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

Mar 2023

Project Reference Number

NIA2_NGESO036

Project Registration

Project Title

Hydrogen Production for Thermal Electricity Constraints Management

Project Reference Number

NIA2_NGESO036

Project Licensee(s)

National Energy System Operator

Project Start

March 2023

Project Duration

1 year and 6 months

Nominated Project Contact(s)

Louis Priday

Project Budget

£520,000.00

Summary

Thermal constraints are forecast to cost consumers between £500m and £3b a year between now and 2030, owing to an increase in renewable generation and a lack of capacity on the transmission system to transfer power from where it generated to where it is used.

Hydrogen electrolysis has the potential to mitigate some of these constraints by acting to store excess generation at times of high renewable generation. However, this will only be realised if the facilities are located in the right place and can operate in a way which provides a benefit to the electricity system. This project aims to investigate the potential for such facilities to provide constraint management services and suggest the right market signals to encourage investment in the right areas.

Preceding Projects

NIA2_NGESO031 - Service Provider Capability Mapping

NIA2_NGESO010 - The Role for Hydrogen as an Electricity System Asset

NIA_NGGT0184 - Gas and electricity transmission infrastructure outlook

10023216 - Green Hydrogen Injection into the NTS

Third Party Collaborators

Gas transmisson & Metering

Arup

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

Transmission constraints are already increasing due to clustering of renewable generation connections. Constraints can be addressed through network reinforcement. However, this is costly and can be a lengthy process given consenting and construction timescales. The majority of current constraint management actions involve the redispatch or curtailment of generation, leading to cost and carbon system operability impacts. This increase is driven by significant growth in renewable generation in Scotland, northern England and offshore, and further growth in continental interconnectors in the south. By 2030 some areas of the network are expected to see peak power flows which are 400% greater than current boundary capability. This is expected to lead to GB thermal constraint costs forecasted to be between £500m to £3bn annually out to 2030.

Method(s)

This project consists of six work packages:

WP1: Digital site locator

To develop a model that depicts multiple factors related to energy constraints and Hydrogen Production Facility (HPF) construction and operations which enables the NGESO to interrogate, weigh, and visualise the location of these factors.

To create a scoring system for site criteria enabling potential HPF site locations to be selected and ranked.

Deliverables:

- A UK wide mapping of variables for HPFs siting on energy constrained areas with cumulative ranking assessed to 1 km hexagon grid cells. Variables may include distance to water sources, distance to electricity substations, gas infrastructure, etc.
- A tool for the client to interrogate the mapped variables by hexagon grid cell and apply bespoke weighting for each variable.
- A short list of potential HPF site locations ranked in order of preference, according to pre-agreed site criteria.
- Dedicated section included in the overall report that presents methodology and key findings/ conclusions of the site location and selection work package.

WP2: Commercial Model

To develop a commercial model that supports the investigation into the high-level feasibility of operating hydrogen plants as a method of balancing thermal grid constraints.

Deliverables:

- Excel-based commercial model that summarise the key inputs and outputs for each of the scenarios outlined. Key outputs are expected to be cost forecasts and the levelised cost of hydrogen for each scenario as well as system operability benefits.
- Dedicated section included in the overall report that presents methodology and key findings/ conclusions of the commercial model work package.
- The model will include a dashboard to make it more approachable in case it will be rerun in future by National Grid with different inputs or for checking further scenarios than those defined and agreed in the workshop.

WP3: Economic and Regulatory Feasibility

In conjunction with Work Package 1, WP3 will seek to define the most suitable locations (based on pre-defined location criteria) for a HPF, and will model its operation (power supply to electrolyser, injection etc.) to achieve “optimal” commercial and system operability benefits. Finally, it aims to define the regulatory requirements to deliver the right investment signals to hydrogen plants whilst minimising constraint management costs for the NGESO.

Deliverables:

- Excel based model that will define what will output the facility and system benefits.
- Dedicated section in the report that will present the results of the model and outline the regulatory framework and market design requirements for hydrogen system constraint management.

WP4: Modular plant design

To develop modular HPF design concepts to assist in determining the high-level characteristics and constraints of archetype plant designs. This work will feed into the assessment of electrolysis capacity requirements, water consumption and land area required.

Deliverables:

- Modular HPF design outlined for up to three HPF archetypes, each archetype design will provide information on:
1. Peak hydrogen production rate
2. Raw water demand
3. Total power demand
4. Total land area demand
- Dedicated section in the report summarising HPF modular design concepts and selected designs for identified site locations.
- Literature Review
- High level process flows and site layout

WP5: Hydrogen injection to the gas grid

To explore the feasibility of hydrogen produced from the HPFs being blended into the gas grid to understand what is the minimum level of hydrogen needed to make blending into the NTS technically and commercially viable.

