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

Sep 2023

### Project Reference Number

NIA_NGT0224

## Project Registration

### Project Title

The Economics of Electrolysers Using Curtailed Electricity

### Project Reference Number

NIA_NGT0224

### Project Licensee(s)

National Gas Transmission PLC

### Project Start

September 2023

### Project Duration

0 years and 3 months

### Nominated Project Contact(s)

Kelvin Shillinglaw, box.GT.innovation@nationalgas.com

### Project Budget

£98,666.00

### Summary

This project will produce an analysis of the potential volume of hydrogen that could be produced from curtailed electricity out to 2035, and also analyse the economics of hydrogen production from curtailed electrons.

The use of curtailed electrons to produce hydrogen would have a range of benefits, including:

· Utilise otherwise wasted energy, where a significant amount of constraints are currently coming from constraining wind behind the Scottish transmission boundaries

· Displacing the use of alternative fossil fuels (which may reduce reliance on imported fuels)

· Generate carbon savings

· Provide a significant volume of hydrogen to the market and end users.

· Help stimulate the development of the hydrogen market

### Third Party Collaborators

AFRY Management Consulting Ltd

### Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

## Problem Being Solved

Renewables in Great Britain (GB) are curtailed due to two main reasons: insufficient electricity demand, and insufficient transmission capacity. System Operator payments to wind generators are currently averaging over £150m/year, with a significant amount of this cost coming from constrained wind behind the Scottish transmission boundaries.

This curtailed, 'excess' renewable electricity could, theoretically, be used to generate hydrogen. This electrolytic hydrogen production could be used to:

- Serve a local market,
- Transport via truck or barge to additional consumers,
- Blend into the gas transmission system
- Transported by hydrogen pipelines once infrastructure is developed.

There is a need to explore the economics of hydrogen production from curtailed electrons. If existing commercial mechanisms are insufficient to support electrolyser business case viability, then there is a need to explore additional commercial levers to support the business case for electrolytic hydrogen production using curtailed electricity.

## Method(s)

The project will analyse the volumes of hydrogen that could be produced from curtailed renewables within three scenarios. Then, the economics of hydrogen production from curtailed electricity will be analysed, considering four different electrolyser operating regimes, providing forecasts for specific sample years in sample zones.

The project will further analyse the electrolyser operating regimes that do not achieve financial viability using existing market mechanisms, and will look at how this could be achieved through reductions in the price of constrained power, and also how additional commercial mechanisms could support the economic viability of electrolysers using constrained power from renewables.

The project will result in a technical report summarising the work undertaken and the outputs.

Measurement Quality Statement

The measurement approach used to meet Data Quality objectives will be through the identification of high calibre project partners who are experts in their given field. The methodology used in this project will be subject to our supplier's own ISO 9001 certified quality assurance regime and the source of data, measurement process and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and made available for review.

Data Quality Statement (DQS)

The project will be delivered under the NIA framework in line with the agreed Energy Networks Innovation Process document and NGT internal policies. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

## Scope

The project is split into six work packages detailed below:

WP1 Hydrogen Production and Curtailed Electricity

2 weeks

Analysis of the volumes of hydrogen that could be produced from curtailed electricity in three scenarios.

WP2- Analysis of Electrolyser Economics
5 weeks

Analysis of electrolysers using curtailed electricity economics and commercial viability over the forecast horizon (out to 2035), under four different operating profiles. The analysis will be done on an annualised basis, for sample years, sample zones for each of the three scenarios.

WP3 – Analysis of additional revenues to support electrolysers
2 weeks

Further analysis of electrolyser operating models using curtailed electricity in WP2 that do not achieve financial viability, to explore how this could be achieved through reductions in the price of constrained power and exploring the volume of additional curtailed electricity required to achieve financially viability.

WP4 – Analysis of Hydrogen Business Model and Hydrogen Certification to support Electrolysers

7 weeks

Analysis of how subsidy mechanisms could support the economic viability of electrolysers using constrained electrons, including; Hydrogen Business Model, Hydrogen certification, and the potential for ESO curtailment reduction services.

