national gas transmission

SIF Project Registration

Date of Submission

Mar 2022

Project Reference Number

10024392

Project Registration

Project Title

Nuclear Net Zero Opportunities (N-NZO)

Project Reference Number

10024392

Project Licensee(s)

National Gas Transmission PLC

Project Start

March 2022

Project Duration

2 Months

Nominated Project Contact(s)

David Hardman - david.hardman@nationalgrid.com

Project Budget

£107,494.00

Project Summary

Scope: This proposed Discovery Phase Project will focus on how future deployments of Advanced Nuclear Technologies (ANTs) for hydrogen and electricity generation can best be integrated into Gas and Electricity Transmission Systems, providing a constant supply of low-carbon hydrogen for consumers. It will consider approaches for accomplishing this based on cost-effectiveness, security of energy supply and assisting the achievement of Net Zero targets.

Themes: The project touches on several Whole System Integration themes, but particularly:

- Coordinating energy transmission, distribution and system operation across gas and electricity: Nuclear power has been an essential contributor to the UK energy mix. As existing nuclear capacity is retired, there is the opportunity to design and deploy emerging technologies to support cogeneration, improving the resilience of both the energy grid.
- Future policy and regulatory conditions as well as market designs to support whole system approaches: Outputs from the project will directly support future policy decision and shape regulatory frameworks. These can help with the deployment and integration of ANTs to support the whole energy system.

Whole Systems Innovation: This project will support rapid decarbonisation for both consumers and UK businesses, notably in heavy industry, residential and transportation. This study will assess the potential location of future nuclear by balancing a series of logistical factors such as cost to the consumer, hydrogen throughput, regulatory hurdles, reliability, and availability of hydrogen transport.

Project Partners: Because this project focuses on the interface between nuclear, gas and electricity, it requires a whole-system approach, and a set of partners to reflect that. Our consortium consists of gas and electricity transmission and distribution network operators, the electricity system operator (ESO) and two energy generators. Several other energy network licensees (the energy system operator and the gas distribution network's), have also expressed a keen interest in outputs from the project, with a desire to become involved in later projects.

- **Energy Networks:** Energy network licensee's include National Grid Gas Transmission Network (NGGT) as leading project partner, with National Grid Gas Transmission Network (NGET), National Grid ESO and Northern Gas Networks (NGN).

- **Generators:** Rolls-Royce and URENCO.
- **Industry Experts:** Frazer-Nash Consultancy is a leading systems and engineering consultancy with extensive energy system expertise, and broad network of relevant supporting stakeholders. Frazer-Nash has been identified to undertake the Discovery Phase implementation, as a technology agnostic collaborator performing independent assessments of the proposed whole system approach and the potential benefits for consumers.

VIDEO - https://www.youtube.com/watch?v=MaQ1XhkwBpg&list=PLrMOhOrmeR6ktSag0RbT7zPNVn0p1P2f6&index=28

Third Party Collaborators

Urenco Limited

Frazer-Nash Consultancy

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

Context: Next generation nuclear reactors, Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs), collectively known as Advanced Nuclear Technologies (ANTs), can play a critical role in meeting the Government's published ambitions around future low-carbon hydrogen production and use, in addition to their electrical power output.

They offer two key benefits:

- High-grade output heat that can increase efficiency of hydrogen production via electrolysis.
- High availability of energy supply compared to intermittent renewables.

Both the Government's "Ten Point Plan for a Green Industrial Revolution" (2020) and the Hydrogen Strategy (2021) identify the growth of low-carbon hydrogen as a key element in achieving net-zero. They also emphasise the role that next generation nuclear reactors could potentially play in unlocking efficient production of hydrogen.

Problem: The large quantities of hydrogen produced from future nuclear reactors will necessitate the use of pipelines to transport hydrogen to key industrial clusters, as well as more distributed end-users. This raises questions over how the existing National Transmission System (NTS) can be used to transport this hydrogen, and how, in turn, the NTS can enable the development of nuclear hydrogen production. R&D is being undertaken on the production of hydrogen from nuclear power, but there is a critical gap in knowledge around where best to site future nuclear-hydrogen production and the requirements on the NTS to transport this hydrogen to end-users. This project will address this gap. Through scenario modelling, it will consider current and future siting options for future nuclear-hydrogen production and how these could interface with the NTS.

Opportunity: Initially, we will define a set of end-user scenarios for low carbon hydrogen demand (including industrial clusters and key transport hubs). We will determine how future nuclear-hydrogen siting options, under current regulatory frameworks, can service this demand using the NTS and the benefits and barriers of developing this. We will then consider new credible siting options for nuclear-hydrogen production and determine the additional benefits these may provide to transporting hydrogen to the end-users, along with the greater challenges and barriers these new sites may present. In each case we will consider the regulatory, operational, engineering, commercial, social and wider energy systems issues.

