2023 Annual Innovation Report

February 2024

1. Foreword

We are delighted to publish our report on the innovation and research we have carried out across EirGrid and SONI in 2023.

Innovation and research are at the heart of EirGrid and SONI's ethos and it is essential in increasing our knowledge to help us to accelerate to where we need to be in light of the Governments' ambitious targets. This approach has allowed us to unlock solutions and initiatives to realise sustainable energy benefits. EirGrid and SONI have innovated 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] to focus on the necessary support structures, frameworks, and the people who help make innovation part of who we are and how we go about doing what we do for energy citizen in both jurisdictions. Our innovation and research strategy complements recent publications from EirGrid and SONI on the Shaping Our Electricity Future, by focusing our collective research and innovation to deliver on Ireland and Northern Ireland's government targets, while enabling and supporting the innovation and research in the wider power system ecosystem to deliver on longer term net zero carbon commitments.

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 building new ones as we know partnerships and relationships within the power system ecosystem are vital as we strive 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 Northern Ireland and Ireland, to ensure we are on the right path to deliver on a reliable and cleaner energy future.

Alan Campbell,
Managing Director,
SONI

Liam Ryan,
Chief Innovation and Planning Officer,
EirGrid Group

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

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2. 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 responsibility for operating and planning the development of the electricity transmission system in Northern Ireland. We operate, implement changes and enhance the wholesale electricity market on the island of Ireland. EirGrid also develops and operates interconnections 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, primarily from wind generation. Our collective ambition is to achieve whole economy net zero carbon emissions, 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, Climate Action Plan 2023 (CAP 23) 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 $MtCO_2eq$ for 2021 to 2025 and 20 $MtCO_2eq$ for 2026 to 2030. CAP 23 sets an objective to reach a climate neutral economy no later than 2050.

In Northern Ireland, Climate Change Act[4] targets 80% of electricity to be generated from renewable energy sources by 2030 and the UK Net Zero Strategy[5] targets carbon net zero by 2050 as well. Currently, Department of Agriculture, Environment and Rural Affairs of Northern Ireland are developing the climate action plan for Northern Ireland which will include carbon budgets for the period of 2023-2027.

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[6]. The Annual Innovation Report is also a key deliverable forming part of Role 2 Independent Expert within SONI's Forward Work Plan 2023-24[7] 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 2023 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. 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.

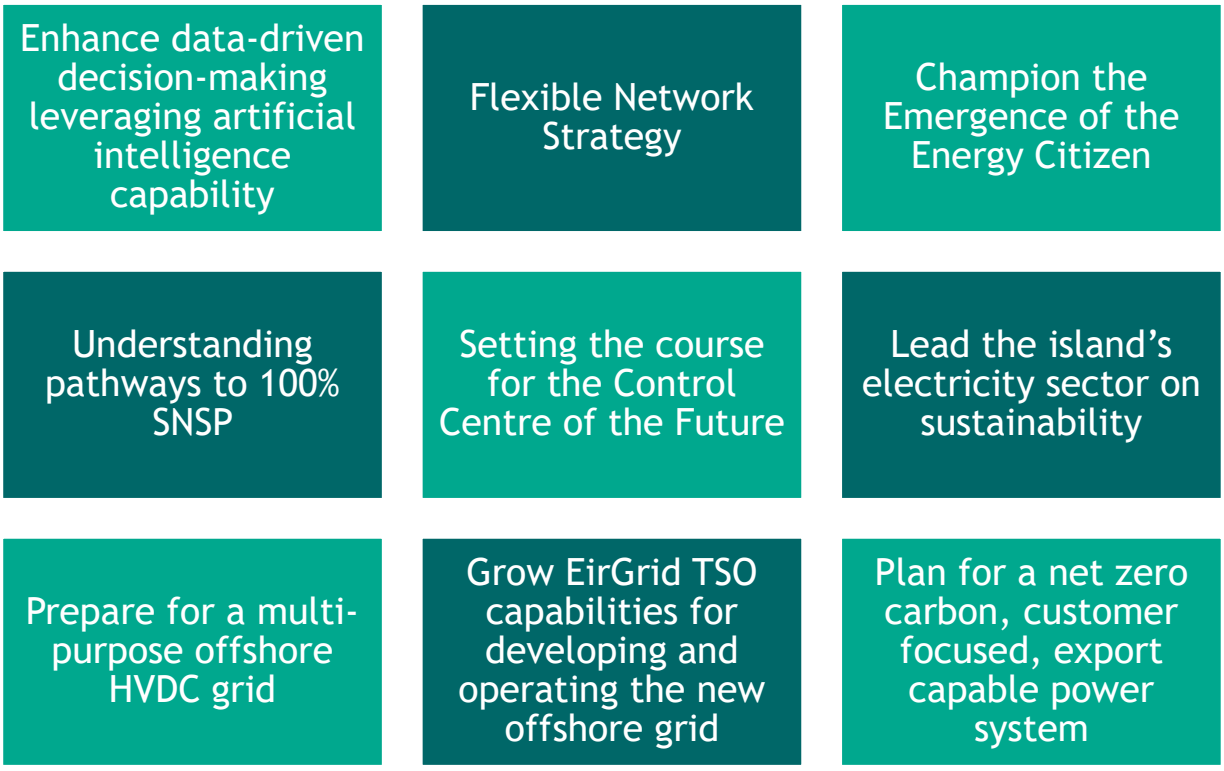
[3] EirGrid and SONI, DS3 Programme EirGrid | SONI
[4] Climate Change Act (Northern Ireland) 2022
[5] Department for Business, Energy & Industrial Strategy, UK Net Zero Strategy 2021
[6] CRU, PR5 Regulatory Framework Incentives and Reporting, 2020
[7] SONI, SONI Forward Work Plan for 2023/24, 2023

3. Innovation in 2023

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.

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. The identified strategic innovation programmes are listed below and expanded in the next few pages.



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

Project status descriptions are listed below:

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

This report documents progress on innovative programmes throughout 2023. The picture below illustrates a selection of our commitments between 2021 and 2025 and gives an idea how innovation projects in 2023 fit into the longer-term plan.
Please note, items above the timeline are longer scale memberships and programmes, and items below the timeline are individual projects.

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 (ESIG) 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 (IRDG) 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.

Global PST Consortium

- The consortium gives us the opportunity to connect with other ecosystem partners and creating intentional, inclusive, and purpose-driven collaboration to solve common challenges.

ENTSO-E Research Development & Innovation Committee

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

NexSys - 5 year programme

- NexSys will identify credible and accelerated pathways for a net zero energy system, and have developed technologies and talent needed for the energy transition.
- We are an industrial partner of the overall programme and have identified three targeted projects with NexSys researchers as well.

