Shaping our electricity future

A roadmap to achieve our renewable ambition

EIRGRID SONI

Disclaimer

EirGrid Plc and SONI Ltd have followed accepted industry practice in the collection and analysis of data available. While all reasonable care has been taken in the preparation of this data, EirGrid and SONI are not responsible for any loss that may be attributed to the use of this information. Prior to taking business decisions, interested parties are advised to seek separate and independent opinion in relation to the matters covered by this report and should not rely upon data and information contained herein. Information in this document does not amount to a recommendation in respect of any possible investment. This document does not purport to contain all the information that a prospective investor or participant in the Single Electricity Market (SEM) may need.

For queries relating to this document or to request a copy contact:

info@EirGrid.com

Or

info@soni.ltd.uk

Published [November 2021].

Copyright notice

Preface

This inaugural Shaping Our Electricity Future Roadmap was prepared by EirGrid and SONI in consultation with stakeholders across society, government, industry, market participants and electricity consumers.

Shaping Our Electricity Future Roadmap provides an outline of the key developments from a networks, engagement, operations and market perspective needed to support a secure transition to at least 70% renewables on the electricity grid by 2030 – an important step on the journey to 80% and to net zero by 2050. Inherent in this is a secure transition to 2030 whereby we continue to operate, develop and maintain a safe, secure, reliable, economical and efficient electricity transmission system with a view to ensuring that all reasonable demands for electricity are met.

The publication of this Roadmap is a watershed moment for both Ireland and Northern Ireland. It informs a pathway to achieving energy objectives and climate ambitions across both jurisdictions.

In Northern Ireland the Department for the Economy launched a consultation entitled "*Energy Strategy for Northern Ireland*" in March 2021. The proposed vision for the new Energy Strategy is to achieve net zero carbon emissions by 2050 while maintaining affordable energy for consumers. The Energy Strategy is expected to be published before year end.

In 2019 the Irish Government published their first Climate Action Plan setting out the Irish State's climate objectives including to achieve at least 70% of electricity from renewables by 2030 and an energy wide net zero target by 2050. The enactment of the Climate Action and Low Carbon Development (Amendment) Act 2021, has now put Ireland on a legally binding path to net zero emissions no later than 2050.

Energy and climate policy in both jurisdictions contemplates an overall transition to net zero by 2050 and the Shaping Our Electricity Future Roadmap provides an outline of the key developments to support this transition.

It identifies the transmission network reinforcements needed to manage renewable generation and demand growth. As part of this Roadmap, EirGrid and SONI have developed corresponding engagement plans to underpin delivery of this network, recognizing that engagement and public acceptance is key to a successful transition. The operation of a power system with large levels of renewable generation needs an enhanced operating capability and tools that are also considered as part of the Roadmap.

EirGrid and SONI are committed to updating this Shaping Our Electricity Roadmap at regular intervals to cater for evolving energy policy. In parallel, EirGrid and SONI will continue to work with key stakeholders in exploring the necessary market reforms to attract investment in renewable energy and system services and to optimize participation of community owned and demand-based energy resources.

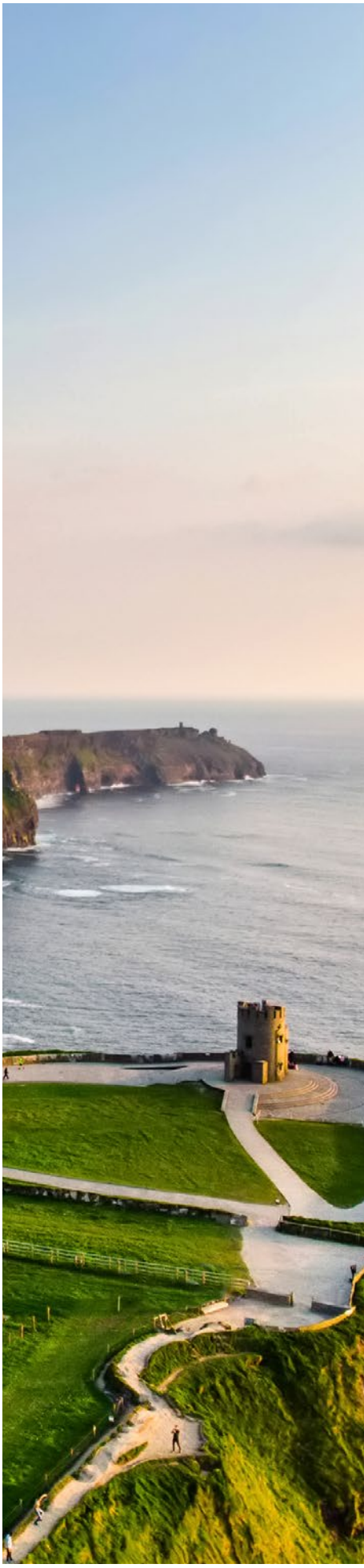
This Roadmap is informed by a comprehensive consultation process with stakeholders across society, policy makers, industry, market participants and electricity consumers. The valued feedback has contributed to our growing body of knowledge on how to decarbonise the electricity system and to support decarbonisation of the broader economy while maintaining a safe and secure supply of electricity for consumers. The wealth of comments and recommendations have been applied to improve the key drivers, planning assumptions, modelling and design of the initiatives proposed in the Roadmap.

We would like to personally thank all who participated in the stakeholder engagement and consultation process. EirGrid and SONI will continue to work together with stakeholders across society, industry, governments, regulators and consumers in achieving renewable ambitions while maintaining a power system that is safe, affordable, secure, reliable and sustainable.

Mark Foley
EirGrid Group
Chief Executive

Alan Campbell
SONI
Managing Director

Contents



1. Executive Summary

1.1 Introduction

EirGrid and SONI plan and operate the electricity system in Ireland and Northern Ireland. Our primary role is to operate the all-island grid and market. We send power from the generation site to where it is needed, at the most economic price possible.

The EirGrid and SONI corporate strategies are shaped by climate change and the need for a secure transition of the electricity sector to low-carbon, renewable energy. The context of climate change is well understood and beyond scientific doubt. The only question now is how fast society can respond to limit the damage and therefore protect our planet for current and future generations.

The publication of this Roadmap is a watershed moment both for our industry and for society in Ireland and Northern Ireland. It informs a pathway to achieving energy and climate ambitions and objectives across both jurisdictions.

In Northern Ireland the Department for the Economy launched a consultation entitled "Energy Strategy for Northern Ireland" in March 2021. The proposed vision for the new energy strategy is to achieve net zero carbon emissions by 2050 while maintaining affordable energy for consumers. The energy strategy is expected to be published before year end.

In 2019 the Irish Government published its first Climate Action Plan setting out the Irish State's climate objectives. The Programme for Government: Our Shared Future (2020) further outlined and increased this ambition, including to achieve at least 70% of electricity from renewables by 2030 and an energy wide net zero target by 2050. The enactment of the Climate Action and Low Carbon Development (Amendment) Act 2021, has now put Ireland on a legally binding path to net zero emissions no later than 2050.

Energy and climate policy in both jurisdictions contemplate an overall transition to net zero by 2050 and the Shaping Our Electricity Future Roadmap provides an outline of the key developments to support this transition. As a crucial first step on this transition, this Roadmap identifies the key initiatives required to reach at least 70% renewable electricity by 2030 from a network, engagement, operations and market perspective.

During this significant electricity system transition we will need to deliver against the Renewable Ambition (at least 70% of electricity from renewables by 2030 – an important step on the journey to 80% and to net zero by 2050) while retaining the essential reliability, resilience, and affordability of the Ireland and Northern Ireland electricity systems. We also need to consider the impacts of ageing infrastructure, the retirement and displacement of fossil fuel generators, an increase in renewable energy supply and storage, a rise in demand from large energy users and distribution connected customers, the social impacts of electricity infrastructure and a change in consumer preferences, behaviours, and expectations of their electricity supply.

This Roadmap draws on an extensive public and industry engagement in the first half of 2021. It identifies the network reinforcements needed to manage a fundamentally different generation fleet, new technologies and demand growth. EirGrid and SONI have developed corresponding engagement plans to underpin successful delivery of this network, recognising that engagement is key. In parallel, EirGrid and SONI will continue to work with key stakeholders in exploring the necessary market reforms to attract investment in renewable energy and system services and to optimize participation of community owned and demand-based energy resources. The capability and tools required to operate a power system with large levels of renewable generation are also considered as part of the Roadmap.

1.2 Scope and objectives

The main objective of the Shaping Our Electricity Future initiative is to outline a secure transition to deliver the Renewable Ambition. In consultation with governments, regulators, and stakeholders we have used scenario-based analysis across the whole electricity system to identify a roadmap to delivery of the Renewable Ambition in an economic and reliable fashion.

Given the relatively short planning horizon to 2030, Shaping Our Electricity Future provides a deliverable, economically feasible, dynamic, and transparent roadmap that delivers system reliability while meeting the Renewable Ambition. This analysis is on achieving at least 70% RES-E by 2030. However, the future evolution of the power system beyond 2030 is also implicitly considered in delivering the broader EU ambition of net zero carbon emissions in the economy by 2050.

1.3 Whole of system approach

EirGrid and SONI believe that the Renewable Ambition can be delivered while maintaining the stability of the power grid. This Roadmap is informed by stakeholder and public engagement feedback, comprehensive modelling and analysis of network reinforcements and detailed reviews of market operations and system operations.

The scale of the transition is challenging and the current approaches to network planning, public and industry engagement, electricity system operation and electricity markets need to be transformed if the Renewable Ambition is to be achieved.

Our networks analysis identifies key transmission network projects in Ireland and Northern Ireland. These projects will now need to be progressed appropriately through the respective EirGrid and SONI grid development frameworks. In addition, we will seek to maximise the use of existing power grid infrastructure, apply proven technologies, optimise the delivery of renewables and demand connections pipeline – all in the context of overall system reliability.

Ireland and Northern Ireland are already world leaders in renewable integration. However, to achieve at least 70% renewables we must evolve our proven practices of system operation even further to allow operation at 95% System NonSynchronous Penetration (SNSP) by 2030. Enhancements to current operational policies, electricity market rules, together with support from regulators and government bodies will be needed to allow us to bring online and operate the appropriate resources on the system in a timely and efficient manner.

The Roadmap is based on consultation and studies spanning across transmission networks, stakeholder engagement, power system operation and electricity markets with the aim of developing an integrated vision of the 2030 power system and electricity markets for Ireland and Northern Ireland.

