2024 Annual Innovation Report

March 2025

1. Foreword

We are delighted to publish our report on the innovation and research we have carried out across EirGrid and SONI in 2024, and give some insight on the areas of focus in the next 12 months to continue to transform the power system for future generations in a secure and affordable manner.

Innovation and research are important to EirGrid and SONI as they are essential to addressing the challenges and opportunities which lie ahead as we accelerate to deliver on the Governments' policy ambition. This approach has allowed us to unlock solutions and initiatives to realise secure, affordable and sustainable energy benefits. EirGrid and SONI have innovated and continue to innovate to deliver key projects, such as Shaping Our Electricity Future Roadmap Version 1.1[1], Tomorrow's Energy Scenarios and Rate of Change of Frequency.

We are continuously working on optimising our Innovation and Research Strategy[2] focused on the necessary support structures, frameworks, and the people and research institutes who help make innovation part of who we are, as well as how we go about our work for the energy citizen in both jurisdictions. This strategy is focused on driving the innovation and research required to meet the government set targets.

Collaboration and knowledge sharing with our partners is a fundamental part of how we separately and collectively seek to deliver on our current commitments to our strategic innovation programmes. Looking forward, we are seeking to strengthen existing relationships, as well as build new ones as partnerships and relationships within the power system ecosystem are vital to enable further innovation as part of our strategic programmes of work.

The proposed strategic innovation programmes are EirGrid and SONI's view of the important areas of innovation to be investigated. Our innovation and research strategy will ensure we can deliver effective solutions to a wide range of technical, economic and social challenges that have been identified by the Shaping Our Electricity Future Roadmap.

It is vital we begin our journey of discovery now and introduce disruptive innovation into our planning and operational practices as soon as we can. We need to understand what options and solutions are best for Ireland and Northern Ireland, to ensure we are on the right path to deliver on a reliable and cleaner energy future. Our collaboration with the research and third level institutions is accelerating the work we are doing and also developing the future energy leaders in Ireland and Northern Ireland.

Gerard Carlin,
Director of Networks and Innovation,
SONI

Liam Ryan,
Chief Transformation and Technology Officer,
EirGrid Group

[1] EirGrid and SONI, Shaping Our Electricity Future Roadmap, 2023 EirGrid | SONI
[2] EirGrid and SONI, Innovation and Research Strategy, 2023 EirGrid | SONI

2. Executive Summary

Welcome to the 2024 Annual Innovation Report that is published for public awareness. The report outlines our progress in the Innovation and Research area over the 2024 calendar year. This report follows a similar structure to the previous 2023 Annual Innovation Report.

We share the details of the projects we have progressed in 2024 and group them under our nine Strategic Innovation Programmes which are key to our Innovation & Research Strategy.

In 2024, we published 17 research papers, worked with over 20 external bodies and captured over 90 ideas in our innovation process. This report focuses on 32 projects in detail. Over the year we completed 9 projects and progressing the rest of the 23.

We have identified a new initiative which focuses on Evidence-Based Environmental Guidelines (EBEG). We share the background work, propose some options and present our preferred option.

The report documents progress of EirGrid and SONI on innovative programmes throughout 2024 and points out our ambition for future developments of programmes and new initiatives to begin.

Contents

Version	Publication Date	Changes
1	11/2/2025	Version published for public consultation
2	31/3/2025	Version published after public consultation
3	15/5/2025	Graphics updated in section 5

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3. Introduction

EirGrid operates and develops the electricity transmission system in Ireland and, more recently, has been mandated to operate, develop and own Ireland's offshore grid. SONI has the responsibility of operating and planning the development of the electricity transmission system in Northern Ireland. EirGrid and SONI operate, implement changes and enhance the wholesale electricity market on the island of Ireland. EirGrid also develops and operates interconnectors with neighbouring grids. EirGrid and SONI also enable third-party interconnectors. We send power from where it is generated to where it is needed.

Both EirGrid and SONI have a critical role to play across the island in helping to deliver on the respective climate targets. We are world leading Transmission System Operators (TSOs) in variable non-synchronous renewable electricity integration. Through the successful progress of strategic innovation programmes such as DS3[3], we have developed solutions that allow us to currently operate the system with up to 75% renewable generation at any given moment, from wind and solar generation. Our collective ambition is to achieve whole economy net zero carbon emissions, in a sustainable and affordable manner resulting in the need for a transformed energy system. The key to this transformational journey is our ability to innovate and address ever more complex system, market, and infrastructure challenges.

In Ireland, the Climate Action Plan 2024[4] (CAP 24) targets 80% of electricity to come from renewable energy sources by 2030. It also specifies carbon sectoral emissions ceilings for the electricity sector as 40 MtCO2eq for 2021 to 2025 and 20 MtCO2eq for 2026 to 2030. CAP 24 sets an objective to reach a climate neutral economy no later than 2050.

In Northern Ireland, the Climate Change Act[5] targets 80% of electricity to be generated from renewable energy sources by 2030 and the UK Net Zero Strategy[6] targets carbon net zero by 2050 as well. The Climate Change (Carbon Budgets 2023-2037) Regulations (Northern Ireland) 2024[7] set out carbon budgets for 2023-2027, 2028-2032 and 2033-2037.

In our current Shaping Our Electricity Future Roadmap for Ireland and Northern Ireland, we provide an outline of the key developments from a networks, engagement, operations and market perspective needed to support a secure transition to at least 80% renewables on the electricity grid by 2030. The roadmap also provides a foundation to support the broader transition to net zero by 2050. The roadmap not only gives us an integrated vision of the 2030 power system and electricity markets but identifies key areas of innovation and how to implement them: to allow delivery of ambitious government targets for Ireland and Northern Ireland.

The Annual Innovation Report is a key deliverable for EirGrid detailed in the CRU's PR5 Regulatory Framework Incentives and Reporting, CRU/20/154[8]. The Annual Innovation Report is also a key deliverable in forming part of Role 2 Independent Expert within SONI's Forward Work Plan 2024/25[9] under project ID FWP019. Through this project we will consult with industry on the multi-year innovation programmes, consider all responses provided and use this to inform our decision-making process and publish a final version of the Annual Innovation Report.

This Annual Innovation Report documents progress of EirGrid and SONI on innovative programmes throughout 2024 and points out our ambition for future developments of programmes and initiatives. The innovation programmes mentioned here reflect the ambitions of our Innovation and Research Strategy. Please note that we are including a proposal for a new programme of work, Evidence-Based Environmental Guidelines, and this is expanded in Section 0. We welcome feedback on this report to enable us to gather the views of our stakeholders, and ensure the projects are deemed appropriate by all.

[3] DS3 Programme EirGrid | SONI
[4] Climate Action Plan 2024
[5] Climate Change Act (Northern Ireland) 2022
[6] UK Net Zero Strategy 2021
[7] The Climate Change (Carbon Budgets 2023-2037) Regulations (Northern Ireland) 2024
[8] PR5 Regulatory Framework Incentives and Reporting, 2020
[9] SONI Forward Work Plan 2024/25

4. Innovation in 2024

90+ Over 90 ideas captured in our innovation process	**32** 32 projects described in detail in this report
17 17 research papers produced in 2024	**20+** Over 20 external bodies involved in collaborative projects

In 2024, we captured over 90 ideas that covered various innovation or research projects and covered process improvements. As some of these ideas are in their infancy and some are process improvements which we classify as our incremental innovation, we are reporting on 32 projects in this report in greater detail.

4.1. Incremental Innovation

Some ideas were covering improvements in our processes and finding new ways of doing some of our usual activities. Key highlights are below:

- We are working on our Innovation processes based on the ISO 56 000 series of standards. ISO 56000 covers a state-of-the-art innovation playbook and set of practical support tools and methods. This aims to provide strategic innovation management guidance to build and grow business.
- Informed by ISO 56 000, we are investigating available tools for capturing innovative ideas and progressing them to completion. Such dedicated tools would make the innovation management more systematic, thus driving innovation projects from inception to fruition faster.
- We have developed Python scripts to help us model new trends in flexibility. Various studies are carried out on flexibility, and we are incorporating their findings into our modelling by developing our own specific tools (Python scripts) to help us include future flexibility into our modelling.
- We carry out projects across multiple teams and departments. Thus, we are continuously improving our processes in making collaboration more efficient. For example, internal websites with key information to help employees across the organisation to find the required data.
- A significant number of studies we carry out use a lot of data from various teams within the organisation and external sources. We develop tools to automate the data collection and data checking as input data quality is very important for the study output to be useful.

4.2. Research Papers

We also have worked with over 20 external bodies over the various projects, and during the year we produced 17 research papers which can be found below:

1. Maximising power transfer and RES integration using Dynamic Line Rating (DLR) technology: Ireland TSO experience; CIGRE 2024.
2. The Idea of Fed-Balancing Energy Market, a Smart Use of Balancing Capacity Auction Results; CIGRE 2024.
3. A Data-Driven Machine Learning Framework for Day-ahead Estimation of Dynamic Line Rating in Power Systems; CIGRE 2024.
4. Transforming the power system for future generations – the role dynamic capacity markets and de-rating factors; CIGRE 2024.
5. Novel Settlement Mechanism for Encouraging Flexibility in the Balancing Markets; CIGRE 2024.
6. Future Electricity Market Design to Ensure Resilient and Efficient Operations; CIGRE 2024.
7. Enhancing the Evaluation of Rate of Change of Frequency During Fault Contingencies Simulated in Phasor-Domain Tools; CIGRE 2024.
8. Voltage Harmonics Trends based on Field Measurements on the Irish Transmission Network; CIGRE 2024.
9. Development of Look-ahead Reactive Power Resource Optimisation Tool for Voltage Security in IBR Dominated Systems; CIGRE 2024.
10. Impact of Converter-based Demand on Frequency Quality in the Ireland and Northern Ireland Power Systems; CIGRE 2024.
11. High Inverter-Based Resource Integration: The Experience of Five System Operators; in IEEE Power and Energy Magazine, vol. 22, no. 2, pp. 78-88, March-April 2024.
12. Dealing with interactions in modern power electronics dominated power systems; in CIGRE Future Connections, May 2024.
13. Stability Assessment of Low-Inertia Power Systems: A System Operator Perspective; IEEE PES General Meeting, Seattle, WA, 21-25 July 2024.
14. Emerging Challenges of Integrating Solar PV in the Ireland and Northern Ireland Power Systems; IEEE PES General Meeting, Seattle, WA, 21-25 July 2024.
15. Tackling Solar Energy Integration Challenges on the Ireland and Northern Ireland Power System; in 23rd Wind and Solar Integration Workshop, October 2024.
16. Power System Dynamic Modelling and Analysis in Evolving Networks; in CIGRE Green Books, August 2024.
17. On the Negative Correlation of Stochastic Voltage Dependent Loads; accepted for presentation at the 23rd Power System Computation Conference, Paris-Saclay, France, 4-7 June 2024.

The research work explained above has clear potential future applications to our activities. For example, one project aimed to enhance grid efficiency by accurately predicting day-ahead dynamic line ratings without the need for physical sensors. By leveraging machine learning, this approach eliminates sensor installation and maintenance costs while improving real-time capacity forecasting. This enables better grid utilisation, reduces congestion, minimises curtailments of renewable energy, and enhances system reliability.

Another paper explored the future challenges facing the all-island power system as it integrates a substantial 8 Gigawatt (GW) of solar generation capacity, including 2.5 GW of embedded Photovoltaic (PV) by 2030. The study identifies four key challenges: minimum operational demand, ramping effects, short-term variations, and post-fault behaviour. To address these challenges, several potential solutions has been recommended: Enhance the visibility of Distributed PVs (DPVs), improve forecasting, increase the system strength, reduce the system's dependency on conventional units, enhance DPV controllability, update emergency protocols, develop dynamic models of aggregated DPVs, TSO–Distribution System Operator (DSO) model exchange, enhance DPV fault-ride-through capability, mandate DPV voltage support requirements.

EirGrid and SONI have a proven track record in the delivery of transformational innovation in support of the energy transition and we are currently delivering a portfolio of innovative projects to achieve the government targets. These targets now necessitate enhancing and accelerating EirGrid and SONI's approach to overcome the identified limitations of many established technological, operational and market practices. We need to act now to encourage an even greater innovation culture across both companies so that we have the capability to create novel solutions to address whole system challenges.

Our Innovation and Research Strategy aims at enhancing our capabilities within these fields. It is designed to help us become more innovative by putting in place the necessary support structures, frameworks, and to maintain continuously evolving mindset that promotes innovation, so that our staff are empowered to enhance our innovation and research capability.

4.3. Strategic Innovation Programmes

The strategic innovation programmes identified as part of the strategy are EirGrid and SONI's view of the crucial areas of innovation and research that we need to focus on to ensure we can respond effectively to the challenges ahead. These programmes were developed with external engagement as our Innovation and Research Strategy was developed. These programmes are expanded in the next few pages.

Please note that Annex 1 contains more details on each project and Annex 2 contains the list of terms and abbreviations.

Project status descriptions are listed below:

- Completed – project has been completed and project has no outstanding actions.
- In progress – project has a scope agreed, resources are available, and work is being carried out.
- Initiated – project is in scoping stage or scope is agreed but project work is not started yet.

Enhance data-driven decision-making leveraging artificial intelligence capability

Objective

Support the development of EirGrid and SONI's next generation artificial intelligence capability to enhance data driven decision making and transparency.

Benefit

Continue the collaboration at EirGrid and SONI for next generation artificial intelligence technologies and use cases. Build EirGrid and SONI's capability in explainable artificial intelligence and promote data governance and open data to bring society, decision-makers, and industry on the machine-enabled decision-making journey. Explore opportunities to use artificial intelligence and/or machine learning (AI/ML) capabilities across a variety of areas including network planning, forecasting within both control centres and predictive maintenance to support asset management for EirGrid.

Projects

Completed

- **Control Centre Tools Implementation**
  Implementation of Look-Ahead Security Assessment, Voltage Trajectory and Ramping Margin Tools to increase levels of instantaneous renewable generation.

In progress

- **Exploring how AI/ML can help determine strategic network reinforcement projects in the transmission system including technology, length of cable/overhead line etc.**
  Project to prioritise network reinforcement projects to achieve CAP targets more efficiently, considering an AI-based method for faster, streamlined analysis due to limited resources and the computational intensity of their current non-AI project.
- **Virtual Dynamic Line Rating Sensors**
  Project aims to alleviate network congestion and improve grid efficiency by using advanced weather forecasting and AI to predict dynamic line ratings without costly hardware sensors.

Initiated

- **Exploring how AI/ML can help determine strategic storage, demand or generation projects in the transmission system, including technology, export/import capacities, duration of storage, etc.**
  Project aims to prioritise the integration of new storage, demand, and generation projects to achieve CAP targets more efficiently, considering an AI-based method for faster, streamlined analysis due to limited resources and the computational intensity of their current non-AI project.

Status and Vision

Artificial intelligence and machine learning are a very active area across multiple sectors and the energy sector is not an exception. We are working on individual projects to better evaluate the capability of such tools and will be developing a more structured approach to this in the near future.

Flexible Network Strategy

Objective

Continue understanding and utilising the benefits of flexible network technologies to maximise the use of the transmission grid while minimising the requirement for new network build.

Benefit

To meet our carbon emission and renewable energy targets, we have investigated flexible network technologies, such as Dynamic Line Ratings and Dynamic Power Flow Controllers. These technologies can provide a means to reduce network congestion, act as an alternative to extensive new network build, provide system services/operational flexibility, maximise utilisation of existing network assets, enable greater output from Renewable Energy Sources of Electricity (RES-E) generation hubs and create potential economic/reliability benefits. We are at a stage where we are implementing these technologies while finding innovative ways of extracting the most benefit. For example, understanding most suitable locations for large scale demand and generation.

Projects

In progress:

- **Dynamic Line Rating**
  Trial and investigation of DLR devices to enable usage of real-time thermal loading limits to increase existing network capacity. Capital investment approved for 12 lines.
- **Dynamic Power Flow Control**
  Procurement and installation of modular, easy to re-deploy devices to maximise existing network capacity.
- **NexSys - Enhanced utilisation of power system network infrastructure**
  Investigate the benefits of existing and future technologies that could improve the real-time utilisation of existing networks and push operational stability limits higher.

Status and Vision

We had great success in understanding dynamic line rating and dynamic power flow control technologies and thus are focusing on their implementation as documented in the project descriptions in Annex 1.

The plan is to do more horizon scanning to identify other technologies with a high Technology Readiness Level to focus on implementation and also investigate technologies that need more research to mature and make them closer to implementation ready.

Champion the Emergence of the Energy Citizen

Objective

Continue understanding and facilitating consumers' changing interaction with power system technologies and services.

Benefit

Continue enhancing EirGrid and SONI's understanding of all aspects of an active energy citizen, their behaviour and what drives their choices. Prepare EirGrid and SONI to play our role in facilitating the relevant national policies with respect to community participation and best practice pre-application community consultation programmes. Trial and iterate solutions to gain deeper understanding of new energy technologies (for example small scale PV, smart tariffs etc), the scale of consumer investment and how these can support EirGrid and SONI transform the power system for future generations. Support our public engagement strategies by disseminating best practice research on community engagement and participation.

Projects

Completed:

- **CleanerGrid 2023/24**
  Competition for third-level students to use data from Smart Grid Dashboard and/or from the Single Electricity Market Operator (SEMO) website to create a digital prototype of a website, application or dashboard that will encourage citizens to be more mindful of their energy use at times of peak demand and encourage them to flexibly adapt their electricity use.

In progress:

- **CleanerGrid 2024/25**
  Competition for third-level students to present their vision of what the growing energy sector will need to look like in 2050 to have sustainably achieved net-zero emissions.
- **Public Engagement with Energy Transitions in an Era of Climate Crisis**
  Impartial analysis of EirGrid's evolving public engagement processes, based on a mapping of actors, and a framework to codify different elements of existing strategies.