2021 | 2022 | 2023 | 2024 | 2025

HyLIGHT

- Roadmaps for sustainable large-scale implementation of hydrogen technologies.

MaREI Public Engagement

- Public engagement with energy transitions in an era of climate crisis.

READY4DC

- Community of experts that assess and give recommendations on the major technical and legal aspects of designing and building an interoperable multi-vendor DC grid.

CleanerGrid

- Competition for third level students.

Sources of very low frequency oscillations

- Identifying the sources of very low frequency oscillations on the all-island.

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 or machine learning capabilities across a variety of areas including network planning, forecasting within both control centres and predictive maintenance to support asset management for EirGrid.

Projects

In progress

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

Completed

- **Real-time Contingency Analysis & Network Optimisation Control Centre Tools**
  Development and validation of decision support tools to capitalise on network flexibility introduced with the use of innovative Power Flow Control technology.

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 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.
- **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.

Champion the Emergence of the Energy Citizen

Objective

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

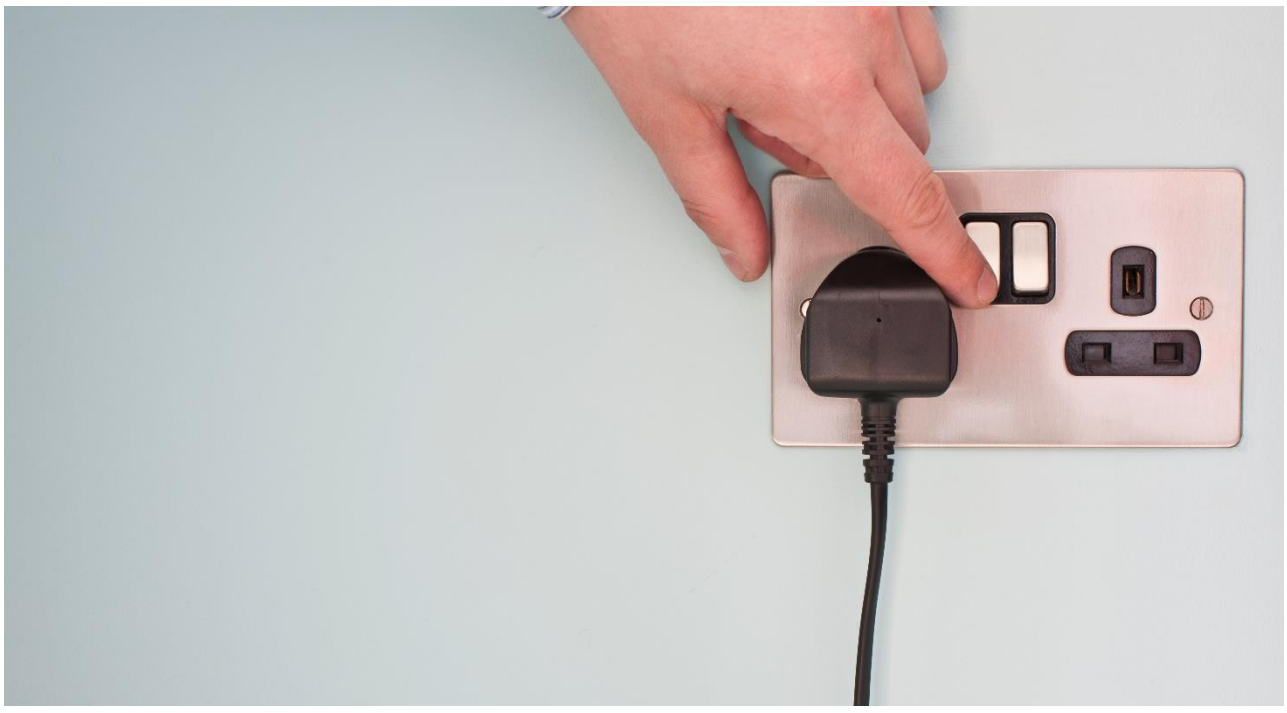
Benefit

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

In progress:

- **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.
- **CleanerGrid**
  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.



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% 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

In progress:

- **Modelling and Analytics of Emerging Technologies**
  Investigate the need for improved inverter-based resource (IBR) models & 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.
- **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.
- **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.

Initiated:

- **NexSys - Mitigation of Extreme Weather Events on High-RES Dependent Network**
  Analyse temporal and spatial resolution data to consider the role of HVDC links and the spatial correlation of low-RES events across Europe.

Completed:

- **Min 7**
  Study on relaxing the minimum number of conventional generation units that must be dispatched on the all-island system to identify potential insecurities and instabilities.
- **Phase-locked loop and grid forming modelling**
  Evaluation and recommendations on phase locked loop modelling and selection and implementation of suitable grid forming control configuration.