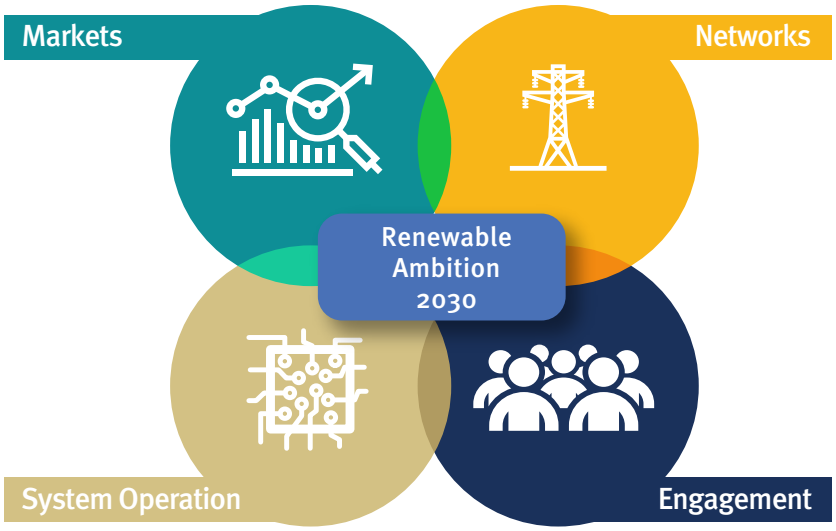


Figure 1: Renewable Ambition 2030

The process followed in support of our reviews in electricity markets, network planning and system operations is shown below:

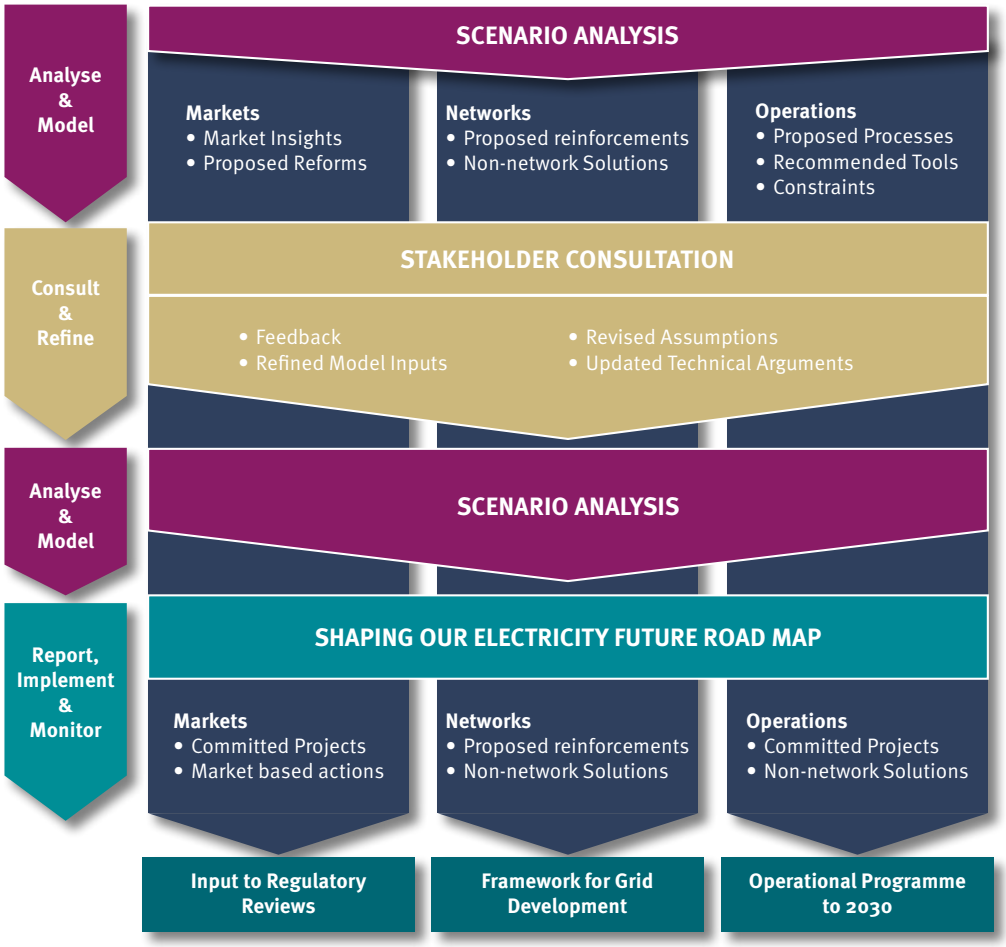


Figure 2: Review process

An outcome of the consultation feedback was the importance of ongoing stakeholder engagement to the successful implementation of the initiatives outlines in this Roadmap. Consequently, engagement is included as a core component of the Roadmap going forward.

1.4 Extensive consultation

In March 2021, EirGrid and SONI launched the Shaping Our Electricity Future consultation. This detailed a summary of our initial thinking on how the electricity grid, market and system operation could evolve to achieve the Renewable Ambition. The Shaping Our Electricity Future consultation processes proved successful in delivering against its key objectives:

- Offer a broad set of perspectives and views from across society and industry
- Provide clarity on a way forward that will ultimately deliver on our renewable obligations.
- Identify clear milestones and timelines that consider power system operations and market dependencies
- Provide input to a coordinated plan to inform the development of electricity infrastructure, and enhancement of system operations and electricity markets.

The consultation process, supported by the Shaping Our Electricity Future Consultation Paper, sought opinions and insights in the following areas:

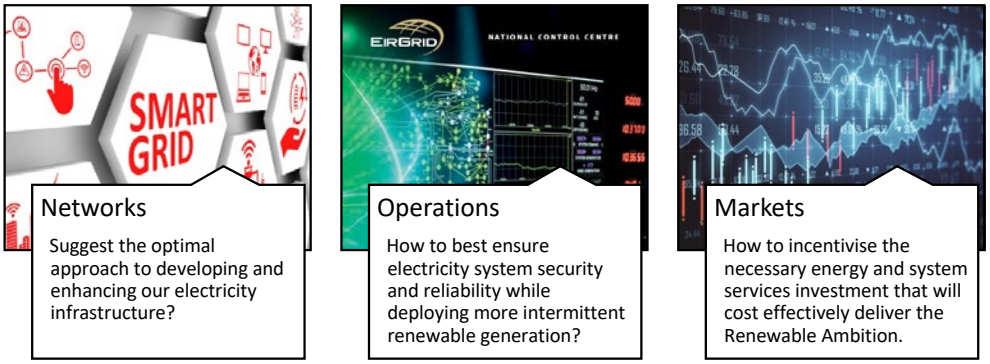


Figure 3: Areas of interest

EirGrid and SONI conducted a range of engagement and participation activities over the course of 14 weeks – this included a deliberative dialogue process in Ireland and national forums involving industry and civil society in Ireland and Northern Ireland. Furthermore, we engaged with rural communities, local businesses, and young people. There were over 100 events across Ireland and Northern Ireland with over 500 submissions received as part of the consultation.

The consultation focused on four distinct network development approaches and presented a series of questions relating to the enhancements needed to system operations and electricity markets to meet the Renewable Ambition.

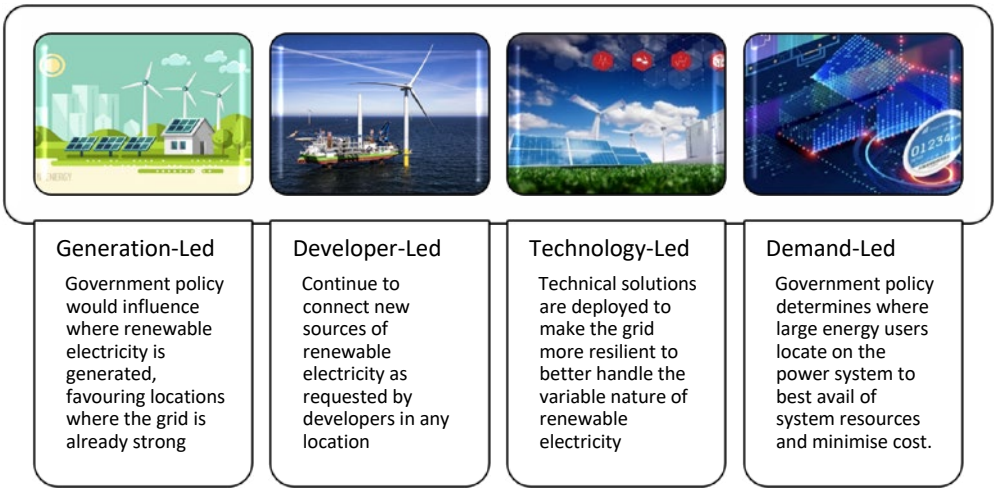


Figure 4: Four approaches

Focusing on networks, the feedback from the consultation process was broadly consistent across Ireland and Northern Ireland – the key difference was offshore wind deliverability by 2030. The feedback can be broadly grouped into the following key themes:

Public Engagement Feedback

- **Community ownership of renewables** – strong desire that communities should be supported and incentivised to develop community owned renewable projects.
- **Costs** – no appetite for the cost of electricity to rise because of the transition to a low-carbon electricity system.
- **Economic development** – need for rural communities to share in any economic upturn as a result of the implementation of the Renewable Ambition.
- **EirGrid and SONI roles** – the public in either jurisdiction was not fully aware of EirGrid and SONI and their respective roles in relation to the electricity grid and markets
- **Environment and ecology** – concern how the outcome of Shaping Our Electricity Future would impact on the landscape across Ireland and Northern Ireland.
- **Landowner concerns** – a key concern was the recognition and protection of landowner rights where infrastructure development takes place on farmland.
- **Micro-generation** – communities are eager to get involved and believe micro-generation should have a relatively significant role in attaining at least 70% renewables.
- **New technology / future proofing** – ensuring the grid is fit for purpose beyond 2030 and that the grid utilises technology to minimise new grid infrastructure.
- **Offshore generation** – a large amount of feedback supported offshore generation; many stakeholders felt that it has a less negative environmental and visual impact.
- **Onshore generation** – wind energy was accepted as a solution to support decarbonisation. However, the public generally preferred onshore solar generation.
- **Public acceptance / licence** – consultation process clearly identified and reinforced the need for public acceptance / licence by energy infrastructure developers.
- **Public Engagement Processes** – stakeholders were adamant that it must be genuine open and honest engagement.
- **Security of supply** – security of energy supply is an important consideration in reaching the renewables target.

Industry Feedback

- **Alternative technologies** – consider mature non-wires alternatives and new technology options in any future development of the network.
- **Costs** – similar to public engagement feedback, no appetite for the cost of electricity to rise because of the transition to a low carbon electricity system.
- **Market enhancements** – electricity markets must evolve significantly to support investment for new and existing market participants.
- **Network delivery** – public acceptance is crucial for the timely delivery of new grid infrastructure.
- **Network reinforcements** – commence building the required network infrastructure to support renewables as quickly as possible.
- **Operations processes and tools** – must evolve to manage increased variable generation mix with a focus on facilitating increased penetration of renewable generation.
- **Renewable targets** – 70% renewables is a step on a journey towards a net zero energy system and this should be implicit in any plans from EirGrid and SONI.
- **Resourcing** – considered that EirGrid /SONI requires the funding and resources to implement the proposed program of work.
- **Security of supply** – similar to public engagement feedback, security of energy supply is an important consideration in reaching the renewables target.

The consultation feedback highlighted that there is a high level of support for the aims and ideals of the pathway to a low carbon future and a clear understanding that concerted action must be taken to address climate change.

There was no clear coalescence of support around any one of the four network development approaches outlined in the consultation report in Ireland or Northern Ireland.

- **Ireland:**
    - **Public Engagement Feedback:** A significant number of responses indicated support for Generation-Led and Demand-Led approaches. There was some support for the Technology-Led approach, with the Developer-Led approach receiving the least support of the four.
    - **Industry Engagement Feedback:** There was clear support for the Developer-Led approach, but also for a hybrid of the different approaches (Generation-Led, Developer-Led, Technology-Led and Demand-Led).

- **Northern Ireland:**

    - **Public Engagement Feedback:** A significant number of responses indicated support for Generation-Led and Demand-Led approaches or a blend there-of. Participants and respondents were less enthusiastic about the other two options.

    - I**ndustry Engagement Feedback:** There was strong support for the Developer-Led approach but also for a hybrid of the different approaches (Generation-Led, Developer-Led, Technology-Led and Demand-Led). Concerns were raised about the feasibility of connecting offshore wind at scale by 2030.

The majority of responses highlighted that if the challenges ahead are to be addressed and the Renewable Ambition is to be achieved, a whole of society approach is necessary. Stakeholders stressed that Shaping Our Electricity Future is a significant step in the right direction. However, this type of engagement must continue if the objectives of the Renewable Ambition are to be achieved.

The feedback received is used as an input to, and directly influences this Roadmap. We have reflected on the feedback and updated the inputs for the scenario-based modelling of network analysis, system operations and electricity markets to achieve the Renewable Ambition.

1.5 Key messages

A detailed review of the public and industry consultation feedback combined with EirGrid and SONI analysis of electricity grid, system operations and electricity markets provided the following insights:

Shaping Our Electricity Future Roadmap provides an outline of the key developments to support a transition to a net zero by 2050. As a crucial first step in this transition, this Roadmap identifies the key initiatives required to reach at least 70% renewable electricity by 2030 from a networks, engagement, operations and market perspective.

There is enough planned renewable capacity to meet the Renewable Ambition. The number of renewable projects in the development pipeline in Ireland and Northern Ireland suggests that there is more than enough capacity planned and at the various stages of development to deliver the Renewable Ambition.