WP5– Reporting & Workshop

2 weeks

A technical report will be produced detailing the work carried out in the project, including a technical summary of the findings and cost benefit analysis. This will also include the ENA Closure Report.

## Objective(s)

· Forecast volumes of hydrogen that can produced from constrained electricity under three different scenarios

o Volumes forecast at hourly granularity across the forecast period (out to 2035)

· Analysis of the business case and economic viability of electrolysers using curtailed electricity in four different operating models. This analysis will be undertaken for each of the three scenarios, for 1, 10, 100 and 1000 MW electrolysis capacity.

o A comparison will be provided with the costs of baseload ‘blue’ hydrogen production

· Commentary on electrolyser operational flexibility and how this may impact capex and opex costs under the operating models

· Analysis of the electrolyser operating model’s ability to comply with the low carbon hydrogen standard over the forecast horizon (out to 2035)

· Analysis of electrolyser operating models that do not achieve financial viability and exploration of how this could be achieved through reductions in the price of constrained power (identifying the price required to make the electrolyser economic) and the volume of additional curtailed electricity required for the electrolyser to achieve financial viability

· Analyse how subsidy mechanisms (i.e., Hydrogen Business Model, Certification, ESO service) could support the economic viability of electrolysers using constrained energy from renewables.

## 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. This is because it is a transmission project.

## Success Criteria

The following key criteria need to be met for the project to be considered successful:

· Objectives met to time and cost.

· Project findings inform the potential market development of electrolytic hydrogen using curtailed renewables in the near term (out to 20350).

## Project Partners and External Funding

Lead Network: National Gas Transmission plc

Supplier: AFRY

## Potential for New Learning

The project will provide the parties with an understanding of the economics of electrolysers using curtailed electricity from renewables using existing market mechanisms, and an exploration of how additional subsidy mechanisms could support the economic viability of electrolysers using constrained energy from renewables.

The findings from the project will be uploaded to the ENA Smarter Networks portal and will be shared via National Gas innovation social media.

## Scale of Project

The project will predominantly involve desktop research and whole system modelling for WP0, WP1, WP3, WP4. The project gives a short-term outlook from 2025 – 2035, utilising a proprietary BID3 market modelling with data from gas and carbon price forecasts and the suppliers GB Value of Flexibility report, including electrolyser cost and efficiency forecasts.

This work provides value for money relative to the investment due to being able to understand the role electrolysers could play in translating curtailed ‘excess’ renewable electricity into hydrogen, with the aim to reduce curtailment payments to wind generators, currently averaging at £150m/year, maximise renewable electricity connection to the electricity network, provide a significant volume of hydrogen to the market, and generate carbon savings.

Having this project on a local or regionalised zone level would provide less potential on understanding the volumes of hydrogen that could be produced from curtailed electricity. Hence, this project takes a whole (GB) system approach to modelling hydrogen production from curtailed electrons.

## Technology Readiness at Start

TRL1 Basic Principles

## Technology Readiness at End

TRL3 Proof of Concept

## Geographical Area

Great Britain

## Revenue Allowed for the RIIO Settlement

None – hydrogen focused innovation project.

## Indicative Total NIA Project Expenditure

External total - £74,000

Internal total - £24,666.67

Project total - £98,666.67

# 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 provide insight into the economics of hydrogen production using curtailed electrons from a whole system perspective. While in the UK a low carbon hydrogen standard is being applied, electrolytic hydrogen production is still in its infancy due to the challenging business case of producing via this method.

However, renewable electricity is forecast to be increasingly curtailed, which presents a low hanging fruit opportunity to understand the value of producing hydrogen from curtailed electrons and reducing ESO curtailment payments. The hydrogen produced can be offtaken to industrial clusters, transported via a repurposed HyNTS, or even blended within the existing NTS to facilitate the transition.