Setting the course for the Control Centre of the Future

Objective

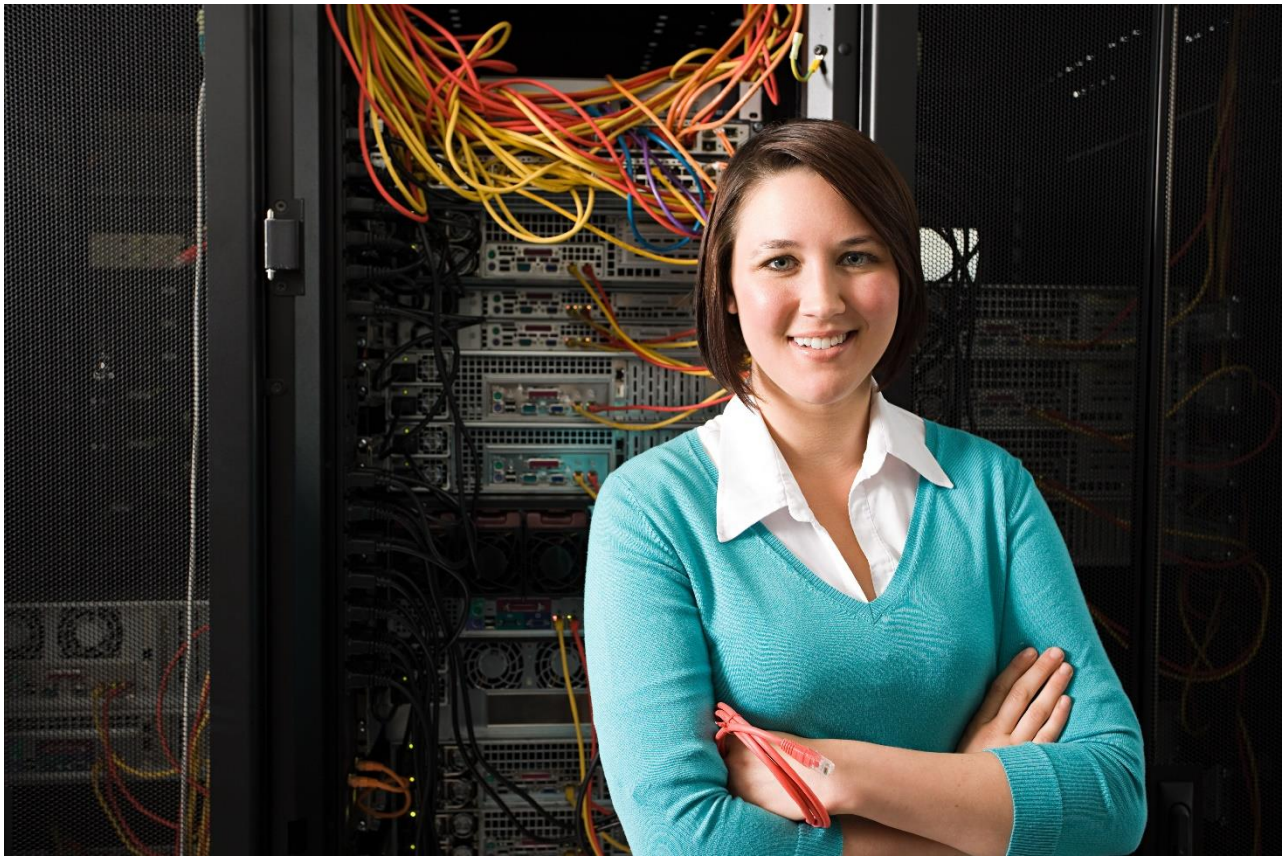
Identify what security tools and capabilities are required to maintain the protection of EirGrid and SONI's control centres now and in the future.

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

We are working in this area with a focus on determining future actions and currently working in a planning stage and will be engaging in standalone research projects in the near future.



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 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

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.

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

Initiated:

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

Completed:

- **READY4DC**
  Community of experts that assess and give recommendations on the major technical and legal aspects of designing and building an interoperable multi-vendor DC grid.

Deprioritised:

- **Advanced Power Flow Control**
  Investigate established and new HVDC and storage technologies to evaluate cost-effective design solutions for transmission reinforcement.

  This project is still run by EPRI, however, we stopped engagement in this project due to other priorities within the business. Please refer to 2022 Annual Innovation Report[8] for more details.

[8] EirGrid and SONI, 2022 Annual Innovation Report EirGrid | SONI

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

Initiated:

- **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.

Completed:

- **ENTSO-E Offshore Network Development Plan**
  A roadmap for the expansion and enhancement of the offshore grid infrastructure, enabling the efficient transmission of electricity from offshore generation sites to onshore areas and across borders.

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

In progress:

- **HyLIGHT**
  3-year programme to provide the knowledge, data and the necessary tools to guide decarbonisation and roadmaps for large-scale implementation of hydrogen technologies in Ireland.

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.

Completed:

- **Emissions from Dispatch Balancing**
  Emissions from Dispatch Balancing services make up the vast majority of the GHG emissions. We want to gain a better understanding and modelling of these emissions to help us achieve our target of 35% reduction by 2030, over 2019 levels.
- **Impact of electrification on the electricity sector carbon emissions**
  Irish Government targets to decarbonise some sectors. This involves an increased level of electrification of these sectors. This study aims to understand the impact this will have on the electricity systems carbon emissions.

4. 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. This sandbox would serve as a platform for facilitating innovation trials, removing barriers to innovation, and promoting the uptake of new technologies.

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.

4.1. Proposal: Data Sandbox

Over the past year EirGrid and SONI teams have spent significant time considering the exact scope and nature of a Sandbox programme. Through our research discovery phase considering existing arrangements such as QTP, and further to consultation with internal Subject Matter Experts with relevant internal personnel, we have determined there is significant value in a data-focused sandbox environment for the power system environment. This in turn resulted in a proposal of a *Data/Analytics Sandbox*. Based on our extensive review of use cases, there are a wide range of sectors that utilise data sandboxes to trial new technologies and services. These traditionally are constituted by software and information services but have also spread to other industries including the power sector. The traditional definition of a 'Data Sandbox' refers to a secure and scalable environment that allows an organisation to test and experiment with real-world data without compromising the integrity of the actual databases. The term has its origins in the web services/technology sector.

The benefit of such data sandboxes is that innovative companies can 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 occurs 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 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.

At this time, the proposed sandbox framework is intended to take the form of a data portal that makes curated datasets available to external parties. Parties that have potential solutions to grid or market issues could apply to access the Sandbox proposal. Under this proposal, the sandbox owner (EirGrid or SONI) will review the prospective application, and, where successful, they will grant access to the sandbox for a set period of time. The applicant then theoretically has a time-limited window to make use of the Data Sandbox.

5. Next steps

This Annual Innovation Report documents progress of EirGrid and SONI on innovative programmes throughout 2023 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. 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.

The consultation is published on our EirGrid[9] and SONI[10] consultation portals.

[9] EirGrid, Consultation Portal
[10] SONI, Consultation Portal

6. Annex 1 – Project details

Enhance data-driven decision-making leveraging artificial intelligence capability

Control Centre Tools Implementation

Status	LSAT: completed RMT: completed VTT: in progress
Scope	Implement a Look-Ahead Security Assessment Tool (LSAT) to enable Grid Controllers to analyse the stability of the power system 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 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 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 2023	LSAT is live in the control rooms in Dublin and Belfast. Some bugs have been resolved and a number of functionality enhancements have been implemented. Full server redundancy and Disaster Recovery functionality has been implemented. RMT is live in both Dublin and Belfast control rooms as of July 2022. In 2023 a piece of work commenced with the variable generation forecast providers to enhance the ramp forecast calculations, with focus on how their methodologies can be improved. The ramp forecast is integral to calculating the variable generation uncertainty and it makes up the largest portion of the ramping requirement feeding into the scheduling process. This work will continue into 2024, with added focus on solar and offshore wind. Several defects were also identified throughout 2023, some of which are resolved, with commitments to resolve the remainder in 2024. VTT Single Point Optimisation functionality has been completed. Master Solver functionality is undergoing User Acceptance Testing. The tool has been deployed to the control rooms in Dublin and Belfast. Parameter tuning is in progress.
Further Planning	LSAT and RMT are operational tools in the control rooms. Phase-1 of VTT is close to completion. Planning for phase-2 will start in 2024.
Future Potential	The tools are live in production environments. LSAT and RMT are fully integrated in business process as decision support tools in the control rooms. Business process for VTT will be developed in 2024.