Additional network infrastructure must be built to achieve the Renewable Ambition. Our studies identify a significant number of required network reinforcement projects to modernise the grid capability so that the Renewable Ambition can be supported. Building network infrastructure is complex and can take many years to deliver from planning through to energisation. The scale of work outlined in this Roadmap will be very challenging to deliver.

Maximising the use of the existing power grid is key to delivering the Renewable Ambition. Optimising the use of the current infrastructure can help reduce the scale and quantity of network reinforcement projects needed to achieve the Renewable Ambition. Using technologies such as active power flow controllers can help manage network congestion and maximise existing network capacities. This approach also assists in mitigating challenges associated with building new overhead lines or underground cables such as societal acceptance and prolonged outages of key infrastructure.

In the short to medium term, the system adequacy position in Ireland will be challenging. Over the coming decade, demand is forecast to increase, older high emissions capacity will exit the market (approx. 20% of portfolio), new capacity will enter and outages on ageing plant is expected to increase. A secure transition and the orderly coordination of these factors is crucial to maintaining system reliability over the coming decade.

Significant volumes of new generation capacity are needed in Ireland and Northern Ireland, starting from now and to the end of the decade, so that demand growth can be met. In the short to medium term, there are risks of shortfall in supply in Ireland. These risks can be mitigated by coordinated timing of plant decommissioning, together with the delivery of new capacity needed to replace them, to cater for increases in demand and help manage the power system. The situation in Northern Ireland is more stable but requires careful monitoring.

New large scale dispatchable resources (low carbon) are needed – the Roadmap estimates 2 to 3 GW of new dispatchable capacity is needed across Ireland and Northern Ireland for a secure transition to 2030. New capacity is required to meet demand in situations where renewable resources are not available – this new capacity will be significantly less carbon intensive than the legacy plant it replaces. A balanced portfolio of batteries, demand side, interconnection and renewable gas ready conventional capacity will be required to meet our needs. Gas-fired generation is expected to play an ongoing key role, replacing retiring conventional plant and providing the multi-day capacity, during extended spells of low wind and solar output. Furthermore, it will ensure security of supply during periods of high demand, and low renewable output. In the longer term, other innovative technologies such as long duration batteries, new demand side management techniques and new pumped storage facilities could also play an important role.

Continued secure operation of the power system is critical. We are currently trialling operation of the power system with System Non-Synchronous Penetration (SNSP) levels of up to 75% and Rate of Change of Frequency (RoCoF) up to 1.0 Hz/s. Satisfactory completion of these trials to demonstrate our capability to operate the power system securely at these levels will form the basis of further changes to our operational practices to achieve our Renewable Ambition.

Operating the future power system with fewer conventional synchronous generators will be technically challenging. To deliver on the Renewable Ambition, it will be necessary to accommodate large penetrations of variable non-synchronous renewables such as offshore wind, onshore wind and solar, whilst keeping curtailment levels to a minimum. This will require us to be able to operate the power system with SNSP levels of up to 95% and with significantly reduced numbers of conventional units online.

System services will play a key role in managing the resilience of the power system. The new system services arrangements introduced in 2016 have been key to achieving 40% renewables by 2020. New system service capabilities from low carbon sources are required to address the technical and operational challenges arising from levels of instantaneous renewables increasing to close to 100% by 2030.

Service providers connected to the distribution network and partnerships between the Transmission System Operators (TSOs) and Distribution System Operators (DSOs) are required to help release the full potential of demand-side flexibility. Demand side flexibility will be critical to ensuring we can enable the transition to at least 70% RES-E and facilitate electrification of the heat and transport sectors while maintaining power system security. A demand side management strategy covering the participation of demand side resources in the energy, capacity and system services markets is required to incentivise the necessary behaviours and flexibility.

Market design needs to be closer aligned to long-term renewables policy objectives of Ireland and Northern Ireland. This is critical for ensuring investments by third party developers are appropriately targeted to provide solutions for the all-island system challenges at an affordable cost to the consumer. This must be done whilst implementing evolving GB and EU policy.

Stakeholders acknowledged both EirGrid's and SONI's evolution in their approach to engagement, and the accelerated speed at which this has happened. Stakeholders believe this needs to be sustained, iteratively evolved, and be supported by consistent and targeted communications at local and national level. At every opportunity stakeholders reinforced that engagement should be open, transparent and consistent across the board. It is particularly important that stakeholders are empowered and respected in their engagement with EirGrid and SONI.

To enable the deliverability of electricity infrastructure the consultation process clearly identified and reinforced the need for public acceptance. This is achieved when stakeholders feel they can trust EirGrid's and SONI's approaches to the planning and development of infrastructure. In addition to this, it was highlighted that this must also be achieved by electricity infrastructure developers, to enable delivery of renewable and low carbon infrastructure to generate electricity and provide system services.

There was strong support for the connection of micro-generation from communities across Ireland and Northern Ireland. Communities are eager to get involved in this aspect of the electricity system and believe micro-generation should have a relatively significant role in attaining at least 70% renewables.

There was strong support for community ownership of renewables and that communities should be supported and incentivised to develop community owned renewable projects. Many stakeholders believed a community-led approach to renewable project development would provide significant community benefit, support acceptance of energy infrastructure and demonstrate a grassroots contribution to achieving climate action targets. However, stakeholders strongly communicated that systems need to be put in place to foster and encourage ideas in this area.

There was repeated reference to the need for rural communities to share in any economic upturn as a result of the implementation of a roadmap with major Renewable Ambition. This includes balancing the infrastructure modelling across the island, encouraging large energy users to locate in regional cities and balance the requirement of offshore and onshore generation, in order to sustain jobs and investment.

EirGrid and SONI recognise cost is a key concern in a secure transition and we are committed to working with governmental and regulatory stakeholders to help ensure a secure, reliable but also affordable electricity system out into the future. As regulated utilities we acknowledge the responsibilities of our regulators in ensuring that customers and network users receive value for money while we are appropriately funded to make the necessary network investments. Those investments go towards the efficient operation, development and maintenance of the networks. Based on the experience of other jurisdictions, EirGrid and SONI believe it will be challenging to maintain electricity prices at current levels. However, the cost of not carrying out this transition to a low carbon electricity system is considerable and could include increasing carbon taxes; cost associated with climate change mitigation and; higher exposure to volatile international oil and gas prices such as we have seen in recent times.

1.6 Shaping Our Electricity Future Roadmap – Multi-year plan

The key components of the Shaping Our Electricity Future Roadmap are grouped under four areas

- Network Infrastructure
- Engagement
- System Operations
- Electricity Markets

1.6.1 Network infrastructure

Overview

Between now and 2030 there needs to be a transformational step change in the volume of network reinforcements delivered across Ireland and Northern Ireland to support the Renewable Ambition in an efficient and effective manner.

The objective of the networks strand of Shaping Our Electricity Future is to describe how the transmission network in Ireland and Northern Ireland could evolve out to 2030. This follows detailed consultation with government, regulators, industry participants, stakeholders and the general public where we used scenario-based analysis to identify a transmission network roadmap. The future evolution of the power system beyond 2030 is also implicitly considered in delivering on ambitions to be carbon neutral before 2050.

Scenario overview

As part of the Shaping Our Electricity Future consultation in spring 2021, four separate network approaches were developed to assess how the electricity transmission network in Ireland and Northern Ireland could be developed to support the projected changes in electricity demand, generation and interconnection by 2030.

The outcome of this process is blended scenarios for both Ireland and Northern Ireland which reflects the detailed feedback received from all stakeholders. They reflect a balance of different views and were validated against current and evolving government policy in both jurisdictions.

The following is a high-level summary of the separate scenarios for Ireland and Northern Ireland. The values in the table are the additional capacities compared to the year 2021. All figures are rounded to nearest 100 MW.

Table 1: Summary of the separate scenarios for Ireland and Northern Ireland

	Ireland	Northern Ireland
Demand	46.5 TWh (~High GCS Scenario)	10.1 TWh (~High GCS Scenario)
Offshore Wind	+5,000 MW	+100 MW (Pilot)
Onshore Wind	+1,300 MW	+1,100 MW
Solar PV	+1,500 MW (500 MW micro-generation)	+400 MW (100 MW micro-generation)
Batteries	+1,450 MW	+200 MW
De-rated Gas Capacity	+2,000 MW	+600 MW

A comprehensive set of network planning studies has been undertaken to determine what potential network reinforcements are needed to ensure the Renewable Ambition is delivered in both jurisdictions in the context of growing demand.

It is important to note that:

- Potential projects identified in Shaping Our Electricity Future are required in addition to other committed projects which are currently progressing through EirGrid and SONI's grid development processes.
- The network analysis for Shaping Our Electricity Future is strategic in nature – each individual project will require a detailed assessment to determine the optimum path forward. At the heart of these grid development frameworks is engagement.

Table 2: Potential transmission network reinforcements

Reinforcement Category	Ireland	Northern Ireland
New circuits	4	3
Uprate existing circuits	17	7
Replace existing circuits	5	-
Upvoltage existing circuits	2	-
New transformer	1	-
Power flow controllers	6	-
Dynamic line ratings	5	2
Total	**40**	**12**

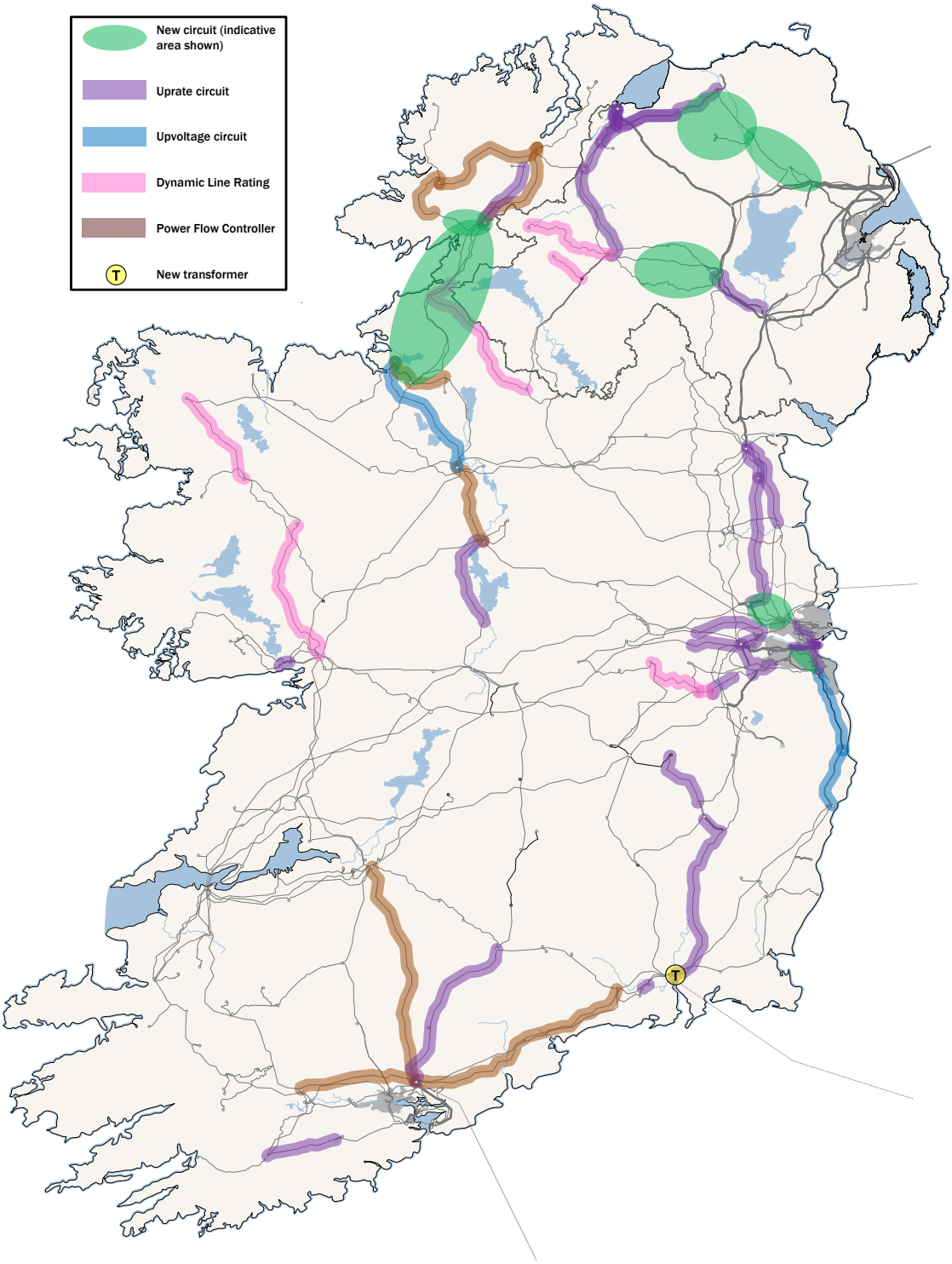


Figure 5: Map of Ireland and Northern Ireland detailing reinforcements

Network enablers

There is a number of key strategic enablers that have been identified as being fundamental for infrastructure delivery within the required timeframes out to 2030. These have been identified based on a combination of project delivery experience, engagement with stakeholders and communities. These enablers are described below.

