Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

May 2024

Project Reference Number

NIA2_SGN0062

Project Registration

Project Title

Electrolyser Horizons: Unveiling the Techno-economic Landscape for Sustainable Hydrogen Production in GB.

Project Reference Number

NIA2_SGN0062

Project Licensee(s)

SGN

Project Start

May 2024

Project Duration

0 years and 10 months

Nominated Project Contact(s)

Johana Duran Santos

Project Budget

£287,083.00

Summary

This project will assess the feasibility, scale, and potential of a robust and sustainable hydrogen production industry across Great Britain as currently there is no detailed analysis that evaluates the potential for electrolytic hydrogen production across the country.

This project will develop an evaluation framework that consists of techno-economic analysis, alongside representative case studies with the potential of replication across the UK for various electrolyser options, accounting for diverse inputs and scales and existing infrastructure across GB.

The aim is to provide valuable information related to the feasibility, challenges, and unique opportunities for electrolytic hydrogen. The research will also provide valuable insights and recommendations that will contribute to the advancement of the hydrogen sector in alignment with the UK's Net-Zero goals.

Third Party Collaborators

University of Surrey

University of St Andrews

University of Strathclyde

PNDC

Nominated Contact Email Address(es)

sgn.innovation@sgn.co.uk

Problem Being Solved

The use of low-carbon hydrogen to help meet the UK government's Net Zero by 2050 (2045 for Scotland) target is becoming increasingly more important. Hydrogen can be used to decarbonise the UK's gas network and hard-to-abate sectors which have significant associated carbon emissions e.g., transport, domestic and commercial heating, and manufacturing, not only helping to progress government's Net Zero targets but also contributing to SGN's decarbonisation strategy. However, for hydrogen uptake to be widespread enough to help facilitate the energy transition and, more specifically, the decarbonisation of the UK's gas network, a secure and reliable supply of low-carbon hydrogen must be ensured.

Low-carbon hydrogen can be produced sustainably using a range of energy sources, for example green hydrogen is produced using electricity generated by wind (and other renewables) to power electrolysis, pink hydrogen is produced using electrolysers powered by waste heat from nuclear power operations, and yellow hydrogen is produced through electrolysers powered by solar energy. As it stands, hydrogen production across the UK is dominated by legacy processes which are fossil fuel dependent and thus have high associated carbon emissions e.g., grey hydrogen produced via Steam Methane Reforming (SMR). To enable the use of hydrogen as a facilitator in the energy transition, sustainable and low-carbon hydrogen production facilities must be established along with associated infrastructure.

One of the main challenges with sustainable hydrogen production techniques is that they are generally more expensive than legacy methods such as SMR without Carbon Capture and Storage and rely on co-location with other energy sources which are not always as easily accessible. Past investment in sustainable hydrogen production facilities has been generally low and thus the availability of low-carbon hydrogen is not at the level required to support widespread uptake – in 2023, the UK had only 5 megawatts (MW) of green hydrogen production operational. In the UK government's hydrogen strategy delivery update of 2023, their low-carbon hydrogen production ambition was raised to have up to 10 gigawatts (GW) of production capacity by 2030 which highlights the disparity between current and future ambitions for low-carbon production capacity.

Government incentives such as the Hydrogen Production Business Model (HPBM), Hydrogen Production Delivery Roadmap and the first Hydrogen Allocation Round (HAR1) are providing a much-needed boost to the low-carbon hydrogen economy. In December 2023, 11 green hydrogen production projects were announced totalling 125MW capacity with over £2 billion of revenue support from the HPBM and £90 million from the Net Zero Hydrogen Fund. Following the successful HAR1 announcement a second hydrogen allocation round (HAR2) has been announced which aims to support up to 875MW of capacity in 2025. Whilst these steps are positive in supporting the hydrogen economy and low-carbon hydrogen production, the nation still lacks a clear view of total production potential taking into account existing energy assets, energy feedstocks, available technologies and economic considerations. A clear view of what opportunities are available both now and in the future is needed to inform strategic decision making, investment and policy decisions surrounding low-carbon hydrogen production and uptake to support the decarbonisation of the gas grid and wider net zero ambitions.

Method(s)

This project will be undertaken in a collaborative manner between a consortium of academic institutions made up of The University of St Andrews, The University of Surrey, The University of Strathclyde, and the Power Networks Demonstration Centre (PNDC). The project is as a desk-based research project which will encompass modelling and a GIS element. The main focus of the project will be the development and application of a novel techno-economic modelling solution to assess the feasibility and applicability of different electrolyser technologies to support the rollout of hydrogen production facilities to work towards meeting net zero targets.