This project will highlight how future nuclear-hydrogen production can be effectively interfaced with the NTS to deliver low carbon hydrogen to key end-users at scale. It will be key to the enabling and development of low carbon hydrogen production in the UK.

Project Approaches And Desired Outcomes

The Big Idea

Aims: This ambitious project has substantial support and interest from across the sector. It addresses multiple aims of the Whole Systems Integration challenge:

- **Decarbonisation:** Generation of clean hydrogen and electricity will significantly decarbonise gas and electricity transmission and distribution.
- **Consumer Benefits:** Improve security of supply and lead to both carbon and cost savings for end consumers, as cogeneration can be flexible and technology cost is forecast reduce over time.
- **Co-ordination of system participants:** Begin to understand the whole-system effects of deploying ANTs.
- **Future Market Design:** Cogeneration of hydrogen and electricity from a single site, for transportation to multiple consumer groups, will significantly influence future market design.

Discovery Phase: This phase will address a broad range of barriers and challenges to determine the feasibility of deploying ANTs for hydrogen generation. Proposed activities will include:

- **Definition of Demand Scenarios:** Define potential hydrogen demand scenarios, including the currently forecasted demand. Identify large-scale users of zero-carbon hydrogen (e.g. industrial clusters) and other off-take points (e.g transport hubs), as well as distribution networks for smaller commercial and domestic heating applications.
- **Definition of Supply Scenario:** Predict potential hydrogen production capability from ANT sites and consider different future production scenarios (low, medium and high).
- **Nuclear-Hydrogen Siting:** Investigating challenges around site location, and solutions to optimise interaction with future NTS infrastructure strategies and plans. Consider sites permitted by current regulations, as well potential future locations, subject to overcoming regulatory hurdles. This will include developing recommendations for future policy and regulatory frameworks that could help incorporate ANTs technology as a hydrogen generator for the NTS.
- **Modelling and Impact Assessment:** Investigate how the NTS would need to operate to support hydrogen production and demand, for each of the identified scenarios. Evaluating the crossovers and potential barriers that exist between current and future nuclear and energy network regulations.

Deliverable: The project will deliver a report detailing the feasibility of utilising nuclear-hydrogen for different future scenarios, including any related consumer benefits and identified technical, commercial and regulatory challenges. A roadmap will be delivered, highlighting necessary requirements for creating a viable interface between ANTs and the NTS.

Future Work: The roadmap will determine areas where further work is required and be used to develop suitable Alpha and Beta phases. Future work will eventually evolve towards a designing and demonstrating the feasibility of ANTs for hydrogen production, either within a research facility, such as the National Grid's FutureGrid site, or within a live network.

Innovation Justification

Hydrogen Production from Nuclear: Significant R&D is taking place in academia and industry to develop nuclear-hydrogen both in the UK and worldwide, for example Exelon Generation have announced demonstration of nuclear-hydrogen production will begin at Nine Mile Point plant in USA by 2022. This work is largely focused on techniques to generate hydrogen from new generation nuclear reactors. UK Government has provided policy and funding support to generating these technologies.

Low temperature electrolysis is already a commercially viable hydrogen production methods, with other future techniques, of lower maturity, still under development. For example, the utilisation of nuclear reactor heat to increase efficiency, with high temperature electrolysis and thermochemical water splitting techniques.

Advanced Nuclear Technology: These reactors will lead to smaller modular nuclear plants, driving down costs and reducing installation times. These reactors will become operational within the next decade, generating affordable and localised electricity. Whilst development of ANTs is proceeding at pace, there is very limited research and analysis associated with the potential for these technologies to cogenerate hydrogen alongside electricity.

Research Gap: ANTs are emerging technologies, which are receiving significant of R&D focus. However, little research attention to investigate how these new technologies can interface effectively with existing networks for transmission and distribution. However, utilising this infrastructure will be essential for deploying this technology to meet net zero at an affordable price.

The way this new technology can integrate with the whole energy system is the key focus of our project.

Key Research Areas: Filling this research gap will require research, analysis and modelling the integration of ANTs with the gas networks for hydrogen transportation. More analysis is needed into the location and capacity of gas networks to transport the required volumes of nuclear produced hydrogen. This thinking needs to take place at an early stage to mitigate the risk of these technologies being developed without a clear strategy for future integration.

Current Understanding: Frazer-Nash is actively involved in a wide-range of nuclear innovation projects and has conducted preliminary work to investigate hydrogen production from nuclear power. This includes the use of thermochemical and high-temperature electrolysis methods for increasing the efficiency of hydrogen production. This work will be fed into this current project along with any updates on hydrogen production from nuclear. It will be ongoing in parallel with the current project to understand how the ANTs can be integrated with the transmission/distribution networks, adding significant value.