Table 3: Summary of networks workstreams

Workstream	Description
Ireland	Enablers include: • Government and regulatory policies in place to support locating generation and large energy users where electricity grid capacity is available / anticipated to be available in the future. • Implementation of an end–end TSO/TAO joint approach to optimise programme delivery time of electricity infrastructure • Implementation of a transmission outage review and transformation programme • Deliver an electricity grid Technology Toolbox solution for enhanced network operation • Work with TAO/DSO to derive a delivery plan for the Dublin region (including station works, new bulk supply nodes, refurbishments and any new build requirements) • Develop flexible networks strategy for deployment of “non-wires” electricity grid technologies
Northern Ireland	Enablers include: • Deliver an electricity grid Technology Toolbox solution for enhanced network operation • Develop flexible networks strategy for deployment of “non-wires” electricity grid technologies • Implementation of an end–end TSO/TO joint approach to optimise programme delivery time of electricity infrastructure

1.6.2 Engagement

EirGrid and SONI together with the governments, regulators, DSOs, the general public and industry will both lead and underpin the Ireland and Northern Ireland response to climate change in the electricity sector. It is EirGrid's and SONI's role to plan and develop the grid for the 2030 Renewable Ambitions of each jurisdiction. For this to happen, EirGrid and SONI need to make an evolutionary shift in how we engage with the public.

In the next decade, we will develop very significant amounts of new grid infrastructure. More than ever before, it's important that we gain the support of individual landowners, their neighbours, and their wider communities.

Our public engagement will provide a comprehensive, thoughtful, transparent and inclusive approach. We must listen to those who live near future grid infrastructure. Only with their support will we be able to achieve the scale of change required in the next few short years. The scale of this challenge is enormous – but the benefits will be immeasurable.

In response, EirGrid and SONI are making community engagement and participation part of our core Shaping Our Electricity Future Roadmap. This will complement and enable our well-established expertise in engineering. Our aim is to develop a cohesive approach that reflects and is framed by the secure transition to a low carbon electricity system – and by the urgent context of climate action. As we improve the way we engage with the public, we must recognise and reconcile the impact of these changes on existing projects.

Table 4: Summary of engagement workstreams

Workstream	Description
Ireland	Enablers include: • Embed Consultation and engagement toolkit within the Framework for Grid Development – "Putting Communities at the Heart of Grid Development." • Regional Energy Citizen's Assemblies - modelled on Ireland's Citizens Assembly but at a local level, liaising with Non-Government Organisations and Civil Society as appropriate. • Follow up with individual local authorities on future grid needs in their area, including Climate Action Regional Offices. Engage more proactively with regional assemblies • Partner with schools / a national youth organisation with regional reach to deliver awareness programmes/initiatives on transitioning Ireland to a cleaner greener energy future. • EirGrid will explore the introduction of a 4th Strand of Community Funding specifically for micro-generation to support landowners and communities in transitioning to a cleaner greener energy future. This strand is in addition to our existing strands on Community / Sustainability / Biodiversity. • Coordinate and host regional knowledge hub initiatives that support communities with the practical information and tools to commence their community energy journey. • Develop a knowledge hub for communities to explore topical queries in relation to the grid such as EMF, underground cabling, overhead lines, cost of the grid, how EirGrid is funded, how renewable electricity sources work, smart technologies, operations, sustainability etc.
Northern Ireland	Enablers include: • Embed SONI's enhanced 3 Part process and Consultation and engagement toolkit within Northern Ireland project delivery – "Putting Communities at the Heart of Grid Development." • Subject to regulatory approval, engage elected representatives CEOs, Planning officials – complete a biennial cycle of council engagement on key topics and how we engage. Including annual workshop with council planners and regular updates to SOLACE. Supported by colleagues in NIE Networks as appropriate. • Develop a knowledge hub for communities to explore topical queries in relation to the grid such as EMF, underground cabling, overhead lines, cost of the grid, how SONI is funded, how wind energy works etc.
Industry	Enablers include: • Establishment of and subsequent regular hosting of a Shaping Our Electricity Future Advisory Council. • Coordinate regular Shaping Our Electricity Future Industry forums

1.6.3 System operation

In order to deliver on government renewable electricity and climate policies in Ireland and Northern Ireland, it will be necessary to accommodate unprecedented penetrations of variable non-synchronous renewables such as offshore wind, onshore wind and solar whilst keeping curtailment levels to a minimum.

This will require a significant evolution of the operation of the power system and for EirGrid and SONI to deal with unique challenges that will not be faced in larger move heavily AC interconnected power systems for years to come.

The System Operations strand of Shaping Our Electricity Future is divided into four main workstreams:

- **Operational Policy:** The objectives of this workstream are to undertake operational studies and analysis and develop operational policies to facilitate the transition to 70% RES-E by 2030;
- **Standards and Services:** The objective of this workstream is to ensure we have the right operational standards and appropriate system services frameworks to support investment in required capability;
- **Operational Tools:** The objective of this workstream is to identify and oversee the delivery of enhanced and new integrated control centre technologies and tools that are required to operate the system securely and efficiently with increasing levels of variable non-synchronous RES; and
- **Technology Enablement:** The objective of this workstream is to facilitate the development and integration of new technologies and innovations on the power system to enable them to operate efficiently and effectively.

All four workstreams are underpinned by a holistic TSO-DSO Partnership. With so many of the future generators and system service providers expected to be connected to the distribution system as the portfolio decentralises and diversifies, we will need to partner with the DSOs to ensure that the needs of both distribution and transmission systems, and ultimately the needs of consumers, are met.

Figure 6: System Operations Workstreams

The following table is a high-level summary of the System Operations strand.

Table 5: Summary of system operations strand

Workstream	Description
Operational Policy	The objectives of the operational policy workstream are to undertake operational studies and analysis and develop operational policies to facilitate the transition to at least 70% RES-E by 2030. • Identifying technical scarcities and operational needs – both now and projected for the future • Developing operational protocols, policies and procedures for new Interconnectors • Completing system studies to facilitate the transition of key operational metrics including, but not limited to, SNSP, inertia and minimum number of sets • Revising and developing operational policies to assist in operating the power system with new system services provision capabilities and the new operational systems and tools
Standards and Services	The objective of the Standards and Services workstream is to ensure we have the right operational standards and appropriate system services commercial frameworks to support investment in required capability. This will help ensure we achieve at least 70% RES-E and 95% SNSP by 2030. • Clarifying the system technical needs, both now and projected for the future • Reviewing the Grid Code (and where appropriate, working with the DSOs in relation to the Distribution Code) and bringing forward proposed modifications to the Regulatory Authorities as appropriate • Developing the technical requirements for a new commercial framework for procurement of system services, taking effect from 1 May 2024 • Publishing the standards that service providers will need to adhere to and monitoring the performance of service providers against these standards on an ongoing basis • Developing a framework for flexible network management that will seek to incentivise the supply and demand sides to provide flexible network services and alleviate network congestion

Workstream	Description
Operational Tools	The objective of the operational tools workstream is to identify, conceptualise and oversee the delivery of enhanced and new integrated control centre technologies and tools that are required to operate the system securely and efficiently with increasing levels of variable non-synchronous renewables. • Identifying the needs for enhanced and new tools driven by factors such as increasing levels of variable non-synchronous RES, increasing demand and new demand categories, new transmission network including flexible devices, new interconnectors, and new scheduling and dispatch processes driven by market and system services changes • Conceptualise the new innovative tools required to support the secure transition • Developing the IT, data management and physical infrastructure required to support these developments • Ensuring that relevant interfaces and data exchanges are in place with the DSOs and other stakeholders • Ensuring appropriate training in the use of tools
Technology Enablement	The objective of the technology enablement workstream is to facilitate the development and integration of new technologies and innovations on the power system to enable them to operate efficiently and effectively. • Enabling hybrid connections and arrangements with a view to optimising use of existing infrastructure • Addressing the challenges associated with the integration of large-scale storage technology • Facilitating the provision of System Services from new and existing RES as well as small-scale flexible generation • Enabling Demand Side Management to maximise its potential • Engaging with large energy users to investigate the potential for large energy users to contribute to system flexibility • Proactively engaging with industry and academia to review and evaluate emerging technologies which are not covered by the other work streams

1.6.4 Electricity markets

EirGrid and SONI have identified key market initiatives to evolve the current market design to achieve the Renewable Ambition. It is acknowledged that EU legislation determines the overall structure of much of our current and future market design and that Regulatory Authorities and the Single Electricity Market (SEM) Committee have an oversight, approval and legal role in the development of any new SEM rules and processes.

These initiatives inform the transition to achieve the renewable transition and therefore may be updated or revised in the future. This could be for several reasons, e.g. EU directives, government policy, regulatory decisions and socio-economic requirements.

Specifically, the suggested key changes that might inform the evolution of the market design to support the Renewable Ambition are grouped under two pillars:

1. **Aligning markets to the operational challenges of high renewables –** evolving the design of the wholesale electricity and system services markets to provide aligned incentives for third-party investment. This will provide the necessary energy and system services to meet dynamic demand requirements and physically operate the power system to deliver the Renewable Ambition.

2. **Full integration of SEM in the Great Britain and EU Markets** – evolving the market structures to best utilise interconnection to improve the economic outcomes for SEM consumers and to facilitate the long-term the export of renewable energy efficiently and effectively. Specifically:

    - **Full SEM integration into Great Britain Market –** with the withdrawal of the Great Britain from the EU on Jan 1, 2021, the SEM region no longer has a Day-ahead market with Great Britain and the broader EU markets. The intraday trading facilities between SEM and Great Britain are still in effect.

    - **Full SEM reintegration into EU Market** – The reintegration of the SEM into EU electricity markets to allow the cross-border trading of energy and services will be required when the SEM has a direct physical interconnector with the continental European systems. To achieve full reintegration will require a significant programme of work that will encompass integration into new EU platforms for intraday and balancing timeframes.

Under these two pillars the Roadmap proposes a pathway of markets initiatives, key decision points, milestones and implementation timelines to inform how to achieve the Renewable Ambition in an affordable, effective and timely manner. This multi-year plan is a starting point for discussion within the industry to debate the needs and challenges in achieving the Renewable Ambition and facilitate appropriate design decisions in a timely coordinated fashion.

Table 6: Summary of markets workstreams

Workstream	Recommendation
Electricity wholesale market Alignment and Implementation Scheduling and Dispatch	Alignment of the energy market with high penetration of renewable generators - leading to scheduling and dispatch changes to ensure all market technologies and participants have equal access and opportunities Programme Plan on dispatch and scheduling changes to include: • Wind dispatch tool enhancements • Energy Storage Power Station (ESPS) capability • Low carbon inertia services capability • Fast frequency response capability • Reserve services capability dispatch and scheduling from new providers
Capacity Market alignment with a high-RES world and system requirements	Capacity market modelling changes and associated changes to the capacity market consistent with requirements for operating the power system with high renewables
Re-integration Design and Resource adequacy considerations post 2027	The existing State Aid approved capacity mechanisms expires in 2027. This initiative seeks to evolve the capacity market to ensure new resource adequacy support is compliant with EU regulations, our evolving power system needs and European Capacity Market State Aid approvals.
Future Arrangements	Auction design and proposed procurement mechanisms for the system services needed to operate the power system at high RES. Development of an overarching commercial and legal framework to drive necessary 3rd party investment to meet challenges of high renewables.
Investment Drivers Renewable support mechanism	Provide insight and analysis to policy makers on the impacts to costs and affordability as a result compensation of oversupply
CRU Demand Transmission Use of System (DTUoS) review	Provide input to CRU on their approach to DTUoS review and feedback to their subsequent Call for Evidence paper Carry out qualitative analysis to identify tariff options for modelling. Assess implications of designs changes.
Transmission Loss Adjustment Factor Review (TLAF)	Review TLAF methodology to ensure an equitable allocation of losses and to encourage appropriate siting of plant.
Post Brexit SEM/GB Day ahead Capacity allocation arrangements	Full Integration of Great Britain and SEM Market • Re-establishing day-ahead electricity trading arrangements between Ireland, Northern Ireland and GB.