- Dedicated section in the report setting out how a HPF may feed hydrogen into the gas grid.
- Identify preferred locations for blending onto the NTS
- Understand operational constraints for hydrogen injection (such as hydrogen flow rate variance)
- The Capex and Opex for injection of hydrogen into the NTS
- Understand the minimum level of hydrogen production for hydrogen injection into the NTS to become commercially viable.
- Identification of known unknowns and recommendations for future further work in this area.

WP6: Synthesis and Recommendations

To synthesise learning from all work packages and make recommendations for further work.
Identification of potential demonstration sites/pilot projects with supporting justification.

Detailed scope for demonstration of thermal constraint management by a hydrogen electrolyser plant/s, suitable for use in an innovation funding bid.

Dedicated section in the report providing clear recommendations for future further work in this area.

In line with the ENA's ENIP document, the risk rating is scored Low.

- TRL Steps = 2 (TRL change 3)
- Cost = 2 (£520k)
- Suppliers = 1 (1 Supplier)
- Data Assumptions = 1

Scope

This project will develop models and tools to build a detailed understanding of the potential for hydrogen electrolysis to reduce thermal constraints on the electricity transmission network. The results of work packages on location, commercial models, and the economic and regulatory feasibility will feed into a proof-of-concept design for an electrolysis facility.

The project will also investigate the feasibility (both technical and commercial) of the hydrogen produced to alleviate thermal constraints subsequently being injected into the gas grid.

Objective(s)

This project aims to:

- Identify where HPFs need to be located to provide balancing mechanism services to National Grid ESO and to achieve "optimal" commercial and system operability benefits.
- Investigate the high-level feasibility of operating hydrogen plants as a method of balancing thermal grid constraints and other system services.
- Define the regulatory requirements to deliver the right investment signals to hydrogen plants whilst minimising constraint

management costs for the ESO.

- Develop modular HPF design concepts to assist in determining the high-level characteristics and constraints of archetype plant designs.
- Explore the feasibility of hydrogen produced from the HPFs being blended into the gas grid.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The ESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. Benefits to all consumers will be in the form of reducing use of system charges (BSUoS / TNUoS) through reduced spending on constraints in the balancing mechanism and/or reduced spending on transmission reinforcements. These benefits would come as a result of work following on from this project.

Success Criteria

The project will be successful if the following questions are answered:

- Can green hydrogen production facilities meet the operational and technical requirements to provide thermal constraint management services for transmission system operation?
- How should commercial terms be structured for green hydrogen production facilities to provide constraint management services?
- How can the right market signals (investment) be provided to green hydrogen developers given locational, operational and downstream H2 gas usage considerations?
- Are there any regulatory challenges around commercial terms?

Project Partners and External Funding

Arup will be delivering this project.

Gas Transmission & Metering will be funding WP5 specifically, the remainder is funded by the ESO.

Potential for New Learning

While other projects have looked at the value of hydrogen in other ways, the technical, commercial and economic case for electrolysis facilities responding to a signal from an electricity system operator to provide constraint management services has not been investigated in detail before. With constraints rising sharply to 2030 and beyond, understanding the potential for this technology to reduce costs for consumers is vital if we are to encourage the optimal placement and operation of this technology.

All the above will be published in a final report on the ENAs Smarter Networks Portal, and a webinar summarising the key results will be held. Industry participants will benefit from this work by giving them a basis on which to inform decisions about their own investments into the technology.

Scale of Project

This project will span 18 months with ARUP delivering the work.

At a project cost of £0.5m against constraint costs in the billions in the latter half of this decade, even small savings resulting from bringing forward an electrolyser project by a year, or by encouraging development in the right areas would lead to savings.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

This project will cover the whole of the GB network.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£520,000

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 increase our understanding of how electrolysis technology could help reduce constraint costs, lowering the costs to consumers of integrating renewable energy. It could enable a faster net zero transition through the ability to reduce constraint costs at a quicker rate than building new electricity transmission infrastructure alone. Furthermore, hydrogen produced by these plants could help decarbonise other sectors.

Further work/projects can be developed to take the findings of the project further, rather than increasing the scope of this project e.g. WP4 on plant design could be taken forward into a demonstration project, and/or learnings on how to encourage the best outcomes for the electricity network can be taken forward by the ESO through new or existing processes or markets.