Real-time Contingency Analysis and Network Optimisation Control Centre Tools

Status	Completed
Partner(s)	EPRI (Electric Power Research Institute), SmartWires
Scope	Develop and validate open-source software tools that will enable Transmission System Operators to capitalise on network flexibility introduced with the use of innovative Power Flow Control (PFC) technology. Provide enhanced situational awareness and an optimised decision support tool in relation to PFC devices.
Rationale	One key challenge of the integration of high levels of energy coming from renewable sources is managing grid congestion in a cost-effective and efficient manner. The use of Dynamic PFC technology seeks to address this. The technology assists in dynamically controlling power flows to alleviate overloads and mitigate congestion. It is anticipated that the co-ordinated control of multiple PFC devices strategically located throughout the power system can maximise the use of existing infrastructure, aid in the management of network congestion and contribute to the integration of increased levels of renewable generation in real time. To maximise the benefits offered by this technology, new tools are required to support real time operation and day-ahead operational planning. Such control and scheduling capabilities are not currently available in any control room in the world and the open-source outcomes of this project will aim to bridge that gap.
Expected Impact	• Provide significant benefits in terms of controlling power flow on grids, minimising congestion, and deferring investment in new transmission assets. • Maximise the benefits offered by these devices. • Enable the control centres to optimise the use of this technology to maximise the amount of renewable energy that can be transported on the grid.
Progress in 2023	All project deliverables have been completed. The project has been closed off. The project has delivered a “proof of concept” tool that can be integrated into existing platforms for maximisation of transmission capacity utilisation in planning and operational timeframes.
Further Planning	Next steps will be considered as part of the Operational Tools & Capability Enhancement (OTCE) Programme.
Future Potential	This project has demonstrated the potential to improve the resiliency and efficiency of the grid through supporting a reduction in generation constraints, transmission outage management, enhancing reliability and decreasing the costs of connecting renewable and demand customers. Next steps will be considered as part of the OTCE Programme.

Flexible Network Strategy

Dynamic Line Rating

Status	In progress
Partner(s)	ESBN Transmission Asset Owner, NIE Networks
Scope	Trial and investigate Dynamic Line Rating (DLR) implementations in Ireland and Northern Ireland, trial of 'Direct Measurement' DLR technology, consideration of 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 2023	The first scheme was deployed on the Lisheen – Thurles 110 kV overhead line in 2022 and we have been monitoring its performance throughout 2023. An order has been placed for the supply of a second scheme for installation on the Cashla – Dalton 110 kV overhead line in 2024.
Further Planning	The plan in 2024 is to deploy another DLR scheme and to continue gathering data and increase our learning from the existing DLR schemes. Continue working with ESBN and NIE Networks on further implementation of this technology.
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.

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 is 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 2023	ESBN Transmission Asset Owner has been engaged in a process of prequalification and selection of candidates to take part in a competitive tendering process which will result in a term contract of providers.
Further Planning	Following completion of the procurement process the first pilot installation at Binbane will begin construction (CP1388).
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)	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 2023	In late 2023, a researcher was recruited to take part in the project. An initial kick off meeting between NexSys EirGrid was held in late November 2023. The scope was finalised and agreed with the NexSys team.
Further Planning	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 2024.
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

Public Engagement with Energy Transitions in an Era of Climate Crisis

Status	In progress
Partner(s)	MaREI (The SFI Research Centre for Energy, Climate and Marine research and innovation)
Scope	Transition based assessment of actors, roles and agency in energy grid system change. • A synthesis review of international literature on 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. Comparative Analysis of Community Benefit Fund • Scoping review of community benefit literature. • Mapping existing initiatives and stakeholders. • In-depth case-study research in three different locations. • Comparative analysis of findings. Assess the impact of community benefit funding using comparative analysis of three different case studies. • Development of 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 & Exploitation** • Establish project identity and presentation guidelines, including brandings and templates for all deliverables. • 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. • Participation in and presentation 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 2023

In 2023 progress has been made in all work packages including:

- WP1 – Regular reviews
- WP2 - Mapping of public roles in energy system change
- WP2 - Synthesis of literature on engagement in electricity system change
- WP2 - 4 x research led Practitioner Reflection Sessions.
- WP2- Journal review paper energy research & Social science – Draft available November 2023
- WP2 - Paper on EirGrid's Multi-stage and Deliberative Engagements Process – Draft submitted July 2023
- WP2 - Discussion Paper on EirGrid's Multi-stage and Deliberative Engagements Process
- WP3 – Data collection and programme methodology
- WP4 – Draft paper in preparation following UNIC CityLab conference, November 2022, showcasing EirGrid Public Engagement approach.
- WP4 International Collaboration – Literature review.

Further Planning

The project has exposed the EirGrid Public Engagement team to international best practice and the expertise of the researchers from MaREI. There is opportunity to participate in research activities, co-author journal papers and present EirGrid's work in this area to new audiences e.g., the European University of Post-Industrial Cities https://www.unic.eu/en

It extends our international network in Public Engagement, domestically creating learning opportunities for programme partners (Irish Rural Link, Development Perspectives, SECAD, MCo) and our communities. It positively impacts on current work practices, deepens community relationships and maintains focused development of best practices, helping us to deliver company strategy and objectives. It sets a baseline for the evaluation of EirGrid public engagement processes and importantly will contribute to the library of international best practice.

Future Potential

Current programme is running until October 2024. Community Benefit Funds and community engagement is an increasingly influential factor on the successful deliverability of projects. This programme will test current approaches and generate a literature base which will reflect EirGrid's pioneering approach in this area giving rise potentially to the identification of other aspects of Public Engagement that can be developed to further Energy Transitions in an Era of Climate Crisis.

Adding to available literature and international case studies.

CleanerGrid

Status	In progress
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 2023	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.
Further Planning	The next steps are to host the award ceremony in 2024 January where the winners will be awarded their prizes. Planning will then begin for the potential next version of the CleanerGrid competition.
Future Potential	The winning entries will be analysed and there is the potential to work with finalists to further develop and implement their solutions within the EirGrid or SONI company websites. There is great potential that the CleanerGrid competition will develop into an annual competition either with the same scope or with a varied scope.