Status and Vision

We have had great success with the 'Public Engagement with Energy Transition in an Era of Climate Crisis' project. As this project is nearing its end, we will be exploring the lessons learned and identifying future potential studies in similar areas.

We are building on the success of the inaugural CleanerGrid competition which started in 2023 and concluded at the beginning of 2024. We are continuing this to engage with third level students to explore various opportunities which may occur in the future.

This is an area that keeps evolving and we will be looking for potential collaborative projects.

Understanding pathways to 100% SNSP

Objective

Translate net zero carbon pathway research into real-world trials of next generation technologies and routes to integration.

Benefit

Enhance EirGrid and SONI's understanding of pathways to 100% System Non-Synchronous Penetration (SNSP) by assessing the impact and real-world performance of mass integration of emerging technologies such as inverter-based resources (wind and grid scale Photovoltaics (PV), grid forming control, electrolysers, and distributed energy resources (for example small scale PV). Prepare EirGrid and SONI to operate at 100% SNSP by delivering minimum viable products and trials to further inform EirGrid and SONI's understanding of the solutions required and routes to integration.

Projects

Completed:

- **Roadmap for implementation of electromagnetic transient study capabilities in EirGrid and SONI**
  Develop a roadmap for the implementation of electromagnetic transient study modelling and simulation capabilities at EirGrid and SONI.

In progress:

- **Increasing SNSP limit to 80%**
  To meet the 2030 climate targets, Ireland and Northern Ireland need to integrate more renewable energy into their power systems, and this study assesses the impact of increasing the SNSP limit from 75% to 80%.
- **Low Carbon Inertia Solutions Phase II**
  The Low-Carbon Inertia Services (LCIS) program Phase II aims to address future system inertia needs and placement, anticipating increased wind and solar generation and operation with a single synchronous generator, following the successful Phase I procurement of 10,963 Megavolt Ampere (MVA.s of inertia.
- **Modelling and Analytics of Emerging Technologies**
  Investigate the need for improved inverter-based resource (IBR) models and tools to enable planners to accurately simulate and assess power systems with high IBR penetration levels, as well as refining and verifying aggregated distributed energy resource (DER) models.
- **NexSys - Mitigation of Extreme Weather Events on High-RES Dependent Network**
  Analyse temporal and spatial resolution data to consider the role of high voltage direct current (HVDC) links and the spatial correlation of low-RES events across Europe.
- **Sources of very low frequency oscillations**
  Develop an offline tool for identifying the source of very low-frequency oscillations for the All-Island Power System.
- **System Strength Definition**
  Define system strength for the All-Island power system with high-level Inverter-Based Resources, establish appropriate metrics for various timeframes, and identify methods for evaluating and monitoring these metrics both offline and online.

- **Tackling Solar Energy Integration Challenges**
  This project investigates the challenges of integrating 8 GW of solar generation, including 2.5 GW of distributed PV, and provides recommendations to address these challenges.

Initiated:

- **Short-Circuit Modelling and Protection System Performance Analysis for Systems with High Level of Inverter Based Resources**
  This research project investigates the impact of Inverter-Based Resources on EirGrid's protection system, using advanced short-circuit models to assess fault responses, identify challenges, and propose mitigation measures.

Status and Vision

This is a very active area for EirGrid and SONI. In order to meet Government targets, we have to find ways to operate the grid with higher levels of generation from renewable sources.

We had success at achieving high levels of SNSP and we are continuing to push ourselves to find ways at operating the gird at even higher levels.

As these levels start to increase, we find the grid operating in conditions it did not operate before, and we encounter phenomena not seen before. As a result, a big focus will be to continue to work on how to increase the SNSP level but also to understand how the grid behaves when it is operated at such high levels.

Setting the course for the Control Centre of the Future

Objective

Identify what security tools and capabilities are required to maintain the protection of EirGrid and SONI's control centres now and in the future.

Benefit

Maintain the use of only the best security tools with regard to detection, protection and monitoring. Foster excellent relationships with reputable, well-established security partners. Continue to improve and modernise security posture to meet the demands of the evolving threat landscape. Intensive engagement of the Enterprise Security team in identifying new tools and features as well as establishing the Control Centre of the Future.

Projects

In progress:

- **Operational Tools & Capability Enhancement**
  The programme aims to develop the Control Centre of the Future and enhance operational capabilities to manage a power system with high levels of variable non-synchronous renewable generation.

Status and Vision

This is an area we are focusing on to develop and the aforementioned programme is a great step at setting a plan for us to work to in the near future. We will work with our partners to scope projects to advance us in this area.

Lead the island's electricity sector on sustainability

Objective

Accelerate and expand implementation of existing grid-wide evidence-based environmental measures, and wherever possible, move beyond impact avoidance/reduction to enhance the environment in response to the biodiversity and climate emergency.

Benefit

Continue to enhance EirGrid and SONI's and society's understanding of the impact the power sector has on the all-island environment, and support learning and skill development to achieve the transition. Deliver societal benefits and support societal engagement with EirGrid and SONI by publishing evidence of clear and measurable action on environmental protection and enhancement. Prepare EirGrid and SONI to innovate alongside our stakeholders and customers in the pursuit of a fully sustainable and circular power system with minimal impact and enhancement of the environment over every timeframe. EirGrid and SONI will continue to evaluate emissions based on Science Based Targets and will make any results transparent. Integrate and retrofit assets with biodiversity mitigations and, where possible, enhancements. Standardise Nature Inclusive Design (NID) on EirGrid delivered offshore grid assets and support and advise developers in their own sustainable contestable design. This requires consideration of the effects of the continued growth of offshore windfarms on marine ecosystems to include hydrodynamics and sediment transport, fisheries, birds, and marine animals.

Projects

Completed:

- **Fast Frequency Response (FFR) Product Review**
  This project aims to inform decisions on categorising Fast Frequency Response (FFR), aligning its definitions and requirements for both directions, considering different FFR needs for Ireland and Northern Ireland, and defining FFR response characteristics.
- **Fuel Mix Disclosure – Automation of Quarterly Calculations**
  This project aims to design, test, and implement an automated fuel-mix calculation for suppliers in Ireland and Northern Ireland, using a Python-coded data processing pipeline that integrates multiple data sources and utilises Azure Cloud resources and Microsoft automation tools.

In progress:

- **Nature Inclusive Design including Biodiversity Enhancement**
  Series of nature restoration projects exploring planting shallow-rooted native shrubs, building back better at passing bays and retrofitting certain overhead line uprate projects with bird diverters.

Status and Vision

We have had great progress on the projects mentioned in this section. Our next step is the proposed initiative as it is outlined in Section 8 regarding the Evidence-Based Environmental Guidelines (EBEG).

Prepare for a multi-purpose offshore HVDC grid

Objective

Understand the capabilities and dependencies to delivering a multi-purpose, multi-terminal, multivendor high voltage direct current (HVDC) grid.

Benefit

Continue enhancing EirGrid and SONI's understanding of HVDC technologies and their development roadmap. Prepare EirGrid to embrace and develop HVDC assets considering the asset lifecycle from technology qualification to asset management. Prepare EirGrid and SONI to support the development of multi-purpose HVDC grids for offshore by understanding the implications for infrastructure development, multi-jurisdictional grid operation and multi-purpose, multi-jurisdictional markets. Participate in international working groups to further develop policies, technical standards, financial and legal frameworks for HVDC offshore grids.

Projects

Completed:

- **Increased ramp rates**
  A trial is being proposed, where the ramp rate limit on East West Interconnector and Moyle Interconnector will be adjusted.

Status and Vision

This is an area where EirGrid has been involved in various collaborative studies and workshops. The next step will be to collect the knowledge gained for the various engagements and build a plan for the next few years of focus topics for this Strategic Innovation Programme.

Grow EirGrid TSO capabilities for developing and operating the new offshore grid

Objective

Support EirGrid to develop scalable processes and solutions to manage the development of an offshore network.

Benefit

Enhance EirGrid's understanding of best practice and next generation offshore Transmission Asset Owner capabilities and solutions. Prepare EirGrid to fulfil its role in the planning, development, operation, and maintenance of an offshore transmission system throughout the three phases of the network development model. Enhance ways of engaging with communities and developers through novel solutions, processes, and data. Reduce the cost and risk of working offshore through digital solutions.

In Northern Ireland, SONI continues to support the Department for the Economy in its development of an Offshore Renewable Energy Action Plan.
This includes a collaborative approach with a number of key stakeholders and government departments.

Projects

In progress:

- **Offshore Wind Development Harmonic Distortion Mitigation Co-ordination**
  This project aims to ensure that the five offshore wind developments of phase-one, connected by long cables to the same region of the transmission system, operate coherently without negatively affecting each other, by investigating interactions and optimising mitigation measures.
- **Offshore Wind Supplemental Programme**
  To fill critical knowledge gap by providing a collaborative, cross-cutting research platform to address offshore wind-specific research and development needs throughout the project lifecycle.

Status and Vision

Initiating a structured Offshore Wind Supplemental Programme is a great start for this Strategic Innovation Programme.

This is an area where EirGrid has been involved in various collaborative studies and workshops. The next step will be to collect the knowledge gained for the various engagements and build a plan for the next few years of focus topics for this Strategic Innovation Programme.

Plan for a net zero carbon, customer focused, export capable power system

Objective

Facilitate a plan-led, whole system approach to scheduling and exporting large volumes of renewable energy via electrical interconnection or via emerging energy carriers such as hydrogen and its derivatives.

Benefit

Continue to enhance EirGrid and SONI's understanding of the opportunities and challenges resulting from a range of emerging renewable technologies that are quickly becoming technologically and economically feasible at large scale, for example solar PV and offshore wind. Continue to investigate production scenarios of hydrogen and its potential to act as a long-term seasonal store of renewable energy. Continue to investigate other technologies to complement Ireland and Northern Ireland's large renewable resources such as batteries, pumped hydro storage and additional electrical interconnection with neighbouring countries. Prepare EirGrid and SONI to facilitate and capture benefits arising from the mass deployment of these new technologies and the benefits to the power system and its customers of potentially becoming an energy exporter.

Projects

Completed:

- **National Resource Adequacy Assessment Model Development**
  This project aims to develop an enhanced methodology for national resource adequacy assessment to monitor the reliability of a 100% renewable power system, replacing the Generation Capacity Statement and aligning with European modelling activities.
- **Non-Wires Alternatives – Outage Transformation Programme**
  The project aims to identify which non-wire solutions beyond those already employed by EirGrid can facilitate additional outages on the grid in the EirGrid's context.
- **SEM/GB Multi Region Loose Volume Coupling Research Project**
  The aim is to have an informed view on the current and future direction of Great Britain's (GB's) market and the possible implications for the Single Electricity Market (SEM).

In progress:

- **HyLIGHT**
  Programme to provide the knowledge, data and the necessary tools to guide decarbonisation and roadmaps for large-scale implementation of hydrogen technologies in Ireland.
- **Net Zero Markets**
  This project aims to identify additional non-wire solutions to facilitate more planned outages on EirGrid's network without requiring permanent grid reinforcements.

Initiated:

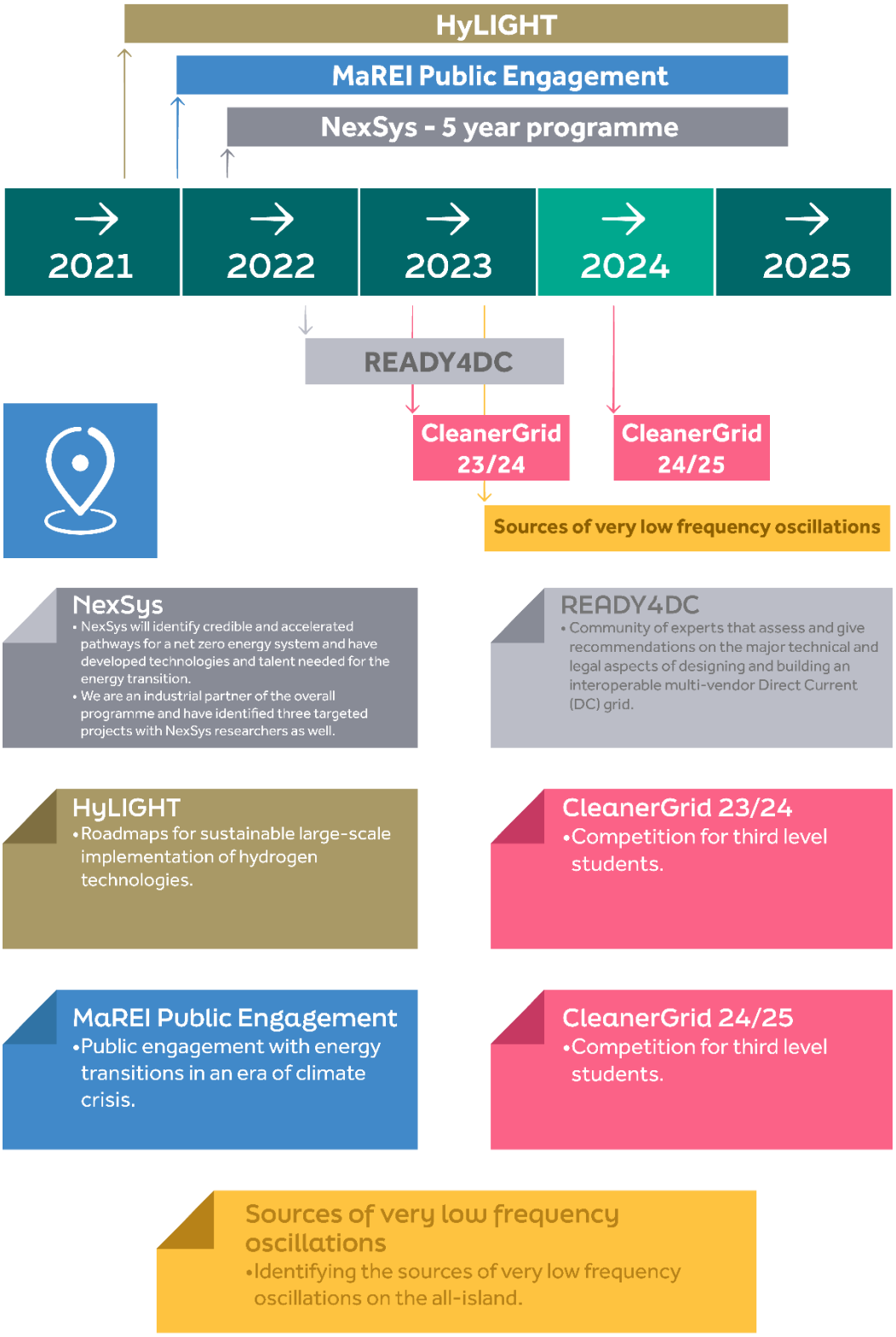
- **NexSys - Impact of Green Hydrogen Integration onto the All-Island Power System**
  Investigate optimal location, scheduling and dispatch of electrolysers as well as the impact of largescale hydrogen production from offshore wind on the SEM.

Status and Vision

This programme has a very wide focus as it is addressing areas that may help achieve the net zero system. We have had successful engagements in understanding the potential hydrogen may have in the future. We will be continuing scoping projects to consider different technologies and also consider areas such as market impacts such change may have.

5. Key projects and memberships

The illustration below shows a selection of our commitments between 2021 and 2025 and gives an idea how innovation projects in 2024 fit into the longer-term plan.



We also hold several memberships to support our innovation and research. The key ones are listed below:

Electric Power Research Institute (EPRI) membership

- Membership gives us access to independent, objective thought leadership and industry expertise on a very wide range of topics. Energy transition is supported by the various studies and collaborative work carried out with EPRI.

Energy Systems Integration Group membership

- Membership gives us access to the group's expertise in modern energy systems, focusing on the combined strength of electricity, heat and fuel systems. This is extremely beneficial to us as all these sectors working together will help us meet the government set targets.

Industry Research and Development Group membership

- Membership gives us access to a wide Innovation Network of member companies and colleges. It allows us to work together to drive excellence in innovation.

European Network of Transmission System Operators for Electricity Research Development and Innovation Committee

- Working collaboratively with other European TSOs on addressing common challenges.

6. Innovation Trials Sandbox

EirGrid and SONI are actively exploring the establishment of an Innovation Trials Sandbox as a means to support the development and introduction of novel and emerging technologies, products and business models in the power system ecosystem. Both the 2021 and 2022 Annual Innovation Reports have mentioned Innovation Trials Sandboxes and requested feedback from stakeholders. This feedback was positive, with all responses being in support of such an arrangement. The 2023 Annual Innovation Report, in turn, discussed a renewed focus on a Data Sandbox as a potentially beneficial iteration of the concept. This was included as part of the consultation on the report, and respondents were largely positive in their reception.

6.1. Data Sandbox

EirGrid and SONI have previously explored the development of Data/Analytics Sandbox. This was accomplished through a research discovery phase and consultation with internal subject matter experts, which pointed to value in such a data-focused sandbox environment. The intended benefit of such data sandboxes is that innovative companies could potentially access data that is useful for trialling of systems and controls that are able to unlock efficiencies that will enable a net-zero power system. This would occur in a safe and controlled environment, enabling fast-fail or accelerated delivery of successful products that are closer to production ready. In the field of innovation, there are risks and rewards that should be acknowledged, such as risk of low-quality data from TSO or risk that third parties are unwilling to share findings. In such cases, mitigations are the controls and ability to terminate trials.

