2024 E.S. Cornwall Memorial Scholarship
Second Quarterly Report

Net Zero Innovation
National Grid Electricity Transmission

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

nationalgrid
Electricity Transmission

Neha Moturi

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Abbreviations

AI	Artificial Intelligence
ENA	Energy Networks Association
ESO	Energy System Operator
ETDP	Engineering Transmission Design Principles
EV	Electric Vehicle
FES	Future Energy Scenario
FSO	Future System Operator
GB	Great Britain
IDD	Infrastructure Development and Delivery
LW	Leading the Way
NET	Navigating Energy Transitions
NG	National Grid
NGED	National Grid Electricity Distribution
NGET	National Grid Electricity Transmission
NGP	National Grid Partners
NGV	National Grid Ventures
NIA	Network Innovation Allowance
NZI	Net Zero Innovation
Ofgem	Office of Gas and Electricity Markets
RESO	Regional Energy System Operator
RIIO	Revenue = Incentives + Innovation + Outputs
SIF	Strategic Innovation Funding
V2G	Vehicle-to-Grid

Executive Summary

The global energy sector is undergoing a significant and exciting period of change as we transition to a net zero carbon future. UK transmission and distribution service providers have published various future energy system predictions (known as Future Energy Scenarios) to help inform current day network investment decisions, policy changes and carry out innovation accordingly. Whilst these future scenarios equally achieve net zero, they are diverse in technology uptake, consumer behaviour, regulation and government policy, renewable generation mix etc. further emphasising the level of uncertainty ahead of us.

The complex nature of the future energy system and how its various elements interact with each other requires 'Whole System' thinking, which involves collaboration with other network licensees and participants in the wider industry. I am excited to be working as an Innovation Engineer in the Net Zero Innovation Team at National Grid Electricity Transmission (NGET) as my first placement. More specifically, my primary responsibility is to look after the Whole System portfolio of projects which has given me exposure to a diverse array of technologies and services that are strategically designed to benefit our networks whilst also delivering best value to customers.

In this report, I have summarised a few select innovation projects that I have encountered in my current role which I believe are relevant to the Australian power sector. Firstly I introduce the Energy Networks Association (ENA) through which I have engaged with two innovation projects. More specifically these are the 'Automated Routing of Infrastructure' and 'Artificial Intelligence for Connection Offers' projects. I then highlight some innovations within the distribution space at National Grid and the cost savings to the business associated with these developments. Finally I summarise other activities I've been fortunate enough to engage in during my placement.

Table of Contents

Acknowledgements 2
Abbreviations 3
Executive Summary 4
Energy Networks Association Basecamp 6
Artificial Intelligence for Connection Offers 6
Automated Routing of Infrastructure 7
National Grid Electricity Distribution Innovation 8
Innovation Project Example: Maritime Decarbonisation 8
Innovation Project Example: Planning Regional Infrastructure in a Digital Environment (PRIDE) 9
Other Activities 11
Bibliography 13

Energy Networks Association Basecamp

The Energy Networks Association (ENA) is a not-for-profit organisation which aims to help companies safely deliver electricity and gas across Great Britain in a collaborative manner. Their mission is to help share best practices, protect the industry's reputation, and influence those who have an interest in the industry's ambitions [1].

Each year the ENA hosts an Innovation Basecamp, where network operators can showcase problem statements that outline the technical challenges they are facing. The challenge areas are quite varied and range from flood alarms to fleet decarbonisation, and all fit into one of the following six themes [2]:

1. Building Better and Faster: This challenge area calls for submissions which modernise the planning, procurement, and construction process in order to deliver projects faster and more innovatively.
2. Decarbonisations Network Operations: This challenge area requests for net zero considerations in every stage of a project lifecycle to reduce emissions associated with network operations both today and in the future.
3. Flexibility and Forecasting: This challenge area encourages the testing of market-based solutions to increase flexibility and efficient of the energy system.
4. Maximising Use of Existing Infrastructure: This challenge area aims to maximise the use of existing network capacity to reduce future infrastructure requirements and ultimately reduce costs for end consumers.
5. Net Zero Transition Impacts: This challenge area calls for innovations which enable network service providers to tackle the energy transition more proactively.
6. The Consumer Journey to Net Zero: This challenge area priorities how we can support the needs of all consumers to enable a fair and equitable energy system transition.