Understanding pathways to 100% SNSP

Min 7

Status	Completed
Scope	To enable the efficient and secure operation of the power system, EirGrid and SONI schedule and dispatch units to adhere to their respective Operating Security Standards. These standards ensure that the All-Island transmission system is operated in a secure and reliable manner. The minimum number of conventional units that must be dispatched on the all-island system is currently set to eight. This limits the amount of non-synchronous renewable energy that can be accommodated on the system. The ultimate objective of this project is therefore to relax the minimum unit constraint to enable operation of the system with seven units and the associated higher levels of renewable generation in a safe and secure way. The project has the following steps: • Carry out a study to evaluate the feasibility of relaxing the minimum number of conventional units on to allow for having the minimum of all-island units set to seven, with increased SNSP (Rate of Change of Frequency (RoCoF) constraint of 1 Hz/s and inertia constraint of 20 GWs) to enable more renewable energy onto the All-Island power system. • Evaluate security and stability of the future snapshots (2022 and beyond) where operational system constraints related to the minimum number of units are relaxed. • Identify potential insecurities and instabilities when operating with less than eight large units, through voltage & frequency stability and dynamic studies. • Identify mitigations for any potential insecurities and instabilities.
Rationale	A reduction in the number of synchronous generators on the system leads to a reduction in system inertia, reserve and ramping capabilities, system strength, and synchronising torque. It is therefore likely that different technical scarcities might arise when operating our system with seven units; increasing the need for other system requirements to support frequency, voltage, rotor angle stability and system strength domains. In order to securely operate the system with a minimum of seven conventional units, and thus transition towards accommodating higher levels of non-synchronous renewables, this study evaluates in detail and identifies the technical scarcities of the all-island system (2022 and beyond), identifies any mitigations and recommends whether a trial to relax this important Operational System Constraint can commence or not.
Expected Impact	• It is anticipated that the developed tools and automations will significantly improve study efficiency and enable further exploration of a vast space of study scenarios, quickly but comprehensively identify issues, and support efficient identification of potential mitigations. • The existing PLEXOS model used for market modelling simulations does not allow for model ramping, so it is expected that a python-based ramping assessment tool will be developed to carry out statistical analysis and calculate ramping capability and ramping requirements for 1,3, and 8 hours ahead.

Progress in 2023	The studies commenced in 2022 and were completed in May 2023 allowing the MIN 7 Trial to begin. The MIN 7 trial commenced on May 29th, 2023, and is ongoing. Up until the end of December 2023, there was over 500 hours of 7-unit operation. The studies have shown that the system can be operated securely with a minimum of 7 large units ON constraint, (Ireland - 4 and NI – 3 units) and with an inertia floor of 23 GWs (this can include 4 GWs from the Moneypoint synchronous condenser). The study had identified that certain faults could cause power imbalances and unrealistic frequency variations in phasor-domain simulations, affecting the accuracy of RoCoF evaluation. A new Python-based toolkit called TREx was developed, leveraging industry and academic expertise. TREx has allowed for a more realistic assessment of RoCoF during fault contingencies in offline studies and it acknowledges the blocking behaviour of certain RoCof relays during low voltage conditions to prevent false tripping.
Further Planning	Separate studies on trial closure are being performed prior to proposing a potential change in operational policy, which is a critical milestone for the SOEF programme.
Future Potential	The ramping assessment tool, TREx, and automations can be used for future studies and significantly increase study efficiency.

Modelling and Analytics of Emerging Technologies

Status	In progress
Partner(s)	EPRI
Scope	The goal of this R&D effort is to support the reliable integration of inverter based and distributed energy resources in transmission planning and protection activities. The project will develop generic models of onshore and offshore wind, PV, battery energy storage, hybrid plants, and distributed energy resources (DER) for bulk system planning and protection studies and corresponding tools, as well as tools and methods that assist planners in studying the impact of inverter-based resources on the bulk system. Issues such as weak grid analysis and tools, relay settings and grid forming convertors are all covered, with a focus on informing model and tool development across the industry.
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 inverter-based resource (IBR) system with distributed energy resources (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, 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 inverter-based resources can be captured in transmission planning and resource adequacy studies, ensuring system reliability while integrating increasing levels of variable energy resources (VER) 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 Electromagnetic Transients (EMT) analysis is required. Identification of when/where/how much Grid Forming capability is needed in the system.

Progress in 2023	Key areas of interest during 2023 included defining Grid Forming (GFM) and understanding the impact on protection, determining whether or not a generating plant and IBR is grid forming, determining the value and use cases of GFM technology and creating a roadmap for Adoption of Future Inverter Technology and proposing methods for identifying when and where GFM should be located, and finally, determining how to accurately represent IBR fault level contribution. A number of tools and models were also developed. The tools created include a Grid Strength Assessment Tool (GSAT) with enhanced capability for identification of system strength challenges in on-line and off-line modes as well as an IBR short-circuit modelling and Voltage Controlled Current Source Parameterisation Tool. The key model developed is a new enhanced IBR dynamic model for RMS simulation (REGC_C) integrated in commercial software platforms. This model provides an approximate representation of fast control loops and extends applicability of RMS tool. The technical briefs and updates covering these areas and other related topics were also prepared.
Further Planning	Additional work will be conducted in 2024 to develop better understanding of IBR behaviour and modelling requirements for weak grid conditions as well as modelling and assessment of Grid Forming technologies. Upskilling of EirGrid and SONI engineers to address challenges related to planning and operation with high levels of IBR.
Future Potential	Project learnings are constantly incorporated in the business process and support the model development and assessments necessary to meet the 2023 renewable targets.

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

Status	Initiated
Partner(s)	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 the impact and mitigations of extreme weather events on a high renewable energy source (RES) dependent network covering the following scope: • Documentation of actual cases of weather-related extreme RES ramping events worldwide. • Examination actual high wind speed shut-down events in Ireland and Northern Ireland. Compare what was forecast to 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 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 off-shore 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 & future generation portfolio 2030 timescale. • In the 2050 timescale, to gain a better understanding of the effect of low-RES periods on interconnection & 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 2023	Project scope was defined and recruitment initiated by the university.
Further Planning	University is working to recruit a post-doctoral researcher to work on this project
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.

Roadmap for implementation of EMT study capabilities in EirGrid and SONI

Status	In progress
Partner(s)	Guidehouse, EPRI, E-Bridge
Scope	The objective of this project is to develop a roadmap for the implementation of 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 electro-mechanical phenomena in traditional power systems. However, its applicability is being challenged as Inverter Based Resources (IBRs) like wind and PV displace synchronous generators. While the dynamics of synchronous generators are governed by the laws of physics and 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 & Capability Enhancement (OTCE) Programmes.
Expected Impact	Develop enhanced capabilities to study the impact of IBRs and weak system conditions to enable development 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 2023

Work in 2023 has focused on:

Task 1: Review of international practice and experience/challenges introducing EMT.