We have engaged in an academic consultation into best practices and the potential of Data Sandboxes in the proposed form. Results were largely positive, drawing on successful use cases by international electrical utilities and pointing to the potential of developing a full business case for an EirGrid and SONI specific Data Sandbox. Furthermore, as mentioned previously, consultation on the 2023 Annual Innovation Report indicated broad support for a Data Sandbox arrangement by respondents.

Despite these initial positive indicators, EirGrid and SONI have currently paused activities directly related to the Data Sandbox initiative. This decision was made due to current limitations with open data spaces and associated security risks but was also informed by current industry trends in Artificial Intelligence and Machine Learning which are viewed as a priority.

7. Evidence-Based Environmental Guidelines (EBEG)

We have identified a new programme of work we want to focus on. We present the background to this, share some options and present our proposal.

7.1. Introduction and Context

In April 2012, EirGrid published the Grid25 Implementation Programme 2011-2016, and associated Strategic Environmental Assessment (SEA). The SEA identified a number of Environmental Mitigation Measures envisaged to prevent, reduce and, as fully as possible, offset any significant adverse impacts on the environment of implementing the Implementation Programme.

Environmental Mitigation Measure 3 concerned the preparation of EBEGs.

Between 2012 and 2016, EirGrid scoped, prepared and published a total of 10 EBEG volumes.

These comprised of a series of authoritative studies examining the actual effects of the construction and existence of transmission infrastructure in Ireland on various environmental topics, such as population, ecology and cultural heritage. The studies thereby provided evidence-based benchmarks to facilitate the robust preparation of projects – and related environmental impact assessments - with an evidence-based understanding of likely environmental impact.

The studies determined the actual effect, in respect of a number of environmental topics, of the construction and operation of transmission projects in a representative range of Irish environmental conditions – typical, non-standard, and worst-case.

While of significant value in terms of ensuring a robust environmental assessment in respect of EirGrid's various project planning applications, it also highlighted and reinforced EirGrid's standing as an environmentally responsible developer in dealings with various State consenting authorities, environmental and other authorities and agencies, as well as with communities and landowners.

It should be noted that, since the publication of these EBEGs, subsequently publish evidence-based authoritative Ecology Guidelines (revised once) and Cultural Heritage Guidelines for project development of transmission infrastructure, in collaboration with key State authorities such as the relevant Government Departments, the National Parks and Wildlife Service etc.

The 10 EBEG volumes and the 2 subsequent Guidelines have been distributed to Consultants working on behalf of EirGrid on various projects. This ensures a consistency and robustness to environmental assessments. It is no coincidence that there have been minimal environmental objections to planning applications, no Legal challenges, and no Refusals of planning permission since the publication of the studies; this of course has significant cost, and programme benefits for grid infrastructure delivery.

The studies, while authoritative, were conceived as an ongoing body of work that can be continuously updated to take account of new information and/or developments.

At this stage, the EBEGs are 10 or more years old. While much of these documents may remain relevant, there have been substantial changes to the type, scale, and quantum of EirGrid's project portfolio onshore and offshore, since their publication. Furthermore, as expected due to the passage of time, there have been significant changes to legislation and scientific understanding since the publication of the original EBEG. Driven by a continuous digital revolution, there has also been a continued growth in the engagement of the public, and wider civic society, in infrastructure projects, and public access to environmental decision-making.

As such, without updates and new research, the lack of updated EBEG introduces risk that

- The accelerated project delivery mandated by European law and Irish government will be hampered by legal challenge linked with inadequate environmental assessments
- Unforeseen environmental impacts arise, or are not adequately mitigated, and these adversely impact the public, Communities, built and/or natural heritage and other resources.

The key changes to the type, scale, and quantum of EirGrid's project portfolio are set out in the next sections.

7.1.1. Significant new onshore Underground Cable Projects

In recent years, in response to public feedback and other considerations, EirGrid has undergrounded significant new grid infrastructure. Whilst potentially considered generally favourable from an environmental perspective (e.g. given reduced visual impact, removal of bird strike impact), EirGrid has nevertheless established a growing evidence base for significant environmental impacts from Underground Cable (UGC) projects.

This is because the offroad sections of such UGC (while most cable is laid in road) result in significant impacts to biodiversity, rural farm boundaries, cultural heritage, and landscape and visual impact. For instance, the Kildare Meath (400 kV) Grid Upgrade is predicted to result in 1.5 km permanent hedge/treeline loss and a minimum of 365 trees at risk. The East Meath-North Dublin (220 kV) Grid Upgrade is predicted to result in 0.7 km permanent hedge/treeline loss and minimum of 542 trees at risk. Both projects additionally (temporarily) remove several kilometres of roadside hedgerows, to allow for temporary 'passing bays' during inroad cable laying.

Furthermore, the competition for services in the national transport network means laying cables in roads requires intensive collaboration on problem-solving conflicts with other local government, utility and transport agencies.

And furthermore, UGCs additionally disrupt farming activities, both from traffic disruption during inroad laying, and construction (and permanent access track requirements) in offroad sections. On the Celtic Interconnector project, significant archaeological finds have been identified offroad in rural eastern Cork with significant cost implications to the public purse, and programme delays arising from recording and reporting such finds.

The existing EBEG on Habitats, Bats, and Cultural Heritage do not comprehensively address the survey methods, impact prediction and mitigation options to resolve the above challenges with UGCs.

7.1.2. Significant new offshore projects

In 2021, EirGrid was designated as the owner and operator of the Celtic Interconnector (under construction), and as the offshore Transmission Asset Owner of all future grid connecting new offshore wind. This is in addition to EirGrid's existing role in developing and owning certain interconnectors. Specifically, as regards EirGrid's offshore projects:

- The Celtic Interconnector comprises 575 km subsea cable (500 km)
- Powering Up Offshore - South Coast is a project to build the new transmission grid infrastructure necessary to bring approximately 900 Megawatt (MW) of electricity onshore from wind farms in the sea off Ireland's south coast

None of the existing EBEG volumes comprehensively address the survey methods, impact prediction and mitigation options for offshore development (and including nearshore works below the High Water Mark). Specific risk areas form the gaps in the existing EBEG include:

- Cultural Heritage: The technical requirements to satisfy the Underwater Archaeology Unit of the National Monuments Service, including the protection of shipwrecks and the unique challenges posed by UGCs intersecting submerged peat forests of cultural heritage value in intertidal areas
- Ecology: Types of geophysical surveys, including use of Marine Mammal Observers, that reduce the effectiveness of the underwater noise abatements for cetaceans as well as the evidence base is

required for integrating technically viable and cost-effective Marine Nature Inclusive Design features into cable protection, and offshore substation scour protection
- Electromagnetic Fields (EMFs): The impact of EMF on both commercial and non-commercial fisheries, and the effectiveness of mitigation measures (including Target Burial Depth)

7.1.3. Changes to overhead line technologies

Key aspects of overhead lines requiring an updated evidence-based review include:

- The potential for new 'composite' polesets to mitigate landscape and visual impacts from steel masts, and other innovations such as pre-cast foundations and other technologies:
- The agreement with the Electricity Supply Board (ESB) (since 2019) on a retrofitting programme for bird flight diverters on any line being uprated, plus changes to ESB's own diverter specifications, and a new option to provide perch and nesting platforms posts to attract birds away from structures thereby mitigating fire risk.

7.1.4. Scientific, legal and technical developments across environmental fields

The scope of changes both nationally and internationally to law, guidance, and academic evidence affecting the ten EBEG volumes is too broad to summarise here. However, a common workflow to all topics is the need to update the literature review to update the knowledge base on predicted impacts, and effective mitigation options.

7.2. Progress to date

Since 2014, EirGrid, together with its consultants, have used the EBEGs to ensure robust environmental assessments of its projects. EirGrid has collaborated, to great reputational success, with various Statutory Authorities and non-Statutory agencies in the preparation of evidence-based guidelines for project development. Indeed, EirGrid's approach to environmental assessment, (including their novel approach encapsulated by the EBEG) was commended as best practice in the peer-reviewed scientific literature in 2019 (Gonzalez et al., 2019)[10].

The EBEG guidelines set environmental topic activities into the context of EirGrid's 6-Step Framework for Grid Development, meaning that project studies, surveys and assessments are carried out, at an appropriate time, with consequent project cost and time savings.

It has been particularly evident on some of EirGrid's largest projects, such as the Celtic Interconnector (consented), the Kildare-Meath Grid Upgrade (subject to consent), and the East Meath North Dublin Grid Upgrade cable (consented), that there has been little if any substantive objection to those projects on the grounds of environmental impact, as such impact can be predicted with authority against an empirical baseline, and mitigation measures applied.

Over this time, as EirGrid's environmental and biodiversity reputation has increased, there are a number of opportunities to build on the strength of the original EBEGs, both with revised and updated studies, but also related documents, reports, Codes of Practice etc. between EirGrid and State Authorities that continue to minimise objection in the consenting and delivery phases of project development.

As a snapshot, a number of key initiatives that EirGrid is undertaking, but which ultimately need to be reflected in updated EBEGs are set out in the following sections.

[10] González, A., Bullock, C., Gaughran, A. and Watkin-Bourne, K., 2019. Towards a better understanding of SEA effectiveness in Ireland. *Impact Assessment and Project Appraisal*, *37*(3-4), pp.233-246.

7.2.1. Underground Cable Projects

High Voltage Forum

To support development of high voltage electricity networks, a 'High Voltage Interface Forum' ('the HV Forum') was initiated between Key Partners within the Electricity and Roads Sectors to bring together stakeholders in open dialogue and establish the ways of working that will deliver on the CAP 24. This recognises the unique challenges presented by the accommodation of high voltage underground cables in public roads, where this is nevertheless the optimal solution. The HV Forum developed a high level 'Cooperation Agreement' in August 2023 which was agreed by relevant parties including EirGrid, ESB Networks (ESBN), Transport Infrastructure Ireland, Department of Transport, and representatives from Local Authorities.

The Roads Sector had expressed concerns about the potential effects of underground cables where they are located in roads, in terms of road asset integrity, performance and roads operations, traffic safety and disruption, as well as associated costs and liabilities. The HV Forum is delivering new standards for implementation on consultation, engagement, design, and costs to address these concerns and to optimise cable projects.

Through the HV forum, EirGrid has committed to assessing all reasonable alternatives in terms of underground cable routing (i.e. fully exploring in-road and off-road options). EirGrid consults with the Roads Sector at an early stage in its underground cable projects to ensure concerns and heard and addressed.

This commitment brings with it greater examination of off-road routes for underground cables. This would likely result in increased routing through hedgerows and treelines located on field boundaries as the cable travels across the countryside. Such cables will normally be trenched through hedgerows and treelines resulting in a hedged section being permanently removed. An Over Cable Planting Strategy has the potential to reduce the effects on hedgerows and treelines by allowing the affected area to be replanted post-construction.

Over Cable Planting Strategy

Since 2021, EirGrid has been developing an Over Cable Planting Strategy to mitigate the diverse impacts arising from the need to permanently remove hedges and trees above HV cables, when these must leave roadways and enter farmlands. As a result, key milestones to date (2023-2025) are as follows:

2023

- Confirmation of precedence by other TSOs in Continental Europe (Amprion, Transnet, Tennet) for planting of certain shallower-rooted shrubs and trees over HV cables at voltages comparable to those operated by Eirgrid Group.
- Establishment of a European Working Group on Planting over UGCs, under the Renewable Grid Initiative's Integrated Vegetation Management initiative11.

2024

- Establishment of an internal Working Group at EirGrid on Planting over HV UGCs supported by and reporting to the Chief Infrastructure Office, which supports and enables effective engagement with ESB on technical matters arising.
- Procurement of a Chartered Arboriculturist to identify suitably shallow-rooting, native shrub species, and planting specifications suited to farmland contexts.
- Drafting of a new standard detail for off-road cables (currently under agreement with ESB) providing for 1000m soil cover, and the integration of a high-performance Root Barrier Membrane.

[11] Launch of Best Practice Guide: Integrated Vegetation Management (IVM) in Europe

2025

- Costing and provisional specification of a high-performance root barrier membrane on the Kildare Meath Grid Upgrade, and East Meath to North Dublin Grid Project (in agreement with ESB).
- Agreement with ESB, to provisionally adopt EirGrid's draft strategy (subject to relevant provisos and further testing) within the ESB's new national trenching and ducting framework.
- Agreement with ESB to scope and price a lab-based test of the preferred high performance root barrier membrane specification, to derive a Thermal Resistivity, to allow integration into cable de-rating calculations.
- Procurement of a Root Radar specialist to validate estimated maximum root depths of candidate shrub species.

7.2.2. Submarine cable and offshore substation projects

FlatEMF Research Initiative

Anecdotal evidence suggests that EMF can influence (migratory) behaviour of commercial flatfish (see paragraph below). The fishing community has expressed concerns about the effects of EMF to the European Union (EU)[12]. These concerns have been noted by the European Unition which as a result stresses the need for further research into avoidance and mitigation of negative effects[13]. The evidence base for concerns of effects of EMF on flatfish is thin as only a couple field studies have been conducted[14] . More research is needed to facilitate a fact-based discussion on the impact of EMF resulting from subsea power cables on commercial flatfish species.

State of knowledge Flatfish are bottom-dwelling species, they naturally habit close to the (buried) offshore cables. It is hypothesized that plaice might be able to sense the Earth's magnetic or associated electric fields, because of their orientation skills[15]. In addition, a study found a significant difference in the number of European flounder (Platichthys flesus) that migrate over a cable emitting a small versus a large electromagnetic field. During low levels of EMF (lower than 50 MW, since direct EMF measures were not available) flounders passed the cable more often than during high EMF-levels[16]. This study was based on six individuals. Lastly, in a toxicity study where flounders were exposed to a 3.7 mT field (DC) for a period of 7 weeks, no difference in mortality was observed[17]

Following engagement with the Renewable Grid Initiative (RGI) on the above, EirGrid became consortium partner part-funding novel research on this matter, under the FlatEMF workstream[18]. Bimonthly meetings are chaired by the RGI.

In order to have a scientific foundation for a fact-based discussion, the FlatEMF initiative, has numbered Work Programmes (WPs) to combine a combination of ecological research (WP1), technical research (WP2) and community and stakeholder engagement (WP3).

[12] Eendracht Maakt Kracht (2019) Major Concerns Offshore Renewable Energy
[13] Official Journal of the European Union (Wednesday 7 July 2021) P9_TA(2021)0338, The impact on the fishing sector of offshore windfarms and other renewable energy systems, (2022/C 99/10)
[14] CSA Ocean Sciences Inc. and Exponent. 2019. Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA. OCS Study BOEM 2019-049. 59 pp.
[15] Metcalfe, J. D., B. H. Holford, en G. P. Arnold, 'Orientation of plaice (Pleuronectes platessa) in the open sea: evidence for the use of external directional clues', Mar. Biol., vol. 117, nr. 4, pp. 559–566, dec. 1993, doi: 10.1007/BF00349766
[16] Hvidt, C. B., M. Klaustrup, S. B. Leonhard, en J. Pedersen, 'Fish along the Cable Trace Nysted Offshore Wind Farm Final Report 2004', Orbicon as, Final report 02584872_A, 2006;
[17] Bochert, R. en M. L. Zettler, 'Long-term exposure of several marine benthic animals to static magnetic fields', Bioelectromagnetics, vol. 25, nr. 7, pp. 498–502, okt. 2004, doi: 10.1002/bem.20019
[18] Join the FlatEMF study to discover the impact of subsea electricity cables on marine wildlife

WP 1 - Ecological research consists of:

- Determining most suitable model flatfish species, which is of commercial interest and representative for the Irish Sea, Baltic Sea, English Channel and North Sea.
- Conducting field work which consists of (either/or) a bottom trawl study determining abundance, diversity and life history (size/age) of flatfish around cables under different circumstances (weather conditions, habitats and seasons) for both Alternating Current (AC) and if sufficient funds are available, also DC power systems incl. reference locations. Conducting a laboratory study on behavioural effects of different EMF levels designed to determine changes in foraging and migratory behaviour on adult fish (and possibly juveniles depending on available funding) in AC and DC power systems.
- Ensuring that lessons learned from other EMF sensitive species are included in the work and elements of this research are (where possible) applicable to other species.

WP 2 Technical research consists of:

- Identifying and releasing design specifications needed for magnetic field modelling; – Investigating EMF monitoring options (possibly included in design); Investigating mitigation options in terms of feasibility, costs, reduction.
- Developing modelling guidelines for EMF calculations.
- Investigating field measurements and modelling discrepancies, including geographical differences in geomagnetic field, ensuring the work is applicable to many locations.
- Placing a continuous monitoring station to gain more insight in magnetic field levels and patterns and compare the findings this to measurements available in literature.

WP 3 - Communication and stakeholder engagement

- Production of Communication strategy and its execution including:
    - Identifying key stakeholders.
    - Gathering existing knowledge and project generated information.
    - Communication planning;
- Define types of results needed for fact-based discussion.
- Obtaining input from fisheries communities on a national level to find a basis for support.
- Lead discussion with and achieve participation of green Non-governmental organisation.
- Knowledge dissemination across EU member states and fisheries organisations.

To date there is no evidence for significant effects of EMFs on the flatfish species assessed. In the event this is confirmed, funding provisionally assigned to develop mitigation measures to counter the disturbing effects from EMF may not be required.

The provisional results of the FlatEMF project will be disseminated publicly in early 2025. The lead researchers will subsequently submit a paper to the peer-reviewed literature later in 2025.

7.3. Identification of Need

As has already been referenced above, the original EBEGs are now over a decade old. The authoritative international studies and research on which they are based has inevitably been updated over this period, and this subsequent data needs to be gathered and reviewed.