The project encompasses a thorough examination of electrolyser technologies, scales, existing infrastructure, and the geographical nuances of Great Britain to produce fossil fuel-free hydrogen. The project will start with a detailed literature review exploring the historical context and recent advancements in hydrogen production through electrolysis. The strengths and weaknesses of various electrolysis methods will be analysed, with a focus on understanding the characteristics and sources of different inputs essential for sustainable hydrogen production, taking into consideration the existing natural gas and electricity grid infrastructure. Whilst the focus will be on the journey to 2035, the project will briefly address the potential developments to 2050 such as potential emergence of pink (nuclear) hydrogen.

The collected data will be systematically analysed against a defined methodology to determine the techno-economic feasibility of diverse electrolyser options and how the recommendations may vary according to advances in available and emerging commercial electrolyser technologies.

The project comprises the creation of a GIS database that visually represents the spatial relationship between energy resources, available resources, optimal electrolyser locations, and existing natural gas and electricity grid assets. A final report will form the basis for informed decision-making in the sustainable hydrogen production landscape.

Measurement and Data Quality Statement:

Data quality assurance will be achieved through internal and external review with the previous agreement of SGN and the partners to

protect the confidentiality of the information. Where the project relies on third-party data, e.g. as input to the models to be developed in WP3, the pedigree of the data must be verified before using it for model input. Where possible, the data will be confirmed by two independent sources prior to utilisation. Where there is doubt in the veracity of the data, it will be peer-reviewed by the project team to ensure quality and agree on whether the data should be included.

All data generated by the project will be stored on each University's cloud-like storage system, with the possibility of centralising the storage of reports in one university storage system. The data stored on university servers is protected with multifactor authentication systems, and an online backup is automatically generated. It is, therefore, extremely resilient to disasters and/or hardware faults. Data can be transferred from anywhere with an internet connection. The data is encrypted in transit to ensure a secure connection. All investigators and researchers will be discouraged from storing data on laptop or PC hard drives, external hard drives or portable media (USBs or CD Roms) as these storage media do not offer adequate protection in relation to loss, damage or inappropriate access. No confidential data will be stored on individual machines. University servers with multifactor authentication provide total control over storage location and assurance of protecting confidential data provided to the project. Its use also provides the opportunity for access by external collaborators, investigators, and researchers on the project via a hosting account. The use of a hosting account allows for the storage and retention of long-term shared data. This type of account ensures that "project memory" is maintained in one central location and not in individual accounts or machines.

The partners will follow the 'data protection principles' outlined in the Data Protection Act (2018) to ensure data is handled with appropriate security. Data related to stakeholder engagement can include personal data. As part of the informed consent process, participants will be asked to provide written consent to allow data to be made openly available. Participants will be allowed to choose not to consent to make personal data openly available, in which case their details will be anonymised using pseudonyms. If the data includes personal details of people other than the participants, an attempt will be made to seek consent from the relevant person. If consent cannot be obtained, the details will be replaced with pseudonyms.

Scope

The project will be broken down into 8 Work Packages (WP) which will each deliver a specific element of the wider project scope. Within the scope of this study, the economic and technical assessment will be given precedence over other key aspects, setting the foundation for subsequent analyses.

WP1 – Project Inception:

This WP will focus on outlining comprehensive goals and objectives of the project with clear roles and responsibilities defined and how work will be split across the suppliers.

WP2 – Literature Review and Context:

This WP will encompass a comprehensive review of existing online literature to define and outline key considerations for the project. Topics that will be researched include an overview of hydrogen colours and production methods, characterisation of electrolysers for hydrogen production (technical features, commercial availability, costs), overview of sustainable hydrogen production up to 2035 and 2050, uses of hydrogen, predicted demand profiles and global hydrogen production and utilisation strategies.

Existing and emerging infrastructure and resources will also be outlined.

WP3 – Methodology Definition and Model Development:

This WP describes the methodology and models to conduct an in-depth analysis to comprehensively assess the economic, social, and environmental impacts of electrolytic hydrogen.

The selection and development of the methodology will be guided by defining the requirements for the economic assessment, shedding light on essential considerations that will directly influence the considerations for the selection of the best electrolyser technology. The key steps to define the technical and economic requirements will include the following:

- Methodology definition for the technical analysis (hydrogen production efficiency, quality, quantity, operational data)
- Model development (key data inputs, revenue, costs, financial metrics, sensitivity analysis)
- Sustainability and risk analysis (Rapid evidence analysis, Social Cost Benefit Analysis)

The model will be developed using Python and the optimisation modelling framework Pyomo. A rigorous sensitivity analysis will be undertaken to understand the model's rigour in terms of changing parameters across the 2024–2035-time horizon.

WP4 – Data Characterisation and Data Management Plan:

This WP will encompass the identification of key data sources and data retrieval according to the methodologies in WP3.

