SIF Project Registration

Date of Submission

Mar 2022

Project Reference Number

10025738

Project Registration

Project Title

A Holistic Hydrogen Approach to Heavy Duty Transport (H2H)

Project Reference Number

10025738

Project Licensee(s)

SP Energy Networks Transmission

Project Start

March 2022

Project Duration

2 Months

Nominated Project Contact(s)

Michael Eves

Project Budget

£139,341.00

Project Summary

This project explores low carbon solutions by identifying the most efficient transition for the rail decarbonisation potentially using different low carbon solutions; the discovery scope will be desktop analysis. The Discovery output will identify an optimised example using innovative connection for demonstration in the Beta phase.

The project addresses all of the Zero Emission Transport Challenge aims by "developing the technologies, infrastructure and processes required to accelerate zero emission transport options" between electricity, hydrogen and rail networks that reduces carbon emissions by removing diesel trains, plus "maximises the connection of renewable energy and storage".

Desktop analysis will assess connection points, capital and operating costs, land usage, and emissions, comparing:

1. Conventional rail electrification – 100% route electrification using large single-phase connections

2. Full electrification – 100% route electrification + multiple 3 phase connections at lower voltages using power electronics

3. Partial electrification – short sections of electrification with 3 phase connection at lower voltages using power electronics + battery electric trains

4. Green hydrogen – hydrogen production and fuel cell trains – an alternative to electrification

The desktop analysis will highlight areas where additional information is needed to help inform the business cases in order to recommend the solution for an optimum combination of Electricity and Hydrogen for Rail applications including business models and their scalability. This is a unique opportunity to benchmark both against diesel and roadmap how this will work effectively for rail.

SP Transmission plc will be the lead organisation with 5 key partners:

· Network Rail (infrastructure provider) brings information about the rail network and electrification costs for traditional transmission connections.

· Ricardo Energy and Environment (3rd party innovator) brings expertise in decarbonising electricity supplies and connecting traction network to distribution network through novel power electronic devices.

· Leeds University (academic user) brings rail and power electronic expertise from their Institute for High Speed Rail and System Integration

· SP Distribution plc providing local network knowledge and data visibility

· ScottishPower ltd, who have a new Hydrogen division set up to drive this topic

This project will help:

· Electricity and rail customers gain quality, service and cost benefits.

· Electricity asset owners gain tool sets for providing cost connection offers to Network Rail that meet both sector's requirements.

· Network Rail to develop tailored and different electrification programmes to switch from diesel to electricity on the 60% of the rail network that is not presently electrified.

Third Party Collaborators

Ricardo

Nominated Contact Email Address(es)

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Problem Being Solved

Problem:

Transportation is a major polluter at 27% of UK greenhouse gases in 2019, with passenger and freight trains causing 1.6 $MtCO_2e$ pa. The rail industry has a target of removing all diesel passenger trains by 2040 (2035 in Scotland). There is a challenge to decarbonise the remaining 60%.

Conventionally rail electrification uses high voltage, single phase, connections. Removing diesel potentially adds 3TWh of single-phase rail demand to the existing 4TWh of traction power that Network Rail possesses. This results in high costs per passenger for single-phase connection which are a long distance from viable connection points. These networks also need to connect other decarbonisation solutions.

Opportunity:

Government studies support an agile approach in designing a sustainable, affordable and reliable solution for decarbonisation. There is opportunity to integrate hydrogen into rail decarbonisation; which is in the electricity and rail customers' interest in addition to considering technologies such as power electronic and storage.

The UK and Scottish Government both have targets of 5GW for hydrogen production capacity by 2030, and the UK government aims for 1GW by 2025. This capacity will consist of green and blue hydrogen (produced by steam reformation of methane with carbon capture, use, and storage).

Hydrogen production assets have a potential role to play in balancing supply and demand for electricity by turning down or off in peak periods and turning up when supply of renewable energy is high, either in response to price signals or direction from the system operator. Furthermore, they could ease network constraints by responding to signals from TOs or DSOs in the future.

In addition, the rail sector can benefit from novel technologies such as power electronics and battery storage.

Our opportunity lies in comparing their viability for delivering optimal low carbon transport to the consumer.