Environmental-related legislation and Case Law has evolved significantly over the decade, including new Maritime legislation, new Planning legislation, new Cultural Heritage legislation, as well as significant Court judgements relating to ecology and other aspects of the environment. The collective regulatory change arising from the new Maritime Area Planning Act 2021 (and establishment of the Maritime Area Regulatory Authority), the new Planning Act 2024, among other changes, is unprecedented in the history of the state's planning legislature. The updated EBEGs must be set into the context of latest legislation and Legal precedent.

The national and international policy context on environmental priorities has also altered profoundly over the last decade, with a key focus on climate action and resilience, renewable energy technologies and associated grid infrastructure delivery, and nature restoration. Indeed, this paradigm shift toward the imperative for all public and private bodies to mainstream action on climate and nature is reflected in Ireland declaring a twinned biodiversity and climate emergency in 2019[19], and the ambition and urgency in the European Union's 2024 Nature Restoration Law[20]

EirGrid's original EBEGs were primarily based on the prevailing grid technology of the time, being onshore overhead line and substation infrastructure. EirGrid is now planning and developing significant underground cable projects, offshore projects, and projects with new or innovative technologies. These need to be considered in the updated EBEGs.

EirGrid has significantly enhanced its reputation over the last decade in the area of environmental mitigation, biodiversity and public awareness and interest in community development. There is a need for updated evidence-based studies to inform EirGrid's approach to environmental assessment, biodiversity enhancement, and stakeholder and community engagement and interaction – both offshore and onshore.

[19] Dáil Éireann debate - Thursday, 9 May 2019
[20] Nature Restoration Law

7.4. Option Appraisal

EirGrid has considered four options with regard to the EBEGs, in order of lowest to highest activity below:

- Option 1 - Continue to rely on the current EBEGs (i.e. a Do-Nothing option): there is no doubt that much of the current EBEGs remain relevant; however, in a significantly altered development context, from an environmental and stakeholder perspective, it is considered to be a retrograde step to seek to promote EirGrid's environmental credibility while relying on out-of-date studies.
- Option 2 - Update selected studies: in particular to focus only on environmental topics where there has been a profound contextual change, such as new legislation. However, even preliminary screening of the EBEGs has identified that there have been important changes across all topics over the last decade, and more so that EirGrid's current technology toolbox is not adequately reflected across all of the studies and guidelines.
- Option 3 - Update all studies with replacement studies: this would been a similar number of large authoritative studies, from which guidelines, practice notes etc can be developed. This has the benefit of a large suite of evidence-based information and conclusions but will have time and cost implications (including the resource required to disseminate effectively).
- Option 4 - Update all studies with evidence-based guidelines, practice notes, technical notes, tools and digital enhancements, Codes of Practice, and other collateral where required: this would ensure the capture of the most up-to-date information and data be targeted and scoped to present as a document for easy review, adoption and use by project managers, consultants, and other stakeholders. The nature of the collateral for each environmental topic would be determined in collaboration with key stakeholders to ensure the most useful product to ensure sustainable and successful delivery of grid infrastructure projects through the planning and consenting process.

7.5. Delivery of Preferred Approach

Following consideration of the options above, EirGrid's Planning and Environment team, with the Infrastructure Office, proposes to pursue Option 4 - Update all studies with evidence-based guidelines, practice notes, technical notes, tools and digital enhancements, Codes of Practice, and other collateral as required.

The various environmental topics will be scoped, initially by EirGrid's in-house Planning and Environmental team, but subsequently using subject matter experts to inform an initial scope, which will then be presented to, and discussed with relevant Statutory and non-Statutory stakeholders.

It should be noted that the scoping of these updated Evidence Based Environmental Studies is a Business Plan objective for EirGrid in Financial Year 2025.

Consultants, potentially the same as involved in the scoping exercise, will undertake the preparation of the updated studies and their subsequent agreed document form, with strong oversight by the Planning and Environmental team, potentially with a Working Group composed of key stakeholders.

These documents, tools and other outputs will ultimately be published, and provided to relevant stakeholders including consenting authorities, with the intention of assisting the timely passage of EirGrid's projects through the planning and consenting processes.

7.6. Proposed Initiative

The proposal for which funding is being sought concerns the scoping, preparation and publication of a suite of Evidence-Based Environmental Guidelines, covering a variety of environmental topics, and comprising a range of document types. These build on highly successful and innovative EBEGs originally published in 2014, which require to be updated for a number of reasons set out in this paper.

It is proposed that the scoping of the updated EBEGs will commence in Q1 2025 (calendar year) and will include procurement of subject matter experts. Scoping will also identify key stakeholders, who will feed into the scope and nature of the updated EBEGs. This scoping exercise is planned to be complete by the end of Q3 2025 (calendar year).

It is proposed that consultants will be appointed to commence the preparation of the updated EBEGs from Q4 2025 (calendar year); given there is likely to be a variety in timeframes across the various environmental topics, it is anticipated that the overall timeline for updating the studies will extend to end of Q3 2026 (calendar year), although this really depends on the agreed scope.

In this latter regard, the updating of the EBEGs will be treated as a project, and subject to careful and robust project management, including governance of scope, costs, and risks.

At the outset, and based on current market rates, and the scope of similar project activity. During the procurement process, there will be strong focus on cost-savings, efficiencies, and discounts.

7.7. Benefits

Updates to the EBEG (and the specific workstreams in progress) provide the following key benefits to EirGrid and their stakeholders:

- Reduced consenting risk to support the accelerated delivery of renewable energy grid connections onshore and offshore in support of EirGrid's ambition (in Shaping our Electricity Future) and the Irish government's ambition (in the Climate Action Plan 2024) of 80% renewables by 2030.
- Programme reductions in consenting timeframes to accelerate renewable delivery, by clarifying through empirical evidence, actual versus perceived environmental impacts from grid projects, to assist competent authorities in timely and informed review of grid consent applications.
- Streamlined delivery of road transport, green and blue infrastructure projects, through close collaboration on opportunities to collaborate with other state developers.
- Reduced environmental impact and/or enhanced mitigation performance on grid development projects onshore and offshore, to benefit the public, communities, and both built and natural heritage.
- Improved and focused action on nature in support of Ireland's 4th National Biodiversity Action Plan 2023-2030[21].
- Enhanced archaeological conservation onshore and offshore, and transparent reporting on significant finds, in support of Ireland's Draft Strategy for World Heritage in Ireland 2024-2034[22], and effective implementation of the 1972 UNESCO World Heritage Convention in Ireland.
- Contribution to the peer-reviewed literature on environmental impacts from grid developments, including the impact of EMF on commercial flatfish, via the FlatEMF initiative, and the viability of planting native shrubs over high voltage cables.

7.8. Risks and Mitigation

In summary, the EBEG mitigate multiple risks to EirGrid's social licence to operate, and therefore delivery of the Climate Action Plan and the just transition to the 80% renewables ambition.

[21] Ireland's 4th National Biodiversity Action Plan 2023-2030
[22] Public Consultation on Strategy for World Heritage in Ireland 2024 – 2034

8. Our Vision

Our vision for the future focuses on three key pillars:

- Pillar 1: Research – Generation of knowledge and insights
- Pillar 2: Innovation – Application of knowledge and insights to realise value
- Pillar 3: Processes – Systematic and strategic approach to research and innovation management

8.1. Pillar 1: Research

The EirGrid Innovation & Research Strategy identifies the importance of co-ordination and collaboration with our industry and academic partners. We also recognise that there is a need to diversify our research partners and branch into other research areas and research institutions. We will require the input of experts from across multiple sectors and countries to meet government targets related to the pursuit of net zero.

8.2. Pillar 2: Innovation

Our innovation initiatives will be guided and shaped by the knowledge and insights gained from our research projects as well as our Innovation and Research Strategy and framework.

We are planning to champion the innovation programmes aligned to the nine SIPs by utilising the Innovation Champions (as mentioned in the Innovation and Research Strategy). The focus would be to continually evolve the scope, promote and champion innovation projects from the SIPs through the Project Portfolio Management system, which is our system for managing the projects.

8.3. Pillar 3: Processes

The Innovation & Research Strategy identifies the importance of co-ordination and collaboration with our industry and academic partners, as well as establishing the needed frameworks and internal processes and enablers for driving and supporting innovation and activating our research and innovation purpose. The aim of this particular pillar is to establish those necessary frameworks.

This pillar covers key areas such as:

- Making the innovation process digital, transparent and accessible to all our colleagues
- Allowing our colleagues to innovate by offering training and development and time and space to innovate
- Further enhancing innovation by establishing roles of Innovation Champions and focusing on enhancing innovation capability and offering it as a service.

9. Next steps

This Annual Innovation Report documents EirGrid and SONI's progress on innovative programmes throughout 2024 and points out our ambition for future developments of programmes and new initiatives to begin. The innovation programmes mentioned here reflect the ambitions of our Innovation and Research Strategy. Feedback was sought on this report to enable us to gather the views of our stakeholders, and ensure the projects are deemed appropriate by all. A public consultation on this report ran from February 14th to March 12th on both EirGrid and SONI consultation portals. No recommendations were made by stakeholders during this consultation period.

We are continuing our work on the innovative programmes and we look forward to working with our stakeholders. Feel free to contact us via research@eirgrid.com or research@soni.ltd.uk .

10. Annex 1 - Project details

Enhance data-driven decision-making leveraging artificial intelligence capability

Control Centre Tools Implementation

Status	LSAT: completed RMT: completed VTT: completed
Scope	Implement a Look-Ahead Security Assessment Tool (LSAT) to enable Grid Controllers to analyse the stability of the power system in real time and in the near future facilitating optimal system operation with higher levels of wind and solar integration. Implement Voltage Trajectory Tool (VTT) to enable Grid Controllers to assess the impact of varying sources of reactive power across the power system to ensure that local voltage management issues are efficiently managed. Implement Ramping Margin Tool (RMT) to enable Grid Controllers to accurately schedule and dispatch the Ramping Margin services, and manage changing demand and generation profiles, with increased wind and solar integration.
Rationale	A core objective of EirGrid, SONI and the DS3 Programme is facilitating levels of SNSP up to 75% to meet public policy. To increase the levels of instantaneous renewable generation on the system it is necessary to deliver a suite of Control Centre Tools to enhance the stability analysis, voltage control and frequency management capability of the control centre. For example, voltage management in Ireland and Northern Ireland is becoming more challenging due to the reduction of available reactive power resources and the disperse location of wind farms, combined with increasing installation of HV underground cables. Enhanced voltage control management capability in the control centre is critical to facilitate this challenge.
Expected Impact	• Enable operation of the All-Island power system with up to 75% SNSP. • Enable operation of the All-Island power system with world leading levels of variable renewable generation in a safe and secure manner while minimising the level of constraint and curtailment of wind and solar through LSAT. • Determine optimal reactive targets for different types of devices, delivering voltage trajectory plans secure against contingency events for a near time horizon through VTT. • Enable operation with reduced number of conventional plants on-line and, thus, facilitate increased levels of SNSP in the All-Island system. • Enable grid controllers to accurately schedule and monitor the ramping margin reserve services through RMT. This enables more effective management of changing demand and generation profiles with increased wind and solar integration.
Progress in 2024	LSAT, RMT and VTT are operational tools in the control rooms. Planning for enhancements of the tools will start in 2025.
Future Potential	The tools are live in production environments. LSAT, VTT and RMT are fully integrated in business process as decision support tools in the control rooms.

Exploring how AI/ML can help determine strategic network reinforcement projects in the transmission system including technology, length of cable/overhead line etc.

Status	In Progress
Partner(s)	Trinity College Dublin (TCD)
Scope	Objective: Insight into the suitability of Artificial Intelligence (AI) / Machine Learning (ML) methods into the prioritisation of network infrastructure projects in Network Delivery Portfolio (NDP); an existing goal of an internal team. Included: Development of a notional proof-of-concept and presentation of results to relevant EirGrid personnel. Excluded: All use of sensitive EirGrid models and data.
Rationale	An important step towards accomplishing CAP targets is network reinforcement in the transmission system. We have a list of new network reinforcement projects. However, they have limited resources and want to gain insight into how projects are prioritised to accomplish this goal most effectively. This could be accomplished through a bespoke analytical tool. We are working on a similar non-AI based project already, but this is considered to be computationally intense. An AI-based method could accomplish this in a faster, more streamlined manner.
Expected Impact	The project aims to produce a proof-of-concept of a tool that may eventually become useful to our application as above. This specific project does not aim to produce such a tool, only provide insight into potential for future development.
Progress in 2024	• Project suggested internally as a potentially useful study. • Project pitched to and accepted by TCD. • MSc student recruited by TCD. • Project kick-off (October 2024). • First progress meeting (November 2024).
Further Planning	This project aims to conclude in the latter half of 2025. The expected outcome is a Master's thesis document. This document will theoretically provide insight into the proposed method using general/test use-cases, pointing to its potential to address the application. These outcomes will subsequently inform decisions whether to further pursue the method, with potential for expanded studies based on real-world power system data. Such studies could take the form of further post-graduate projects.
Future Potential	The outcomes of this project will serve as a proof of concept for the proposed idea. Favourable outcomes could pave the way towards an expanded PhD/Post-Doc level project that could make use of EirGrid data/models and produce a specialist for the internal EirGrid team.
Dissemination	The project is planned to produce academic publications discussing results that would be available to the wider industry and general public.

Virtual Dynamic Line Rating Sensors

Status	In Progress
Scope	This project aims to alleviate network congestion by enhancing the current-carrying capacity of the electricity grid. By leveraging advanced weather forecasting and artificial intelligence techniques, it predicts dynamic line ratings without requiring the installation of costly hardware sensors. This innovative approach focuses on cost-effective, data-driven solutions to improve grid performance and efficiency.
Rationale	Traditional methods rely on conservative static estimates of seasonal meteorological data, which restrict the grid's capacity to accommodate growing renewable energy sources. As renewable energy generation increases, the existing grid infrastructure faces challenges in managing the additional load. This project offers a viable solution by enabling higher renewable energy integration while minimizing the need for expensive network upgrades or reinforcements.
Expected Impact	The project's outcome will allow for more efficient utilisation of grid infrastructure, supporting the transition to renewable energy. It will help reduce network congestion costs, delay costly reinforcements, and contribute to a more sustainable energy industry without relying on additional physical sensors.
Progress in 2024	Work Package-1: Develop AI models- Proof-of-concept development (Jan 2024-Oct 2024) • A proof-of-concept was successfully developed and validated using the Lisheen-Thurles transmission line as a reference. The model reliably predicted line ratings under varying extreme weather conditions, with calibration enhancing its accuracy. • Following the NDP, critical transmission lines in Ireland are identified as candidates for DLR deployment. This approach has been used for predictions of line ratings for these segments ahead of actual sensor installations. (Yet to assess the reliability of the virtual sensor approach on these segments, they must be compared against the actual sensor installation approach)
Further Planning	Work Package-2: Network-wide scaling & Cost Benefit Analysis (Nov 2024-Dec 2025) • Assess the reliability of this approach on additional lines identified in the Network Delivery Portfolio. • Explore collaboration with internal teams and external stakeholders for potential issues in the approach to improve the overall approach and feedback for pilot implementation and scaling. • Refine forecasting techniques to further enhance accuracy and reliability under diverse climatic conditions.
Future Potential	This project offers transformative applications for grid operations and can be used in 3 different ways: • Real-time Deployment: Enhancing live grid control centres to optimize network capacity dynamically. • Backup Support: Serving as a reliable alternative when sensor data from traditional DLR installations is unavailable. • Strategic Implementation: Leveraging this approach in low-congestion grid areas to maximize cost efficiency.

The project also has several future phases:

Phase 1: Network-wide scaling & Cost Benefit Analysis (Apr – Mar 2026)

- Apr – Jun 2025: Select pilot lines from Network Delivery Portfolio and begin to forecast line ratings on selected lines.
- Jul – Sep 2025: Assess the reliability of this approach on additional lines identified in the Network Delivery Portfolio.
- Oct – Dec 2025: Conduct techno-economic analysis and asses the financial benefits.

Phase 2: Stakeholder Engagement & Feedback Loop (Nov – Mar 2026)

- Collaborate with internal teams and external stakeholders for potential issues in the approach to improve the overall approach and feedback for pilot implementation and scaling.

Phase 3: Action on stakeholder feedback for further improvements (Apr – Oct 2026)

- Apr – Oct 2026: Incorporate suggestions from stakeholders to further improve the model

Phase 4: Integration & Stakeholder Engagement (Nov – Apr 2027)

- Nov – Jan 2026: Develop integration roadmap for SCADA/EMS systems.
- Feb – Apr 2026: Conduct workshops and internal training for operations teams.

Phase 5: Dissemination & Policy Development (May 2027 – Oct 2027)

- May – July 2026: Publish reports, engage with industry stakeholders, and present at conferences.
- Aug– Oct 2027: Work with regulators on policy inclusion and finalize Business-As-Usual (BAU) adoption.

Dissemination

1. Internal Knowledge Sharing

- Conduct workshops and training sessions for internal teams on virtual DLR applications.
- Develop technical reports summarising findings, challenges, and key improvements.

2. Industry Engagement & Collaboration

- Present findings at industry forums (e.g., CIGRE, ENTSO-E, IEEE conferences).
- Publish whitepapers and case studies to share best practices.
- Engage with other TSOs for potential cross-border applications.

3. Regulatory & Policy Contributions

- Share results with regulatory bodies to influence future grid innovation policies.
- Provide input for national and European digitalisation and grid modernisation initiatives.

4. Public & Academic Dissemination

- Publish results in peer-reviewed journals and engineering publications.
- Collaborate with universities for further R&D on machine learning models and enhanced forecasting.

Exploring how AI/ML can help determine strategic storage, demand or generation projects in the transmission system, including technology, export/import capacities, duration of storage, etc.