Most of the data produced will be technical and quantitative, coming from publicly available sources. However, the project will use and produce raw and processed quantitative data as part of the analysis. The project will also include qualitative data from stakeholder engagement pursued through an external facing workshop to collect feedback and relevant information that will inform the production of actionable recommendations for policymakers, industry, and researchers.

WP5 – Techno-Economic Analysis for Available and Emerging Commercial Electrolysers:

· Analysis of techno-economic data against the defined Methodology in WP3.

· Interpret results regarding the feasibility of available electrolyser options.

· Interpret results, taking into consideration the feasibility, challenges, and opportunities associated with emerging technologies.

WP6 – Sustainability Analysis and Risk Assessment:

· Conduct Rapid Evidence assessment to inform sustainability and risk assessments.

· Sustainability analysis of electrolyser schemes and data coming from WP5, against the defined Methodology in WP3, social cost benefit analysis.

· Development of risk assessment of selected case studies.

· Presenting risk classes in a risk matrix

WP7 – GIS visualisation to Map Out the Outputs of the Project

This work package assumes that WP5 and WP6 together produce geographic information of where the electrolysers are likely to be sited and their potential sizes which can then be integrated into a Geographic Information System (GIS) which will map out energy resources, optimal electrolyser locations and existing infrastructural assets.

The required data to feed into the GIS will be identified and the required format defined. Python and qGIS will be used to develop the visualisation. The results will be integrated with OpenStreetMap to make the visualisation interactive.

Deliverable: GIS database.

WP8 – Findings, Recommendations and Dissemination

This WP will produce the final report which will be the product of an iterative process in which SGN and the partners will discuss the findings and results from all work packages to be tailored into a detailed technical account that describes the work's literature review, methods, analysis, and scientific contributions. The results will also be synthesised into a summarised report that includes actionable recommendations for policymakers, industry stakeholders, and researchers based on the project's outcomes and developed in the previous interim reports.

After the integration of the final report, a final workshop will be delivered to present and discuss the findings and contributions with relevant stakeholders, as agreed upon by SGN and the partners.

Deliverable: Integral final report comprising all outputs and actionable recommendations.

Objective(s)

The project will develop a comprehensive assessment method to evaluate the techno-economic feasibility of a sustainable electrolytic hydrogen production industry aligned with our UK Low-Carbon Hydrogen Standards. To do this, the objectives are to:

- Undertake a detailed literature review exploring the historical context and recent advancements in hydrogen production through electrolysers. Presenting the strengths and weaknesses of various electrolysis methods, focusing on understanding the characteristics and sources of different feeds essential for sustainable hydrogen production, considering the influence and opportunities from existing natural gas and electricity grid infrastructure.
- Contribute valuable knowledge to the hydrogen production industry, offering insights into strategic decision-making by creating a systematic and comprehensive approach for conducting a comprehensive techno-economic analysis of electrolyser options for

hydrogen production in GB. The universities will use this approach to deliver a detailed assessment of potential optimal hydrogen system design, likely investment required, barriers and challenges, important synergies as well as recommendations to facilitate the path to a new hydrogen enabled future.

- Provide valuable insights into sustainable electrolytic hydrogen production that will guide investments and policy initiatives toward a sustainable and economically viable hydrogen future in GB, addressing key aspects of techno-economic feasibility, scalability, geographic, and sustainability considerations.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a.

Success Criteria

The success of this project will depend on the production of a comprehensive final report which will assist networks and wider energy industry stakeholders in understanding the opportunities available regarding electrolytic hydrogen production to help decarbonise the gas grid and support hydrogen uptake.

Project Partners and External Funding

This project is a collaborative project and will be developed by four individual academic institutions working alongside one another. The academic institutions all exhibit significant capabilities in the fields of study relating to electrolytic hydrogen production, techno-economic analysis, and energy system integration. Each institution will take the lead or co-lead on certain WPs:

- University of Surrey (WP3, WP4, WP5)
- University of St Andrews (WP2, WP3, WP4, WP5)
- University of Strathclyde (WP1, WP3, WP4, WP6, WP8)
- Power Networks Demonstration Centre (PNDC) (WP7)

Potential for New Learning

This project will highlight areas of opportunity for electrolytic hydrogen production across GB and will provide actionable recommendations for policymakers, investors, and industry stakeholders regarding the techno-economic feasibility of different electrolyser technologies and the most optimal locations to develop production facilities given the current and future (up to 2035) outlook of GBs energy transition. The project findings will help to support the wider hydrogen economy and future low-carbon hydrogen uptake. This holistic overview will be presented to key stakeholders in accessible formats to help aid in decision-making – the techno-economic modelling will be available in a user-friendly Excel interface and the geographical analysis will be visually represented in a GIS database. All new learnings will also be compiled in reports and a dissemination workshop will be hosted.