- In this task our partners have reviewed international experience and challenges in the use of EMT with primary focus on large-scale system impact/stability studies. 12 TSOs, 1 OEM and 2 industry experts have been interviewed and the key learnings have been documented in a report issued to EirGrid and SONI.

Task 2: Review of current and past study practice and needs in EirGrid and SONI

- In this task the framework partners have interviewed key internal stakeholders within EirGrid and SONI to understand their current and past study practices, and their needs for the future.

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.

- In this task the framework partners have developed a procedure so that EirGrid and SONI can undertake a comparative technical assessment of commercial EMT packages. The form of this assessment involves the development of a questionnaire for the EMT vendors to describe the capability of their products and their compatibility with existing EirGrid and SONI models.

Further Planning

Work in 2024 will focus 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 Operational Tools & Capability Enhancement (OTCE) Programme.

Phase-locked loop and grid forming modelling

Status	Completed
Partner(s)	AFRY, Energynautics, Avasition, HickoryLedge LLC
Scope	This project considers Grid Forming (GFM) and Phase Locked Loop (PLL) modelling and analysis and was divided into two work packages, which was further divided into seven tasks. The scope of each task is as follows: Work Package 1: Evaluation and Recommendations on PLL modelling. • Task 1.1: Theoretical evaluation of PLL assumptions and survey of industry practice. • Task 1.2: Evidence based investigation of PLL performance at low system strength. • Task 1.3: Development of PLL models to be used in RMS simulations. Work Package 2: Selection and implementation of suitable grid forming control configuration. • Task 2.1: Critical overview of grid forming configurations. • Task 2.2: Agreement on model specification and testing procedure for recommended grid forming configuration. • Task 2.3: Development of agreed grid forming configuration model. • Task 2.4: Documentation and reporting.
Rationale	Shaping Our Electricity Future (SOEF) is a pioneering initiative that will ensure that the power systems in Ireland and Northern Ireland are capable of operating resiliently with 80% electricity generated from renewable resources by 2030 in line with government targets. This project is part of the SOEF programme. To meet renewable targets, the power systems of Ireland and Northern Ireland must be able to run at or above 95% SNSP at times. At high levels of SNSP, the dynamic behaviour of converters dominates many aspects of power system stability. Several examples in literature point out the importance of modelling PLL, which states that the PLL and fast current controls of the grid-following converters are major potential causes for converter-related stability issues, especially in weak grid situations. Also, the importance of modelling PLL dynamics was investigated in previous projects, the EU-SysFlex and MIGRATE projects. At high levels of SNSP, the power system will increasingly depend on converter-based resources to provide essential services such as inertia, short circuit power, and reactive power that have traditionally been obtained from synchronous generation. It is the emergence of this dependence that provides the primary motivation for pursuing grid-forming converters. Grid-forming converters offer the potential to provide similar or superior functionality to the essential reliability services from synchronous generation. There have been recent developments in the generic Inverted-based Resource (IBR) model with PLL and grid-forming converters for RMS tools. However, these models are not compatible with the current EirGrid Online security assessment tool (LSAT) (see Control Centre Tools Implementation project detailed earlier). This modelling project's aim was to develop models for IBRs with PLL and grid-forming converters that are compatible with LSAT.

Expected Impact	In 2023, this project developed an Inverter Based Resource (IBR) model with PLL and Grid-forming converters, and the following configurations were developed: Grid following with PLL IBR representation including: • Discrete Fourier transform - based PLL – IBR models. • dq based PLL- IBR models. Grid Forming IBR representation including: • Virtual synchronous machine control based GFM models. • Extended grid following control based GFM models. • Extended grid following control based GFM models with Virtual Inertia. • Extended grid following control based GFM models with Virtual Inertia and Virtual Impedance. All models were tested and validated using hardware in the loop simulation results. Limitations for generic RMS simulations have been demonstrated and simulations with Electromagnetic Transients (EMT) modelling with the help of manufacturer modelling files is recommended.
Progress in 2023	Within the last year, models were developed, tested, and validated with hardware in the loop simulation results.
Further Planning	This project is now completed.
Future Potential	The developed models will be used for the Low Carbon Inertia Services 2nd phase study, which is also considering inertia from IBRs.

Sources of very low frequency oscillations

Status	In progress
Partner(s)	Queen's University Belfast
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 means 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 2023	Project is at its early–stages as it started in October 2023.
Further Planning	The project focuses on the following three key areas: • Identify a comprehensible set of events to extract useful knowledge and critical conditions that would lead to very low frequency oscillations. • A qualitative assessment of the control updates already undertaken by some units driving oscillations will be required to evaluate the impact of these updates. The algorithms should be enhanced to mimic the response of such units before and after the updates. The objective of such qualitative assessment would be to demonstrate: (i) the positive impact of updates on the incident recorded before them and; (ii) the negative impact on the incidents recorded after these updates. • Scope requirement for an offline tool: it is important to identify scenarios and conditions where the algorithm might fail and propose mitigation options or alternatives. More attention will be paid to alternatives, especially methodologies that would require the use of a subset of input data or other alternative data sources (state-estimator, control room dynamic security assessment). Alternatives for a lack of input data or inaccurate input data will be considered.
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.

Lead the island's electricity sector on sustainability

Nature Inclusive Design including Biodiversity Enhancement

Status

East West Interconnector initial investment: completed

East West Interconnector further investment: not started

Onshore Nature Inclusive Design: in progress

Offshore Nature Inclusive Design:

- Design Risk Assessment and Functional Spec: in progress
- Project implementation: not started

Partner(s)

Informed by engagement with Renewable Grid Initiative, Tennet, MARINEFF (University of Southampton), Department of Agriculture, Food, and the Marine, and (in 2024) National Parks & Wildlife Service Marine Unit, fisheries associations.

For onshore Nature Inclusive Design on TAO assets, ESBN delivers the measures, scoped by EirGrid.

For onshore Nature Inclusive Design on interconnector assets owned by EirGrid, EirGrid delivers the measures.

For offshore Nature Inclusive Design on EirGrid's offshore assets, EirGrid delivers the measures.

Scope

In 2019, EirGrid commenced a series of nature restoration projects starting with the East West Interconnector (EWIC) Biodiversity Project, in collaboration with Hitachi Energy.

In 2022, EirGrid established a new requirement for consultants to implement 'Nature Inclusive Design' (NID) proposals across capital projects, in collaboration with ESBN, landowners and other parties where appropriate.

Onshore NID examples include:

- Woodland planting and meadow habitat creation on onshore substation sites.
- Exploring planting shallow-rooted native shrubs over off-road cables.
- Building back better passing bays (where road boundaries are temporarily removed during underground cable construction), by reinstating road boundaries 'better than before' using species-rich locally sourced native species (5 woody species per 30m, excluding brambles/ivy).
- Retrofitting certain overhead lines with bird flight diverters to mitigate legacy bird strike risk, in the course of replacing wires on uprate projects.

