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

Jan 2026

Project Reference Number

NIA_SPEN_0125

Project Registration

Project Title

ConnectRail Hub

Project Reference Number

NIA_SPEN_0125

Project Licensee(s)

SP Energy Networks Distribution

Project Start

January 2026

Project Duration

1 year and 9 months

Nominated Project Contact(s)

Ross Davison

Project Budget

£620,000.00

Summary

The Connect Rail Hub project is a NIA-T2 research initiative exploring the feasibility of a secure, interoperable data-sharing infrastructure between the energy and rail sectors. The project will identify operational and planning needs, map data dependencies, and define performance indicators to support cross-sector information sharing.

A key focus is the development of a grid-rail ontology to standardise data semantics and improve communication. The project will also examine cyber-physical infrastructure models to propose an architecture that supports digital twinning and integrated data flows.

Third Party Collaborators

University of Glasgow

University of Leeds

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

ConnectRail Hub is a research-led initiative supporting the Flexible Railway Energy Hubs' programme in accelerating the decarbonisation of the rail transport network through digital innovation. The project will assess the development of a cross-sectoral (grid-rail) microgrid digital twinning architecture, focusing on data interoperability, cyber-resilience, and regulatory alignment.

Method(s)

The project will support decarbonisation and improve efficiency across the electricity and rail sectors, the project will use a combination of technical innovation and collaborative governance. The approach is designed to be practical, secure, and future-ready.

Develop Digital Tools
Build a digital twin framework and identify requirements for modelling and simulating how railway energy hubs interact with the electricity grid. This will allow us to test scenarios for adherence before implementation.
Create a standardised data model (ontology) so that both sectors can share and interpret data seamlessly.
Design Secure Infrastructure
Develop cyber-physical architecture requirements to enable real-time data exchange between rail and energy systems.
Identify cybersecurity measures to protect critical infrastructure and ensure resilience against potential threats.
Establish Governance and Policy
Define clear data governance protocols covering ownership, access, and compliance with regulations.
Work closely with stakeholders to ensure the solution meets operational needs and regulatory requirements.
Validate Through Demonstration
Apply the developed methods to a railway energy hub case study, assessing technical feasibility, operational benefits, and commercial viability.
Produce a cost-benefit analysis and roadmap for wider rollout.

This approach combines digital approach with strong governance and stakeholder engagement. It ensures that the solution is not only technically robust but also practical, secure, and aligned with industry standards.

Scope

The ConnectRail Hub project aims to accelerate decarbonisation of the rail transport network by enabling cross-sector integration between electricity and railway systems through advanced digitalisation. The project will develop a Data Sharing Infrastructure (DSI) and a cyber-physical framework to support real-time, secure, and resilient data exchange between SP Energy Networks and the rail sector.

Key elements of the scope include:

Decision Support Framework: Design tools to enable data-driven operational and planning decisions across both sectors.
Grid–Rail Minimum Viable Ontology (MVO): Create a standardised data model to ensure semantic interoperability for digital twins and real-time data sharing.
Cyber-Physical Infrastructure: Develop architecture and connectivity requirements for integrating railway energy hubs with the electricity grid.
Cybersecurity and Resilience: Define strategies and monitoring tools to protect critical infrastructure and maintain operational continuity.
Data Governance: Establish policies and protocols for secure, compliant, and transparent data sharing.
Case Study: Apply the developed frameworks to a railway energy hub demonstrator, validating feasibility and identifying barriers to rollout.

Objective(s)

· Objective 1 – Examine the feasibility of a decision support framework that integrates cybersecurity principles and analytical methodologies to enable data sharing between SPEN and the rail sector. This includes identifying key technical and organisational challenges, assessing potential benefits, and evaluating the implications for operational processes and practitioner engagement across both domains. The study will also explore how data-driven insights can inform strategic and operational decision-making.

· Objective 2 – Investigate the structure and semantics of a grid-rail ontology to support standardised data representation. The aim is to enable semantic interoperability and facilitate coherent data exchange between the energy and rail sectors, ensuring consistency in interpretation and integration of shared datasets.

· Objective 3 – Analyse the conceptual requirements for digital twinning within a secure and resilient grid-rail Cyber-Physical Infrastructure (CPI). This includes evaluating resilience strategies, operational continuity mechanisms, and the potential role of digital twins in supporting real-time monitoring, predictive analytics, and scenario-based resilience assessments.

