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# NIA Project Registration and PEA Document

### Date of Submission

Nov 2021

### Project Reference Number

NIA2_NGET0002

## Project Registration

### Project Title

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

### Project Reference Number

NIA2_NGET0002

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

June 2022

### Project Duration

1 year and 4 months

### Nominated Project Contact(s)

Atia Adrees (box.NG.ETInnovation@nationalgrid.com)

### Project Budget

£323,739.00


### Summary

This project aims to analyse the benefits of linking electricity and hydrogen vectors from a whole-system perspective to determine the optimum capacity, location, technologies, and system benefits of electrolysers under different future development scenarios. The impact of power-to-gas on the whole energy system, particularly, integration of renewable generation (provision of system balancing and ancillary services), electricity transmission network operation and development, will be investigated. The project will develop an integrated whole system model to optimise the portfolio and locations of electrolysers considering several factors such as system constraints, end-use application of hydrogen, hydrogen transportation costs to end-use, and water availability to provide cost effective investments to achieve decarbonization of energy networks.


### Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

### Problem Being Solved

To achieve decarbonisation, the electricity system will integrate increasing amounts of variable renewables and inflexible nuclear generation whilst enabling the electrification of the heat and transport sectors. These changes will increase the need for system flexibility. At the same time, the capacity and operating hours of traditional sources of flexibility, such as conventional coal and gas generation, will reduce. The greater variability in electricity supply due to increased renewable generation and exacerbated peaks in electrical demand due to the electrification of heat and transport will require reinforcement of generation, transmission, and distribution assets, while reducing their utilisation. This reduction in utilisation and increase in the capacity required to achieve the same performance, will lead to higher system costs.

### Method(s)

This project will evaluate the benefits of linking electricity and hydrogen vectors to determine the system benefits of electrolysers in various credible scenarios to net-zero by 2050. The project will develop an integrated system model to optimise the portfolio and locations of electrolysers considering several factors such as system constraints, end-use application of hydrogen, hydrogen transportation costs to end-use, and water availability. The developed model will be employed to determine the optimal energy system capacity and operation, focusing on the electricity transmission network's new development, operation, and utilisation. The benefits and system impact of electrolysers across the whole energy system will be quantified by comparing the modelling results for a system with and without large-scale electrolysers. The analysis will also include an assessment of the optimal capacity, technology, and locations of electrolysers under different scenarios and using electrolysers for network congestion management to reduce network constraints and associated costs and the need for network investment.

**Data Quality Statement (DQS):**

The project will be delivered under the NIA framework in line with OFGEM, ENA and NGET internal policy. 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 supplier's own 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.

**Risk Assessment and Audit**

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

TRL Steps = 1 (2 TRL step)

Cost = 1(£323,739)

Suppliers = 1 (1 suppliers)

Data Assumption = 1 (Data will be gathered using available network model)

## Scope

**Task 1 [M1, M10 and M12]: Review of long-term scenarios for the UK**

**Subtask 1.1 [M1]:** This activity will involve selecting a set of credible future development scenarios used in the analysis considering a range of scenarios from the CCC (including CCC sixth Carbon budget, the climate change risk assessment), BEIS (the climate change report just published), and National Grid FES to achieve net-zero 2050 targets.

**Deliverable 1 [M1]:** Report on set of decarbonisation scenarios for simulation studies.

**Task 2 [M2-M4]: Update of the topology and parameters of the integrated model for electricity transmission planning**

The objective of this task is to update the current model's topology and parameters against the selected set of scenarios.

**Deliverable 2 [M4]:** Report on integrated whole-system model for optimisation studies

**Task 3 [M3-M11]: Optimal portfolio and system implications of Power-to-Gas under different scenarios**

This task aims to study the system benefits of electrolysers from the whole system perspective with the primary focus on electricity transmission network and system balancing, while also identifying the infrastructure needed to support the transport of hydrogen and the requirement for hydrogen storage.

**Subtask 3.1 [M4-M9]:** System implications of electrolysers with focus on its impact on electricity transmission operation and development

The benefits and system impact of electrolysers across the whole-energy system will be quantified by comparing the modelling results for a system with and without electrolysers. The analysis will also include assessment of the optimal capacity, technology, and locations of electrolysers under different scenarios developed in Task 1 and using electrolysers for network congestion management to reduce network constraints and associated costs and need for network investment.

**Subtask 3.2 [M7-M10]:** Role and value of electrolysers in the context of ancillary services

The analysis will be conducted by enhancing the Imperial advanced frequency-secured Stochastic Unit Commitment (SUC) model, considering renewable generation uncertainty while ensuring supply security and frequency stability, taking into account the largest infeed loss and reduction in system inertia. The synergies and conflict between management of transmission network constraints and providing balancing services by electrolysers will be investigated.

**Subtask 3.3 [M8-M11]:** Transport of hydrogen and need for hydrogen storage

This task will investigate the feasibility of hydrogen transmission infrastructure and existing gas networks at various pressure tiers (i.e. high, medium and low pressure) to transport hydrogen to end user.

**Deliverable 3 [M13]:** Report on the benefits of optimal portfolio and system implications of electrolysers under different scenarios.

**Task 4 [M9-M15]: Sensitivity studies**

A range of sensitivity studies will be performed to analyse conditions that can affect the deployment of the electrolysers and, consequently, their system implications.

