Ofgem Strategic Innovation Fund

Discovery End of Phase Report Template

Completion Information

In accordance with the SIF Governance Document, the end of phase reporting is designed to facilitate learning and knowledge dissemination. It will also inform Ofgem's decisions whether a Project satisfies the SIF Eligibility Criteria and whether a Project can move onto the Alpha Phase (subject to a successful Alpha Phase application).

The Project must submit an End of Phase Report to the Monitoring Officer by email or link to file sharing site. In addition, the Project must present findings at a public Show and Tell webinar scheduled for the end of May 2022.

In addition to concluding the Discovery Phase of SIF, should the Project be intending to progress to the Alpha Phase, this report will also form part of the application assessment process. The Show and Tell webinar will also be attended by the expert assessor panel responsible for Alpha Phase assessments.

The Monitoring Officer will review this End of Phase Report and assess the performance of the Project against the SIF Eligibility Criteria.

Your answer to each section can be up to 400 words. The Project may include diagrams to support responses but no hyperlinks unless we have explicitly requested. Up to 5 pages of appendices may be provided to support the report, including the finalised Project finance spreadsheet and risk register to support your responses to sections 4 & 6. Projects are encouraged to use appendices only where necessary, with the intention that the information provided in the End of Phase report focusses on the key elements of the Project, in a manner that is easily reviewed and accessible to a range of stakeholders.

Project Number	**Rail Decarbonisation Planning**
Date Written	**Sarah Buckley, Consultant, EA Technology**

Section 1 -	**Discovery Phase – Project Summary**
Please provide a summary of the key findings from your Discovery Phase Project. Describe the innovative aspects of the work including any new findings or techniques. Please provide a short factual summary of the most significant outcomes of your work.	
You should describe: • How your Project has met the aims of the specific SIF Innovation Challenge. • How your perception of the problem and opportunity evolved. • Why the problem relates to energy network functions, and the potential role of energy networks to realise future opportunities. The innovative, novel and/ or risky aspects of the work, including any new findings or techniques.	
Significant work has been done to date to determine the best approach to decarbonise the rail industry, however, despite electrification being the favourable option, the level, costs and timescales for electrification on the national rail network remain uncertain. To meet the 2050 targets for electrification in the Eastern Region alone, it is estimated that the length of electrified track will have doubled, and power requirements will more than triple. Depending on the level of electrification works that are carried out, the need for hydrogen varies significantly, both in quantity required and in the geographical locations where it will be needed. The estimated demand for hydrogen by 2040 varies significantly between 16,700t and 64,000t of hydrogen (H2) per annum. 64,000t of H2 per annum is nearly 4 times the	

amount proposed in the Traction Decarbonisation Network Strategy; 9% of the current national hydrogen production, and over double the current amount produced via electrolysis.

Regardless of which low carbon solution is adopted, decarbonisation of the rail network will add demand to the energy system. All major new electricity demand connections of significant size are competing for capacity in a highly competitive and dynamic market, and therefore the headroom available is continuously changing. In addition, any large-scale demand increase, is likely to trigger upstream network reinforcement works. Any project programme needs to allow sufficient timescales for these works, noting that these have long lead times (i.e. between 3-10 years) and will require interaction with multiple stakeholders.

- The greatest challenge is to replace diesel rolling stock with cleaner, more environmentally friendly, forms of traction power. With a proportion of the current diesel rolling stock approaching their end of life, there is pressure on the rail industry to find viable low carbon solutions in the near future.
- Investment and decarbonisation plans across the three sectors (electricity, gas and rail) are not aligned and to date, have been developed in isolation.
- Further work is required to understand the viability of the proposed electrification schemes, as well as the whole-life costs of different electrification system types versus alternative traction power technologies (e.g. battery or hydrogen). This requires collaboration from all three sectors to develop a data-driven methodology that can determine the least-regrets options to achieve rail decarbonisation in the required timeframes.

Due to the proposed scale of electrification across the UK's rail network and the key stakeholders involved, this Discovery project focused mainly on the north east of England.

Section 2 -	**Discovery Phase – User Needs**

Please summarise your understanding of user needs including how you are translating these into requirements?

You may want to describe:

- How you have defined your scope boundaries and demonstrate why you believe you have got the scope of your project right.
- What would need to happen to make the user journey as a whole work as well as possible (in particular, you are able to talk about other services that are part of the same journey, and the opportunities and challenges involved in making changes to those services).
- How you have tested your own assumptions against the needs of your users
- How the approach you have taken will minimise the burden on your future users and avoid duplication of effort through user journeys.
- How you have considered the wider interactions of your outputs with the energy sector and other sectors. Show how you have looked at the wider user journeys your service might be a part of.