Post Brexit SEM/GB **Day ahead Capacity calculation arrangements**	Reintegration of Northern Ireland and Ireland into the European Electricity Markets • With the completion of the Celtic interconnector, re-establishing day-ahead electricity trading arrangements between Ireland and Europe. • This arrangement provides the ability to import and export renewable electricity to and from Europe.
Post Brexit SEM/GB **Future market timescales work**	Possible GB/EU technical procedures for other electricity market timeframes - Intraday, Forwards, balancing – development of methodologies and implementation
Full integration with EU Capacity Calculation Region (CCR)	In advance of Celtic interconnector operations, the SEM will need to establish a CCR, or join an existing region (CORE CCR for example).
Full EU Market Integration Design	With the completion of Celtic, the SEM market construct will be required to evolve to be compliant with EU law. This will include addressing ex-ante and ex-post pricing, self-dispatch and central dispatch, Regional Coordination Centres (RCC) operations and cross border services

1.7 Security of supply

A critical and sometimes misunderstood aspect of electricity is that it is a basic need. It is a necessity to maintain our quality of life and the success of every aspect of our economy. Understandably, our risk appetite for shedding load to maintain power system security is extremely low.

The analysis of power system supply adequacy that supports the Generation Capacity Statement has provided an increasing body of evidence that there is an increased risk of supply shortages of supply on the Ireland power system commencing winter 2021 and beyond.

Through previous Generation Capacity Statements, we forecast increases to demand and the closure of conventional plant due to age, financial viability and environmental legislation. The cause of the increased risk to security of supply relates to an upward trend in existing generation plant outages driven by factors such as age and the failure of developers to deliver meaningful capacity which they were awarded 10-year contracts on. Addressing the security of supply risk while transitioning to a more renewable based generation fleet adds an additional layer of complexity to achieving our Renewable Ambition and maintaining a safe, affordable, secure, reliable and sustainable supply of electricity to consumers. The needs are particularly acute in the short to medium term in Ireland – the situation in Northern Ireland is more stable but requires careful monitoring.

To cater for a range of credible future scenarios and to ensure the transition is managed in a secure manner, EirGrid is working with DECC and CRU to implement a plan which will ensure that security of supply is maintained over the short to medium term paving the way for an orderly transition toward the Renewable Ambition.

This is complementary to the market initiatives highlighted in the Shaping Our Electricity Future Roadmap and will provide mitigating solutions where feasible by leveraging the Roadmap and through existing market mechanisms.

In the short-term, there is an urgency to address the risks to security of supply. Given the serious nature and quantum of the identified shortfalls, there is a need to develop mitigating solutions that are outside of the current market construct. Where such solutions are approved, they will be proportionate and informed by clearly stated positions on the immediate short-term supply deficits and associated risks. For the longer term needs we require action now to deliver replacement new capacity through enhancements to markets in order that investment in new capacity can support the Renewable Ambition through a secure transition.

Current analysis and projections for Northern Ireland indicate there is enough capacity in the short to medium term to meet system needs. SONI continue to monitor the Northern Ireland adequacy position and carry out studies to understand the impact on system adequacy from risks such as low power plant availability, delays to contracted new capacity, loss of interconnection support, an outage of large thermal unit and run hour limited new capacity.

1.8 Next steps

The publication of this Roadmap triggers the start of a multi-year journey to address emissions in the electricity industry and to support other sectors, such as heating and transport. This will be the largest body of work that EirGrid and SONI has undertaken as companies to date.

The purpose of the Roadmap is to provide the scope, timeline and estimated market enhancements, system operations upgrades and infrastructure reinforcement costs for actionable projects that will inform and guide the governments, regulators, industry stakeholders and consumers on a pathway to maintaining an affordable, secure, and reliable power system while meeting our ultimate ambition for a renewables-based power system. The Roadmap aims to minimize infrastructure costs and the risk of events that can adversely impact future consumer prices, while also defining an all-of -system program of work that can achieve the Renewable Ambition by 2030.

The Roadmap will be updated at least every 2 years, in response to the latest technology, economic, policy and system developments as we continue to work together with governments and regulators and in consultation with industry stakeholders and the general public in making our energy system safe, affordable, secure, reliable and sustainable.

2. Consultation and Stakeholder Contributions

2.1 Overview

In March 2021, EirGrid and SONI launched the Shaping Our Electricity Future consultation. This detailed a summary of our initial thinking on how the electricity grid, market and system operation could evolve to achieve the Renewable Ambition. The Shaping Our Electricity Future consultation proved successful in delivering against its key objectives:

- Offer a broad set of perspectives and views from across society and industry
- Provide clarity on a way forward that will ultimately deliver on our renewable obligations.
- Identify clear milestones and timelines that consider power system operations and market dependencies
- Provide input to a coordinated plan to inform the development of electricity infrastructure, and enhancement of system operations and electricity markets.

The consultation process, supported by the Shaping Our Electricity Future Consultation Paper, sought opinions and insights in the following areas:

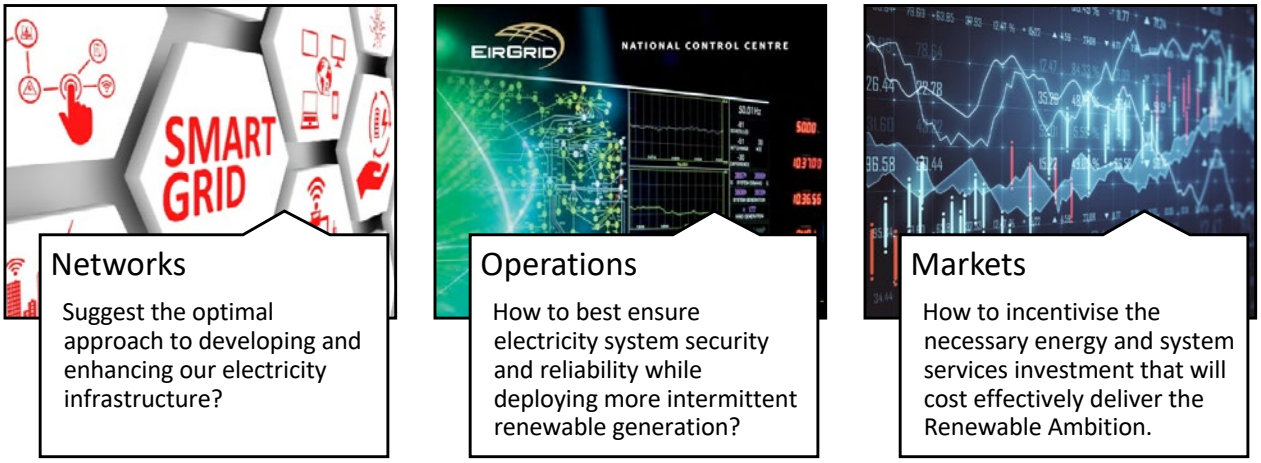


Figure 7: Areas of interest

EirGrid and SONI conducted a range of engagement and participation activities over the course of 14 weeks – this included face-to-face public interactions in Ireland and national forums involving industry and civil society in Ireland and Northern Ireland. Furthermore, we engaged with rural communities, local businesses, and young people. There were over 100 events across Ireland and Northern Ireland with over 500 submissions received as part of the consultation.

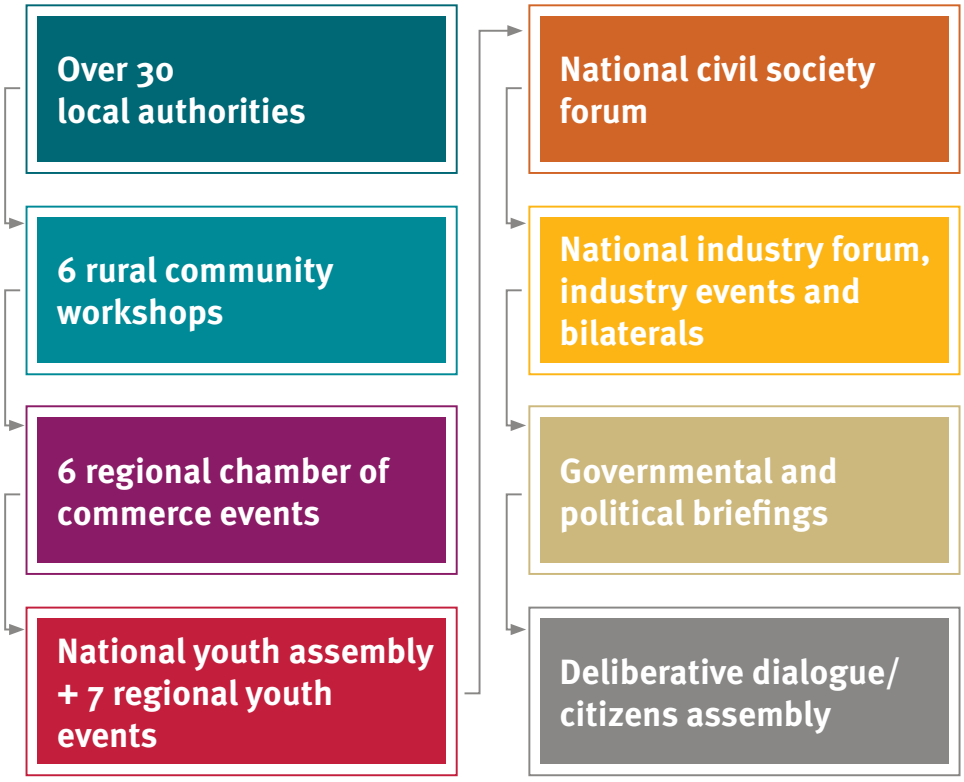


Figure 8: Summary of engagement in Ireland

Figure 9: Summary of engagement in Northern Ireland

The consultation focused on four distinct network development approaches and presented a series of questions relating to the enhancements needed to system operations and electricity markets to meet the Renewable Ambition.

