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

Feb 2025

Project Reference Number

NIA2_NGET0085

Project Registration

Project Title

Track to Zero

Project Reference Number

NIA2_NGET0085

Project Licensee(s)

National Grid Electricity Transmission

Project Start

March 2024

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Neha Moturi

Project Budget

£200,000.00

Summary

Track to Zero aims to assess the impact of 100% railway electrification on the transmission network across England and Wales, identifying existing and future congestion points. A key focus is exploring a novel battery storage solution to support railway electrification, potentially deferring or reducing the need for traditional railway feeder stations. By integrating energy storage, the project will evaluate grid flexibility, cost implications and network efficiency. A comparative cost analysis will be conducted, examining electrification costs before and after battery deployment. Findings will provide insights into grid constraints, cost savings and decarbonisation pathways, supporting efficient railway electrification while minimizing network stress. The learnings will inform all Network Licensees across GB as well as Network Rail on optimal investment strategies for a sustainable rail network.

Preceding Projects

10025479 - Resilient and Flexible Multi-Energy Hub Networks for Integrated Green Mobility

NIA_SPEN_0089 - Resilient and Flexible Railway Multi-Energy Hub Networks for Integrated Green Mobility (Hubs)

10025738 - A Holistic Hydrogen Approach to Heavy Duty Transport (H2H)

10037453 - A Holistic Hydrogen Approach to Heavy Duty Transport (H2H) - Alpha

Third Party Collaborators

Leeds University

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Transportation accounts for the largest share of greenhouse gas (GHG) emissions in the UK, contributing 24% of total emissions in 2020. Within this sector, the rail industry is the single largest consumer of electricity, using 4 TWh annually, which represents 1.2% of the UK's total electricity consumption. Additionally, recent data indicates that 60% of the UK's 20,000 miles of railway tracks are non-electrified. The planned railway electrification brings several challenges to transmission network operators associated with connection, operation and planning. Firstly, it is expected to increase the country's power demand by an additional 3 TWh per annum and transmission connections in rural areas will require deep reinforcements. Secondly, operational challenges are a result of the inflexibility that comes with railway load. Conventional railway electrification would lead to 8.7TWh of demand that is inflexible, contributing to existing peak demand congestion. Thirdly all initial planning studies to date have been in the Scotland region and currently there is little understanding on the infrastructure requirements and congestion points for England and Wales where 83% of the national railway rail tracks serve 89% of the whole population.

Method(s)

R&D has been selected as the approach for this project as it enables the investigation of innovative solutions for railway decarbonisation. Further research will enable the exploration of solutions such as battery storage and renewable energy integration which are essential for achieving 2030, 2040 and 2050 Net Zero targets. This approach also enables a holistic assessment of requirements by providing tools (e.g. simulations) to better understand the interactions between railway electrification and existing grid infrastructure, ensuring the design of cost-effective and sustainable network upgrades. This project will also dedicate research into the costs, benefits and trade-offs associated with the proposed decarbonisation strategy. As such, risks can be identified early and TNOs can make more strategic decisions on the future infrastructure requirements.

Data Quality Statement (DQS):

· The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / 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 access control, 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 quality assurance regime. Quality assurance processes and the source of data, measurement processes 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 will be made available for review.

Scope

The scope of the project will be to quantify the transmission network requirements for railway electrification/decarbonization. This will be achieved through close collaboration with Network Rail to identify the current locations and capacity of conventional feeder stations before identifying the locations of future conventional feeder stations based on the Traction Decarbonisation Network Strategy (TDNS). The aggregate power capacity requirements will be quantified, and a “base case” cost analysis will be carried out to determine the financial implications of conventional railway electrification.

The project will introduce the battery hub concept in the second work package, which serves to determine the optimal combination of Energy Storage Hubs and traditional feeder stations to electrify/decarbonize railway. Energy Hubs will be sited according to voltage support requirements and power capacity requirements. The third work package will assess the cost implications of deploying the Energy Storage Hub based on findings from the second work package and assess it against the benefits delivered to the electricity sector, railway sector and end-consumers. Other benefits will also be identified such as potential wind curtailment reductions and flexibility service benefit.

Objective(s)

The objective of this project is to determine the potential of battery storage technology (i.e. Energy Storage Hubs) to operate as railway trackside storage in the transition to 100% railway electrification/decarbonization and provide whole system benefits to the railway sector, electricity sector and end-consumers.