Status	Initiated
Partner(s)	TCD
Scope	Objective: Insight into the suitability of AI/ML methods into the prioritisation of storage, demand or generation projects in NDP; an existing goal of internal team. Included: Development of a notional proof-of-concept and presentation of results to relevant EirGrid personnel. Excluded: All use of sensitive EirGrid models and data.
Rationale	An important step towards accomplishing CAP targets is integration of new storage, demand or generation projects. We have a list of storage, demand and generation projects to be connected. However, they have limited resources and want to gain insight into how such projects are prioritised to accomplish this goal most effectively. This could be accomplished through a bespoke analytical tool. We are working on a similar non-AI based project already, but this is considered to be computationally intense. An AI-based method could accomplish this in a faster, more streamlined manner.
Expected Impact	The project aims to produce a proof-of-concept of a tool that may eventually become useful to us our application as above. This specific project does not aim to produce such a tool, only provide insight into potential for future development.
Progress in 2024	• Project suggested internally as a potentially useful study. • Project pitched to and accepted by TCD. • MSc student recruited by TCD. • Project kick-off (October 2024). • First progress meeting (November 2024).
Further Planning	This project aims to conclude in the latter half of 2025. The expected outcome is a Master's thesis document. This document will theoretically provide insight into the proposed method using general/test use-cases, pointing to its potential to address the application. These outcomes will subsequently inform decisions whether to further pursue the method, with potential for expanded studies based on real-world power system data. Such studies could take the form of further post-graduate projects.
Future Potential	The outcomes of this project will serve as a proof of concept for the proposed idea. Favourable outcomes could pave the way towards an expanded PhD/Post-Doc level project that could make use of EirGrid data/models and produce a specialist for the internal team.

Flexible Network Strategy

Dynamic Line Rating

Status	In progress
Partner(s)	ESBN Transmission Asset Owner, Northern Ireland Electricity (NIE) Networks
Scope	The scope of this project is to trial and investigate DLR implementations in Ireland and Northern Ireland, to trial 'Direct Measurement' DLR technology, and to consider the 'Indirect' DLR technology and studies on the wider roll-out of this flexible network solution.
Rationale	DLR installations enable the usage of real-time thermal loading limits which increase transmission capacity of lines safely without high-cost burden or extensive outages. The dynamic ratings are determined from the live environmental conditions, while seasonal static ratings assume conservative limits. DLR offers the potential to facilitate the connection of greater volumes of variable renewable generation with less infrastructure upgrades and provides a medium-term solution for congested lines. The technology also offers the capability to forecast line ratings based on weather forecasting.
Expected Impact	• Increase the capability for variable renewable generators to export power onto the grid without the requirement of building/upgrading network infrastructure. • Ease congestion problems experienced on the grid as well the future potential to use forecast dynamic line ratings within our processes.
Progress in 2024	Installed DLR sensors on the Cashla – Dalton 110 kV overhead line. The motivation and driver for the installation of DLR on the Cashla – Dalton 110 kV overhead line differs from that of the Lisheen- Thurles 110 kV line, which was installed in late 2022. This is explained as below. • The Lisheen - Thurles line forms a radial circuit that only connects to windfarms. During periods of high windspeed the combined output of those windfarms would approach the prevailing static seasonal rating of the overhead line; this would occur during all seasons but would be more frequent during the summer season. If nothing was done with the existing overhead line, the new windfarm would be constrained from exporting in full or in part during those times. The solution options were, uprate the overhead line or install DLR. With the installation of the DLR it can be seen during periods of high windspeeds that the true power carrying capacity of the existing overhead line far exceeds that indicated by the prevailing static seasonal line rating. This has eliminated the need to constrain off the new windfarm due to concerns about overloading the overhead line. • The Cashla – Dalton 110 kV overhead line forms part of the meshed transmission network meaning it operates in parallel with another transmission circuit. During periods of high wind generation, the combined load on the Cashla – Dalton 110 kV overhead line and on the parallel circuit will exceed the capacity of the Cashla – Dalton 110 kV overhead line. This can only be permitted for a short period time because it presents a security of supply risk. If the parallel circuit was to be forced out of service at such a time the Cashla – Dalton 110 kV overhead line would then be overloaded, and the system operator would have to take action to protect it from being damaged. Such action could include disconnecting

demand customers. This is known as an ‘n-1’ (n minus one) risk and the system operator will normally act to prevent such risks from arising by curtailing the wind generation so that the combined load does not exceed the capacity of the Cashla – Dalton 110 kV overhead line. It is expected that the installation of the DLR will show that at times of high wind generation, which coincides with periods of high windspeed, the real power carrying capacity of the Cashla – Dalton 110 kV overhead line is much higher than that indicated by the prevailing static seasonal line rating and that the ‘n-1’ risk only arises at a much higher level of wind generation than previously thought. This will in turn reduce by a significant margin the extent of the curtailment of wind generation in the region.

Also in 2024, a DLR sensor was installed on the Dalton Station 110 kV busbar. This a novel application of DLR in that we are not aware that any other utility has done this before. The busbar in Dalton Station has a relatively low rating and this constrains the permitted load on the connecting circuits. High loads arise on the busbar at times of high wind generation which coincides with periods of high windspeed. It is expected the DLR will show that at these times much higher loads can be safely carried by the busbar than previously thought which will reduce the level of constraints imposed on the connecting circuits. There is a plan in place to uprate the busbar but that will take some years to complete due to the difficulty in obtaining the required outages. In the meantime, the installation of the DLR is an inexpensive and quick to install interim measure (not a solution) that it is hoped will help reduce the extent of the curtailment of wind generation in the region while awaiting completion of the busbar uprate project.

Further Planning

Further planning steps include to analyse the data provided by the DLR schemes on the Cashla – Dalton 110 kV overhead line and the Dalton Station 110 kV busbar with a view to maximising their benefits. This will likely result in the identification of a requirement for some minor uprate works in Dal-ton Station, such as the replacement of lowly rated bay conductor.

Install a further DLR scheme. The Cathaleens Fall – Corraclassy 110 kV overhead line has been identified as the candidate circuit for this installation.

Future Potential

The data from trials is being analysed to further our understanding. The trials are deployed on different sections of the networks with the aim that each new trial will give us understanding and insights in new areas. This knowledge will progress these technologies into our BAU.

Publications

A paper was published titled; ‘Maximizing power transfer and RES integration using DLR technology: Ireland TSO experience’ and presented this at the Cigre conference in Paris in August. The paper is based on experience gained from the DLR scheme installed on the Lisheen -Thurles 110 kV line and analysis of the data captured during the twelve-month period October 2022 to September 2023.

Dynamic Power Flow Control

Status	In progress
Partner(s)	ESBN Transmission Asset Owner
Scope	Dynamic Power Flow Control devices are modular devices suitable for installation on 110 kV, 220 kV, 275 kV and 400 kV circuits that will be installed on an as-required basis in the most beneficial locations on the transmission network. The candidate lines are as follows: • Flagford – Sliabh Bawn – Lanesboro (110 kV) • Sligo – Srananagh – Corderry (110 kV) • Letterkenny – Tievebrack - Binbane (110kV) • Letterkenny – Cathaleen's or Letterkenny – Clogher (110 kV) • Killonan – Knockraha (220kV) • Clashavoon – Knockraha or Cullenagh – Knockraha (220 kV)
Rationale	The energy system is in a transition that leads to a changing load flow pattern. As a result, transmission grids are operated closer to their thermal and dynamic stability limits. Since building new transmission lines to relieve the congested lines are both expensive and challenging from a consenting perspective, the market for alternative technologies is growing. Usually Phase Shift Transformers (PST) are used to perform power flow control. These are devices that allow active power flow to be controlled, thereby reducing power flow on congested lines while diverting power flow to lines with spare capacity. The disadvantages of PSTs are their reactive power consumption and their limited control speed. In addition, they are large and heavy devices requiring extensive civil works infrastructure to be in place at installation sites. Solutions like Dynamic Power Flow Controllers (DPFC) promise to be modular and relatively easy to re-deploy. This way it will be possible to move them around the network to where they have the biggest impact and improve system stability and transfer capacity.
Expected Impact	• The deployment of dynamic power flow control devices will have an important role to play in network congestion management and maximising the existing network capacity. • These devices will also assist in minimising the need for network reinforcement projects and mitigating the challenges associated with building new overhead lines or underground cables such as societal acceptance and prolonged outages of key infrastructure.
Progress in 2024	In 2024 the tendering process was completed for the supply and installation of a DPFC device in Binbane 110 kV Station and for the establishment of a framework contract for the supply of multiple devices at multiple locations over a five-year period commencing 2025. Two suppliers have been appointed to the framework contract and one of them has been identified as the preferred bidder for the supply of the first device, the device to be installed in Binbane 110 kV Station under CP1048. The stated delivery period is 22 months so the earliest possible date for delivery is in late 2026, with completion of the installation to follow in 2027.
Further Planning	EirGrid will apply for planning permission for the installation in Binbane.
Future Potential	Shaping Our Electricity Future has identified a number of candidate locations for dynamic power flow control. These projects will progress through the EirGrid six step framework for developing the grid. Progress through this framework can be monitored in the EirGrid Network Delivery Portfolio.

NexSys – Enhanced utilisation of power system network infrastructure

Status	In progress
Partner(s)	University College Dublin (UCD) through NexSys Programme
Scope	The NexSys programme aims to determine how energy systems should evolve to have more renewable electricity towards 2030 and subsequently get to the net zero carbon goal by 2050. This particular project is one of three targeted projects which are in addition to the broader NexSys hub programme. This project seeks to develop an understanding of enhanced utilisation of power system network infrastructure covering the following scope: • Quantification of the benefits of existing and future technologies that could improve the real-time utilisation of existing networks and enable operational (stability) limits to be pushed higher. • Development of a multi-year, stochastic planning optimisation tool that selects passive and active measures to minimise investment costs, renewables curtailment, etc. Sections of the grid will be used to demonstrate the optimisation approach on timescales from 2030 towards 2050, with the impact on capital investment, network loading, renewables curtailment, etc. • Investigation of high wind conditions or post-disturbance network overloads, supported by system service product designs to encourage provision of congestion-relieving capability.
Rationale	In addition to the significant network reinforcements that are needed over the next few years to support our renewable ambition, there is a need to explore potential options for better utilising our existing network infrastructure to minimise extensive network build and thus investment costs.
Expected Impact	• Gaining a greater understanding of the potential for network planning to incorporate static and dynamic technology options to facilitate maximisation of existing network utilisation. • Building a greater understanding of the operation of dynamic technology options that will support maximisation of network utilisation.
Progress in 2024	No results achieved yet due to recent joining of a researcher to the project. Initial research is underway, and direct engagement with EirGrid will take place in early 2025.
Future Planning	Reviews are planned for Q1 2025 to review the project and agree on the project plan.
Future Potential	The project has a 24-month programme with useful outputs not expected until completion of the project. The outputs will influence EirGrid's approach to making best use of existing assets. The expectation is that research on optimising locational signals will be a key outcome.

Champion the emergence of the energy citizen

CleanerGrid 23/24

Status	Completed
Partner(s)	Academia/Third level students
Scope	CleanerGrid is a competition for third level students from any discipline to utilise existing power system data from the EirGrid and SONI SmartGrid dashboards and/or the SEMO website to create a digital prototype of a website, application or dashboard that will encourage everyday energy users to be more vigilant of their energy use.
Rationale	There is a significant amount of data publicly available on our websites. This competition encourages students to become more aware of the energy sector and the decarbonisation challenges and to ultimately develop innovative ways of using publicly available power system data to inform and empower the Energy Citizen.
Expected Impact	• Competition entries will present new ways of using the existing data and some may be considered for further development and possible implementation. • It is anticipated that awareness of the challenges faced in the energy industry will be raised among third level students.
Progress in 2024	This competition opened for applications and expressions of interest in September 2023. The competition itself ran for the month of December and the deadline for submissions was 30th November 2023. The judging took place in December 2023 and the top three teams were notified and invited to attend the award ceremony in January 2024. The award ceremony took place and winners were announced.
Future Potential	The winning entries were analysed for the potential to work with finalists to further develop and implement their solutions within the EirGrid or SONI company websites. The initially identified potential that the CleanerGrid competition will develop into an annual competition has been realised and another competition was set up.

Public Engagement with Energy Transitions in an Era of Climate Crisis

Status

In progress

Partner(s)

MaREI (The Science Foundation Ireland's Research Centre for Energy, Climate and Marine research and innovation)

Scope

The scope can be organised into four areas as listed below:

- A Transition based assessment of actors, roles and agency in energy grid system change that includes:
  - A synthesis review of international literature on the engagement practices in electricity grid system change.
  - A scoping review with a view to map actors, roles and agency in energy grid system change.
  - An Integrated review of EirGrid's Multi-stage and Deliberative Engagement Processes.
  - Mapping emerging public and new local initiatives.

- A Comparative Analysis of Community Benefit Fund including the:
  - Scoping review of community benefit literature.
  - Mapping existing initiatives and stakeholders.
  - In-depth case-study research in three different locations.
  - Comparative analysis of findings.

- The Assessment of the impact of community benefit funding using comparative analysis of three different case studies. This involves the:
  - Development of a multi-stakeholder engagement plan.
  - Mixed-method data collection strategy (desk and field-based).
  - Data consolidation and cross-case examination.
  - Distilling key learnings and policy recommendations.

- Dissemination and Exploitation. The aims of this are to:
  - Establish project identity and presentation guidelines, including brandings and templates for all deliverables.
  - Produce a project microsite to include information about the objectives and work plan, upcoming events, published papers and other relevant materials.
  - Establish a social media presence, building on existing networks.
  - Research briefs summarising and adapting results of journal articles into learning or policy briefs.
  - Participate in and present at relevant conferences, workshops, EirGrid organised and other relevant events.

Rationale

EirGrid has a long history of engagement with local communities. Understanding this from the context of transforming the power system for future generations requires some careful consideration. EirGrid's evolving public engagement promotes a more vibrant engagement strategy seeking to connect people, problems and solutions in a more inclusive manner. As a recognised pillar for transformation, understanding how best to leverage public engagement in different forms is crucial.

The project entails an impartial analysis of EirGrid's evolving public engagement, based on a mapping of actors, and a framework to evaluate different engagement processes and programmes. This approach will simultaneously offer guidance and develop suggestions throughout the consultation and engagement lifecycle, seeking to capture learnings from both engagement processes and outcomes.

Expected Impact	• Improve our methodology when embarking on community benefit funding strategies; increase the level of collaboration with communities; investigate the current process using an engaged research approach; critically assess current practices. • Gather learnings from international good practices; contribute to journals on the process and the outcome adding to the available literature for this discipline.
Progress in 2024	EirGrid has been involved in a review of international best practice facilitated by the MaREI researchers. The team has co-authored journal papers and presented EirGrid's work in this area to new audiences e.g., the European University of Post-Industrial Cities https://www.unic.eu/en. It has broadened the audience to EirGrid's Public Engagement approach domestically, creating learning opportunities for communities and stakeholders and programme partners including Irish Rural Link, Development Perspectives, South East Cork Area Development, MCo. It has positively impacted on current work practices, deepening understanding and reflection, influenced and guided development of our community engagement and helped maintain focused development of best practices.
Future Planning	The extended timeframe means that the project will be completed in April 2025 at which time all deliverables will have been met, including additional outcomes such as identification of impact tracking, monitoring and evaluation.
Future Potential	It will aim to provide a toolkit on impact evaluation, with a catalogue of proposed approaches for monitoring and evaluation in the public engagement space, and guidance for EirGrid on tracking, monitoring and impact evaluation. It will set a baseline for the evaluation of EirGrid public engagement processes for our own development. It will create original academic reference specific to the Irish context, contributing to the library of international best practice and creating reference of value to our international peers. It will enable the EirGrid Public Engagement team to continue to develop pathways to champion the emergence of the role of the citizen in this era of energy transition.
Dissemination	This project will create original academic reference specific to the Irish context, contributing to the library of international best practice and creating reference of value to our international peers and wider industry, at home and abroad. Useful learning documents will also include impact case study briefs.
Further Information	https://www.marei.ie/project/public-engagement-with-energy-transitions-in-an-era-of-climate-crisis/
Publications	Boyle E, Revez A, Deane A, Ó Gallachóir B. (2024) Levers and obstacles for implementing public engagement practices in electricity grid development. Heliyon.10(15). https://doi.org/10.1016/j.heliyon.2024.e34955Boyle E, Galvin M, Revez A, Deane A, Gallachóir BÓ, Mullally G. (2022) Flexibility & structure: Community engagement on climate action & large infrastructure delivery. Energy Policy.167:113050. https://doi.org/10.1016/j.enpol.2022.113050 Boyle E, Revez A, Duffy G, Farrell A, Deane A, Ó Gallachóir B, et al. (2025) Public participation in the development of electricity grid infrastructure: Early engagements and community forums. Energy Research & Social Science.120:103878. https://doi.org/10.1016/j.erss.2024.103878 Revez A, Boyle E, Deane A, Walsh M, Wilson A, O'Gallachoir B. (2025) Public Engagement Practice for Electricity Grid System Change. Journal of Environmental Policy & Planning. 2025; Under Review.