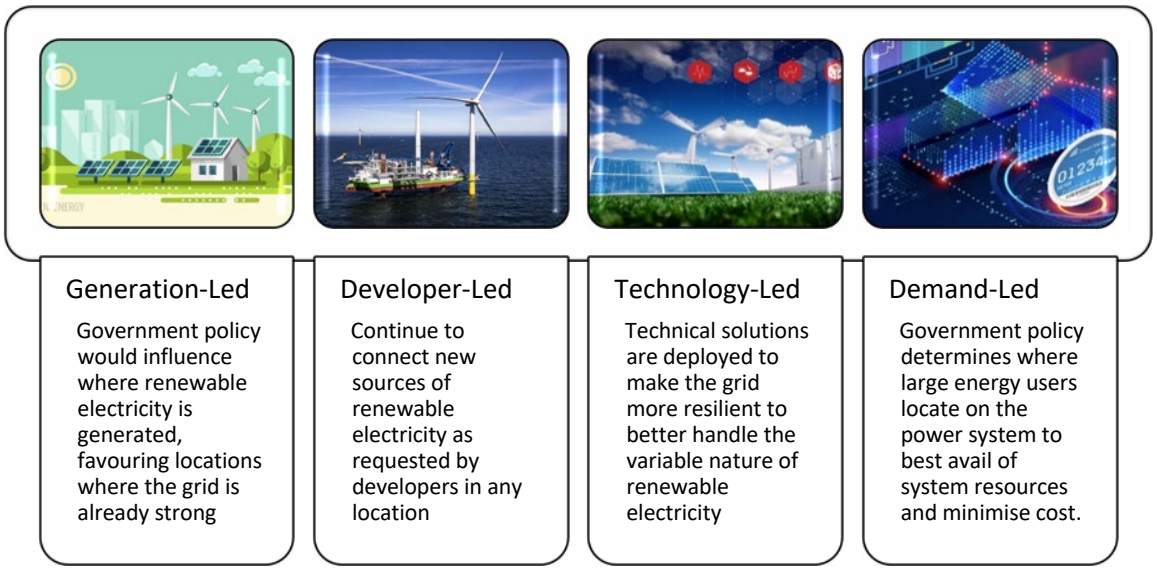


Figure 10: Four approaches

Focusing on networks, the feedback from the consultation process was broadly consistent across Ireland and Northern Ireland – the key difference was offshore wind deliverability by 2030. The feedback can be broadly grouped into the following key themes:

Public Engagement Feedback

- **Landowner concerns** – a key concern was the recognition and protection of landowner rights where infrastructure development takes place on farmland.
- **Costs** – no appetite for the cost of electricity to rise because of the transition to a low-carbon electricity system.
- **EirGrid and SONI roles** – the public in either jurisdiction was not fully aware of EirGrid and SONI and their respective roles in relation to the electricity grid and markets
- **Security of supply** – security of energy supply is an important consideration in reaching the renewables target.
- **Economic development** – need for rural communities to share in any economic upturn as a result of the implementation of the Renewable Ambition.
- **Offshore generation** – a large amount of feedback supported offshore generation; many stakeholders felt that it has a less negative environmental and visual impact.
- **Onshore generation** – wind energy was accepted as a solution to support decarbonisation. However, the public generally preferred onshore solar generation.
- **Micro-generation** – communities are eager to get involved and believe micro-generation should have a relatively significant role in attaining at least 70% renewables.
- **Public Engagement Processes** – stakeholders were adamant that it must be genuine open and honest engagement.
- **Public acceptance / licence** – consultation process clearly identified and reinforced the need for public acceptance / licence by energy infrastructure developers.
- **Community ownership of renewables** – strong desire that communities should be supported and incentivised to develop community owned renewable projects.

- **New technology / future proofing** – ensuring the grid is fit for purpose beyond 2030 and that the grid utilises technology to minimise new grid infrastructure.
- **Environment and ecology** – concern how the outcome of Shaping Our Electricity Future would impact on the landscape across Ireland and Northern Ireland.

Industry Feedback

- **Renewable targets** – 70% renewables is a step on a journey towards a net zero energy system and this should be implicit in any plans from EirGrid and SONI.
- **Network reinforcements** – commence building the required network infrastructure to support renewables as quickly as possible.
- **Network delivery** – public acceptance is crucial for the timely delivery of new grid infrastructure.
- **Alternative technologies** – consider mature non-wires alternatives and new technology options in any future development of the network.
- **Market enhancements** – electricity markets must evolve significantly to support investment for new and existing market participants.
- **Security of supply** – similar to public engagement feedback, security of energy supply is an important consideration in reaching the renewables target.
- **Operations processes and tools** – must evolve to manage increased variable generation mix with a focus on facilitating increased penetration of renewable generation.
- **Costs** – similar to public engagement feedback, no appetite for the cost of electricity to rise because of the transition to a low carbon electricity system.
- **Resourcing** – considered that EirGrid /SONI requires the funding and resources to implement the proposed program of work.

The consultation feedback highlighted that there is a high level of support for the aims and ideals of the pathway to a low carbon future and a clear understanding that concerted action must be taken to address climate change.

There was no clear coalescence of support around any one of the four network development approaches outlined in the consultation report in Ireland or Northern Ireland.

- Ireland:
    - **Public Engagement Feedback:** A significant number of responses indicated support for Generation-Led and Demand-Led approaches. There was some support for the Technology-Led approach, with the Developer-Led approach receiving the least support of the four.
    - **Industry Engagement Feedback:** There was clear support for the Developer-Led approach, but also for a hybrid of the different approaches (Generation-Led, Developer-Led, Technology-Led and Demand-Led).
- Northern Ireland:
    - **Public Engagement Feedback:** A significant number of responses indicated support for Generation-Led and Demand-Led approaches or a blend there-of. Participants and respondents were less enthusiastic about the other two options.

- **Industry Engagement Feedback:** There was strong support for the Developer-Led approach but also for a hybrid of the different approaches (Generation-Led, Developer-Led, Technology-Led and Demand-Led). Concerns were raised about the feasibility of connecting offshore wind at scale by 2030.

The majority of responses highlighted that if the challenges ahead are to be addressed and the Renewable Ambition is to be achieved, a whole of society approach is necessary. Stakeholders stressed that *Shaping Our Electricity Future* is a significant step in the right direction. However, this type of engagement must continue if the objectives of the Renewable Ambition are to be achieved.

The feedback received is used as an input to, and directly influences this Roadmap. We have reflected on the feedback and updated the inputs for the scenario-based modelling of network analysis, system operations and electricity markets to achieve the Renewable Ambition.

2.2 Structure

An overview of the public consultation and detailed responses to feedback received can be found in Appendix 2. We have also published other documents relating to the consultation - these are illustrated in Figure 11.

Feedback from the public consultation in Ireland relating to the draft Shaping Our Electricity Future

Feedback from the public consultation in Northern Ireland relating to the draft Shaping Our Electricity Future

Feedback from the industry consultation in Ireland and Northern Ireland relating to the draft Shaping Our Electricity Future

Figure 11: Public and industry feedback documents

The feedback received as part of the consultation has assisted in the development and evolution of the Shaping Our Electricity Future Roadmap. These influences are varied and widespread.

To assist our customers and stakeholders to understand how their feedback has influenced the final Roadmap, we have produced summary tables showing actions taken in responses to feedback themes for each programme workstream. The tables list the sections of this report where more information can be found by feedback theme and action.

Table 7: Summary of changes based on public feedback

Action taken (what did we do?)	IE or NI	Section	Onshore Electricity Generation	Micro-generation of Electricity	Community Ownership of Renewables	EirGrid and SONI Role	Public Engagement Processes
RESS 1 locations assumed to connect including community based projects	IE	5	●	●	●		
Increased levels of microgeneration solar PV	IE	5	●	●	●		
Host event the role of the Energy sector, Government and Civil Society in Decarbonisation at UN COP26	IE	6				●	●
Deliver on company strategy commitment of "Engage for Better Outcomes for All"	IE	6				●	●
Regional Energy Citizen's Assemblies	IE	6				●	●
Continue proactive engagement with individual local authorities	IE and NI	6				●	●
Host Future Energy Conference for Elected Members	IE	6	●	●		●	●
Youth Activation / Sponsorship Partnership	IE	6				●	●
Our Energy Future Project with Renewables Grid Initiative and Friends of the Earth	IE	6	●	●	●	●	●
Further develop Community Benefit Fund framework	IE	6	●	●	●		
Develop Energy Advocates / Champions	IE	6				●	●
Community Energy Collaboration Roadshow / Knowledge Hub	IE	6	●	●	●	●	
Landowner Engagement	IE	6					
EirGrid Sponsored Apprenticeships – Upskilling in Renewable Development	IE	6					
EirGrid Young Energy Citizen of the Year Awards	IE	6					●
Energy Tourism Initiative	IE	6					
Develop collaboration and learning opportunities across the EU	IE	6					●
EirGrid Awareness Raising Campaign	IE	6				●	
EirGrid Knowledge Hub	IE	6	●	●	●	●	●
Commentary added in relation to net zero ambition.	IE and NI	3	●	●			
Increased Total Electricity Requirement (TER)	IE and NI	5	●	●			
Offshore wind installed capacity of 5GW by 2030	IE	5					
Commentary on commitment to long-term ambition of net zero power systems	IE and NI	3	●	●			
Included detailed commentary on security of supply and long-term adequacy	IE and NI	4					

Social Acceptance / Licence	Electricity Demand and Economic Development	Security of Supply and Data Centres	Environment and Ecology	Agriculture	Cost	Energy Storage	Offshore Electricity Generation	New Technology / Future Proofing
●			●					
●								
●	●	●	●	●	●			
●	●							
●	●							
●								
●	●							
				●				
	●							
●								
●								
●								
●	●	●	●		●	●	●	●
						●	●	
						●	●	
							●	
			●			●	●	
		●	●					

Table 8: Summary of changes based on common industry feedback

Action taken (what did we do?)	IE or NI	Section	Costs	Increased Renewable Targets
Included costs relating to reinforcements that already have received capital approvals.	IE and NI	5	●	
Increased Total Electricity Requirement (TER)	IE and NI	5		●
Offshore wind installed capacity of 5GW by 2030	IE	5		●
Commentary on commitment to long-term ambition of net zero power systems	IE and NI	3		●
Set up an SOEF advisory council	IE and NI	6		
Developed strategic enabler relating to capability, capacity and resourcing	IE and NI	6		
Quantified the level of thermal capacity required in 2030	IE and NI	5		
Included detailed commentary on security of supply and long-term adequacy	IE and NI	4		
Added more detailed multi-year plans for electricity markets, system operations and networks	IE and NI	6		●

Table 9: Summary of changes based on network industry feedback

Action taken (what did we do?)	IE or NI	Section	Maximise the Use of Existing Grid	Non-wire Alternative Technologies
Use of power flow controllers and dynamic line rating as reinforcement solutions	IE and NI	5	●	●
Created initiative to develop a flexible network strategy	IE	6	●	●
Revising the technology toolbox for enhanced network operation	IE	6	●	●
Increase battery electricity storage in IE and NI	IE and NI	5	●	●
Created initiatives to develop a new planning consents strategy and grid development transformation programme	IE	6		
Created initiative to transform the transmission outage process in Ireland	IE	6		
Created an initiative to support optimally locating generation and large energy users from a grid capacity perspective.	IE and NI	6	●	
Commitment to report annually on progress of transmission projects	IE	6		
Added an initiative to work with the TAO and DSO to derive an infrastructure delivery plan for the Dublin region	IE	6		
Created initiative to support project delivery through greater social acceptance while operating within defined regulatory process.	NI	6		
Provided commentary in relation to choosing best performing solutions for system needs based on multi criteria analysis	IE	Appendix		
Provided details of EirGrid and SONI scenario planning approach	IE and NI	5		
Included narrative in relation to achieving the net zero ambition	IE and NI	3		
Very high uptake of 936,000 vehicles in line with Ireland's Climate Action Plan 2019 and 273,000 in NI based on NIEN modelling.	IE and NI	5		
New LEU demand in regions of Ireland and Northern Ireland	IE and NI	5		
Reduced levels of offshore wind in Northern Ireland	NI	5		
Increased levels of offshore wind in Ireland achieving 5GW by 2030	IE	5		
Updated demand and generation assumptions to reflect aspects of the four consultation approaches	IE and NI	5		
RESS 1 locations assumed to connect including community based projects	IE	5		

Coordinated Planning	SOEF Advisory Council	Stakeholder Engagement	Resourcing the TSO	Long-term Security of Supply
●				●
●				●
●				●
●				●
●	●	●		
			●	
●				●
●				●
●	●	●	●	●

Delivery of Transmission Infrastructure	Long-term Proactive Planning	Progression of Existing and New Grid Projects	System Outages to Accommodate Reinforcements	Underground Cable	Regional Development	Delivery of Offshore Wind in Northern Ireland	Northern Ireland Demand and Generation-Led Approach
●	●						
	●						
	●						
	●						
●	●	●					
			●				
	●				●		
●	●	●					
●	●	●	●				
●	●	●					
●				●			
	●						
	●						
	●						
					●		
						●	
	●						
							●
					●		