The basecamp, held in Manchester this year, is a two-day event to which various innovators are invited to attend and listen to the challenge areas presented by representatives from network service providers. The ENA then opens a submission window (which is 6 weeks long) for innovation ideas in response to the challenge statements. Successful ideas are then fast-tracked for discussions with network representatives directly or progress through to the follow-on event, Basecamp Pitching, where innovators pitch their ideas to a panel of industry experts. Innovation projects resulting from this process are funded by either the NIA or SIF mechanism which are detailed in the first quarterly report.

As part of my role responsibilities, two of the challenge areas that I am supporting on behalf of NGET are:

1. Artificial Intelligence (AI) for Connection Offers
2. Automated Routing for Infrastructure

Artificial Intelligence for Connection Offers

The DNO connection application process, particularly at the HV and EHV levels, can be lengthy and requires coordination across multiple teams including connections, primary network design and engineering design teams. To improve time efficiency, this challenge area aims to explore the feasibility of using AI to streamline the connections application process. The initial step would involve assessing whether AI could accurately categorize each application to ensure it reaches the appropriate team. Additionally, AI could perform a "sense check" on the application form values to spot potential errors. This approach may also benefit transmission/distribution connections, and it would be valuable to understand if similar techniques could be applied across different types of networks.

It is anticipated that the solutions proposed for this challenge area will address how network service providers can leverage AI to evaluate a customer's connection application, recommend suitable types of connection offers and generate those offers. Furthermore, the ability to identify key missing or potentially incorrect information in an application will help expedite the application process. Other questions that may be addressed as part of this project include:

- What algorithms, data quality, and minimum data volume are necessary to produce a connection offer at the HV and EHV levels?
- How can we establish and monitor a confidence level for the accuracy of AI-generated offers?
- Can AI be applied to conduct power system studies to any extent?

It is recognised that the key constraints in this project will be performing power system studies via AI and we are yet to understand the minimum data requirements and quality of data to enable the proposed AI capabilities.

Automated Routing of Infrastructure

Currently, there is no consistency in corridor route planning across the various transmission and distribution network service providers. There is no certainty amongst planners and stakeholder groups that the selected routes are the most optimal and any rework causes delays in consenting.

The Energy Networks Commissioner, Nick Winser, has set out 18 recommendations in a report to help accelerate the delivery of transmission infrastructure. Some of the key recommendations are [3]:

- Recommendation 1 – The Future System Operator (FSO), as supported by Ofgem, is to be established as soon as possible which should be responsible for producing the Strategic Spatial Energy Plan (SSEP).
- Recommendation 2 – The scope for new short-term and long-term regional flexibility markets should be assessed by the newly established FSO.
- Recommendation 6 – National Policy Statements should be updated urgently and regularly thereafter.
- Recommendation 8 – The Electricity Transmission Design Principles (ETDP) is proposed as a new document and yet to be created.
- Recommendation 9 – The 'Future Systems and Network Regulation' consultation should be terminated and Ofgem should work with Transmission Operators to establish a new regulatory arrangement.
- Recommendation 12 – The FSO and TOs should work with the Government to design and implement a focused information campaign on the need for a grid refresh.
- Recommendation 13 – Community benefit should be more carefully evaluated and a public set of guidelines for this should be established.

Two recommendations in particular are relevant to this challenge area, which are explained in greater detail below [4]:

1. An automated corridor routing process should be implemented as a standard practice. This approach enables a wider range of corridor routing options to be evaluated than would be feasible manually. A landscape architect would oversee this automated process, utilizing its output to make the final corridor route decision. Regulatory and planning approval processes will need to acknowledge and accept this approach along with its supporting tools.

2. A route design process based on the Electricity Transmission Design Principles (ETDP) should be adopted. A new tool should be developed to facilitate this process by supporting the design of the location within the corridor and the selection of the appropriate asset type (e.g., overhead line, tower, cable). A design engineer would oversee this automated process, using its output to make the final decision on the proposed route design. Regulatory and planning approval processes will need to recognize and accept this method and its tools.