**Deliverable 4 [M14]:** Report on the drivers for the deployment of electrolysers and their whole system implications

**Deliverable 5 [M15]:** Integrated Electricity planning tool and user guide documents and demonstration.

## Objective(s)

The main objective of this work is to identify the optimal locations for large-scale electrolysers to reduce system reinforcement and operational costs and quantify the benefits of multi-vector approach to reduce future network costs.

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The project supports energy networks for the cost-effective transition to the net-zero employing the multi-vector approach. If savings in the energy bills are achieved through a multi-vector approach in the future, they will be distributed among the consumers.

**Technical and wellbeing impact:**

Based on the findings in this research, energy networks may start adopting the whole system approach to energy network planning that will reduce network reinforcement and operational costs, which will positively impact consumer bills. The consumer impact of any of the methods or solutions developed in this project is not dependent on any of the following factors:

- Dwelling and location (potentially including tenure)
- Readiness for digital technology
- Personal and social factors (for example, households with disabilities and medical conditions, or which speak English as a foreign language).

## Success Criteria

The project will be considered successful if the developed model identifies a few optimal locations of large scale electrolysers in each selected decarbonization pathway.

## Project Partners and External Funding

NGET NIA funding £315,000

NGGT NIA funding £8,739

ESO

## Potential for New Learning

The project aims to deliver the following new learning:

The benefits of linking electricity and hydrogen vectors for cost-effective integration of variable renewable generation in the GB network and the optimised portfolio and locations of electrolysers for various credible pathways to net-zero.

The learning will be disseminated through the reporting via the ENA portal and either ENA, CIGRE dissemination webinars and publications depending on the project outputs.

## Scale of Project

It is set up as a desktop study. This is the optimal size for this project as desktop study will enable us to identify the optimal location of large-scale electrolysers.

## Technology Readiness at Start

TRL2 Invention and Research

## Technology Readiness at End

TRL4 Bench Scale Research

## Geographical Area

The project will be a desktop study.

## Revenue Allowed for the RIIO Settlement

Not Applicable

## Indicative Total NIA Project Expenditure

NGET NIA funding £283,500

NGGT NIA funding £7,865.10

# 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 identify optimal locations of large-scale electrolysers to produce hydrogen. The deployment of large electrolysers at optimal locations will decrease network reinforcement costs to accommodate a large integration of variable renewable generation. In addition, the flexibility provided by electrolysers will lower the operating costs of the low carbon electricity system. The green hydrogen produced using electrolysers can help to decarbonise the heat and transport sector. Hence, this project will facilitate the cost-effective and secure transition of energy systems to net-zero.

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

Not applicable

## 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)

Not applicable

### Please provide a calculation of the expected benefits the Solution

In 2020, the wind farms in the GB produced 69 TWh of electricity and 3.8 TWh of electricity was lost to curtailment because of network constraints. This curtailed energy could have powered around 1.25 million homes or around 3 million people. The curtailed energy also led to curtailment costs of £282 million – around £10 per household in 2020 and these costs likely to grow, considering the government's commitment to quadruple the amount of offshore wind capacity to 40GW by 2030.

Electrolysers provide the means of generating hydrogen from water and electricity. They also act as a form of flexibility: allowing hydrogen to be produced at times of least cost to the wider energy system, minimizing the loss of energy through curtailment of renewable energy that needs to be curtailed and the curtailment costs.

The ability of the system to optimise production to high energy supply times, store hydrogen and then use it for heating, power production and other applications across transport and industry, drives this value in both Electric heating scenario and hydrogen dominant system. This optimisation enables significant cost reduction in network and electricity generation investment

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

The method can be readily adopted by all network licensees by adding their network information in the tool.

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

This project will develop a model which will identify the optimal locations of large-scale electrolysers in the GB. The cost of rolling out of the method will be between 200-300k. This cost will cover the additional granularity and any modifications required in the model to use as a standard tool by TOs and ESO.

### 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

n/a

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

Not applicable

### 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.

This is the first NIA project to explore the benefits of linking hydrogen and electricity vectors by developing a bespoke model capable of performing analysis for the GB network and determining optimal portfolio and locations of electrolysers for various credible pathways decarbonisation.

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

Not applicable

## Additional Governance And Document Upload

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

This project will bring together two energy vectors to develop an integrated model which will indicate the optimal locations of large-scale electrolysers in the GB network

- To reduce network reinforcement costs
- To reduce network constraints
- To reduce wind curtailment by producing hydrogen at the time of high winds
- And to provide cost-effective flexibility in the electrical power system

This is the first project implementing multi-vector approach in the GB transmission system with the focus of identifying the optimal locations of large-scale electrolysers.

## Relevant Foreground IPR

Foreground IPR will be created in relation to the test results of the methodology on the NGET network. The supplier will contribute the background IPR in the area of whole system model, whilst NGET will contribute background IPR with regards to the relevant electricity transmission domain knowledge used in the project.

## 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'. National Grid 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 at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

The nature of the research programme means it carries a risk that the research may be unsuccessful i.e., it is possible that the model is unable to identify the optimal locations under a number of constrained parameters. There is also a risk that unforeseen barriers to implementation are indicated during the project, so NGET is unable to consider the research of this scale as business-as-usual.

## 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

Multi-vector modelling and analysis is a new area to fully understand the risks associated with the corresponding solutions. In addition, the method being explored in the project is unique and have not been used anywhere commercially. Therefore, considering the risk associated with the success of the project, NGET believes NIA funding is the best route for the project.

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

☑ Yes