Table 10: Summary of changes based on operations industry feedback

Action taken (what did we do?)	IE or NI	Section	2030 Ambition (Min Gen and SNSP)	Pace of Change
New initiative added to develop and publish an "Operational Policy Roadmap to 2030"	IE and NI	6	●	●
Commentary on the pace of change and the level of ambition	IE and NI	Appendix	●	●
Scope of Qualification Trial Process to allow for trialling of new technologies (e.g. Hydrogen, Grid Forming)	IE and NI	6		
New initiative added related to procurement of low carbon inertia services	IE and NI	6	●	
New initiative added to develop a "Control Centre of the Future" development plan	IE and NI	6	●	●
New initiative added related to integration of new grid technologies (e.g. DLR, Power Flow Controllers) into operational systems	IE and NI	6	●	
Commentary added on the work we are doing on Grid Forming technology	IE and NI	Appendix		
Commentary on the potential benefits of storage and hydrogen	IE and NI	Appendix		
Commentary on the importance of renewable generation forecasting	IE and NI	Appendix		

Table 11: Summary of changes based on markets industry feedback

Action taken (what did we do?)	IE or NI	Section	Holistic Market Design	Concepts of Alignment, Clarity and Commitment
Added workplan to review TLAF following consultation feedback	IE and NI	6	●	●
Demand side strategy included in operations and will have market aspects	IE and NI	6	●	●
Increased pace of change in capacity market to address issues raised	IE and NI	6	●	
Security of supply issues addressed with workplan	IE	6	●	
Recognised the role of Regulators, SEM-C, EU Commission and Specialise Committee on Energy in Market Design	IE and NI	6	●	●
Increased detail on market system changes required to address integration of new technologies	IE and NI	6	●	●

Grid Forming	Hydrogen	Synchronous Condensers	Non-Wire Technologies	Storage	Renewable Generation Forecasting
●	●				
		●			
●	●	●	●	●	●
			●		
●					
	●			●	
					●

Network Tariff Review	Investor Risks Outside their Control	Remove Market Barriers	Capacity Market Review	System Services Update	Alignment with Operations	Markets Supporting Renewable Gas and Hydrogen
●	●					
		●	●			
●	●	●	●	●	●	●
	●	●			●	●

3. Power System Transition

3.1 The all-island power system

The Ireland and Northern Ireland power system is a synchronous system with limited High Voltage Direct Current (HVDC) interconnection to Great Britain. At the time of writing this report, the power system had experienced an all-time peak load of 6.78 GW which occurred in January 2021, and a maximum all-time wind output of 4.47 GW[1] which occurred in February 2021.

Presently there are two HVDC interconnections between the island of Ireland and Great Britain: the 0.5 GW Moyle Interconnector and the 0.5 GW East-West Interconnector. There is over 5.57 GW[2] of wind capacity installed on the power system and there is approximately 9.7 GW of dispatchable capacity, including the interconnectors[3]. Table 12 shows a summary of the peak demand and installed capacity figures for the all-island electricity system.

Table 12: Overview of the all-island electricity transmission system

	Northern Ireland	Ireland	All-island
Peak Demand 2021 (MW)	1,562	5,325	6,786
Installed Wind Capacity (MW)	1,276	4,299	5,576
Installed RES (MW)	1,627	5,152	6,779
Installed Dispatchable Generation Capacity (MW)	2,465	7,313	9,778
Installed HVDC Capacity Import (MW)	450	500	950
Installed HVDC Capacity Export (MW)	500	500	1,000

EirGrid and SONI together operate the transmission systems – North and South – on an all-island basis. The transmission system in Northern Ireland is operated at 275 kV and 110 kV. The transmission system in Ireland is operated at 400 kV, 220 kV and 110 kV. The two transmission systems are connected by means of a 275 kV double circuit from Louth station in Co. Louth (Ireland) to Tandragee substation in Co. Armagh (Northern Ireland).

The 400 kV, 275kV and 220 kV networks form the backbone of the all-island transmission system. They have higher power carrying capacity and lower losses than the 110 kV network. In Ireland, the 400 kV network provides a high-capacity link between Moneypoint generation station on the west coast and Dublin in the east.

In Northern Ireland the 275 kV network is comprised of:

- A double circuit ring;
- A double circuit spur to Coolkeeragh Power Station; and
- A double circuit spur southwards into Co. Louth, in Ireland.

In Ireland the transmission network is comprised of single circuit lines which are interconnected to cover the wider geographical distances between stations. Typically, large generation stations (greater than 200 MW) are connected to the 220 kV or 400 kV networks. The 110 kV circuits provide parallel paths to the 220 kV, 275 kV and 400 kV networks and are the most extensive element of the all-island transmission system, reaching into every corner of the island.

1 EirGrid Group, System and Renewable Summary Report
2 EirGrid Group, Wind Installed Capacities – 1990 to date
3 EirGrid Group, All-Island Generation Capacity Statement 2021-2030 (GCS)

As the energy sector moves towards a sustainable, low-carbon future there will be major changes in how and where electricity is generated, how it is connected to the grid, and in how it is bought and sold. There will also be major changes in how electricity is used, such as for transport and heat.

The electricity system will carry more power than ever before and most of that power will be from non-synchronous renewables such as wind and solar. Coal and fossil oil-based generation will be phased out in the next decade, with natural gas being the transition fuel. Concurrently, in isolation to the changes on the supply-side, there will be significant changes on the demand-side with new technology arriving which will allow electricity users to generate and store power and return any surplus to the grid.

Realising these opportunities will require a significant transformation of the electricity system. More importantly, these changes will need to be managed in a co-ordinated way that delivers the best outcome for the public. As Transmission System Operator and Market Operator in Ireland and Northern Ireland, EirGrid and SONI have central roles to play in leading the secure transition that is now required.

3.2 Climate and energy policy

The EirGrid and SONI corporate strategies are shaped by climate change and the need for a secure transition of the electricity sector to low-carbon, renewable energy. The context of climate change is well understood and beyond scientific doubt. The only question now is how fast society can respond to limit the damage and so protect our planet for current and future generations.

In Northern Ireland the Department for the Economy launched a consultation entitled “Energy Strategy for Northern Ireland” in March 2021. The proposed vision for the new energy strategy is to achieve net zero carbon emissions by 2050 while maintaining affordable energy for consumers. The energy strategy is expected to be published before year end.

In 2019 the Irish Government published its first Climate Action Plan setting out the Irish State’s climate objectives. The Programme for Government: Our Shared Future (2020) further outlined and increased this ambition, including to achieve at least 70% of electricity from renewables by 2030 and an energy wide net zero target by 2050. The enactment of the Climate Action and Low Carbon Development (Amendment) Act 2021, has now put Ireland on a legally binding path to net zero emissions no later than 2050.

Energy and climate policy in both jurisdictions contemplates an overall transition to net zero by 2050 and the Shaping Our Electricity Future Roadmap provides an outline of the key developments to support this transition. As a crucial first step on this transition, this Roadmap identifies the key initiatives required to reach at least 70% renewable electricity by 2030 from a network, engagement, operations and market perspective.

3.3 Community participation in the renewables transition

3.3.1 Why community participation is necessary

EirGrid and SONI consider the active participation of communities to be an integral part of the energy transition. The electricity system ultimately exists to serve the needs of the many communities and businesses in Ireland and Northern Ireland. As such, we believe that communities should be empowered and engaged participants in the energy transition.

EirGrid and SONI believe that participation of communities directly in the energy transition will be necessary to deliver on the ambitious targets set out in both the Programme for Government in Ireland and under the UK Climate Change Act in Northern Ireland. This participation would see local communities coming together and having a much greater stake in energy projects that will ultimately deliver on their energy needs. EirGrid and SONI continually engage with communities on grid infrastructure projects; we consider that when communities across the island have a greater stake in local renewable energy projects, the level of public acceptance of grid infrastructure, which is a critical enabler of renewable energy projects, will increase.

3.3.2 Involving communities in the energy transition

In Ireland, EirGrid recently operated the first Renewable Energy Support Scheme (RESS 1) auction in July 2020. Part of the RESS 1 scheme included a special category for community owned projects. These are defined as projects that are majority owned by the local communities and to whom the benefits of the projects will accrue. In the RESS 1 auction seven such projects were successful. This represents the beginning of a new era for communities investing in their long-term energy needs. EirGrid are of the view that participation in community energy schemes is an important part of delivering the energy transition in Ireland.

On 4th February 2021, the Minister for the Environment, Climate and Communications announced that all projects applying to the community category in future RESS auctions must be 100% community owned. This is to ensure that communities will now be able to retain all the benefits that are associated with generating their own electricity so as to provide a secure long-term financial boost to the community at large and allow reinvestment into securing the community's long-term future. Accordingly, the RESS 2 terms and conditions now include a requirement that community projects must be 100% community owned.

In Northern Ireland, as part of the Department for the Economy's call for evidence into its energy strategy, SONI articulated the same view regarding the importance and benefits of community participation in its response. More broadly, establishing a framework for energy communities to participate in the energy transition enables greater acceptance of critical grid infrastructure. This infrastructure will be required to deliver the energy transition. In many cases, while developers make efforts to compensate local communities for the impact of the project, the presence of an energy community in these areas could enable the community themselves to bring forward projects and to enable communication of their needs in respect of electricity and, more broadly, energy.

At EirGrid, we look forward to the continued participation of communities in the RESS process and in the upcoming RESS 2 auction for Ireland. In Northern Ireland, SONI look forward to continued engagement with the Department for the Economy and how we can play our part in realising Northern Ireland's ambitious renewables targets. As is our belief, we will continue to advocate the importance of placing communities at the heart of the energy transition.

4. Security of Supply

4.1 System adequacy

Maintaining security of supply in the power system means ensuring that there is enough generation to meet both the demand and the operational requirements to run the electricity system securely for each and every hour across the year.

It is evident that the power system technology mix is changing, and new challenges are emerging that must be tackled to ensure that we maintain power system reliability. In the past we have relied on fossil fuel-based power plants that offer dispatchable power to meet the needs of the power user. The reliability of the system was maintained by ensuring that there were enough dispatchable power plants to meet the peak demand of the system while considering the risk of failure of multiple plants for a given set of scenarios.

Looking forward, it is becoming apparent that electricity supply is becoming more unpredictable (increasing difficulty to forecast when wind and solar resources will come on and how they will perform on the power system) and more variable (forecasting how much supply will be received from wind and solar resources at any point in time). We need to transform how we view power system security of supply and dimension the problem accordingly so that future risks and challenges are catered for.

EirGrid and SONI are responsible for assessing the adequacy of the power system – our studies provide an indication of how reliable the power system is for a given scenario. EirGrid and SONI carry out system adequacy studies to evaluate the balance between forecasted electricity demand and the expected generation capacity over a ten-year horizon. In our adequacy assessment studies, the generation portfolio is modelled against a range of forecasted demand levels using the accepted standard of risk.

The Regulatory Authorities in turn design and approve capacity market auctions that are central to securing the capacity requirement needed to ensure system adequacy. New types of capacity such as batteries, demand side units and flexible generators have entered capacity market contracts as a result. Interconnection also plays a role by providing access to capacity when available from different markets areas where a surplus in one market can provide power to meet a generation shortfall in another market.

The capacity market currently procures capacity according to an adequacy standard set by the Single Electricity Market Committee (SEMC). The capacity market uses an economic approach to procuring capacity in accordance with the acceptable measure of risk, i.e. the adequacy standard. The capacity market assumes that load may be reduced when there is not enough generation to meet demand. In practice this would be achieved by cutting off electricity to some customers – however load shedding due to generation shortages like this is a very rare event.

Long-term demand in Ireland is increasing and is forecast to increase significantly due to the expected expansion of many large energy users and the electrification of heat and transport in support of government ambitions for low carbon heat and transport. With the forecasted increase in demand and the expected decommissioning of generation plant due to decarbonisation targets and emissions standards, a significant amount of new capacity is required.

Long-term demand growth in Northern Ireland is relatively stable, with some existing capacity also due to close due to emission standards.

The orderly coordination of the retirement of fossil fuel capacity, the development of new renewable and clean dispatchable capacity and matching the increased consumer demand is critical in mitigating the risks related to potential supply shortfalls – in short, there must be a secure transition.

4.2 Short – Medium term adequacy assessment

There were a number of system alerts in Ireland in Winter 2020/21 – this is not the first time we have had these on the system. They indicate that capacity margins are tight, and a loss of a generator could mean difficulty in meeting demand.