Identifying corridor routes during the design phase requires considerable time and resources, as multiple options must be investigated and numerous data sources analyzed to determine the most suitable routes. This adds time and cost to projects.

In response to this challenge statement, it is anticipated that solutions proposed will facilitate an automated corridor routing process which adopts the Engineering Transmission Design Principles

(ETDP). It is expected that AI-based solutions will be proposed to help expedite the route planning process. Successful delivery of this project must involve a survey of current practices amongst the various TSPs before proposing any potential solutions. This should then serve to build a statement of requirements for the future automated routing tool.

Currently I am in discussion with various representatives from other TSPs driving this project and consultants in the industry who are ready to pursue this as an innovation project. The main constraints on this project will be aligning existing corridor routing tools amongst the TSPs and establishing a standardised routing solution.

National Grid Electricity Distribution Innovation

Each year National Grid Electricity Distribution (NGED) hosts an annual innovation event to reflect on the year's progress towards 2050 net zero targets. The theme for 2024 was "Gearing up for Delivery", where NGED showcased several innovation projects which were successfully developed all the way through to "business as usual" operations. As I look after the Whole Systems portfolio, I attended this event to better understand NGED's strategic objectives and identify opportunities for collaboration.

During the first regulatory cycle (i.e. RIIO-ED1 which encompasses 2015-2023), NGED funded and rolled out 12 new capabilities which were trialled via the NIA funding mechanism. For further details regarding regulatory cycles and funding mechanisms, please refer to the first quarterly report. A few of the products/services that were rolled out are summarised in Table 1.

Table 1 NGED Innovations

Product or Service	**Description**
Open Network Data	An initiative to enable access to network data for external stakeholders.
Statistical Ratings for Overhead Lines	Explores the potential of LIDAR and infra-red sensors on helicopters to improve resilience.
Helicopter LIDAR image capture	Proposes an update to the rating system for overhead lines.
Carbon Tracing App	Rolls out applications and API's to allow customers to track the carbon intensity of the grid.
EV Charging Demand Profile	Involved the largest ever trial of electric vehicle smart charging.

Savings due to RIIO-ED1 innovations are anticipated to amount up to £449M by the end of the second regulatory cycle (i.e. RIIO-ED2 which encompasses 2023-2028). Innovations and delivery in RIIO-ED2 thus far build on the foundations established in RIIO-ED1. The NGED business plan committed to the delivery of the following innovations amongst others:

- Community LV Data Monitoring
- Power Quality Monitoring
- Use of Smart Meters for Monitoring

Other innovations that were showcased are detailed below.

Innovation Project Example: Maritime Decarbonisation

Introduction

Ports have no simple and accurate way to map their decarbonisation pathways. As such, the electricity network does not have visibility of this demand type on the future network. This project will create a tool to:

- Inform and enable ports and their users to plot their most viable decarbonisation pathways.
- Help identify key electricity network investment requirements.
- A tool for critical national infrastructure to foster a more coordinated approach to future investment and create a more effective and efficient journey to net zero.

Progress to Date

The project has completed its scoping phase through Ofgem/UK Research and Innovation's Strategic Innovation Fund (SIF) Discovery funding. It has been successful in securing further SIF funding for an alpha proof of concept phase which will last six months, starting October 2024. Details on SIF project and each phase of a SIF project is detailed in the first quarterly report.

Key outputs of the Alpha phase will include a prototype of the Navigating Energy Transitions (NET) tool, a Virtual Port Environmental prototype and maritime-DNO workshops to build cross sector knowledge and capacity building.

What does this innovation project aim to achieve?

This innovation project aims to achieve:

- Decarbonisation of the maritime sector i.e. reducing carbon emissions across various vessel types, port infrastructure and associated equipment
- Coordination between stakeholders: Improve collaboration between maritime industry and DNOs to facilitate decarbonisation and infrastructure upgrades.
- Development of a NET Model: this tool explores transition scenarios to identify key network investment requirements.
- Grid Preparation for new load patterns: address the novel concept of a maritime "ripple effect", increased electrical consumption around ports due to the port's activities.
- Enhancement of network resilience: Ensure the resilience and viability of ports as critical national infrastructure.
- Cost savings: Estimate and achieve potential savings in reinforcement costs, through a coordinated approach.
- Improved data and planning for DNOs: Provide better data on emerging demands to enhance network planning and coordination capabilities for DNOs.