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 an overall positive impact on consumers in vulnerable situations. The assessment has identified that this project will look to reduce the costs for households, improve the exchange of information between networks and customers while reducing the amount of disruptions to them in the home. Other considerations including the projects impact on supply, immediate health and safety in the home have been made in carrying out this assessment.

Success Criteria

The project will be considered successful when it accurately quantifies transmission upgrade requirements across England and Wales, and the associated costs both before and after application of the battery hub technology. This should entail a transmission network assessment which identifies the peak load contribution from railway demand and the existing and future grid hosting capacity needs through load flow and congestion analysis.

Project Partners and External Funding

Leeds University are the supplier

Potential for New Learning

The scientific/academic findings and breakthroughs will be disseminated through conferences (e.g. IEEE/IET conferences/Energy-Policy/Electricity-markets) and scientific papers (e.g. IEEE Proceedings/Applied Energy/Nature-Energy/Science), subject to commercial priorities and IP protection. Other means of dissemination include regular webinars and Ofgem/UKRI Show/Tell sessions at relevant innovation and sector conferences such as Energy Innovation summit and Rail decarbonisation events. Also the project team will actively organise outreach and publicity events to promote the innovation to other licensees given that it's a cross-sector initiative. Other dissemination opportunities include events with the Rail Industry Association, RSSB, and the energy storage industry.

Scale of Project

This is a low TRL level project encompassing three work packages. The outputs of this project are in the form of detailed reports which provide new learnings primarily to Network Rail and National Grid Electricity Transmission. More specifically, the first work package explores "traditional" electrification via a connection voltage of 25kV to the transmission network and associated infrastructure. Existing and future congestion points on the network will be identified. The second work package will determine optimal combination of Energy Storage Hubs and traditional feeder stations to electrify/decarbonize railway. Energy Storage Hubs will be sited according to voltage support requirements and power capacity requirements. The third work package will assess the cost implications of deploying the Energy Hub based on findings from the second work package and assess it against the benefits delivered to the electricity sector, railway sector and end-consumers. Other benefits will also be identified such as potential wind curtailment reductions and flexibility service benefit.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

This is a desk-based project analysing impacts of railway electrification on the transmission network across England and Wales. No trials will be performed as part of this project.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£180,000

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:

The project facilitates the energy system transition by promoting decarbonisation of the railway sector and reducing transmission network system costs. The decarbonisation of the railway sector is supported by the reduction in fossil fuel dependency which aligns with Net Zero targets such as phasing out diesel trains by 2040 and achieving climate neutrality by 2050. Electric trains are inherently more energy efficient than diesel trains and require lower overall energy consumption for the same transportation output. Trackside battery hubs will operate in conjunction with traditional feeder stations to provide flexible capacity to the network, which will help defer/mitigate future network infrastructure requirements and reduce operational costs. These benefits positively impact end-consumers due to reduced energy and railway costs. Those in rural areas can also benefit from improved grid reliability as grid infrastructure is more limited in these locations.

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

The project investigates railway electrification across England and Wales, including those in rural and remote communities. Typically, rural rail routes may be overlooked for electrification due to high infrastructure costs, leading to service reductions or reliance on outdated diesel trains. The application of Energy Storage Hubs has the potential to reduce transmission network reinforcement requirements leading to a more affordable energy transition. The Energy Storage Hubs may also provide contingency power supply to rural communities in extreme events.

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

N/A

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

While the focus of the project is on the England and Wales region, the railway electrification/decarbonisation problem is applicable to the entirety of GB which currently has 61.8% of track non-electrified. Any learnings from this project in regards to the application of battery storage hubs can be translated to other regions on the wider network and learnings are relevant to all other Network Licensees across GB.

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

The costs associated with rolling out the solution will form part of the scope of the project. Given this is a low TRL project, there is limited understanding of the costs associated with rolling out Energy Storage Hubs and the magnitude of cost savings arising from deferral of traditional feeder stations. As a preliminary estimate, a 10MWh hub includes a battery storage system (£3M), utility side PCS (£500k), traction load inverter (£500k), utility side transformer (£350k), traction transformer (£350k), DC feeder (£250k), AC feeder (£350k), cabling (£1M), control and management system (£700k), and construction (£3M) which totals approximately ~£10M.