Boyle E, Revez A, O'Gallachoir B. (2024) Why the Celtic interconnector is about more than just electricity, RTE Brainstorm, Friday, 16 Aug 2024 16:11 [Available Online]: https://www.rte.ie/brainstorm/2024/0816/1465182-celtic-interconnector-ireland-france-electricity-brexit/

CleanerGrid 24/25

Status	In progress
Partner(s)	Academia/Third level students
Scope	CleanerGrid is a competition for third-level students, working as individuals or in teams of up to six people. Entrants are asked to present their vision of what the growing energy sector will need to look like in 2050 to have sustainably achieved net-zero emissions.
Rationale	The energy sector is changing at a very fast pace to meet the various government set targets. As a result, a lot of change will take place between now and the future. We need to work collaboratively across multiple fields to get a well-rounded view of what can be done in the future.
Expected Impact	• Competition entries will present their vision for the energy sector. Elements of this may be to show new ways of doing things, new ways of using the data or something completely new we never thought of before.
Progress in 2024	This competition opened for applications and expressions of interest in October 2024.
Future Planning	Award ceremony is scheduled to be held in Q1 2025 when the competition will conclude.
Future Potential	The competition will close in 2025 where the entries will be judged and winners will be announced. The winning entries will be analysed for the potential to work with finalists to further develop these ideas.

Understanding pathways to 100% SNSP

Roadmap for implementation of EMT study capabilities in EirGrid and SONI

Status

Completed

Scope

The objective of this project is to develop a roadmap for the implementation of Electromagnetic Transients (EMT) modelling and simulation capabilities in EirGrid and SONI.

The key tasks in this project are:

- Task 1: Review of international practice and experience/challenges introducing EMT.
- Task 2: Review of current and past study practice and needs within EirGrid and SONI.
- Task 3: Suggested procedure to conduct a comparative technical assessment of commercial EMT packages so that EirGrid and SONI can be informed regarding the options available.
- Task 4: Estimate hardware and software requirements.
- Task 5: The EMT roadmap.

Rationale

Dynamic stability of power systems has been traditionally assessed with RMS (phasor-domain) tools. This type of tool is computationally efficient and has provided adequate performance for decades to reproduce typical electro-mechanical phenomena in traditional power systems.

However, its applicability is being challenged as IBRs like wind and PV displace synchronous generators. While the dynamics of synchronous generators are governed by the laws of physics and are well understood, the dynamics of IBRs are determined by the control strategies and specific software implementation for each plant. This includes fast dynamic behaviour that cannot be adequately represented in RMS/phasor-domain simulations.

EirGrid and SONI have identified the need to enhance modelling and simulation capabilities to study new dynamic phenomena associated with large integration of IBRs and low system strength conditions. This project aligns with the objectives of Shaping of Our Electricity Future (SOEF) and Operational Tools and Capability Enhancement (OTCE) Programmes.

Expected Impact

Develop enhanced capabilities to study the impact of IBRs and weak system conditions to enable planning and operation of the power system in a safe, secure, reliable, and economical manner while maximising the integration of renewable generation resources.

The roadmap will provide visibility on all the aspects that need to be considered in the implementation phase, including but not limited to:

- Model specification and validation requirements.
- Industry engagement.
- Model acceptance/verification process.
- Model and Data management process.
- Study process and methodologies.
- Network modelling guidelines. Staff up-skilling.

Progress in 2024	Work in 2024 focussed on the following areas: Task 4: Define hardware and software requirements Task 5: Roadmap development.
Future Potential	The outcomes of this project will feed into the Operational Modelling workstream of the OTCE Programme.

Increasing SNSP limit to 80%

Status	In Progress
Scope	In order to achieve the 2030 climate targets, set by Ireland and Northern Ireland, more renewable energy generation needs to be integrated into the existing power system, which is mainly dominated by non-synchronous sources. EirGrid and SONI are currently using a metric called System Non-Synchronous Penetration (SNSP) which relates the amount of system demand that is met by generation from non-synchronous sources. Currently, the operational policy regarding the SNSP limit is set to 75%. The scope of this study is limited to assessing the impact of increasing the SNSP limit from 75% to 80%.
Rationale	In order to securely operate the system with SNSP of 80%, and thus transition towards accommodating higher levels of non-synchronous renewables, this study evaluates in detail and identifies the technical scarcities of operating the all-island system (2025 and beyond) with 80% SNSP and propose adequate mitigations for the observed scarcities.
Expected Impact	• Increasing the SNSP limit is a key enabler to accommodate more wind and solar generation and thereby contribute to delivering renewable energy targets. • Identify potential issues in the frequency, voltage and angle stability/security domains that would be caused by increasing the SNSP constraint limit from 75% to 80% and recommend adequate mitigation measures.
Progress in 2024	The studies commenced in March 2024 and were completed in December 2024. The study's main observation is that there are some extreme scenarios with frequency and rate of change of frequency concerns and further investigation/alignment on the study mitigations are proposed across the organisation.
Further Planning	Report will be submitted and to be approved by Q1 2025.
Future Potential	After completion of the further investigation on the best possible course in terms of mitigations for the study concerns observed in the frequency domain it is expected that an operational trial will be conducted and if successful the SNSP operational limit can be relaxed to 80% SNSP. In 2023, 41% of energy used on the island came from renewable resources. In 2024, the All-Island system continued to accommodate up to 75% of instantaneous generation from non-synchronous resources (mainly wind and HVDC interconnection). The study conducted to address system operation at 80% SNSP showed no adverse system insecurities that hinder system operation at 80% SNSP. However, the trial would not proceed unless mitigative measures are in place for a fault in the vicinity of an interconnector causing a trip of its export causing excess of generation concerns for the all-island power system. This issue is an existing one and not due to system operation at 80% SNSP. Once the mitigation measures are in place, 80% SNSP limit will enable more renewable generation and reduced needs for renewable generation constraints.

Low Carbon Inertia Solutions Phase II

Status	In Progress
Scope	Low-Carbon Inertia Services (LCIS) program Phase II is a follow up of successful procurement of Phase I, which successfully contracted a total volume of 10,963 MVA.s of the all-island system inertia in total. This equates to ~45% of the current systems' inertia floor. The studies related to LCIS Phase II, focusing on the system inertia needs and placement in the future, where it is expected that significant additional wind and solar generation (with significantly relaxed SNSP limit) will be connected, and the all-island power system will be operated with only a single synchronous generator (for the purposes of setting voltage reference and balancing demand and generation).
Rationale	The LCIS program was designed to fulfil requirements for a system service comprising the provision of synchronous inertia, reactive power support and short-circuit contribution to alleviate future system operation challenges. Many previous studies clearly indicated that frequency stability and security as one of the major concerns for our non-AC interconnected system with a significant SNSP. Both rate of change of frequency (RoCoF) and frequency nadirs/zenith are on their limits for certain operational scenarios. To integrate more non-synchronous renewable sources and accommodate their production in a safe and secure manner, one of the main objectives will be to further reduce the number of large synchronous generators on-load. This will further reduce system inertia and exacerbate both RoCoF and nadirs/zeniths in the future. LCIS Phase II procurement, follow-up of Phase I, will focus on procurement of low-carbon inertia from technologies like synchronous condensers over the coming years.
Expected Impact	• To pave the path towards operating the All-Island Power system with 100% RES by proposing adequate LCIS placement, sizing and procurement • To Improve study capabilities significantly by developing new models and performing study assessments of unique future operational scenarios considering almost no synchronous generation on-load.
Progress in 2024	In 2024, the study has defined the study scenarios and carried out analysis on the defined scenarios to identify inertia, system strength, and steady state and dynamic reactive power scarcities in all island power systems, for year 2028 considering 100% renewable operation. Upon identification of the scarcities, the next step of the study was focused on determining adequate LCIS placement and sizing to mitigate these scarcities.
Further Planning	The study is still on-going, and it will identify the inertia needed for all-island power system for study year 2028 and the best placement of LCIS.
Future Potential	The final results will facilitate the second phase of LCIS consultation and recommendation papers, delivering the adequate locations and sizes for procurement of LCIS. LCIS is a service procured to ensure sufficient levels of Synchronous Inertia, Reactive Power and Short Circuit Capability are available as we transition to operating the power system with fewer conventional thermal units. LCIS is being procured in a phased approach via award of fixed-term contracts to service providers. LCIS Phase 2 will allow to further reduced the minimum number of conventional units on (MUON) and enabling higher level of SNSP, which will increase renewables integration and reduce carbon emissions, enhance security of supply and reduce electricity production costs.

Modelling and Analytics of Emerging Technologies

Status

In progress

Scope

The goal of this multi-year R&D effort is to support the reliable integration of Inverter-Based Resources (IBRs) and Distributed Energy Resources (DER) in transmission planning and protection activities by:

- Developing, validating, and then making available to commercial software vendors, generic models for representing wind, PV, battery energy storage, hybrid plants, and DER in bulk system planning and protection studies and corresponding tools.
- Developing methods and tools to assist planners in studying the impact of IBRs on the bulk system, including
  - the capability to assess the integration of IBRs in weak systems, need for grid forming inverter controls and their performance requirements,
  - the ability to evaluate the impact of location and size of various system strengthening devices,
  - stability assessment of networks with large percentage of IBRs,
  - develop probabilistic methods to evaluate the risk of uncertainty in dynamic models, and
  - develop methods and processes to evaluate fidelity and performance characteristics of generic and user defined dynamic models across simulation domains.
- Developing and verifying methods for aggregating DER models in bulk system simulations, including assessment of interconnection requirements, and exploring the use of T&D co-simulation to improve modelling & verification of aggregate DER models.
- Investigating the protection system performance of power grids with very high levels of IBRs, including 100% IBR generation scenarios and a mix of grid following and grid forming IBR controls, with the objective to provide guidelines and recommendations to protection engineers for conducting fault analysis and protection studies.
- Providing insights and guides, based on technical analysis and studies, on dynamic and fault response performance requirements of IBR and DER.Developing procedures, criteria, and tools to support conformity assessment of IBRs, including IBR unit model validation and IBR plant verification.

Rationale

The project considers the need for advancement in terms of tools, methodologies, and analytics, primarily in transmission planning and protection, as we transition from legacy conventional generation into a high IBR system with DER.

Emerging technologies such as battery energy storage, new forms of demand response, and increased sector coupling are also becoming available and need to be considered. When integrated with the grid, these technologies create new challenges and opportunities for maintaining reliable and efficient transmission system operation.

This project addresses research needs and provides members with important information, analytics, and tools, thereby improving business efficiency and providing for skills needed to address the challenges.

Expected Impact

- Understand and deploy new planning models and tools to ensure that IBRs can be captured in transmission planning and resource adequacy studies, ensuring system reliability while integrating increasing levels of Variable Energy Resources and DER.
- Modelling of IBRs in low short circuit grids and emerging technologies like Grid Forming controls. Improved understanding of the impact of high penetration of IBRs on performance of system protection schemes.
- Stay informed of the latest developments and gain insights into those areas where new challenges have been observed and solutions are emerging, including battery solutions, and offshore wind integration experiences, low inertia operations and energy systems integration.
- Understanding system strength, identification of limitations of conventional stability analysis tools and guidelines for when EMT analysis is required. Identification of when/where/how much Grid Forming capability is needed in the system.

Progress in 2024

Research work conducted in 2024 has contributed to the development of better understanding of IBR behaviour and modelling requirements for weak grid conditions as well as modelling and assessment of Grid Forming technologies.

In addition, EirGrid and SONI engineers have been upskilled to address challenges related to planning and operation with high levels of IBR. Key areas of research have focussed on:

- Fault-Ride Through Performance Analysis of Grid Forming Inverter-Based Resources
- Screening Metrics and Stability Risk Identification Procedures for Networks with High Inverter-Based Resources

Future Potential

The research outcomes are giving better understanding and developing capabilities to plan and operate the All-Island power systems with increasing levels of renewable and interconnection resources and will support achievement of 2030 renewable targets. Project deliverables are first assessed by EirGrid/SONI staff and then incorporated into BAU processes for conducting technical studies.

Grid Code Clause PC.A8 requires users to submit electromagnetic transient (EMT) models when specified by the TSO. We have experienced various incidents in the power system that required detailed EMT analysis but we do not have models to conduct those studies. This project will develop detailed EMT model specifications, in accordance with the Grid Code, to provide guidance to Users on the functionality and contents of these detailed models. The project will also deliver guidelines for model validation tests to be conducted by the Users (clause PC. A8.6) and internal model acceptance procedures.

NexSys – Mitigation of Extreme Weather Events on High RES Dependent Network

Status	In Progress
Scope	The NexSys programme aims to determine how energy systems should evolve to have more renewable electricity towards 2030 and subsequently get to the net zero carbon goal by 2050. This particular project is one of three targeted projects which are in addition to the broader NexSys hub programme. This project seeks to develop an understanding of the impact and mitigations of extreme weather events on a high RES dependent network covering the following scope: • Documentation of actual cases of weather-related extreme RES ramping events worldwide. • Examination of actual high wind speed shut-down events in Ireland and Northern Ireland and comparison of what was forecasted with what materialised. • Documentation of the power output characteristics of different wind turbine types in response to high wind-speeds, and different PV types in response to cloud cover. • Analysis of the probability and impact (magnitude and rate of change in power output) of high speed shut-down events on windfarms in Ireland and Northern Ireland. Analysis of the probability and impact (magnitude and rate of change in power output) of rapid shut-down (and start-up) of PV caused by cloud cover or a solar eclipse in Ireland and Northern Ireland. Determination of whether such events can be reasonably forecast. Focus will be placed on 2030+ levels of RES to take account of significant levels of solar PV (grid scale and roof-top) and large/concentrated offshore wind farms.
Rationale	As the system becomes more and more weather-dependent, and as our climate changes, it is vital that we have an understanding of the probability and impact of extreme weather events, so that we can plan and manage the generation and so that we are equipped with strategies to mitigate the impact of extreme weather.
Expected Impact	• Greater understanding of low-RES periods for current and future generation portfolio 2030 timescale. • In the 2050 timescale, to gain a better understanding of the effect of low-RES periods on interconnection and the required portfolio of technologies to enable a net zero European power system. Greater understanding of operational strategies for extended low-RES periods (2030 to 2050 timescales).
Progress in 2024	Report delivered by UCD in November 2024 with the title: High-level review of weather-related RES ramping events worldwide.
Further Planning	• Report: Low RES periods for Ireland's current & future (2030+) generation portfolio, expected in March 2025. • Report: Forecast and actual weather-related RES ramping events in Ireland, expected in March 2025. • Report: Interconnection & the portfolio effect for low RES periods across Europe, expected in July 2025.
Future Potential	The outcomes of the project will increase our understanding of the potential impact of extreme weather events and most importantly it is expected that the project will support the future development of mitigation strategies for dealing with such events.

	NexSys: Mitigation of Extreme Weather Events on High-RES Dependent Network will support and facilitate the process for operational policy changes by providing data driven insights and actionable recommendations. The deliverables will contribute into the information gathering for drivers, requirements and need for changes. The knowledge obtained through this project will support the study of the system under an extensive and detailed range of conditions.
Dissemination	Five deliverables will be produced as part of this project: • Low RES periods for Ireland's current & future (2030+) generation portfolio. • High-level review of weather-related RES ramping events worldwide. • Interconnection & the portfolio effect for low RES periods across Europe. • Forecast and actual weather-related RES ramping events in Ireland. • Weather-related RES ramping events for Ireland's current & future (2030+) generation portfolio.

Sources of very low frequency oscillations

Status	In progress
Scope	The main objective of this project is to develop an offline tool for identifying the source of very low-frequency oscillations for the All-Island Power System.
Rationale	As the power system moves towards nearly 100% instantaneous renewable penetration by 2030, lower levels of rotational inertia caused by high penetration of inverter-based renewables mean that the power system frequency dynamics become faster and more prone to large transients and oscillations. Sustained oscillations can be harmful and lead to equipment damage and power system instability.
Expected Impact	A simple to use and robust off-line tool for the identification of sources of oscillations and analyses of previous incidents through data mining and machine learning will bring benefits to our oscillation management process and enhance the security of supply of the all-island power system.
Progress in 2024	The initial phase of the project focused on analysing frequency data recorded from a single location on the grid, utilizing Dynamic Mode Decomposition to examine three Very Low Frequency Oscillations observed in the Irish grid in 2021. This analysis successfully identified key oscillation parameters, including frequencies, damping ratios, and amplitudes. The research findings were presented and published at UPEC in September 2024. However, it became evident that relying solely on data from a single location may not fully capture the extent of system-wide oscillations, particularly common mode oscillations that affect multiple regions of the grid concurrently. Queen's University Belfast extended the analysis to frequency variables from multiple grid locations. It was observed that current multivariate methods, while useful, remain computationally prohibitive for real-time wide-area monitoring. To overcome this challenge, a new Fast Multivariate Empirical Mode Decomposition was introduced, enabling the real-time extraction of common mode oscillations. The research findings were submitted to PES 2025 and received positive feedback from the reviewers.

Further Planning	Further analysis for 2021 events will be conducted, incorporating active power and phase angle data across the entire grid. The results will be targeted for submission to an IEEE Transactions journal, aiming to enhance the understanding of grid dynamics and frequency oscillation behaviours. In May and October 2024, multiple oscillation events were observed, including events involving the tripping of interconnectors. These events are of significant interest to the project, and further investigation will focus on the grid conditions that led to these events (June – Dec 2025).
Future Potential	The aim of the project is to develop an off-line tool to bring benefits to our oscillation management process and enhance the security of supply of the all-island power system. Once the tool is proven worthy of implementing it will be integrated into our oscillation management processes.