· Objective 4 – Assess the requirements for a data governance framework to regulate cross-sector data sharing between SPEN and the rail sector. This will involve defining governance protocols related to data types, ownership, access control, and regulatory

compliance, as well as identifying strategies for maintaining data integrity, security, and interoperability within the proposed DSI.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The ConnectRail Hub project is primarily focused on improving system efficiency and enabling decarbonisation through integration of railway energy hubs with the electricity grid. While the direct interaction with end consumers is limited, the project delivers indirect benefits to consumers in vulnerable situations through improved network resilience, cost efficiency, and service reliability.

Success Criteria

SPT will assess the success of the ConnectRail Hub project against clearly defined technical, operational, and governance outcomes.

1. Delivery of Key Technical Outputs

Integrated Decision Support Framework (WP1) completed and validated for operational and planning use.
Grid–Rail MVO (WP2) developed and demonstrated to enable semantic interoperability between energy and rail systems.
Cyber-Physical Infrastructure Design (WP3) delivered, including connectivity requirements and high-level architecture.
Cybersecurity Strategy and Resilience Recommendations (WP4)
2. Governance and Compliance

Data Governance Framework (WP5) produced, covering ownership, access control, and compliance with regulatory standards.
Successful demonstration of governance protocols through the Railway Energy Hub case study (WP6).
3. Validation and Feasibility

Evidence that the proposed Data Sharing Infrastructure (DSI) supports secure, real-time data exchange between SPEN and the rail sector.
Simulation and case study results confirming operational benefits, resilience improvements, and cost-effectiveness.
4. Knowledge Transfer and Adoption

Delivery of a training and implementation roadmap for SPEN teams.
Stakeholder engagement completed, with documented feedback from Transmission Network Operators and rail partners.
5. Measurable Outcomes

Achievement of project milestones within agreed timescales and budget.
Quantifiable benefits demonstrated through cost-benefit analysis, including potential reductions in grid reinforcement costs and improved system flexibility.

Project Partners and External Funding

University of Glasgow

University of Leeds

Potential for New Learning

WP1 – Decision Support Framework

New insights into cross-sector decision-making by mapping operational and planning requirements for both energy and rail.
Identification of data dependencies and KPIs that define performance for integrated systems.
Development of analytical approaches for data-driven operational efficiency.
WP2 – Grid–Rail Ontology

Creation of a standardised semantic framework for data exchange between energy and rail sectors.
Learning around alignment with existing standards and protocols to enable interoperability.
Understanding how ontology-driven integration supports real-time decision-making.
WP3 – Cyber-Physical Infrastructure (CPI)

Knowledge of best practices for CPI design in cross-sector environments.
Identification of regulatory and technical requirements for secure and resilient data sharing.
Development of a high-level architecture for digital twinning and real-time connectivity.
WP4 – Cybersecurity and Resilience

Comparative analysis of cybersecurity standards across energy and rail sectors.
Strategies for threat detection and response, including human-in-the-loop and closed-loop approaches.
Insights into organisational and human factors influencing resilience and security.
WP5 – Data Governance

Frameworks for data ownership, access control, and compliance across sectors.
Development of data quality standards and stewardship models.
Understanding governance mechanisms that ensure trust and transparency in data sharing.
WP6 – Case Study Application

Practical validation of concepts developed in WPs 1–5.
Identification of barriers to implementation and lessons learned for future rollout.
Real-world assessment of cost-benefit and operational impacts of integrated data sharing.

Scale of Project

The ConnectRail Hub project requires the registered scale of investment and scope to deliver meaningful learning and benefits. The integration of railway energy hubs with the electricity transmission network is a whole-system challenge involving technical, commercial, and regulatory dimensions. A smaller-scale project would not provide sufficient insight into these complexities for the following reasons:

Why the Current Scale is Necessary

Cross-Sector Integration Complexity: The project addresses interoperability between two critical infrastructures—electricity and rail. This requires developing and validating a Data Sharing Infrastructure (DSI), cyber-physical architecture, and governance frameworks. These cannot be meaningfully tested at a smaller scale without losing the ability to replicate real-world conditions.
Digital Twin and Cybersecurity Validation: Building and validating digital twins and resilience strategies demands large-scale data sets and realistic operational scenarios. A reduced scope would limit the ability to test cybersecurity measures and resilience under representative conditions.
Stakeholder Engagement and Governance: The project involves multiple stakeholders (SPEN, Network Rail, academic partners) and regulatory considerations. A smaller project would not capture the organisational and commercial challenges that arise in full-scale deployment, reducing the value of learning for future rollouts.