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

Not required as this is a research project.

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

This research project will examine the potential for electrolysis to reduce constraint costs across GB. WP1 will deliver an interactive map of GB presenting data on potential across the network – this will help to identify the number of sites/areas suitable for electrolysis plant aimed at managing constraints. The results will be shared with industry and other networks to feed into their own planning.

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

The project will research costs and benefits of using electrolysis to manage thermal constraints, we cannot provide an estimate for costs to roll out solutions at this stage. The work on the commercial model in this project will help facilitate future estimates of the cost to roll out electrolysis for managing constraints, and along with other ESO work will help identify the potential scale of capacity which is cost effective.

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

Learnings will allow for gas and electricity transmission and distribution licensees to understand locations where there is potential for electrolysis plant built to alleviate constraints on the electricity transmission network. WP5 will provide insight on the potential interactions with gas networks.

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.

Existing ESO and GT&M Activities:

ESO

Modelling hydrogen for reducing constraints

- How to assess the benefits from hydrogen electrolysis potentially as an option in NOA (or the future CSNP).
- The focus is only on assessing electricity network impacts, so unlike this project there is no consideration of wider needs of hydrogen developers or the operating model of electrolysis.

This complements the innovation project as it can help provide data on hydrogen's effect on constraints.

Service Provider Capability Mapping (SPCM) NIA2_NGESO031

- Research into flexibility by requesting information from industry on their capabilities and drivers for investment.

- Phase 1 of the SPCM project could help inform parts of WP2/3 but will not be as in-depth as this project's scope.

FES Bridging the Gap

- Focusing on hydrogen as a source of flexibility.

GT&M:

Gas Goes Green Hydrogen Blending Infrastructure

- Develop a generic functional specification for the infrastructure required to facilitate the injection of hydrogen into the gas grid

Industry:
This project would also seek to build on relevant GB hydrogen projects such as:

Flexible Generation Forecasting (NIA_WWU_068)

The Role for Hydrogen as an Electricity System Asset (NIA2_NGESO010)

- No consideration of managing thermal constraints, so little overlap here -but did input into the redispatch prices we consider in modelling H2 in our tools.

Gas and electricity transmission infrastructure outlook (NIA_NGGT0184)

Green Hydrogen Injection into the NTS (10023216)

- The new project would add to this previous project with considering the behaviour of a plant focused on managing electricity constraints (different profile of injection) and if it is an economic proposal for the electrolyser

Role and value of electrolysers in low-carbon GB energy system (NIA2_NGET0002)

- Does not consider specific thermal constraint value

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

While other projects have looked at the value of hydrogen in other ways, the technical, commercial and economic case for electrolysis facilities responding to a signal from an electricity system operator to provide constraint management services has not been investigated in detail before.

With constraints rising sharply to 2030 and beyond, understanding the potential for this technology to contribute to reducing costs for consumers is vital if we are to encourage the optimal placement and operation of this technology.

Relevant Foreground IPR

The following IPR will be generated in the course of the project:

- A UK wide mapping of variables for HPFs siting on energy constrained areas with cumulative ranking assessed to 1 km hexagon grid cells.
- A tool to interrogate the mapped variables by hexagon grid cell and apply bespoke weighting for each variable.
- A short list of potential HPF site locations ranked in order of preference, according to pre agreed site criteria.
- Excel-based commercial model that summarises the key inputs and outputs for each of the scenarios outlined (including dashboard).
- Excel based model that will define what will output the facility and system benefits.
- Modular HPF design outlined for up to three HPF archetypes.
- Detailed scope for demonstration of thermal constraint management by a hydrogen electrolyser plant/s, suitable for use in an

innovation funding bid.

- An overall report to include dedicated sections on the outcomes of each of the six work packages.

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:

1. A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at https://www.nationalgrideso.com/future-energy/innovation
3. Via our managed mailbox innovation@nationalgrideso.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at https://www.nationalgrideso.com/document/168191/download.

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

Whether there is a viable market for electrolysis facilities to provide services to the ESO is not clear, and this project seeks to demonstrate the potential benefits.

It is not currently clear how the ESO could incentivise the placement of facilities to assist in constraint management. Therefore, it is deemed too high risk for BAU funding to be used at this stage.

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

It is not yet clear whether there is a viable market for electrolysis facilities to provide services to the ESO. We are not aware of such an approach being considered elsewhere in the world, there are many unknowns due to the hydrogen sector in the UK being in very early stages of development. The project could prove it is too costly or complex to implement.

This project has been approved by a senior member of staff

☑ Yes