis/floatation/coagulation processes to assess efficiency and KPIs. Dependency from WP5/6

WP8 - IP/patenting

- Ongoing patent research/development by HydroStar to protect IP, achieving patent for filing

There is a lot of ongoing work to identify the most effective route to meet net zero in the UK and this project is one of many projects to evidence the major or minor role hydrogen will have in different scenarios. Repurposing the UK gas networks with hydrogen to support the challenge of the climate change act has the potential to save £millions with minimal gas customer disruption versus alternative decarbonisation solutions

Objective(s)

The objective of the project is to evidence, research and develop how different technologies for membraneless electrolysis can be used. The project objectives will look at how remediating industrial customers highly contaminated water and producing hydrogen from onsite water sources can help to enable more areas where hydrogen can be produced and injected on the network using the NextGen device.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

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

This project has been assessed as having a neutral impact on customers in vulnerable situations.

Success Criteria

A successful project will produce conclusive evidence as to whether contaminated water can be remediated to a sufficient level to enable production of green hydrogen through a small-scale laboratory experiment for a single NextGen electrolysis device by performing coagulation/flotation of contaminant particles, as well as the production of green hydrogen from the resultant water.

Project Partners and External Funding

The partners for this project are HydroStar Europe Ltd and Cardiff University. The project has been successfully awarded Launchpad funding from Innovate UK (IUK), with each project partner eligible for different levels of funding. Cardiff University are eligible for 100% funding through IUK, with HydroStar and WWU eligible for 70% and 50% funding respectively. The total project costs are £432,134, with £326,039 being funded through the grant from IUK. The remaining costs are to be funded via NIA. The IUK grant will also cover the 10% minimum contribution required under the NIA governance.

Potential for New Learning

The project will result in the development of a decisive new technology which has applications in many different industrial settings which have high gas demands and wastewater produced, who wish to reduce their carbon footprint whilst adopting more sustainable processes within their businesses. The project will play a role in enabling more customers to come online using hydrogen by expanding the range of waters that can be used for electrolysis to produce green hydrogen, and by allowing more strategic placements for hydrogen production. WP5 will look at the types of water that are available from different industrial customer archetypes across GB, meaning the learnings will be applicable nationwide.

Scale of Project

The project will consist of desktop study and small-scale laboratory experiments to validate its hypotheses.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This project and its generated learnings will be applicable to all GDNs across the entire GB network, with outputs being applicable to industrial users with high gas demands and wastewater produced, who wish to reduce their carbon footprint whilst adopting more sustainable processes within their businesses.

Revenue Allowed for the RII Settlement

N/A

Indicative Total NIA Project Expenditure

External: £80,958

Internal: £26,986

Total: £107,944

Project Eligibility Assessment Part 1

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

Requirement 1

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

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

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

This project will look to expand the range of water types that can be used by the NextGen device in the electrolysis process by enabling contaminated water to be used to produce green hydrogen, which alongside the co-location opportunities available at industrial cluster sites, will expand opportunities for green hydrogen to be injected onto the gas network, supporting decarbonisation of industrial sites. This project will conduct engineering design and investigation studies to develop hardware to achieve both electrocoagulation of contaminated water and electrolysis of the remaining water post pollutant removal, and then perform small-scale testing for proof-of-concept at 2kW scale. This reduces the barrier of water availability and quality for hydrogen production, enabling a more distributed approach to generation including onsite generation from renewables.

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

N/A

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

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

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

N/A

Please provide a calculation of the expected benefits the Solution

There is a lot of ongoing work to identify the most effective route to meet net zero in the UK and this project is one of many projects to evidence the major or minor role hydrogen will have in different scenarios. Repurposing the UK gas networks with hydrogen to support the challenge of the climate change act has the potential to decarbonise heating with minimal gas customer disruption compared to alternative decarbonisation solutions.

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

This will be fully replicable across all networks.

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

There are no rollout costs at present as this is a research/proof-of-concept project.

Requirement 3 / 1

Involve Research, Development or Demonstration

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

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

- A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)
- A specific novel operational practice directly related to the operation of the Network Licensees system
- A specific novel commercial arrangement

RIIO-2 Projects

- A specific piece of new equipment (including monitoring, control and communications systems and software)
- A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven
- A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)
- A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology
- A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution
- A specific novel commercial arrangement

Specific Requirements 4 / 2a

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

All networks are looking to decarbonise the network and switch to an alternative energy source. This project will look to expand the range of water types that can be used by the NextGen device in the electrolysis process by enabling contaminated water to be used to produce green hydrogen, which alongside the co-location opportunities available at industrial cluster sites, will expand opportunities for green hydrogen to be injected onto the gas network, supporting decarbonisation of industrial sites. The project has the potential to facilitate the energy system transition by developing a decisive new technology by combining water treatment and hydrogen production into a single NextGen electrolysis device. The route to market is focussed on industrial customers with large gas demands and wastewater production seeking low-carbon alternatives to natural gas. Therefore, all learnings generated by the project can be utilised by the GB networks toward this end.

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

N/A

Is the default IPR position being applied?

- Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

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

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

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

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

N/A

Additional Governance And Document Upload

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

The UK has legally binding targets to reach net zero by 2050. The project will see the development of a game-changing NextGen electrolysis technology within the South Wales Industrial Cluster (SWIC) which can directly use contaminated water for green hydrogen

production on industrial sites, performing a remediation process and high efficiency hydrogen generation using the same device. The innovation is aimed at large gas users wishing to switch to hydrogen who also have large quantities of wastewater from onsite processes, removing the need for extensive purification and water main infrastructure to produce hydrogen more sustainably.

Relevant Foreground IPR

Project outputs forming the foreground IPR will be a small-scale 5kW demonstration unit evidencing the simultaneous remediation of contaminated water and low-cost hydrogen production from impure water, and new patents/IP of a dual-use system for remediation and hydrogen production.

Data Access Details

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

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

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

Ofgem published its final determinations which included a variety of provisions to enable necessary development work on Net Zero projects but also to ensure vulnerable customers are thought about in any decision making. This project has the potential to facilitate the energy system transition and is therefore eligible to use the NIA funding mechanism.

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

The project would only be undertaken with support from NIA funding, it is in the interests of gas customers, the regulator and the UK government and the realisation of any benefits are outside the control of the gas networks. There is no allowance in BAU business plans for this type of work and there is a risk that if hydrogen is not accepted as a means to heat homes in 2050 that this work is no longer valid.

This project has been approved by a senior member of staff

Yes