The benefits to the customer include:

- Increasing quality, security of supply and value for customers through simpler and quicker connection of 3TWh of new rail demand
- Lower electricity system costs and imbalance meeting new Negative Phase
- Sequence limits from 3TWh of additional demand
- A structured approach for the electricity and rail sectors to deliver zero carbon rail electrification
- Carbon reductions of up to of 1.6 MtCO2e pa
- Air quality improvements from removing diesel
- Faster and lower carbon freight, reducing HGVs from roads

This is the first UK project where the electricity, hydrogen suppliers and rail network owners explore innovative options on hydrogen applications.

Project Approaches And Desired Outcomes

The Big Idea

This project supports the delivery of zero emissions rail: making removal of diesel trains quicker and cheaper for the electricity, hydrogen and rail sectors. It meets aims 2-5 of the SIF Discovery phase for Zero Emission Transport and reduces energy bills and carbon emissions.

It addresses the rail industry and their passengers needs by taking a collaborative approach (with all key stakeholders) to address the SIF Zero Emission Transport Innovation Challenge – identifying the optimal solutions from 4 standpoints:

· The rail system – impacts on capex and opex

· For customers – electricity and rail

· For the environment – GHG and air quality

The aim is to demonstrate at a specific site how decarbonisation of rail using hydrogen, power electronics, energy storage and direct renewable generation connections can save costs, carbon and time for electricity and rail consumers.

The current state of readiness is that bespoke projects have considered individual use cases, but there is not yet a definitive comparison of different low carbon solutions nor their relative benefits for railway applications with the appropriate consortia of partners. However, the previous project use cases will be leveraged via the project partners' experience to deliver H2H (these projects are noted in Q3 and Q5 appendices).

Our Discovery study will provide:

· A tool to compare the four solutions

· An assessment of the four solutions for up to three rail lines

· An outline business case for one preferred solution on one of the rail lines

The Alpha and Beta phases will take forward one preferred solution on one rail line. The Discovery phase will assess the electricity system aspects and the electricity system benefits e.g.:

Reducing customer disruption and network impacts

· Increasing understanding of the largest electricity customer (Network Rail) and how demand will increase to 7TWh

· Influencing the rail sector to choose solutions that have the best outcomes for both the rail and electricity sector and both sets of customers

This Discovery study will collate existing knowledge from the project team and public sources. New IP will be created, documented and disseminated under the default IP arrangements in the SIF governance.

Innovation Justification

Previous Innovation Projects

The project team have been part of projects that have investigated solutions to accelerate the decarbonisation of the UK rail sector:

· Rail Safety & Standard Board (RSSB) T1199, Future Costs for Hydrogen and Battery Power for Traction (£66k) assessed several options for trackside battery systems and the costs for these. This project did not include the costs of electricity network connections. One of the recommendations was that further research was needed to assess the feasibility and costs including the costs of electricity network connections.

This was a major motivation for this project, which will leverage learning to assess the solutions from the electricity sector standpoint to develop an optimal demonstration.

Innovate UK has supported a number of First of a Kind (FOAK) projects that cover a range of new solutions for the rail sector, including

Environmental Sustainability. Two relevant projects have been funded under these calls:

· Green Valley Lines (£110k); Assessment of renewable electricity generation and trackside electricity storage for South Wales railway using private wire - this did not consider electricity connections.

· Daybreak (£399k); Development of a low-cost modular convertor connecting renewable electricity generation and trackside electricity storage systems to 25kV overhead line rail systems in parallel with a traditional 25 kV transmission connection. This project focuses on the convertor, which could be part of the range of solutions considered for this new project.

We will use these projects to inform the current benchmarking on electricity and Hydrogen and integrate the Hydrogen solution benchmarking into other hydrogen developments.

University of Leeds were part of the £1.5 million TransEnergy project which addressed both the technology to store electric energy in a form suited to rail and road use, and the modelling to understand how to use the technology to reduce overall energy demand.

We will leverage insights from over £2 million of rail innovation funding; we are aware of the cutting-edge work in Europe, India and New Zealand – no past project combines the electricity and rail aspects in an integrated assessment proposed in this project.

Price Control and Business as Usual Activities

This project is the first innovative collaboration project between the electricity and rail sectors.

The business-as-usual solution is a transmission connection, which can be an expensive and long option for the rural lines that need to be electrified. Consequently, such a proposal or collaboration is not considered within the price control or our normal activities.