A summary of the collection of NID initiatives (EWIC, onshore NID, offshore NID) was published in late 2022.
In 2023, EirGrid committed to procure Design Risk Assessments and Functional Specifications for offshore NID.

Rationale

The Irish Government declared a biodiversity emergency in 2019.
In 2021, the European Parliament adopted a resolution on the EU Biodiversity Strategy 2030 establishing the policy basis for an EU nature restoration plan. In 2022, the European Commission adopted a proposal for an EU-Wide Nature Restoration Law, and the terms of the law were formally agreed in November 2023, with final steps ongoing to include scrutiny by the European parliament's Environment Committee and plenary.

	In our published Nature Inclusive Design Pilots document[11] we stated: "We are integrating marine biodiversity enhancement into offshore cable and substation design. Measures may include artificial reef 'cubes', fish 'hotels', and cable protection materials which encourage shellfish growth while protecting the cable asset". The marine NID measures will serve multiple current, future compliance requirements and other benefits, including: • Restoring nature in response to the biodiversity emergency declared by the Irish Government. • Delivering nature restoration under the Nature Restoration Law, once requirements are defined by the Irish government. • Disclosures by EirGrid required from 2024 under the Corporate Sustainability Reporting Directive. • De-risking consenting process for EirGrid projects through compensatory measures and/or biodiversity enhancement on individual EirGrid offshore cable projects.
Expected Impact	In addition to the benefits for wildlife, enhancing natural habitats will promote nature-based carbon removal and improve the resilience of ecosystems to climate change. It will also be a: • Positive impact on EirGrid's disclosures under Corporate Sustainability. • Reporting Directive. • Reduced risk of Requests for Further Information from planning authorities on individual project consents. • Reduced risk of landowner opposition or litigation grounded on biodiversity impacts; and • Positive impact on ecosystem services (e.g., carbon sequestration in tree planting and pollination services in grassland habitats).
Progress in 2023	Onshore NID: EWIC Biodiversity Project: 200 trees planted; Orchard (ten trees) of Irish 'heritage' fruit trees. Onshore NID: Substations and underground cables: • Tree planting of 49,503m^2 (equivalent to 3.3 x area of Croke Park) • Meadow creation of 27,043m^2 (equivalent to 1.8 x area of Croke Park) • 6.25 km of OHLs retrofit with Bird Flight Diverters. Offshore NID: NID Contract drafted and procurement pathway identified.
Further Planning	We will focus on delivery of the offshore NID contract, and engagement with industry, government, and academia on specific implementation measures. Integration of all the above into an EirGrid Biodiversity Strategy planned for 2024.
Future Potential	All nature inclusive design measures will be implemented, once relevant projects are constructed in accordance with the Outage Programme. The results have been disseminated to: • The national Appropriate Assessment forum, • The national Strategic Environmental Assessment forum, • The Chartered Institute of Ecology and Environmental Management (CIEEM Irish Section Conference, April 2023), • The Government of Malta (Environment delegation), • University College Dublin, School of Geography (third level undergraduate, and Masters Students), • Department of Agriculture, Food, and the Marine, and • The public via the EirGrid website.

[11] EirGrid, Nature Inclusive Design Pilots

Prepare for a multi-purpose offshore HVDC grid

Increased ramp rates

Status	Initiated
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 results of the trial will be compared to the desktop frequency stability studies that were carried out prior to the trial commencing to determine the accuracy of the study tool.
Expected Impact	Based on the overall results of the trial, it is anticipated that EirGrid and SONI will determine whether the new ramp rate limit for the HVDC interconnectors will be put forward for consultation and regulatory approval.
Progress in 2023	Draft trial plan was proposed.
Further Planning	A provisional operating policy must be 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. Following the completion of the trial of the provisional operating policy, EirGrid and SONI will review the results and determine whether the new ramp rate limit for HVDC interconnectors will be put forward for regulatory consultation and approval in accordance with the requirements in LFCBOA. Part of this approval process involves a four-week all-island TSO-led public consultation, which will be communicated via EirGrid's and SONI's public consultation website. We will seek approval from Operational Policy Review Committee (OPRC) to carry out the proposed trial in Q1 of 2024. A draft operating policy will be developed and circulated for review prior to the OPRC meeting. This document will contain a list of operating rules and procedures, including actions to be taken for any change from normal system behaviour, system faults, along with when the trial should be suspended. Additionally, we plan to continue our engagement with Group Regulation to determine the optimal approach for amending the LFCBOA and conducting the public consultation.
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.

Ready4DC

Status	Completed
Partner(s)	Coordinated by WindEurope For additional information please visit www.ready4dc.eu
Scope	• Working group 1: Modelling, simulation framework and data sharing for multi-vendor HVDC interaction studies and large-scale EMT simulation • Working group 2: Legal Framework for the Realisation of a Multi-vendor HVDC Network • Working group 3: Multi-vendor Interoperability Process and Demonstration Definition • Working group 4: Framing the future European Energy System
Rationale	Create and engage a community of experts that will assess and give recommendations on the major technical and legal aspects of designing and building an interoperable multi-vendor DC grid. One major objective will be to prepare the ground for the development of the first multi-terminal, multi-vendor HVDC project in Europe.
Expected Impact	Developed white papers will consolidate the perspectives and views of all relevant sectors on the various technical, long-term planning and legal aspects. The results will target both the offshore and onshore use cases, overall, the application of power electronics-driven grids at every voltage level and will set the steppingstone towards a futuristic grid infrastructure with DC grids playing a central role at every voltage level.
Progress in 2023	Three newsletters, two whitepapers and ten reports were published in 2023 across the four working groups. Please visit https://www.ready4dc.eu/publications/ for additional information.
Further Planning	The published reports will be used for the contribution to the definition of required activities to develop a vision for the future of the European Energy system to create the conditions for a wider penetration of renewables.
Future Potential	The knowledge gained from being a part of this working group will help to ensure that EirGrid remains at the forefront of developments in multi-terminal, multi-vendor demonstrators. Beyond power evacuation, the insights into additional benefits associated with large scale HVDC deployment assessed, will contribute to EirGrid's rational going forward.

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

Offshore Wind Supplemental Program

Status	Initiated
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 2023	We have engaged with EPRI on the scope development for this programme.
Further Planning	The plan is to continue and agree on the scope and start the 12-month project in the beginning of 2024.
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.