Scale of Project

The scale of this project being the whole of GB is reflective of the importance of sustainable hydrogen production to the whole countries' energy transition and not just the aims of SGN. For the uptake of hydrogen to be widespread enough to support the wider energy transition across the whole of GB, a comprehensive and pragmatic analysis of available technologies, energy feedstocks and energy infrastructure must be undertaken across the whole geographical area to identify opportunities for integration and synergy across the wider energy landscape. This will allow the findings of this project to be maximised in terms of the wider energy system and external stakeholders as the necessary infrastructure is likely to cross existing geographical and operational boundaries within GB. If a certain geographical area was to be focused on the project would risk highlighting areas of opportunity which may not prove to be the most optimal for the wider system transition as all the opportunities across the nation would not be visible.

In terms of the potential benefits of supporting the growth of the hydrogen economy and wider implications on the energy transition, the level of expenditure on this project is deemed justifiable.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This desktop-based project will cover the whole of Great Britain in its analysis and thus the findings will be applicable and usable by all GDNs and energy industry stakeholders across this area.

Revenue Allowed for the RIIO Settlement

n/a.

Indicative Total NIA Project Expenditure

Internal costs – £72,678.61

External costs - £218,035.83

Total cost - £290,714.44

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:

The project will help to facilitate the energy system transition by helping to support the widespread uptake of hydrogen by providing insights on the capabilities of electrolytic hydrogen production. The project's outcomes will provide a techno-economic assessment of the viability and feasibility of different electrolyser technologies to support hydrogen production across GB considering available energy infrastructure and feedstocks. The outcomes will be integrated into a visual GIS tool which will allow end users to easily access the information and make informed decisions regarding optimal locations to site electrolytic hydrogen production facilities.

The project will provide actionable recommendations which will help policy makers, investors and industry stakeholders make informed decisions on how best to approach sustainable hydrogen production and the potential that electrolytic facilities have to support the rollout of hydrogen across GB. The use of hydrogen to support the energy system transition hinges on the widespread availability of sustainably produced hydrogen to meet demand requirements thus this project's outcomes will be critical in informing how best to boost hydrogen production across GB to meet these goals.

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

Exploring and quantifying the potential benefits of utilising low-carbon hydrogen to help meet the UK's net zero targets is an area within which there is extensive ongoing work industry wide. This project will directly support the repurposing of the UK's gas grid to transport hydrogen to help achieve net zero targets by aiding in the development and establishment of secure low-carbon hydrogen production facilities to help enable widespread hydrogen uptake. Repurposing of the gas grid can potentially save millions of pounds and significant disruption compared to alternative decarbonisation initiatives.

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

The findings of this project will be applicable and relevant to all gas networks across GB.

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

This is a desktop-based research study thus the cost of rolling out the findings cannot be quantified at this stage.

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

The final report produced as part of the project and the Excel modelling user interface can be directly referenced by network operatives across the whole of GB to inform their strategic decision making – having access to information on potential electrolytic hydrogen production can offer value insights for strategic planning including capacity allocation, demand and supply dynamics and future operational considerations for hydrogen networks. Network Licenses can also use the information generated to inform any wider associated infrastructure development that may be required to support the energy transition and decarbonisation strategies.

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.

Due diligence has been conducted on all other NIA-funded projects from other GDNs and no projects of a similar scope have been flagged thus duplication has not been highlighted as a risk.

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

This project will provide critical insight into the landscape and potential for electrolytic hydrogen production to support the UK's net zero targets. It will provide a comprehensive overview of the current landscape in terms of energy infrastructure, feedstock availability and technologies and will assess the techno-economic, social, environmental and geographic opportunities for electrolytic hydrogen production across the nation. A study of this detail has not been undertaken up to this point and will provide a detailed modelling and visual tool to help support strategic decision-making regarding hydrogen production and adoption for both GDNs and the wider energy industry.

Relevant Foreground IPR

n/a.

Data Access Details

Information relating to the project will be published on the ENA Smarter Network Portal for public access https://smarter.energynetworks.org/.

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

The learnings and deliverables from this project are directly related to electrolytic hydrogen production and will provide actionable recommendations as to the optimal technologies and locations to site electrolysers to support hydrogen uptake. Hydrogen production is a critical component in the energy transition and in enabling the conversion of the gas grid to 100% hydrogen. Distribution of Hydrogen is currently not a business-as-usual activity for SGN or any other GDN.

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

Repurposing the nation's gas grid to transport hydrogen is crucial in supporting net zero targets and a sustainable and secure low-carbon hydrogen production industry is necessary to support this. The NIA framework can support innovative works that build up evidence to support the wider uptake of hydrogen to facilitate the decarbonisation of the network.

This project has been approved by a senior member of staff

☑ Yes