The rail sector has been developing plans to decarbonise the railway for a number of years. The greatest challenge is to replace diesel rolling stock with cleaner, more environmentally friendly, forms of traction power. There are significant doubts in the rail industry (particularly with the train operators) that the current plans for electrification of the rail network will be delivered, leaving them needing to find other viable low carbon solutions to replace the diesel fleets – Hydrogen Fuel Cell (HFC) power being an obvious choice for many of them.

The distribution of hydrogen becomes the key factor in making HFC powered trains operationally useful. There are four realistic options for supplying the refuelling points and depots:

- Road tankers – considered an interim solution as it may not be able to meet the full demand requirements and does not achieve Net Zero unless the tanker is also a zero carbon vehicle.
- On site electrolysers – require sufficient local electricity and water supply.
- Blended gas supply through the existing gas networks – potential to use existing infrastructure but is likely to need additional purification after deblending, plus the technology is unproven for this application. It remains unclear what the local power requirements will be for deblending and purification compared to an electrolyser.
- 100% hydrogen distribution network – it is unclear if this would be capable of providing a fuel cell grade of purity, or whether a local purification plant would still be required. In addition, it is unlikely this method of supply will be available in the timescales the rail sector is working to.

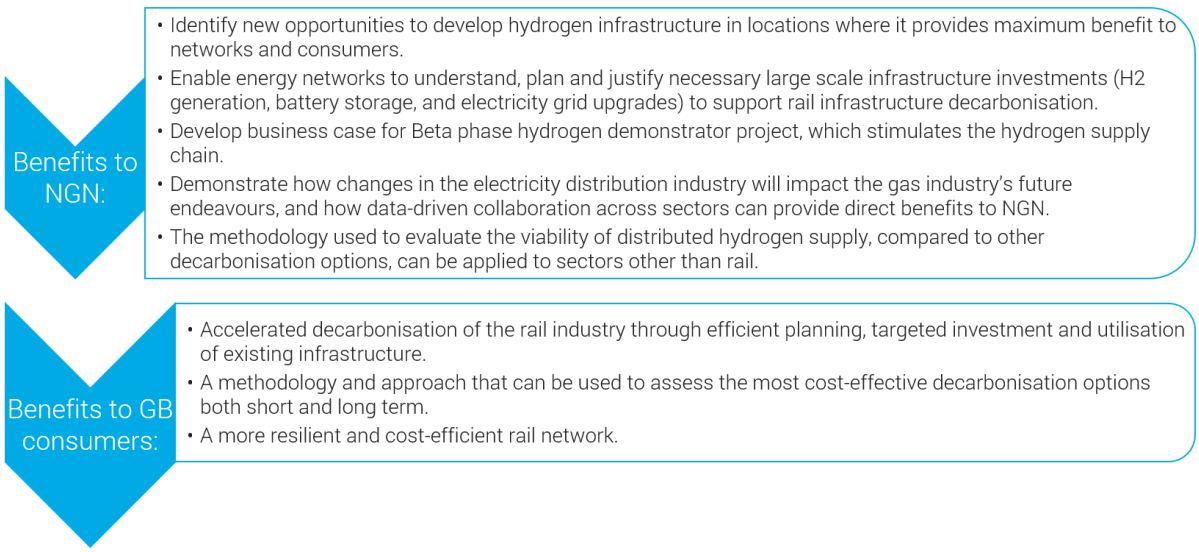
Each of these has advantages and disadvantages, but to date a comparison has not been carried out that considers a cost benefit analysis of each compared to the others, nor to the whole-life costs of different electrification system types.

Future work will identify the optimum, intermittent and long-term decarbonisation options available for the rail industry, based on the capital and operational expenditure, carbon emissions and timescales of the different viable solutions, namely:

- Electrification
- Battery technology
- Local electrolysis hydrogen production and supply
- Hydrogen supplied from gas supplier
- Continued use of diesel or switch to green diesel.

For the gas networks (eg. Northern Gas Networks (NGN)), further analysis will identify new opportunities to develop hydrogen infrastructure in locations where it provides maximum benefit to networks and consumers.