This project will determine how different revenue streams could be stacked to develop an economically viable electrolyser project using curtailed electricity at 1MW, 10MW, 100MW and 1GW capacity, this will enable us as a network to explore the market size of electrolytic hydrogen production the NTS could support in the short term (out to 2035).

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

Although this project does not directly affect vulnerable consumers the energy transition may and as such, we must consider the effect of the work we are doing through the NIA funding. The National Transmission System (NTS) is a key UK infrastructure for the transport of Gas to consumers, including those considered vulnerable. In a scenario where hydrogen replaces methane as a household heat source, it is essential the vulnerable are not excluded by virtue of fuel inaccessibility. In cases where vulnerable consumers already utilise gas it is likely that in a net zero future the optimum option is to provide a consistent energy solution. The transition to hydrogen within the NTS provides continuity of access to the vulnerable of hydrogen as a replacement to methane, with ongoing benefits of efficiency and economy of scale within a closely regulated environment. Ensuring robust NTS assets and consistent hydrogen production options will support the transition of the NTS to hydrogen which in turn supports the availability of gas to the vulnerable.

## 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

The benefits from this project include:

- Analysis of the potential scale of hydrogen production from curtailed renewable generation in the short term (i.e., 2035)
- Detailed exploration of the economic viability of electrolytic hydrogen projects (1 MW, 10 MW, 100 MW, 1 GW) seeking to use curtailed renewable electricity in four different operating models. This will help industry understand whether existing market

mechanisms are sufficient to support the viability of electrolytic hydrogen projects using constrained electrons, or whether additional mechanisms are required to support their viability.

- Examination of the role additional subsidy mechanisms could play in supporting the viability of electrolytic hydrogen projects in conjunction with using constrained renewables.

Value tracking

| | Data Point | Data Point Definition |
|---|---|---|
| Maturity | TRL1-3 | The project will focus on commercially available or emerging technologies some of which may not have previously been applied to transmission systems. |
| Opportunity | - | The project can be applied to all potential future electrolytic hydrogen projects. |
| Deployment costs | - | Deployment costs are not known at the start of the project but will be defined throughout the project. |
| Innovation cost | £74,000 | The cost includes desktop-based work and in person workshops. |
| Financial Saving | - | Any financial savings are not known at the start of the project. Potential for £150M/year savings to reduced curtailment costs and produce low-cost green hydrogen for consumers/end users. |
| Safety | - | No safety aspects considered for the deployment of electrolytic hydrogen connections using curtailed electrons. This project focuses on the market mechanisms and economic production only. |
| Environment | - | Electrolytic hydrogen production is a zero-carbon emission solution and this project will help identify the business models and understand the economics to enable low hanging fruit projects to develop, therefore, leading to quicker adoption on green hydrogen into the NTS. |
| Compliance | Support compliance | The potential emissions reductions could help National Gas meet the medium Combustions Plant Directive and emissions targets. |
| Skills & Competencies | Individuals | The project will inform individuals who are directly involved. |
| Future proof | Supports business strategy | The project will help enable hydrogen in the NTS and support the energy transition.[KS(G1] [IB(G2] |

[KS(G1]Suki/Ian to review
[IB(G2]Add GTIGG benefits to this section as a para above the table

The benefits table will need to be mirrored in the DFN value table

Another benefit will be to inform SIF application

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

The findings of this study will be replicable for GB. However, it is expected economic green hydrogen production via curtailed

electricity will be optimal in certain locations e.g., Scotland transmission zones with high wind penetrations and constrained grid congestion or near offshore wind sites such as East Anglia.

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

At the start of the project the roll out costs are not known. The modelling under three business models identified in this study will provide an understanding on the costs of rollout associated with electrolysers CAPEX/OPEX and selection characteristics dependant on the operating regime and capability of electrolyser type.

### 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

This project focuses on the economic viability of electrolysers using curtailed electricity. The learnings will shed insight on the potential scale of electrolytic hydrogen production using curtailed electricity market development out to 2035, highlighting the role electrolysers could play in reducing electricity network constraints in the short term and also the scale of hydrogen production the gas networks could facilitate through blending or repurposed infrastructure.