While a conventional transformer-based feeder station costs ~£20M and an advanced SFC based feeder station costs >£40M. As such, if Energy Storage hubs can effectively electrify/decarbonise the railway network whilst deferring major infrastructure upgrades, then there is potential to avoid as much as 50% of infrastructure costs associated with traditional railway electrification. This will be explored in more detail in the project.

Requirement 3 / 1

Involve Research, Development or Demonstration

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

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

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☑ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

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

While Energy Storage Hubs will be sited within England and Wales, learnings are directly applicable to other regions across Great Britain. The project will detail risks associated with the technology, siting requirements and other network planning considerations. These learnings can be adapted to suit the requirements of the railway and transmission network beyond England and Wales.

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.

Railway related projects funded by the SIF and NIA include:

1. Resilient and Flexible Railway Multi-Energy Hub Networks for Integrated Green Mobility (Ofgem SIF Discovery phase, 10025479)

2. Resilient and Flexible Railway Multi-Energy Hub Networks for Integrated Green Mobility (NIA project – design phase, NIA_SPEN_0089)

3. Resilient and Flexible Railway Multi-Energy Hub Networks for Integrated Green Mobility (Ofgem SIF Beta phase – live demonstration, 10117383)

The Energy Hub in this collection of projects refers to a DC Microgrid Solution which integrates local renewables, regenerative traction power, EV storage and battery storage. The main focus was to size the various distributed resources, coordinate their flow and supply railway traction and non-traction loads, including lighting, heating, shops, an EV charging carpark etc. The technology architecture is different to the Energy Storage Hub proposed in this project, and required multiple distributed technologies to be interfaced with each other via a microgrid central controller. There was also a focus on hardware-in-the-loop testing to understand how the BESS in the microgrid solution performs in both grid-connected and islanded-mode, which is not an area of interest in the proposed innovation project. Lastly, these collection of past innovation projects address regions in Scotland only with no consideration for requirements across England and Wales.

The proposed innovation project (Track to Zero) will identify the transmission network upgrade requirements to electrify railway both before and after application of a battery storage solution, which is a novel concept and has not yet been investigated in the previous innovation projects. Furthermore, this project will specifically target England and Wales, where there is limited understanding of existing and future congestion points due to railway electrification. The Energy Hub as proposed in this innovation project (Track to Zero) is purely a battery storage solution, which doesn't rely heavily on local renewables to meet traction demand.

4. A Holistic Hydrogen Approach to Heavy Duty Transport (H2H) (Ofgem SIF Discovery phase, 10025738)

5. A Holistic Hydrogen Approach to Heavy Duty Transport (H2H) (Ofgem SIF alpha phase, 10037453)

These projects are focused on Hydrogen-electric trains (primarily hydrogen train), and investigate the flexibility benefits of operating hydrogen and electric trains.

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

Currently no work has been done in the England and Wales region to understand existing and future network congestion points due to 100% railway electrification. Furthermore, the application of a battery storage solution to electrify railway is a new concept, and has potential to defer significant costs associated with traditional railway electrification. The proposed innovation project aims to research these concepts in more detail.

Additional Governance And Document Upload

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

The project is innovative as the implications of 100% railway electrification across England and Wales has not yet been studied. Currently, neither the rail or electricity sectors have visibility of the demand requirements and existing/future congestion points on respective networks due to railway electrification targets. Furthermore, the application and operation of battery storage technology in conjunction with existing overhead line infrastructure to electrify railway is a new concept.

Relevant Foreground IPR

Modelling and simulation tools coupling railway and transmission grids, and cost benefit analysis tools.

Data Access Details

A description of how any data (de-sensitised where necessary) that are expected to be gathered in the course of the project can be requested by interested parties, and, if applicable, reasons why such data cannot be released to interested parties. This requirement may be met by including a link to the publicly available data sharing policy, which is required by virtue of paragraphs 2.13-2.16 of the RIIO-2 NIA Governance Document.

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

Further research is required before any business-as-usual considerations can be made on the application of energy hub technology. The application of battery storage technology to electrify railway is a new concept and Network Licensees require greater confidence before investing time and money on the proposed technology.

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

Currently there is no evidence to support the success of Energy Storage Hubs in electrifying railway. This is a technical risk for National Grid Electricity Transmission and requires collaboration with external partners such as Network Rail to fully explore the idea. NIA funding facilitates the collaborations and resources required to investigate this idea.

This project has been approved by a senior member of staff

☑ Yes