System Strength Definition

Status	In Progress
Scope	The objectives of this project include providing a definition for system strength in the context of operation of the All-Island power system with high share of Inverter-Based Resources (IBRs), defining appropriate system strength metrics for various timeframes ranging from long-term planning to real-time operations, and identifying and defining offline and online evaluation and monitoring methods for the new defined system strength metrics.
Rationale	In order to achieve the 2030 climate targets, set by Ireland and Northern Ireland government, more renewable energy generation needs to be integrated into the existing power system which is mainly dominated by non-synchronous sources. EirGrid and SONI, the TSOs of Ireland and Northern Ireland, are currently using a metric called System Non-Synchronous Penetration (SNSP) which relates the amount of system demand that is met by generation from non-synchronous sources. Increasing the SNSP limit is a key enabler to reduce wind and solar generation curtailment and thereby contribute to delivering renewable energy targets. Currently, the operational policy regarding the SNSP limit of the two jurisdictions Northern Ireland (NI) and Ireland (IE) is set to 75%. The operational policy roadmap to 2030 developed by EirGrid and SONI suggests increasing the SNSP to 95% by 2030 and the replacement of SNSP with a more focused system strength constraint. This project provides a definition and a set of metrics to facilitate implementation of the enhanced operational constraint which is expected to enable integration of higher levels of renewables to meet the government targets.
Expected Impact	Throughout this project, a set of metrics were proposed which can capture some stability challenges introduced by increasing IBRs penetration in the All-Island Power System. Challenges that the current tools and models cannot capture. This allows relaxation of two operational constrains and reaching higher levels of SNSP, as per governments' targets.
Progress in 2024	A set of potential metrics were identified and proposed for different timeframes, i.e., real-time operation, operational planning, long-term planning, and new connections. The suitability of these metrics for the All-Island Power system was examined through conducting dynamic simulations. General thresholds were also proposed for these metrics which should be examined based on unique characteristics of the All-Island power system through conducting EMT simulations. Furthermore, a draft report was prepared on the definition of system strength in EirGrid and SONI, which will be finalized soon.

Further Planning	• Finalising the definition of system strength. • Finalising the list of metrics to measure system strength in operation and planning timeframes. • Determining the thresholds for the metrics through conducting EMT simulations. • Start developing the policy for system strength.
Future Potential	When the definition, metrics, thresholds, and the corresponding policy are finalized, in the operation timeframe they can be utilized: • to take preventive actions in the control rooms in case of potential risks concerned with instability and interactions of IBRs. • as indicators to when perform further detailed studies (EMT simulations). • for monitoring the operational boundaries using simple metrics acting as proxy for system strength. And for the planning timeframe: • as indicators for when it is necessary to perform detailed EMT simulations when system strength is at low levels. • to provide signals for investment in infrastructure, new generation resources, and system services when there are scarcities. • to establish a framework to address low system strength issues in future. This project will replace two currently in-use global operational constraints, i.e., SNSP and MUoN, with system strength constraints targeting local network constraints and scarcities. This will allow for the integration of higher levels of renewables since the system security is represented and hence respected more effectively via the new constraints.

Tackling Solar Energy Integration Challenges

Status	In Progress
Scope	This project aims to investigate the potential challenges that will be posed to the system by integrating 8 GW of solar generation, including 2.5 GW of DPV generation, and will provide recommendations/action plan to tackle these challenges.
Rationale	The latest Climate Action Plan targets up to 8 GW of solar PV capacity by 2030, of which 2.5 GW will come from DPV. These rising solar PV levels pose challenges such as managing operational demand, ramping capabilities, maintaining frequency and voltage stability, and post-fault behaviour of distributed energy resources.
Expected Impact	Highlight the need to: • Enhance visibility of DPVs, • Improve forecasting accuracy, • Increase the system strength, • Reduce the dependency on conventional generating units for system services, • Enhance controllability of DPVs, • Develop DPVs dynamic models, • Facilitate model exchange between TSOs and DSOs, • Enhance DPVs fault-ride-through capability, Mandate DPVs voltage support requirements.

Progress in 2024	The project explored the potential risks and outlined high-level recommendations. The analysis and recommendations were presented to the operation and planning teams within EirGrid and SONI.
Further Planning	In 2025, we will work on developing the required high-level capabilities needed for tackling solar integration challenges.
Future Potential	The affected areas and programs have been identified for further engagement and to implement / consider the recommendations. The necessary actions to tackle these challenges will be fed into relevant tasks/initiatives/programmes. This includes inputs to the Operational Policy Roadmap 2025 – 2035, Operational Forecasting project (Operational Tools and Capability Enhancement programme), and Distributed Energy Resources (DER) Visibility, Controllability, Forecasting, and Modelling (EirGrid-ESBN Joint System Operator Programme).
Dissemination	The outcome and learning from this project have been published as a paper in the 23rd Wind & Solar Integration Workshop which was held from 08-11 October 2024 in Helsinki, Finland[23].

Short-Circuit Modelling and Protection System Performance Analysis for Systems with High Level of Inverter Based Resources

Status	Initiated
Scope	The objective of this research project is to investigate the impact of IBRs on the performance of EirGrid's protection system. Advanced short-circuit models of IBRs with various control systems aims to be used to investigate the fault response of IBRs in the EirGrid system. The performance of the protection system aims to then be assessed in various scenarios, and potential challenges identified. Then mitigation measures aim to be proposed through improving the existing protection schemes or designing new ones.
Rationale	This work aims to contribute to a better understanding of the performance of transmission system protection schemes in power systems dominated by IBRs. It aims to provide protection engineers with models, tools, and guidelines required to perform accurate protection studies on systems with elevated levels of IBRs. The project results are expected to benefit the participants and the public through improved grid reliability and secure system integration of renewable energy resources.
Expected Impact	• Improve understanding of the distinct response from IBRs and modelling capability. • Findings from the project could potentially require changes of fault response from IBRs.
Progress in 2024	Study areas with high IBR penetration have been selected with model collection ongoing.
Further Planning	Using Disturbance Recorder data for system faults to verify submitted EMT models from customers for the selected study areas. A range of contingencies and operational scenarios will then be studied to verify protection performance.
Future Potential	Innovation project will enable increasing capability for protection studies of new and existing IBR connections and increase protection performance.

[23] Tackling solar energy integration challenges on the Ireland and Northern Ireland power system

Setting the course for the Control Centre of the Future

Operational Tools and Capability Enhancement Programme

Status	In progress
Partner(s)	Utilisation of external partners during programme via frameworks.
Scope	Operational Tools & Capability Enhancement (OTCE) programme is being established to deliver the Control Centre of the Future as well as broader operational capabilities with the aim of ensuring we will have the ability to operate the power system with very high levels of variable non-synchronous renewable generation.
Rationale	OTCE will allow capability enhancements to be identified, prioritised, and developed, and spans the capabilities required from long-term operational policy development to real-time operations.
Expected Impact	To achieve the 2030 Government target of 80% of our electricity coming from renewable sources, TSOs will need the capability to operate the power system with up to 95% of instantaneous generation coming from variable non-synchronous renewables. The OTCE programme is contributing to TSO's work to ensure that this transition to higher levels of renewable generation can be achieved in a secure and reliable manner.
Progress in 2024	Programme establishment and the securing of funding and relevant TSO board approvals.
Further Planning	The development of capabilities will follow the TSO's phased implementation framework.
Future Potential	This project is set to launch this year with the goal of identifying the current and future needs of our Operational Forecasting System (Demand and RES Forecast). We aim to deliver solutions that address these needs over the next 2-3 years. This is a project to improve the current in-use forecasting system (it will be by default BAU). Timeline: Forecasting Tools & Processes Design & Development: 2025H1-2027H2; Forecasting Upgrade Enhancements & Automation: 2027H2-2030H2
Dissemination	The improvements and new capabilities will be presented to the applicable stakeholders. The forecast system performance and learnings will be shared with other TSOs in the form of knowledge-sharing sessions.

Lead the island's electricity sector on sustainability

Fast Frequency Response (FFR) Product Review

Status	Completed
Scope	• To inform the decision on whether to split FFR into different categories, for example: (i) A very fast one; and (ii) A fast one. • To consider the need to align FFR definition and requirements (volumes) for both upward and downward directions. • To consider the need for different FFR requirements (volumes) for Ireland and Northern Ireland power systems. • To inform the characteristics and type of the FFR response (e.g., dynamic vs static, trigger point, slope, deadband, etc.).
Rationale	Under the Climate Action and Low Carbon Development (Amendment) Act 2021 and the Climate Action Plan 2023 (CAP23) in Ireland, carbon budgets and the Climate Change Act (Northern Ireland) 2022 in Northern Ireland, the TSOs are each separately responsible for delivering low-carbon reserve services to support the 2030 decarbonisation targets in their respective jurisdictions. In December 2023, the SEM Committee (SEMC) published their decision (SEM-23-103) on the Future Arrangements for System Services, which requested that the TSOs consult on the Day-Ahead System Services Auction (DASSA) Detailed Design and submit associated recommendation papers to the SEMC in 2024. As part of the reserves product review work, this study focused on the FFR. The FFR service is one of the key frequency response services to halt frequency rise/drop and mitigate high rates of change of frequency. Detailed frequency stability studies are performed to investigate different aspect of FFR such as: (i) minimum volume required; (ii) need for both upward and downward FFR service to deal with under frequency and over frequency events; (iii) need for jurisdictional FFR requirements; and (iv) speed of FFR response.
Expected Impact	As per our Operational Policy Roadmap, the procurement of new system service capabilities from low carbon sources has been identified as an essential action to address the technical and operational challenges we have recently seen in Europe and arising from the need to operate with SNSP levels up to 95% by 2030, which underpins achieving the renewable targets in Ireland and Northern Ireland. This study provided basic understanding of the fundamental FFR characteristics in terms of the minimum volumes, speed of response, need for upward/downward FFR and need for jurisdictional FFR. This can help designing the FFR product to cater the system need and facilitate the TSO's consultation and recommendation process on DASSA design.
Progress in 2024	The study commenced on Sep 2023 and completed in May 2024. The study assessed the FFR minimum volume requirements, need for both upward and downward, FFR, need for jurisdictional FFR (Ireland and Northern Ireland) and for All-Island power system and outlined the importance of the speed of response.

Future Potential

As part of the FFR product review, the TSOs proposed that FFR is procured in three activation time sub-categories:

- FFR Enhanced subcategory 1: 150ms & sustainable up to 10s
- FFR Enhanced subcategory 2: 150ms ≤ FFR FAT <300ms & sustainable up to 10s
- FFR Enhanced subcategory 3: 300ms ≤ FFR FAT<1 second & sustainable up to 10s

These changes to the FFR product will have to be implemented by current and new service providers in order to qualify for DASSA that is expected to go live in December 2026.

Fuel Mix Disclosure automation project

Status

Completed

Scope

Design, test and hand over an automated and accurate fuel-mix (or "energy-source") calculation for all suppliers in Ireland and Northern Ireland.

The end-to-end data processing pipeline coded in Python, handles the complexity of semi--structured data from multiple different sources, such as:

- Guarantee of Origin energy certificates
- Renewable energy guarantee of origin
- Meter data from NIE (Northern Ireland Electricity)
- Meter data from MRSO (ESB)
- Meter data from SEMO
- Integrate six datasets of master data into data processing pipeline.

The delivered process is automated and offers user-friendly submission of inputs, and retrieval of calculation results, to and from a cloud-based pipeline.

The Python code is stored, shared, and version controlled using Azure DevOps.

Technologies include Azure Cloud resources, such a functions and logic apps, and Microsoft automation tools integrated with modern SharePoint file handling.

Rationale

Programme aims:

- Reduce manual labour by accelerating an existing two- or three-week manual process, executed multiple times per quarter, to a two- or three-minute automated process.
- Increase accuracy in the data processing pipeline and elimination of potential user error.
- Enable EirGrid Market Operations to update inputs and validate results quickly.
- Improve EirGrid delivery and accuracy of service to electricity suppliers, and EirGrid's management of FMD-data suppliers (NIE, MRSO, SEMO).
- Replace old Excel and Access database macros, as per company policy.

Provide reliable market information to customers, enabling them to reliably choose suppliers of renewable and sustainable electricity.

Expected Impact	Save significant resource capacity in EirGrid Market Operations. Improve information to customers when choosing electricity suppliers. Improve EirGrid's credibility and reputation with the electricity suppliers, and indirectly the Regulatory Authorities. Learning and new processes in EirGrid IT for Cloud-based projects and ongoing support.
Progress in 2024	The project is deployed and tested in pre-production cloud environment. Migration to production cloud environment is planned for January 2025.
Future Potential	The solution is already in use by the business and is realising the expected benefits. Going forward, the innovation can be leveraged to deliver the Annual Fuel Mix report, 80% of which can be re-used. This normally takes months of elapsed time to produce but we expect this to be reduced to minutes for any specific run of the report. The innovation described above, is EirGrid's first cloud-based data use case that completed its project lifecycle into production — to be designed, Python coded, and data modelled by EirGrid itself. As such, the skills, methods and the automation approach developed via this innovation project, will be applied to deliver future data and automation Use Cases.

Nature Inclusive Design including Biodiversity Enhancement

Status	East West Interconnector initial investment: completed East West Interconnector further investment: Delayed (est. Q4 2025) Other Nature Inclusive Design: On-going implementation, and further refinement of actions for nature on all onshore substations, onshore overhead line uprates, onshore underground cable projects, offshore cables and platforms, and interconnectors onshore and offshore.
Partner(s)	Projects where EirGrid designs, implements, and adaptively manages Nature Inclusive Designs (NIDs): • East West Interconnector: Hitachi Energy • Celtic Interconnector: Siemens Energy, Nexans, Sorensons, Greenway Landscaping • Offshore NID: WSP, ARCMarine, and key suppliers including Ecoconcretetech Projects where EirGrid designs, and ESB implements, and adaptively manages: ESB and ESB contractors.
Scope	The objective is to integrate wildlife into grid developments onshore and offshore, in response to the biodiversity emergency declared by the Irish government, without delaying accelerated delivery. There are limits to where nature is permitted on the grid, such as within the energized fenceline (i.e. the live station), or above underground cables. However, the scope includes objectively challenging such restrictions, with reference to precedence in other jurisdictions (e.g. use of green roofs on gas-insulated switchgear substation roofs or permitting planting of certain shallower-rooted shrubs over underground cables).

Rationale

The United Nations reported nature declining at an unprecedented rate in human history. In response, the Irish Government declared a biodiversity emergency in 2019.
In 2024, the EU's Nature Restoration Law received final EU approval. EirGrid must act to deliver on EU and Irish government targets.

Expected Impact

Enhancing natural habitats will promote nature-based carbon removal, improve resilience of ecosystems to climate change, bolster EirGrid's reputation in communities around Ireland, to support acceptance of the grid, and leave a legacy of wildlife for future generations

Progress in 2024

Offshore NID:

- Completed draft Design Risk Assessment of marine nature inclusive design measures.

Onshore NID:

- Detailed ecolandscaping design criteria to integrate woodlands and grasslands into substations agreed with ESB, and communicated to lead consultants
- First fully costed offsite habitat compensation project agreed with ESB, on two major underground cable projects, delivering a net gain in habitat area
- Tripling of bird flight diverter retrofits, relative to 2023, to deliver a total of 45 km spans of overhead lines with reduced bird collision risk as of end 2024

Further Planning

Once published in 2025, the outcomes will also be published in:

- EirGrid's first report on the EirGrid Biodiversity Strategy (to be published July 2025)
- EirGrid's first SEA-related monitoring report on Years 1 and 2 of the Grid Implementation Plan 2023-2028 (to be published July 2025)

EirGrid estimates it will publish learnings from Onshore Nature Inclusive Design in 2027, once the early ecolandscaping initiatives are sufficiently mature.

ARC Marine, working for WSP Consulting, have produced draft technical specifications for a number of Nature Inclusive Designs options. These integrate features promoting marine wildlife colonisation into substation foundation optimisations, scour protection, and cable protection.

The following methods (with timeline) will incorporate successful projects into BAU.

The below are all subject to favourable outcomes form the Design Risk Assessment process:

- Q2 Calendar Year 2025: Finalise EirGrid Review of Arc MARINE design risk assessment and draft functional specification
- Q4 Calendar Year 2025: Specify marine nature inclusive design requirement in tender documents for FEED Design of 'Powering Up Offshore South Coast' project
- Q4 Calendar Year 2025: Procure and deliver third party review of Arc MARINE design risk assessment and draft functional specification
- Q1 Calendar Year 2026: Agree format and scope of revisions to EirGrid offshore functional specifications, to integrate agreed functional specifications

- Q2 Calendar Year 2026: Publish revision to offshore EirGrid offshore functional specifications, embedding marine NID requirement into all future offshore grid
- 2026-2027: Integrate selected marine NID option into FEED design for Powering Up Offshore South Coast project
- 2026 In parallel: Integrate marine NID into planning and environmental assessment documents for Powering Up Offshore South Coast' project

Future Potential

The initiatives, which are already part of BAU, were formalised as specific objectives and policies in the Grid Implementation Plan 2023-2028[24] ensuring enduring implementation up to 2028. They will also be central activities whose implementation will be measured long-term in EirGrid's forthcoming Biodiversity Strategy, intended to be for a ten-year period 2025-2035 (with regular updates).

Dissemination

The outcomes from onshore Nature Inclusive Design are already reported in:
- The EirGrid Annual Report
- The EirGrid Sustainability Report

EirGrid does not yet have a date for installation of its marine NID initiative (see timelines above).
Any learnings will need to await the actual installation of same on offshore grid infrastructure (and monitoring of environmental performance).