Potential Benefits Relative to Investment

System-Level Benefits: By enabling rail demand to act as a flexible customer and reducing grid reinforcement needs, the project can deliver significant cost savings and carbon reductions across the transmission network.
Scalable Learning: The outputs—decision support tools, governance frameworks, and cybersecurity strategies—are designed for replication across other sites and sectors, amplifying the return on investment.
Risk Mitigation for Future Rollout: Testing at scale ensures that technical and regulatory risks are identified early, reducing costs and delays in future implementations.

Why Smaller Scale Would Limit Learning

Limited ability to validate interoperability and resilience strategies under realistic conditions.
Incomplete understanding of organisational and regulatory barriers.
Reduced confidence in cost-benefit analysis and scalability, undermining the case for wider adoption.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

SPT licence area

Revenue Allowed for the RIIO Settlement

0

Indicative Total NIA Project Expenditure

£620,000

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:

Enabling Whole-System Integration

The project creates a data-sharing and cyber-physical infrastructure that links the electricity transmission network with the rail sector, turning rail demand into a controllable and flexible resource.
By leveraging railway traction networks and energy hubs, the solution enables bidirectional power flows, supporting grid balancing and reducing reliance on fossil generation.
Supporting Decarbonisation of Transport and Energy

Rail electrification is a critical component of the UK's net-zero strategy. By coupling rail and grid systems, the project enables efficient use of low-carbon electricity and supports the rollout of electrified rail without imposing excessive grid connection requirements.
The approach aligns with whole-system planning principles, ensuring that transport decarbonisation complements energy system objectives.
Driving Digitalisation and Operational Efficiency

Development of digital twins, data governance frameworks, and cybersecurity protocols ensures secure, real-time data exchange and predictive analytics.
These capabilities improve operational decision-making, resilience, and planning for future energy hubs, creating a scalable model for other sectors.

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

N/A research project

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

The methods developed through the project will allow all TO's, DNO's and ESO to interface using the learnings from the project GB wide.

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

This is an early-stage research project. We will investigate future rollout costs through 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

The learning generated can be used to improve planning, and operations of both systems.

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.

We have checked the Smarter network portal and undertaken literature review of current research and found no similar research in this area. The current state-of-the-art in microgrid solutions for sustainable railway networks focuses on technical challenges, including but not limited to, energy recuperation, energy dispatch for urban rail-based microgrid, energy management to support growth in rail traffic, and resilience and fault tolerance in railway microgrid operations, including software-defined networking (SDN)-based architectures for adaptive and resilient microgrid communications and sensor fault-resilient control strategies for distributed energy resources (DERs) to mitigate erroneous measurements and ensure stable microgrid operation. A key element not actively pursued in the literature is the need for a robust, resilient, and secure Cyber-Physical Infrastructure (CPI) that can support the development of the DSI framework and enable this cross-sector energy coupling. Accordingly, this project aspires to leverage digital technologies to develop a cross-sectoral (grid-rail) microgrid digital twinning framework that ensures data interoperability and cyber-resilience.

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

The ConnectRail Hub project fully satisfies Requirement as it is a research initiative focused on developing new methodologies and technologies for cross-sector data sharing and digital twinning. Specifically, the project will:

Develop a novel methodology for integrated decision support and data governance between electricity and rail sectors.

Explore innovative cyber-physical infrastructure designs and cybersecurity strategies tailored for coupled energy-rail systems. Introduce new operational practices for resilience and secure data exchange, which do not currently exist in GB electricity networks.

These activities represent original research and conceptual development rather than incremental improvements, ensuring the project meets the eligibility requirement for Research, Development, or Demonstration.

Relevant Foreground IPR

N/A this will be under review through project.

Data Access Details

The SP Energy Networks Data Sharing policy can be found here.

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

This is early stage research with no proven benefits or rollout to networks and would not attract funding at the current TRL/CRL. The proposed Method is currently unproven in the GB network, with the business case therefore impeded by the risks of unproven technical performance and uncertainty around installation requirements.

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

The project has a number of technical and commercial risks that make NIA funding essential. These include early stage research combining two regulated industries and require the funding to investigate the landscape for data sharing between them. This will introduce new methods that are unproven and not currently used in SPEN's business as usual activities, NIA provides the most appropriate route to research and develop the methods.

This project has been approved by a senior member of staff

☑ Yes