ENTSO-E Offshore Network Development Plan

Status	Completed
Partner(s)	ENTSO-E
Scope	The objective of the Offshore Network Development Plan (ONDP) is the efficient integration of offshore renewable energy sources (RES) into the European electricity grid. They serve to identify the offshore infrastructure requirements to utilise power generated offshore, across European national borders. The plans build on Member State visions for the expected offshore RES generation in the 2030, 2040 and 2050 horizons. Plans relate to offshore infrastructure only, with related onshore infrastructure needs investigated under the framework of the Ten-Year Network Development Plan 2024.
Rationale	The ONDP are intended to serve as a roadmap for the expansion and enhancement of the offshore grid infrastructure, enabling the efficient transmission of electricity from offshore generation sites to onshore areas and across borders.
Expected Impact	The ONDP is an initial step to identify and plan a pan-European offshore electricity network associated with the efficient development of member state offshore renewable energy (ORE) targets.
Progress in 2023	With a legal deadline set by the TEN-E Regulations to release the first ONDPs by 24th January 2024, report finalisation was required by the end of 2023. This included agreement on conceptual projects, completion of all simulations, verification of all visualisations and report drafting.
Further Planning	Using internationally accepted models, simulations have identified where it appears economic to provide transmission capacity between market areas. Results indicate numerous potential links between European nations which are linearly optimised for a low-cost case. The ONPD plans will feed into TYNDP 2024 which will examine associated onshore requirements.
Future Potential	The ONPD plans are concerned solely with offshore development but will feed into TYNDP 2024 which will examine associated onshore requirements. Through the ONDP project, engagement with key stakeholders, including ACER, Wind-Europe and the Renewables Grid Initiative and through two public events, involvement from a broad variety of stakeholders has been encouraged.

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

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 & 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 & 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 & Ireland & UK hydrogen policy & GHG emission reduction • Determine the policy environment necessary to enable decarbonisation of the Irish energy system • Public perception of hydrogen • Assess socio & 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 2023	EirGrid attended 3 in-person steering group meetings where we provided feedback on students' research and engaged in group debate and discussion on trends in the hydrogen and wider energy industry. We also provided feedback on next steps for project work.
Further Planning	Insight into development of the hydrogen industry, how and where projects might develop and what the ultimate enduring role is likely to be for hydrogen in the Irish energy system.
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.

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 2023	Project scope was defined and recruitment initiated by the university.
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.

Impact of electrification on the electricity sector carbon emissions

Status	Completed
Scope	Currently focused on Ireland, as only Ireland has definitive carbon emission targets. These targets are not available yet for Northern Ireland. The scope is to look at historic, current, and future out to 2030. It also includes the assessment of both the buildings (heating) and transport electrification.
Rationale	Irish Government targets to decarbonise some sectors. This involves an increased level of electrification of these sectors. This study aims to understand the impact this will have on the electricity system's carbon emissions.
Expected Impact	An informed position regarding the impact of electrification on the country's carbon emissions as well as the electricity sector in isolation: • Gain an understanding of the emissions avoided in each sector through electrification (note not all target reduction would come from electrification). • Estimate the increase in emissions from the Electricity sector as a result of this electrification in various different scenarios. • Gain an understanding of the accountability for emissions across sectors (e.g. electricity emissions to charge Electric Vehicles). • Assess the opportunities for demand flexibility in the electrification of these sectors.
Progress in 2023	Completed studies assessing the relative impact of emissions of electrification of heat and transport compared to a baseline electricity system without those additional loads that could achieve the emissions targets.
Further Planning	No further steps planned currently.
Future Potential	More detailed studies could be carried out to assess opportunities for demand flexibility in these electrification sectors to mitigate emissions. Learnings have been shared internally to assist and provide context for future studies.

Emissions from Dispatch Balancing

Status	Completed
Scope	The scope is to develop the modelling of carbon emissions in the Dispatch Balancing Plexos model.
Rationale	We are committed to Science-Based Targets to measure and to reduce our GHG emissions. Emissions from Dispatch Balancing services make up the vast majority of these emissions. Better understanding and modelling of these emissions will help us to achieve our target of reducing GHG emissions by 51% from 2018 to 2030.
Expected Impact	The project will improve the methodology for extracting the best estimate of these emissions.
Progress in 2023	We analysed the dispatch balancing cost model for the backcast 2021-22 and extracted the emissions data. We also analysed some sensitivities to determine the factors that caused the most impact on these emissions.
Further Planning	The methodology can now be used to analyse data for subsequent years, and to track trends. For example, we can now focus on the outcome of the year 2022-23, and provide data and insights into the emissions from Dispatch Balancing. This could then be incorporated into the EirGrid Annual Report.
Future Potential	It is important to be more aware of the constraints most responsible for Carbon emissions. Therefore, this analysis can feed into the Operational Roadmap for the Milestones to 2030 on Dynamic Stability, as prepared by Chief Operations Office within EirGrid.

7. Annex 2 - List of abbreviations

Abbreviation / Term	Definition
CAP	Climate Action Plan
CP	Capital Project
CRU	Commission for Regulation of Utilities
DC	Direct Current
DER	Distributed Energy Resource
DLR	Dynamic Line Rating
DPFC	Dynamic Power Flow Controller
DS3	Delivering a Secure Sustainable Electricity System
EMT	Electromagnetic Transients
EPRI	Electric Power Research Institute
ESBN	Electricity Supply Board Networks
EWIC	East West Interconnector
FWP	Forward Work Plan
GFM	Grid Forming
GHG	Green House Gas
GSAT	Grid Strength Assessment Tool
GW	Gigawatt
HV	High Voltage
HVDC	High Voltage Direct Current
IBR	Inverter Based Resource
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
MtCO2eq	Million tonnes of Carbon Dioxide equivalent
MW	Megawatt
NIE	Northern Ireland Electricity
ONDP	Offshore Network Development Plan
OPRC	Operational Policy Review Committee
OTCE	Operational Tools & Capability Enhancement
PFC	Power Flow Controller
PLL	Phase Locked Loop
PST	Phase Shift Transformers
PV	Photo Voltaic
QTP	Qualification Trial Process
RES-E	Renewable Energy Sources - Electricity
RMS	Stability Analysis
RMT	Ramping Margin Tool
RoCoF	Rate of Change of Frequency
SECAD	South East Cork Area Development
SEM	Single Electricity Market
SEMO	Single Electricity Market Operator
SNSP	System Non-Synchronous Penetration
SOEF	Shaping our Electricity Future

SONI	System Operator Northern Ireland
TSO	Transmission System Operator
UCD	University City Dublin
UNIC	The European University of Cities in Post-Industrial Transition
VTT	Voltage Trajectory Tool
WP	Work Package