### 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.

There will be no duplication of activities done as part of this program. This project will address a gap in National Gas' ongoing innovation work looking at business models for electrolytic hydrogen production to enable hydrogen connections into the NTS to decarbonise and facilitate the transition to net-zero.

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

The below are ongoing projects similar that are being carried out by another Network:

· NIA2_NGESO036: National Grid ESO - Hydrogen Thermal Constraint Management

The above project seeks to explore how electrolysers can support the ESO to balance the electricity system through reducing thermal constraints. The above project aims to define the regulatory requirements to deliver the right investment signals to electrolyser facilities, to minimise constraint management costs to the ESO. The timescale is present day out to 2050. WP5 in the above project covers blending into the NTS from electrolytic hydrogen production via thermal constraint management.

We are carrying out this project because our project seeks to explore how accessing curtailed, otherwise wasted electrons, could support the business case for initial small-scale electrolysers (1 MW+). We seek to explore how not only using existing market mechanisms or the development of an ESO service could support the business case for electrolysers, but also the role of the hydrogen business model subsidy and certification schemes. Our overall aim is to understand the economic viability of electrolysers using constrained electrons in the short term (out to 2035) to shed insight on the short-term market size of electrolytic hydrogen production using curtailed electricity.

· NIA2_NGET0002: Role and value of electrolysers in low-carbon GB energy system

The above project seeks to develop a whole system model to optimise the optimum capacity and location of electrolysers in various scenarios out to 2050.

Our project seeks to explore the economics of electrolysers using curtailed electrons, to explore a range of required commercial levers unlock the initial hydrogen market, focusing on the short-term out to 2035. As well as examining the role of existing market mechanisms, our project will also explore the role of a range of new, bespoke mechanisms that could support the business case viability for initial electrolysers.

## Additional Governance And Document Upload

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

The innovative aspects of this project include:

- Short-term focus to maximise credibility of output, where this project examines whether existing market mechanisms are sufficient to support the economic viability of electrolysers using curtailed electricity in the short term (out to 2035).

- This project will examine a range of electrolyser operating models, including models that have not previously been studied in detail such as direct wire or specific PPA electrolyser operating models.

- For electrolyser operating models that do not achieve commercial viability, this project will provide further innovative benefit by

exploring a range of additional commercial levers to support meeting the business case.

- The outputs from this project will show how different revenue streams could be stacked to develop an economically viable electrolyser project. This project provides further depth by exploring the economic viability of electrolysers at 1 MW, 10 MW, 100 MW and 1 GW capacities.

## Relevant Foreground IPR

This project will not result in any new Foreground IPR.

## Data Access Details

Details on how network or consumption data arising in the course of an NIA funded project can be requested by interested parties, and the terms on which such data will be made available by National Gas can be found in our publicly available "Data sharing policy relating to NIA projects" at www.nationalgas.com/gasinnovation. National Gas data access is managed IAW provisions under 2.15-2.18 for the current NIA Governance Document.

National Gas already publishes much of the data arising from our NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Data Quality Statement (DQS):

The project will be delivered under the NIA framework in line with the agreed Energy Networks Innovation Process document NGT internal policies. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

The methodology used in this project will be subject to our supplier's own ISO 9001 certified quality assurance regime and the source of data, measurement process and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and made available for review.

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

Hydrogen is not currently present in the NTS and therefore understanding business models for electrolytic production is not applicable to natural gas service. Hydrogen is being directed as a future energy solution but RIIO-2 business funding does not allow the development of hydrogen ready solutions and therefore this project cannot be undertaken as part of BAU activities.

## 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

Understand the business models for economic production of electrolytic hydrogen via curtailed renewable generation is in its infancy with a nascent hydrogen market in the UK, therefore early-stage research and assessments will carry additional exposure to risk. The NIA funding reduces this exposure to risk.

## This project has been approved by a senior member of staff

☑ Yes