Opportunity for Collaboration

This innovation project highlights the shift away from fossil-fuels in the transport sector and the need to adopt innovative solutions to help accelerate this transition. As such, network service providers are facing increased pressure from the transport sector to accommodate the combined demand of cars, heavy road users, aviation, maritime, rail etc. Certain locations will see multiple transport loads electrifying simultaneously, resulting in significant additional load, which may respond to the same market signals, despite having different use cases and requirements.

In order to address this challenge, I will be proposing a submission for next ENA basecamp which looks to develop a whole system transport model which (at a minimum) quantifies the peak demand resulting from the transport sector in various future energy scenarios (FES) at grid supply and bulky supply point levels. As such, Network Planners and Strategy teams across transmission and distribution utilities can collaboratively assess the infrastructure and other network requirements to enable more stable or responsive power demand across these sites (e.g. ports, airports etc.).

Innovation Project Example: Planning Regional Infrastructure in a Digital Environment (PRIDE)

Overview

PRIDE was funded through the SIF innovation funding mechanism (please refer to the first quarterly report for further details on funding mechanisms) which commenced in October 2023 for 8 months. The aim of PRIDE was to develop a whole system digital tool and regional governance structure to support local authorities with local area energy planning and serve energy network planning needs. The project brings together different decision-makers across housing, transport, industry and public estate customer segment groups to best understand local needs.

The digital twin solution supports the selection of regional infrastructure options that are faster or better overall value for money to deploy. For example, currently transmission infrastructure is planned without reference to capacity assessments on the electricity network which can result in unnecessary constraint costs. The PRIDE platform helps identify these potential synergies through sophisticated scenario-based modelling which ultimately help justify business cases.

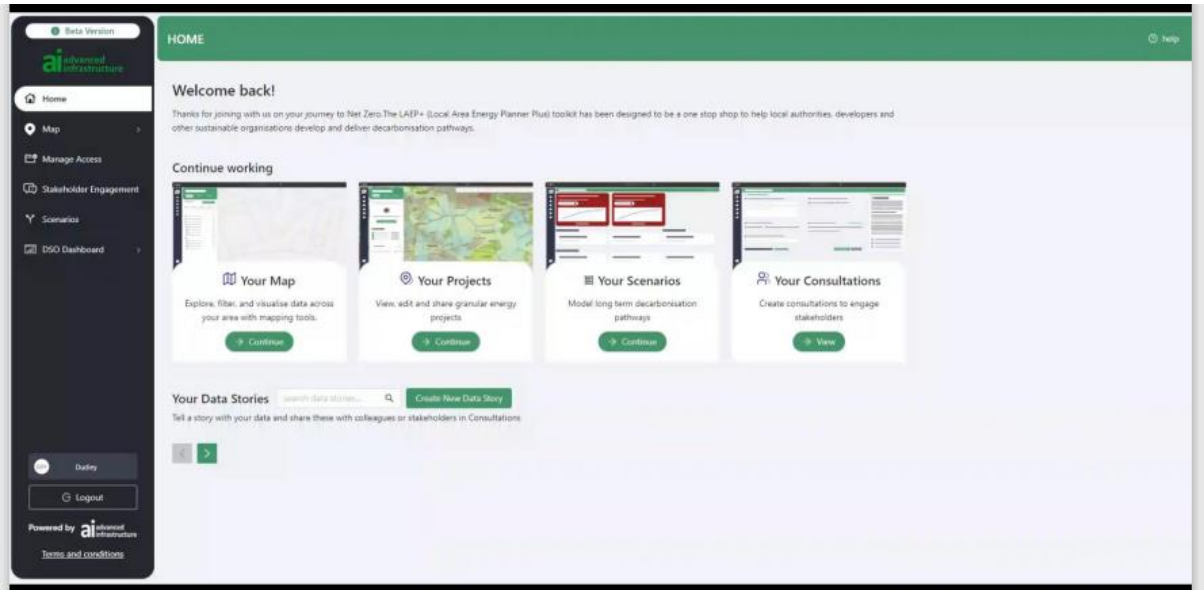

Figure 1 PRIDE Software

Potential Benefits

A similar project, namely Regional Energy System Operator (RESO), found that taking a local, whole-system approach to energy infrastructure decision-making could deliver a net present value of £721M over 30 years. In order to realise these benefits, better data visibility was needed for cost and time-effective stakeholder engagement, which is being achieved through the digital twin solution developed in the PRIDE innovation project. Overall, the benefits captured through this project include:

- Smart local energy systems which create more local opportunities to help balance the grid, ensuring value is captured and distributed at a local level.
- Reduced bills, more jobs, and greater local economic benefits and better support to vulnerable consumers.
- Savings through targeted technology deployment, identifying what and where technology is needed.
- Data led local planning: development of co-ordinated energy and local planning
- Infrastructure investment: targeting investment to where it is needed most
- Economic development: creating and capturing local value from a smart energy system
- Designing the market: to create local opportunities in demand-side response and flexibility services

Other Activities

1. University of Southampton site visit

I had the opportunity to visit the University of Southampton as it is one of the seven partner universities with the Innovation team. The Faculty of Engineering and the Environment at the University owns and operates the R. J. Mitchell Wind Tunnel, which is a low-speed wind tunnel and also the largest in university ownership in the UK. Facilities such as this are particularly useful for network service providers as high voltage overhead lines (OHL) include many components, such as lattice towers, pylons, conductors, insulators, dampers, spacers and other fixtures and fittings. These components are installed at height and are generally exposed to higher wind speeds than at ground level and have the potential to produce wind induced tones through turbulence, vibration modes, vortex shedding and Helmholtz resonance. Given the extensive onshore infrastructure that is planned to meet Net Zero ambitions, more structured research is required to understand the mechanisms of wind induced audible noise and, importantly, practical forms of testing and mitigation.

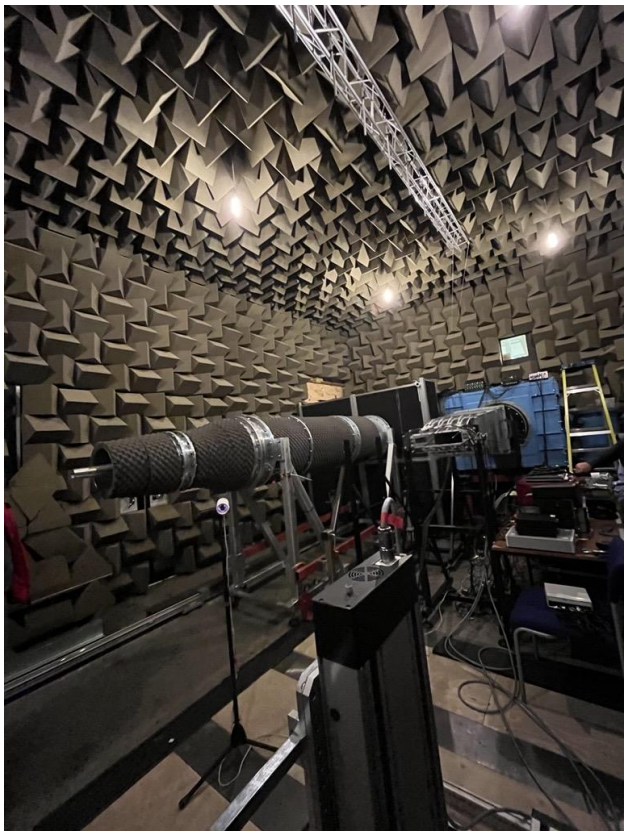

Figure 2 Wind Facility at University of Southampton

Following the occurrence of wind induced noise encountered on a type of glass insulator string that was supplied to National Grid in 2016, National Grid designed a wind tunnel test regime which initially benchmarked various types of insulators already in use on the network against one another. This test was refined and used as part of type-registration for new designs put forward by suppliers, including glass, porcelain, and polymeric designs. Currently this is included as a requirement in National Grid Technical Specification TS 3.04.36 *'Insulators and Insulator Sets for Overhead Lines'.*

Moving forward, National Grid is after a repeatable type-test regime for newer components which may include a combination of wind tunnel testing and computer-based modelling. Ultimately this will help ensure that components do not produce unwanted or unexpected wind-induced noise when put in service.