The following benefits could be achieved through future project phases:



Section 3 -	Discovery Phase – Impacts and Benefits

Describe any leading indicators of potential net benefits to consumers as a result of the Project and justify any changes in proposed impacts since the Application stage. Please provide details of any changes that have been made to the Project and why these were necessary.

You may want to describe:

- If the project is still worth pursing and why is it cost effective to pursue.
- How the Project that progressed towards the benefits outlined in the discovery application.
- An indication on quantitative measurements for associated benefits could be related to the:
- the end consumer
- economic benefits resulting from the project to your users and any other parts of the supply chain, broader industry, and the UK economy, such as productivity increases and import substitution
- impact on government priorities and any associated benefits with this
- environmental impacts, either positive or negative
- any expected regional or wider energy supply resilience benefits
- impacts on consumers of the whole energy system (both individuals, and collectively), including those with any vulnerabilities or experiencing fuel poverty

The existing plan for rail decarbonisation takes minimal consideration of the available capacity on the electricity or gas distribution networks and potential sources of hydrogen. This will lead to inefficiencies, missed opportunities for carbon savings, potentially wasted investment, and a lack of coordination from investing partners.

Further work is needed to showcase how a collaborative data-driven approach can improve efficiency of decarbonisation planning and demonstrate the cross-sector considerations that will need to be made in future infrastructure and investment plans. This will identify least-regrets opportunities in the electricity, gas and rail sectors for coordinated investment to accelerate rail decarbonisation at lowest cost to GB energy consumers and rail users.

Potential development of an analytical 'optioneering' tool (and whole-life-cycle cost model) will lead to:

- Improved infrastructure investment planning to identify efficient investment opportunities that reduce expenditure and stimulate the hydrogen supply chain.
- Accelerated decarbonisation of the rail industry through efficient planning and utilisation of existing infrastructure.
- A cost-efficient, low carbon, reliable rail industry benefiting consumers, industry, and the wider economy.
- A more resilient rail network, that delivers decarbonisation in a coordinated way whilst integrating with the energy sector.

Section 4 -	Discovery Phase – Risks, issues, and constraints

What constraints (i.e., technical, commercial, regulatory etc.) have you encountered during your Discovery Phase that may hinder your ability to progress the solution into Alpha? How do you propose to navigate these? Please provide a copy of the final updated Project risk register outlining the risks and issues you are currently aware of, including a likelihood and impact estimate, and mitigating actions.

You may want to describe:

- any actual or potential constraints in regulation, legislation, commercial contracts

or legacy technology that affect the innovation you are developing
- any barriers for innovations to be delivered into business as usual
- how you will create an innovation that meets user needs while working within these constraints
- if you have identified constraints that can be removed over the short or long term, what your plan is for doing so.

During the course of the Discovery Phase, the following challenges and risks have been identified:

1. Regulatory price controls

   Investment and decarbonisation plans across the three sectors (rail, gas and electricity) are not aligned and to date, have been developed in isolation.

   The Distribution Network Operators (DNOs) have already set out their business plans for the next price control period (RIIO-ED2), where no consideration has been given to the rail industry's electrification plans. Collaboration between all three sectors is required to reduce the impact of misaligned price controls and for the rail industry to meet the 2050 Net Zero targets.

2. Significant code review

   From the start of RIIO-ED2, the cost associated with a new connection to the distribution network will be capped, regardless of the level of network reinforcement required. However, there is not anticipated to be any requirement for the connection to be implemented within a maximum timeframe. The greater the level of network reinforcement required, the longer it will take to implement the necessary works. Collaboration between the rail industry and DNOs is essential to identify the quickest route to decarbonising the rail network.

3. Asset ownership

   Great British (GB) Railways is a planned state-owned public body that will oversee rail transport in GB from 2023. Network Rail currently owns many of the rail depots where refueling hydrogen trains would take place, but leases those depots to train operating companies. If an electrolyser were to be installed in a depot, then the introduction of GB Railways may simplify the ownership and asset management responsibilities.

4. Rolling stock

   The current model, and possibly one that GB Railways may not change in the short-term, is for rolling stock to be purchased by Rolling Stock Owning Companies. It is then leased to Train Operating companies, typically for the duration of a franchise. GB Railways will change the contracting model, but may not change the ownership.

5. Affordability

   Following the measures introduced by the Government to minimise the business impact of Covid-19, Government debt is equivalent to 103.7% of gross domestic product (GDP). Servicing that amount of debt has an impact on what the Government is able to afford in the near-term. As a result, wholesale electrification of the rail network is unlikely to happen until the cost per track kilometer has reduced, and Government finances have recovered. If electrification is unaffordable then the use of alternative technologies becomes more attractive.