Project Plans And Milestones

Project Plan And Milestones

The project will be split into 3 work programmes (WPs), with 3 associated deliverables.

WP1: Baseline Scenario Development

- Collate existing information from ongoing R&D projects focused on nuclear-hydrogen. Includes industry engagement workshops (e.g., OEMs and Industrial Cluster).
- Define future demand scenarios, with varying forecasted demand of large users of zero-carbon hydrogen, as well as transport and the distribution networks for smaller commercial and domestic heating applications.
- Predict potential hydrogen production capability to identify where this site would join to the National Transmission System (NTS).
- Identify current potential Advanced nuclear technologies (ANT) locations, based on current siting regulations.
- Evaluate NTS requirements for facilitating the predicted hydrogen production and demand, considering aspects such as operational, engineering, wider energy system balancing, regulatory and social, etc.

Deliverable 1: Detailed literature review and broad industry engagement to create a high-level impact assessment on the effect of ANT deployment for hydrogen production on the national transmission system. Including detailed PESTLE analysis (Political, Economic, Social, Technological, Legal and Environmental factors).

WP2: Further Scenario Development

- Determine regulatory barriers for new siting locations of ANTs and begin identifying optimal future locations depending on potential regulatory amendments.
- Consider future hydrogen production scenarios (low, medium, high).
- Repeat macroscale modelling, based on the new locations and the identified hydrogen demand and production scenarios.

Deliverable 2: Clearly defined technical, commercial, and regulatory barriers identified, with potential siting locations identified, should these barriers be overcome. Similar Macroscale modelling outputs for the different sites and production scenarios.

WP3: Roadmap and Implementation Strategy

- Analysis of barriers, opportunities, and resources needed for integration with the NTS.
- Identification of policy amendments potentially required to enable optimal deployment.
- Identification of industry actions potentially required to enable optimal deployment.
- Gap analysis to identify next steps, and potential Alpha and Beta Phase projects.

Deliverable 3: A roadmap and implementation strategy for creating a viable interface between nuclear reactors and the NTS agreed by Project Partners.

Final Deliverable: The key deliverables will be collated into a final report. This will assess the current policy framework, assess current activity in this area, and make clear recommendations for the next phase of activity. Including recommendations to project delivery partners, regulators, government, and research bodies, leading to multiple future workstreams.

Meetings:

- Kick Off with all Project Team.
- Weekly meeting between NGGT and Frazer-Nash Consultancy.
- Ongoing engagement meetings with key partners and stakeholders.
- Monthly all project partners.
- Close Out Meeting - in-person if Covid restrictions allow.

Route To Market

Recent Advancements: During COP 26 there have been many announcements detailing the strategy for research and innovation focus to achieve Net Zero by 2050 by the UK Government; this has covered a broad range of technologies and associated policies set out. Nuclear power has received broad support with much greater confidence in the development and deployment of New Build. This is further reinforced by a recent funding announcement by Rolls-Royce SMR, of which Frazer-Nash Consultancy made their own announcement [https://www.fnc.co.uk/discover-frazer-nash/news/frazer-nash-supports-the-rolls-royce-small-modular-reactor-business-to-help-meet-net-zero/], detailing their support to the programme. These developments give real confidence that there is a demand for a future grid requirement that will integrate with ANTs and their production of hydrogen.

Innovation Projects: Through the investment in a roadmap for the integration of advanced nuclear with a future gas transmission network a credible route forwards can be identified with options to pursue in later stages of the SIF. Given the support from generators of both advanced and small modular reactors, through Roll-Royce and URENCO, alongside Frazer-Nash Consultancy as an experienced services provider in the market, we can inform these plans. Co-ordination and communication between multiple energy vectors will help us achieve our Net Zero ambition, and through projects such as this, can help develop a collaborative culture, leading to business as normal plans for collaboration to be developed and implemented.

Whole System Integration: NGGT has identified a demand for interconnection of advanced nuclear sites, alongside the broader needs of NGET for electricity connection. Through this proposed project a roadmap will be identified, with a gap analysis to understand technology, regulatory frameworks and market structures that need development to meet this demand. This will involve defining key milestones for learning, and creation of targets for interfacing with other work that National Grid are doing, for example the FutureGrid project. It will be essential to understand relevant current and planned policy and regulatory frameworks, so that this work can begin to advise on methods for overcoming the obstacles that exist.

The opportunity presented through the SIF provides a route to collaboration, with options for developing both an Alpha and Beta stage of the project. This will help to achieve deployment of advanced nuclear with the option for hydrogen production, transmission, and storage, whilst ensuring that the energy networks are able to prepare for first deployments in around 2030.

Costs

Total Project Costs

107495

SIF Funding

107495

This project has been approved by a senior member of staff

- [x] Yes