2. Innovation Zero London

The Innovation Zero congress is a platform for engaging debates and discussion on critical sustainability issues, whilst also highlighting the innovations and technologies that have the potential to help the UK achieve its net zero targets in the coming years. The congress typically has an attendance of around 10,000 delegates and invites notable speakers from the Government and leading energy companies. A new feature this year was the Innovation Gallery, which showcased the cutting-edge solutions of over 20 leading green tech start-ups and businesses aimed at addressing climate challenge. Amongst these businesses were energy storage pioneers, carbon credits platforms, heat saving innovators, net zero energy specialists and other tech firms.

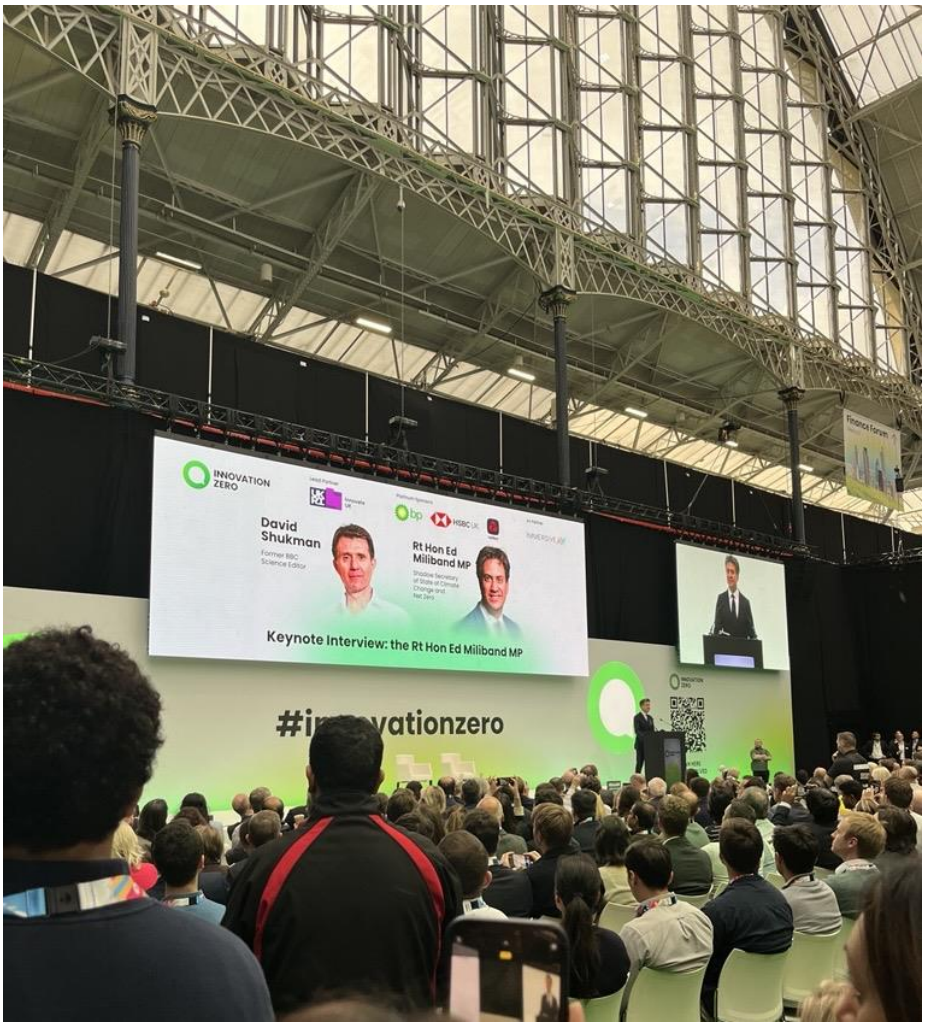

Figure 3 Keynote Speech from Edward Miliband (Secretary of State for Energy Security and Net Zero of the UK)

3. Mission Innovate

Mission Innovation (MI) is a global initiative of 23 countries and the European Commission (on behalf of the European Union) who work collaboratively to address climate change and support the development of innovative technologies. MI runs regular seminars to foster cross sector collaboration where I had the opportunity to present the Vehicle to Grid project (detailed in the first quarterly report) to an international audience.

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