Project Plans And Milestones

Project Plan And Milestones

Pre Project Activities (Mid Jan 2022 – End of Feb 2022)

We will undertake the following activities in advance, demonstrating flexibility:

- Form project steering group: SP Transmission; Transport Scotland (rail policy) and Network Rail (rail infrastructure)
- Agree the trial site selection criteria that will be used
- Select and agree up to 3 rail lines that will be used to assess the 4 solutions
- Gather rail traction and electricity infrastructure data for the selected lines

Phase 1 Project Activities

Task 1: Data Gathering (3 weeks – Ricardo Lead)

Collect information for the 4 solutions for up to three rail lines using criteria agreed in the pre-project phase. KPI include:

- Capital cost (electricity and rail): grid connection, energy storage, rail electrification
- Operating costs: electricity costs: transmission and distribution
- Land requirements: Electricity overhead lines and rail trackside
- Construction timescales: New electricity connections and rail overhead lines
- Planning issues: Electricity overhead lines and rail overhead lines
- Customer impact (+/-): Electricity and rail
- Strategic impact: Addressing key electricity and rail sector challenges
- Environmental: GHG and air quality emissions
- System Integration: Electrical/Mechanical/Civil

Milestone 1 – Report containing information for all 4 solutions using defined KPIs

Task 2: Evaluation Tool (3 weeks – Ricardo Lead)

Develop an evaluation tool using Multi Criteria Analysis to score and rank the counterfactual and 3 innovative solutions for up to three rail lines.

- Develop scoring system, and weighting, for each criteria with the Steering Group.
- Present scoring results to the Steering Group, revising scoring based on the insights and feedback

The preferred solution for each line will be agreed with the Steering Group.

The solution with the largest overall electricity and rail system benefits will be selected as the Business Case to be an Alpha and Beta phase SIF project. This selection will use the number of rail lines that are likely to be suitable – offering the largest financial, customer and environmental benefits.

Milestone 2 – Scoring of all 4 options and selection of option for business case

Task 3: Business Case (3 weeks – Ricardo Lead)

A business case will be created using data and scoring from Tasks 1 and 2. This will include requirements that are relevant to the

electricity and rail sectors, including:

· Quantified requirements: Capex, Opex, rate of return etc.

· Customer requirements: Electricity sector stands of service

· Strategic requirements: Addressing key strategic issues for both sectors

Milestone 3 – Completion and Agreement of Business Case

Route To Market

UK Route to Market

The cost of full electrification is £13 to £32.5 billion. Hence lower cost solutions are needed. This project will assess the feasibility of lower solutions, working closing with Network Rail, who procure, own and operate the rail infrastructure.

These issues are part of Network Rail's Challenge Statements:

· Development of new tools, techniques, equipment and understanding to reduce the cost of electrification.

· Using Large Scale Renewable Developments to Enable Decentralised Supply to the Rail Infrastructure

The demonstrated options would become an option in Network Rail's procurement framework as they electrify the railway; key specifications on each option will be adopted to support a competitive, technically compliant tender.

International Route to Market

The challenges that have motivated this project are also present in rail systems in other countries. Our consortia have insight on this through their visibility of key international rail markets and through some initial work on these topics, for example:

· Meetings with the rail sector in the USA – the largest rail system in the world

· A scoping study to understand the potential for solar PV to provide power to help electrify the rail system in India – the 3rd largest rail system in the world

· Two studies on the need for these solutions for rail lines in New Zealand

This means that the project has:

· The contacts in the rail sector in key rail markets

· Contacts and resources to deliver rail projects in key rail markets

Transition to Business as Usual

New solutions require demonstration. This project is the essential feasibility study needed to scope out a demonstration project. The SIF Alpha and Beta stages could be used to accelerate these solutions towards Business as Usual.

The scale of rail electrification and rail decarbonisation, plus the potential cost savings, will build a persuasive case for the demonstrated solution to become business as usual in the UK and international markets and Network Rail will be responsible to bring forward this solution.

This Discovery study will quantify the capital and operating cost benefits for Network Rail and hence the rail sector. Given the total cost of rail electrification at £13 to £32.5 billion this could be a significant net investment saving.

Costs

Total Project Costs

139341

SIF Funding

108239

This project has been approved by a senior member of staff

☑ Yes