[24] Grid Implementation Plan 2023-2028

Prepare for a multi-purpose offshore HVDC grid

Increased ramp rates

Status	Completed
Partner(s)	East West Interconnector, Moyle Interconnector
Scope	In advance of Greenlink and Celtic interconnectors — due to be commissioned in 2024 and 2026 — a review of the all-island ramp rate is required. A trial is being proposed to increase interconnector ramp rate up to 15 MW/min, where the ramp rate limit on East West Interconnector (EWIC) and Moyle will be adjusted. Initially, EWIC's limit will be increased to 10 MW/min, while Moyle will be set at 5 MW/min for a specified period. Subsequently, these limits will be reversed, with Moyle increasing to 10 MW/min and EWIC adjusting to 5 MW/min.
Rationale	The reason for this trial is to prepare for the Greenlink interconnector.
Expected Impact	Following a trial, EirGrid and SONI will determine whether the new ramp rate limit for the HVDC interconnectors will be put forward for consultation and regulatory approval in preparation for Greenlink.
Progress in 2024	A provisional operating policy was prepared in accordance with Article 3 of the Load Frequency Control Block Operational Agreement (LFCBOA), while simultaneously adhering to the requirements of SOGL Article 563. EirGrid and SONI carried out a ramp rate increase trial from trading day 6th March 2024 to 28th May 2024 (inclusive), where the maximum aggregated ramping rate for all HVDC interconnectors connecting the synchronous area IE/NI to synchronous area GB was increased from 10MW/min to 15 MW/min. In phase 1 of the trial, EWIC's ramp rate was increased to 10 MW/min while Moyle remained at 5 MW/min for a period of 10 weeks. In phase 2, these settings were reversed, with Moyle increasing to 10 MW/min and EWIC adjusting back to 5 MW/min for a period of 2 weeks. The post-trial analysis concluded that the maximum aggregated ramping rate for all HVDC interconnectors connecting the synchronous area IE/NI to synchronous area GB should increase from 10 MW/min to 15 MW/min on a permanent basis. To give effect to this, the LFCBOA between EirGrid and SONI was updated, and a 4-week public consultation was carried out. The updated LFCBOA was approved by CRU and UR on the 10th of December 2024.
Further Information	Public Consultation: Amendment to LFCOA following ramping trials | EirGrid Consultation Portal
Future Potential	If the new ramp rate limit is determined to be suitable, then it will be implemented in our operational policies. Part of this process the public consultation will inform our stakeholders of the outcome of the trial and our learnings.

Grow EirGrid TSO capabilities for developing and operating the new offshore grid

Offshore Wind Development Harmonic Distortion Mitigation Co-ordination

Status	In progress
Partner(s)	Guidehouse Netherlands B.V., EPRI
Scope	The five phase-one offshore wind developments will be connected to the transmission system by long cables, which will be compensated to cater power quality requirements. As all offshore connections will connect to the same region of the system, the shunt filter(s) connected at one node is very likely to affect other nodes. Therefore, it is important to investigate the interaction between them, so all developed solutions can operate coherently without affecting others in a negative way. Furthermore, as the developments are in proximity, there is the possibility to introduce an optimised approach in terms of identifying excess mitigation measure.
Rationale	• Investigate the interaction between the five wind farms, so all developed solutions can operate coherently without affecting others in a negative way. • Investigate the possibility to introduce an optimised approach in terms of identifying excess mitigation measure.
Expected Impact	• Operate all mitigation solutions without affecting others in a negative way. • Introduce an optimised approach in terms of identifying excess mitigation measure. • Efficiencies can be gained not only perhaps in terms of MVAr level connected but also in terms of the supporting infrastructure for the level of mitigation required.
Progress in 2024	• Agreeing on the scope. • Kick-off meeting.
Further Planning	This project is scheduled to be concluded by July 2025 and the following will be developed and/or analysed for all offshore wind farms: • modelling tasks, • harmonic compliance check at 220kV and 66kV nodes of interest, • harmonic filter design and/or adjustments, • combined harmonic incremental limit compliance at nodes of interest, • reporting and • results presentation.
Future Potential	The main idea of the project is to investigate the interaction between the mitigation solutions and identify the possibility of optimisation.

Offshore Wind Supplemental Program

Status	In progress
Partner(s)	EPRI
Scope	To fill critical knowledge gap by providing a collaborative, cross-cutting research platform to address offshore wind-specific research and development needs throughout the project lifecycle.
Rationale	This program will help us enhance our understanding of best practice and next generation offshore Transmission Asset Owner capabilities and solutions. The project will focus on the following areas: • Grid integration and energy systems • Transmission and collection systems • Environmental aspects • Wind generation • Technology trends
Expected Impact	Gaining a greater understanding to help us fulfil our role in the planning, development, operation, and maintenance of an offshore transmission system throughout the three phases of the network development model.
Progress in 2024	During the year we covered several areas. Key ones being: • Offshore Wind Interconnection Optionality • Offshore Wind Industry Trends
Further Planning	The plan is to continue and agree on the priorities for 2025.
Future Potential	The project will share the knowledge via different routes. For example, via technical research reports, whitepapers, annual technical progress reports, technology transfer webcasts etc. The knowledge will be shared within the company and help us fulfil the offshore transmission asset owner role.

Plan for a net zero carbon, customer focused, export capable power system

National Resource Adequacy Assessment Model Development

Status	Completed
Partner(s)	Afry, University College Cork, University of Ulster
Scope	Looking to the power system of the future, EirGrid and SONI, need to be able to monitor the reliability of a 100% renewable power system. The objective of this project is to develop a new enhanced methodology for a national resource adequacy assessment to replace the Generation Capacity Statement methodology and facilitate greater alignment with European modelling activities.
Rationale	The new resource adequacy methodology considers a future power system where the risks are no longer dimensioned by the failure of a large thermal power plant but are linked to low renewable output for multi-day periods or gas disruption.
Expected Impact	The new resource adequacy assessment methodology will provide enhanced capabilities for monitoring security of supply as the power systems transitions towards net-zero. Furthermore, there will be greater alignment with European modelling activities ensure consistency with the wider European messaging.
Progress in 2024	In 2024, the resource adequacy methodology was developed and consulted on. Substantial stakeholder engagement was carried out through this transition. Furthermore, two independent academic assessments were carried out. The draft report was developed and delivered to the RAs on schedule.
Further Planning	The final report will be submitted is formal approval to relevant regulatory authorities. Publication is expected in Q1 2025.
Future Potential	The new resource adequacy assessment methodology will provide enhanced capabilities for monitoring security of supply as the power systems transitions towards net-zero. Furthermore, there will be greater alignment with European modelling activities ensure consistency with the wider European messaging. The new framework will also be the basis for the upcoming Flexibility Needs Assessment.

Non-Wires Alternatives – Outage Transformation Programme

Status	Completed
Partner(s)	DNV
Scope	EirGrid experiences challenges in not being able to take all the outages on its network that are planned over a year. This project aims to identify which non-wire solutions beyond those already employed by EirGrid can facilitate additional outages on the grid in the EirGrid's context. Non-wire solutions (technologies or methodologies) are those which do not require additional reinforcements or assets on the grid, except those that can be temporarily constructed and put into operation in a short period.
Rationale	The purpose of this project is to determine non-wires technologies and practices that are available internationally, and how these could feed into the operational planning environment and outage management approach, to facilitate outages of transmission system that might otherwise not be granted or to reduce risk during the outages.
Expected Impact	By implementing best appropriate practice for the Irish Transmission system, it is expected to be able to facilitate outages of transmission system that might otherwise not be granted or to reduce risk during the outages.
Progress in 2024	Activities in 2024 included a combination of desktop research across publications and papers, interviews with peer TSOs (encountering similar challenges due to similarities in system composition) and workshops with EirGrid. A final report was delivered in May 2024.
Future Potential	Findings from the research included methods, practices, and devices that are currently in increasing use in the network, such as network reconfiguration, special protection systems, dynamic line rating or more frequent static rating changes, dynamic power flow controllers, flexible generation, and demand response. This work has highlighted the value of these to the transmission system for helping to accommodate planned transmission outages.

SEM/GB Multi Region Loose Volume Coupling Research Project

Status	Completed
Partner(s)	Baringa
Scope	The overall objective of the project was to: • Develop a comprehensive High-level Paper on SEM-GB trading arrangements that includes quantitative and qualitative analysis, alongside policy commentary. • To have an informed view on the current and future direction of the GB market and the possible implications for the SEM. The paper includes: • Modelling Multi Region Loose Volume Coupling (MRLVC) in the context of SEM • Implications around the divergence of auction timing between the SEM and GB • Commentary on current GB-SEM trading arrangements post Brexit and future SEM-GB trading arrangements.
Rationale	To call out the implications and opportunities for the SEM with regard to developments in the GB market and future EU-GB trading arrangements.
Expected Impact	To have an informed view of SEM-GB trading arrangements in a post-Brexit context and in light of policy developments in both the EU and the UK. This informed view supports engagements with peers at an EU level to call out implications for the SEM and also to support engagements with relevant stakeholders in this area.
Progress in 2024	Paper was started and completed within a 6-month period.
Future Potential	The work feeds into the *Review Day-Ahead Market Options for SEM-GB (MRLVC)* workstream in the Strategic Market Programme for Celtic Readiness. The findings in the paper are informing ongoing discussions at an EU level on a way forward for MRLVC. The findings have also been disseminated within the businesses to inform colleagues of key issues to be aware of when it comes to SEM-GB trading arrangements.

HyLIGHT

Status	In Progress
Partner(s)	Coordinated by Dublin City University. For additional information please visit www.marei.ie/project/hylight/
Scope	The HyLIGHT programme looks at the future outlook for hydrogen in Ireland under five work packages. The programme also addresses a roadmap for hydrogen to determine a plan for the hydrogen industry in Ireland. WP1 – Hydrogen Production • Techno Economic Analysis and Optimisation • Identification of New Economic Opportunities for H2 Production WP2 – Hydrogen Storage and Delivery • TWh Hydrogen Storage • The evolution of the Gas Grid / Interconnection / tankers / on-site storage WP3 – Hydrogen Demand • Large Industry Heat and Power Users • Hydrogen use in gas turbines • Outlook for E-fuels and H2-enriched Biofuels • Development of Hydrogen Markets in Ireland WP4 – Hydrogen in the Irish Energy System • Energy System Modelling WP5 – Hydrogen Policies, Social and Economic Aspects • EU and Ireland and UK hydrogen policy and greenhouse gas emissions reduction • Determine the policy environment necessary to enable decarbonisation of the Irish energy system • Public perception of hydrogen • Assess socio and economic costs and benefits of large-scale hydrogen roll out.
Rationale	The overall aim of HyLIGHT is to provide the knowledge, data and necessary tools to guide the cost-effective decarbonisation roadmaps for sustainable large-scale implementation of hydrogen technologies in Ireland to enable sector integration for a zero-carbon, secure, resilient energy system. HyLIGHT will achieve its aim by collaborating with the leading national and international companies, universities and stakeholders working to facilitate the delivery of hydrogen to all energy sectors heat, transport and electricity and also to where it is needed in industry, in a safe and cost-effective manner for energy consumers and industry. Over its 3-year timeline, HyLIGHT has four objectives: Vision, Roadmap, Plan, Partnership. The first three each contribute to a project milestone. The fourth facilitates collaboration in optional investment opportunities facilitated by the network and knowledge gained that may build into independent projects outside this project.
Expected Impact	• Roadmap for the hydrogen industry in Ireland. • Report on electrolyser project at Galway Port for green electricity production. • Report on onshore hydrogen storage methods. • Reports on the socioeconomic effects, techno-economic and new economic opportunities of large-scale hydrogen roll out and public perception of hydrogen. • Report on the development of the hydrogen market in Ireland. • Report on hydrogen policy in Ireland and the UK in addition to reducing carbon dioxide emissions.

	• Report for e-fuels and hydrogen enriched biogas. • Report on modelling hydrogen integration onto the All-Island system. • Report on using hydrogen in current gas turbines.
Progress in 2024	Through workshops held by the HyLIGHT group and the distribution of research findings, we were able to learn about the latest developments in the hydrogen sector and incorporate that into our planning for the future of the electricity system.
Further Planning	Concluding the research programme and engaging with partners on key findings.
Future Potential	Project will deliver roadmaps that will help inform EirGrid with future scenario planning which has to consider the effects of hydrogen on the power system.

Net Zero Markets

Status	In Progress
Partner(s)	Afry
Scope	Envisioning the changes that will be needed to electricity markets for Ireland to reach Net Zero in a sustainable way. How will key system metrics feed into overall costs in a variety of scenarios based on government policy and previous EirGrid research.
Rationale	Further expansion of demand and renewables will strongly impact day-ahead, intraday and other electricity markets. How will different demand and generation profiles interact in these markets and what will be impacts be on costs and competitiveness.
Expected Impact	Presenting total system cost scenarios for 2040 and 2050. This can lead to improved internal and external understanding of markets changes needed for achieving Net Zero. These changes are lengthy processes so early visibility is important.
Progress in 2024	Internal workshops were held. leading to a draft final report for internal review. Currently this report is going through managerial and executive review. Guidance was sought from key external stakeholders and progress was shared.
Further Planning	Finalise paper internally and engage external stakeholders for their feedback to support their long-term net zero policy recommendations. The paper will also be relevant to a working group which EirGrid is leading at ENTSO-E on long-term market design which will report to the European Commission.
Future Potential	The document will be useful at European level in advocating for market arrangements which are aligned with Ireland's interests. Specifically, EirGrid is leading a review of electricity markets from a 2030 perspective at ENTSO-E and this work is typically socialised to the Commission and other key stakeholders.

NexSys – Impact of Green Hydrogen Integration onto the Power System

Status	Initiated
Partner(s)	UCD via NexSys programme
Scope	The NexSys programme aims to determine how energy systems should evolve to connect more renewable energy towards 2030 and subsequently get to the net zero carbon goal by 2050. This particular project is one of three targeted projects which are in addition to the broader NexSys hub programme. This project seeks to develop an understanding of the impact of the integration of Green Hydrogen onto the Power System covering the following scope: • Modelling and techno-economic analysis for the all-island power system for a multi energy vector system including electricity and gas systems. • Identification of optimal location, planning and scheduling of electrolysers operation under dynamic conditions in all island power system. • Investigation of the technical capability of green hydrogen system for providing system services and system operation. • Investigation of the likely behaviour of electrolysers during low RES periods and the extent to which their demand can be flexible enough to prevent them adding to system load in these periods. Investigate way of scheduling and dispatching electrolysers i.e. self-dispatch.
Rationale	The production of hydrogen through electrolysis is an area that provides significant opportunity for reducing renewable energy dispatch down, providing system services, as well as decarbonising the gas network. As large demand sources, the location and behaviour of electrolysers will have an important impact on the electricity network and market making it important for EirGrid and SONI to understand fully.
Expected Impact	• Gaining a greater understanding of the benefits and challenges associated with using hydrogen for power generation on the all-island power system. • Understanding the optimum locations for hydrogen electrolysers as well as optimal dispatch schedule for electrolysers taking account of the interactions between the all-island power system and the gas network. • Gaining a greater understanding of the impact of large-scale hydrogen production from offshore wind on the all-island power system and on the various electricity markets.
Progress in 2024	Recruitment carried out by the university. Unfortunately, no successful candidate has been identified.
Further Planning	University is working to recruit a post-doctoral researcher to work on this project.
Future Potential	The outputs will inform future network planning, market design or operational roadmaps.

11. Annex 2 - List of abbreviations

Abbreviation / Term	Definition
AC	Alternating Current
AI	Artificial Intelligence
BAU	Business-As-Usual
CAP	Climate Action Plan
CIGRE	Conseil International des Grands Réseaux Electriques (Council on Large Electric Systems)
CP	Capital Project
CRU	Commission for Regulation of Utilities
DASSA	Day-Ahead System Services Auction
DC	Direct Current
DER	Distributed Energy Resource
DLR	Dynamic Line Rating
DPFC	Dynamic Power Flow Controller
DPV	Distributed Photo Voltaic
DS3	Delivering a Secure Sustainable Electricity System
DSO	Distribution System Operator
EBEG	Evidence Based Environmental Guidelines
EMF	Electromagnetic Field
EMT	Electromagnetic Transients
ENTSO-E	European Network of Transmission System Operators of Electricity
EPRI	Electric Power Research Institute
ESB	Electricity Supply Board
ESBN	Electricity Supply Board Networks
EU	European Union
EWIC	East West Interconnector
FAT	Factory Acceptance Test
FFR	Fast Frequency Response
FWP	Forward Work Plan
GB	Great Britain
GW	Gigawatt
HV	High Voltage
HVDC	High Voltage Direct Current
IBR	Inverter Based Resource
ID	Identification
IE	Ireland
IEEE	The Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardisation
LCIS	Low-Carbon Inertia Services
LFCBOA	Load Frequency Control Block Operational Agreement
LSAT	Look-Ahead Security Assessment Tool
MaREI	Marine and renewable energy research and development centre supported by Science Foundation Ireland
ML	Machine Learning
MRLVC	Multi Region Loose Volume Coupling

MRSO	Meter Registration System Operator
mT	Militesla
MtCO2eq	Million tonnes of Carbon Dioxide equivalent
MVA	Megavolt Ampere
MW	Megawatt
NexSys	Next Generation Energy Systems
NI	Northern Ireland
NID	Nature Inclusive Design
NIE	Northern Ireland Electricity
OTCE	Operational Tools & Capability Enhancement
PES	Power and Energy Society
PLC	Public Limited Company
PST	Phase Shift Transformers
PV	Photo Voltaic
RES	Renewable Energy Sources
RES-E	Renewable Energy Sources - Electricity
RGI	Renewable Grid Initiative
RMS	Stability Analysis
RMT	Ramping Margin Tool
RoCoF	Rate of Change of Frequency
SEA	Strategic Environmental Assessment
SEM	Single Electricity Market
SEMC	Single Electricity Market Committee
SEMO	Single Electricity Market Operator
SNSP	System Non-Synchronous Penetration
SOEF	Shaping our Electricity Future
SOGL	System Operation Guideline
SONI	System Operator Northern Ireland
TCD	Trinity College Dublin
TSO	Transmission System Operator
UCD	University College Dublin
UGC	Underground Cable
UK	United Kingdom
UPEC	Universities Power Engineering Conference
VTT	Voltage Trajectory Tool
WA	Washington
WP	Work Programme