Section 5 -	**Discovery Phase - Working in the open**

How have you worked openly during the Discovery Phase, and engaged stakeholders in a transparent and constructive manner? What have you learnt from the approach you have taken?

You might want to describe:

- ways in which you have talked publicly about the Project
- how you have invited challenge and external input of your approach to the Project
- how have you shared learning, to avoid duplication of work by others and accelerate industry progress on related initiatives
- how your team has been working in the open and have started building relationships with organisations and teams responsible for other parts of the user journey. These could include infrastructure/data owners, regulators, policy makers, investors, and others.

The analysis undertaken during this Discovery Phase has required collaboration across the rail and energy sectors, as well as open discussions with other relevant SIF projects. The table below illustrates the scope of collaboration and stakeholder engagement during this project.

The team publicly presented the project at the SIF public launch event on the 2nd of March and has publicised the project on social media platforms, such as LinkedIn and YouTube.

The analysis took a deeper dive into the decarbonisation plans for the north east of England and therefore, greater input came from stakeholders operational in the North – for example, Northern Powergrid, Network Rail (Eastern Region) and Northern Trains. The level of engagement has been made possible through the support of the project partners and their contacts.

Stakeholder	Sector	Relevance
Northern Gas Networks (NGN)	Gas	**Lead Project Partner** - owns and operates the distribution gas network across North England
Eversholt Rail	Rail	**Project Partner** – owns a portfolio of passenger and freight rolling stock operating across the UK.
Network Rail	Rail	**Project Partner** – owns and maintains most of the railway network infrastructure in GB
UK Power Networks (UKPN)	Electricity	**Project Partner** – electricity DNO for London, the South East and East England
Northern Powergrid (NPg)	Electricity	Electricity DNO for the North East, Yorkshire and northern Lincolnshire

National Grid	Gas	GB transmission system operator investigating the injection / removal of hydrogen in the grid supply
Northern Trains Ltd	Rail	Train operating company
Alstom	Rail	Develops mobility solutions including hydrogen-powered rolling stock
WSP	Rail	Co-authored the TDNS
Element Energy	SIF - Zero Emission Transport	Project partner for SIF Multimodal Hydrogen Transport Refuelling Study
Ricardo	SIF - Zero Emission Transport	Project partner for SIF H2H project
SP Energy Networks (SPEN)	Electricity & SIF	Project lead partner for SIF H2H project and SIF Flexible Railway Multi-Energy Hub Networks project

Table 2 Stakeholder engagement during the Discovery Phase

Section 6 -	**Discovery Phase – Costs and value for money**

Please give a description of how funds were spent with reference to the original budget at Project kick-off and explain any significant variations. Explain how the Project has delivered value for money to consumers. Provide a copy of the final Project Finance spreadsheet.

The project benefited from funding totaling £113,594.26, with a total project cost of £124,994.26. The costs and funding were split between Northern Gas Networks, EA Technology, Frazer-Nash Consultancy, UK Power Networks, Network Rail and Eversholt Rail.

- Northern Gas Networks (NGN) were the lead partner in the consortium, claiming £4,320.
- EA Technology claimed £57,808.75. EA Technology led on the Electricity Sector Baseline Assessment (one of three reports for work package 1); led on the Implementation Plan (work package 2); and communication/marketing material to third party stakeholders.
- Frazer-Nash Consultancy claimed £44,855.47. Frazer-Nash led on the Rail Decarbonisation Strategy and Hydrogen Supply Chain Baseline Assessments (two of three reports for work package 1) and fed into work package 2.
- UK Power Networks (UKPN) claimed £6,610.04.
- Network Rail and Eversholt Rail contributed to the project as unfunded partners.

This Discovery Phase has represented value for money for the consumer because the project partners bring previously developed tools and expertise to demonstrate how a collaborative data-driven approach can improve efficiency of decarbonisation planning across the three core sectors.

Members of the wider stakeholder group have contributed their time and expertise to the discovery phase of the project without reimbursement from UKRI, evidencing their support for this project and representing good value money.

Most importantly, this Discovery project has brought the three core sectors together and initiated cross-sector engagement.

Section 7 -	**Discovery Phase – Special Conditions**

If applicable, please describe how you have met the requirements of any Project specific conditions set out in the Project Direction.
N/A