Last winter we experienced a combination of factors such as very low wind, low available interconnector support[4], poor plant performance and a cold snap resulting in close to record peak electricity demand. We have also experienced some alerts this autumn due to low availability of conventional plant and very low wind. We are working closely with the CRU and DECC to address these issues.

As reported in the Generation Capacity Statement 2021-2030 a number of factors have resulted in capacity challenges in Ireland:

- **Generator Availability** - the availability of a number of existing generators, including those expected to decommission in the coming years, have been reducing over the past number of years. In addition to this, more short duration or run hour limited plant is leading to lower capacity availability than would otherwise be expected, particularly if these restrictions were not in place. Greater adequacy contribution from run hour-limited plant could be possible if additional investments are made or operational performance measures are taken.
- **Forecasted new generation no longer being available** – in some cases new generation that had previously cleared in the capacity market auctions has been withdrawn by a developer. It is worth noting that within the last year 500 MW+ of capacity, which were awarded 10-year contracts in previous capacity auctions, have issued termination notices. This impacts on future adequacy positions and needs to be addressed.
- **Uncertainty in new capacity being available on time** – building new capacity is a complex process and with this comes a range of risks. There are long stop dates built into the capacity markets that mean capacity could deliver up to 18 months after expected auction date which falls in October of each capacity year. Therefore, it is important that there is a secure transition as older plant retires and demand grows so that the adequacy standard is maintained for each capacity year.

4 Great Britain (GB) was also experiencing similar capacity challenges, therefore support was not available over the Interconnectors.

- **Capacity Auctions** - The capacity auction for the period 01 October 2024 to 30 September 2025 was run at the end of January 2021. Insufficient new capacity which was required came forward in this auction.

This position has been exacerbated by the following:

- **Demand** – strong demand growth of around 140 MW/year in median forecast for the 2020 to 2025 periods, primarily due to large energy users such as data centres.

- **Emissions Limits** – fossil fuel generation with high CO2 emissions has been excluded from the capacity market from October 2024 because the plant will exceed EU emission limits. In the absence of having a capacity contract this plant may seek to close earlier than expected.

In the short term, EirGrid expects the number of system alerts may increase over the coming winters as old capacity retires and demand increases. Approximately 1,650 MW of rated capacity is currently planned to exit the market over the coming years.

To cater for a range of credible future scenarios and to ensure the transition is managed in a secure manner, EirGrid is working with DECC and CRU to implement a plan which will ensure that security of supply is maintained over the short to medium term paving the way for an orderly transition toward the Renewable Ambition.

Current analysis and projections for Northern Ireland indicate there is sufficient capacity in the short to medium term to meet system needs. SONI continue to monitor the Northern Ireland adequacy position and carry out studies to understand the impact on system adequacy from risks such as low power plant availability, delays to contracted new capacity, loss of interconnection support, an outage of large thermal unit and run hour limited new capacity.

Table 13: A summary of de-rated capacity requirements

Project Name	Description	Parties	Due Date
Winter 2022/23	To ensure system adequacy, secure cumulative 260 MW of additional de-rated capacity above Q3 2021 position through a CRU/DECC approved emergency process.	CRU/DECC/EirGrid	Q3 2022
Winter 2023/24	To ensure system adequacy, secure cumulative 1050 MW of additional de-rated capacity above Q3 2021 position through a CRU/DECC approved emergency process.	CRU/DECC/EirGrid	Q3 2023
Winter 2024/25	To ensure system adequacy, secure cumulative 1850 MW of additional de-rated capacity above Q3 2021 position through T-3 Capacity Market, but also factors in the needs of the future power system.	SEMC	Q3 2024
Winter 2025/26	To ensure system adequacy, secure cumulative 1950 MW of additional de-rated capacity above Q3 2021 position consistent with the immediate adequacy needs identified in the T-4 but also factors in the needs of the future power system	SEMC	Q3 2025

4.3 Long term adequacy

An adequate portfolio of capacity is required to meet our long-term operating needs. This portfolio will include batteries, demand side, interconnection, renewables and conventional capacity. New dispatchable resources will be needed to ensure that the generation portfolio continues to meet reliability standards and that demand can be met for a range of credible scenarios. New renewable gas ready generation[5] is expected to continue to play an important role, replacing retiring conventional plant and providing the multi-day capacity required to ensure security of supply. This capacity is especially important when large continental-scale weather patterns affect the availability of renewables in Ireland, Northern Ireland and in neighbouring interconnected electricity systems.

One of the most onerous weather patterns for renewable production are blocking anticyclones, whereby wind output is consistently low for multiple days to a week. During such times, the wind outputs in Great Britain and France will also be affected by the same weather regime. To compound this challenge, such instances can be accompanied by a cold snap in winter. Dunkelflaute is a term used to describe these types of conditions – it is a German word which translates as “cold, dark doldrums”.

In such conditions, it is essential to have indigenous resources that can supply electricity over a multi-day, rather than multi-hour, period. Market designs must ensure that such multi-day products bring the relevant services to enhance their role in a reliable generation portfolio into the future.

SEM capacity auctions offer opportunities for fossil fuel plants to recover fixed costs which may not be fully recovered from other markets such as system services or the wholesale market. Capacity markets help ensure capacity is available when it’s needed most. As more renewables is part of the energy market over time, there will be a growing need to price and procure the relevant system services such as longer duration ramping capability and adapt capacity markets to ensure that generation adequacy standards are met and affordability is ensured.

5 Gas turbines, which are a trusted technology class, are expected to play an important role in providing these requirements in the coming decades. The lifetime of a gas turbine is approximately 25 years, meaning that any investment made today is likely to be still in service when the power sector is legally obliged to produce zero or negative emissions. This suggests that new gas units should be renewable-gas (hydrogen, biomethane or syngas) ready, otherwise carbon emissions may be locked into the power sector

5. Transmission Network Analysis

5.1 Network development approach

Timely and efficient development of electricity transmission networks is crucial to delivery of the Renewable Ambition. EirGrid and SONI's Shaping Our Electricity Future consultation technical report[6] presented four approaches for strategic development of the transmission networks in both jurisdictions. Feedback received from stakeholders and energy consumers from the consultation process has been used to develop a final network development approach. It combines elements of each of the four approaches set out in the consultation and will be used to inform the multi-year roadmap.

Figure 12 illustrates the relationship between the four consultation approaches and the final network development approach. The final network development approach is broadly in line with existing policies in Ireland and emerging policies in Northern Ireland. The network development approach will be updated over time to reflect the latest information and changes to climate and energy policies that impact on EirGrid and SONI's grid development strategies.

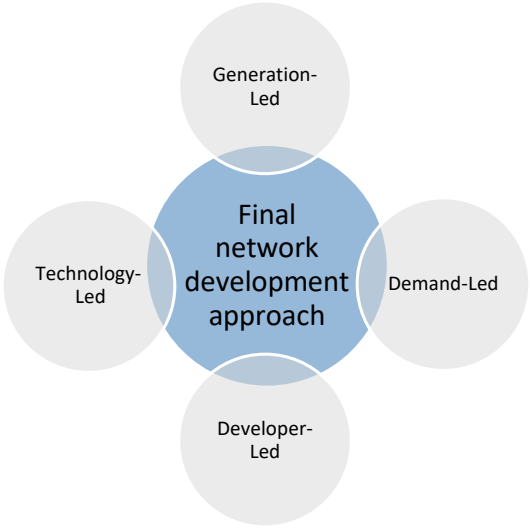


Figure 12: Final network development approach

A comprehensive set of network planning studies has been undertaken using the final network development approach to determine what potential projects are needed to ensure the Renewable Ambition is delivered in both jurisdictions.

These potential projects will require further analysis and investigation before progressing through either EirGrid's Framework for Grid Development or SONI's 3 Part Process for Developing the Grid. The list of projects has been developed using a pragmatic application of the planning standards in Ireland and Northern Ireland. The list may require additional project elements once detailed studies are completed as part of the grid development processes.

As a result, the list of projects developed as part of these studies to define our electricity future should not be seen as a formal plan or programme of works. Potential projects identified inform the networks multi-year plan which is subject to EirGrid and SONI governance frameworks and the appropriate regulatory approvals where required.It is important to note that delivering the Renewable Ambition will require the potential projects identified in Shaping Our Electricity Future as well as other committed projects which are currently progressing through EirGrid and SONI's grid development processes.

6 EirGrid, Shaping Our Electricity Future Technical Report, 2021

5.2 Methodology

The analysis of the transmission network makes use of well-established methods and techniques that are described in the Ireland and Northern Ireland planning standards. The final network development approach reflects the feedback received in the consultation and the best available information. Our study scenario is informed by the final development approach and has been assessed using time-series alternating current (AC) power flow analysis to identify needs arising on the transmission network. Further analysis then assessed the relative performance of the potential reinforcements identified to address the needs.

The process followed in this analysis can be described in three distinct steps:

1. Create generator dispatch schedules over the year that realise the Renewable Ambition of both jurisdictions. Market simulation software (i.e. PLEXOS) is used to prepare these schedules.

2. Test the performance of the transmission system for each of the hourly generator schedules produced as part of the previous step. Performance is assessed using AC power flow analysis software (i.e. PSS/E) that tests power system according to the requirements set out in the Transmission System Security Planning Standards (TSSPS) for each time period of the schedules. The analysis focuses on the single contingency test given the strategic nature of the analysis. The results are used to identify the needs of the transmission network.

3. Identify transmission network reinforcements that satisfy needs identified in the previous step. This is done using the same AC power flow analysis software (i.e. PSS/E) used to identify the needs of the transmission system. The programme of reinforcements ensures that the Renewable Ambition is met. The programme is designed to maximise the use of the existing transmission network and therefore minimise the need for new infrastructure.

5.2.1 Scheduling analysis

This analysis creates a credible hourly generation and demand schedule for the whole of the study year. We make use of PLEXOS market simulation software to do this. A number of future operational rules are assumed when running the analysis, including:

- Operation at up to 95% SNSP;
- A reduction in the inertial floor;
- A Rate of Change of Frequency (RoCoF) limit of 1Hz/s; and
- A significant reduction in the Minimum Number of Units requirement.

The resultant hourly generation and demand schedule provides the input for the network planning studies. To ensure a good voltage performance in the network analysis, a number of generators in Ireland and Northern Ireland were designated as must-run. In Northern Ireland, only generators connected at 275 kV were considered for the must-run rule.

5.2.2 Transmission network needs identification

Having generated the schedule, each time step within the schedule is used to create a snapshot in PSS/E power flow analysis software. This results in a large dataset of study cases modelling every hour of the year in 2030. The performance of the transmission network in each snapshot is then analysed in turn, against criteria set out in the TSSPS.

For the needs identification, we assess the performance of the transmission network for the following conditions:

- The intact network;
- The network following the loss of any single item of equipment such as a transmission circuit (referred to as the N-1 condition); and
- The network following the loss of any 275 kV double circuit in Northern Ireland (this is also considered an N-1 event).

For all of the conditions described above we monitor the performance of the following:

- The thermal loading of any single item of equipment on the transmission network;
- The voltage step observed at any station on the network following a contingency; and
- The voltage profile across the transmission network in both the intact and N-1 condition.

This selection of tests is considered sufficient for assessing the adequacy of transmission system security at this strategic stage of the analysis. The analysis identifies a comprehensive set of transmission network needs, and also allows us to determine the most frequently occurring network needs.

5.2.3 Network development principles

5.2.3.1 Policies

Along with the TSSPS, the development of the transmission network is informed by transmission investment policies which describe acceptable practices, minimum requirements and equipment specification. In Ireland, EirGrid applies policies in respect of overhead lines, cables, transformers and station configuration. These policies complement the TSSPS and are also applicable when developing network reinforcement alternatives. In Northern Ireland, SONI makes use of certain policies, such as those relating to technologies, which are set by the asset owner NIE Networks.

5.2.3.2 Transmission network technologies

There is a range of technologies that can be considered when developing the transmission system. Different combinations of technologies can be selected depending on the approach that is taken to achieving that development. These technologies are taken from a standard suite of technologies that are agreed with the Transmission Asset Owners (TAO) in Ireland and Northern Ireland.

5.2.3.3 Study scope and limitations

These studies focused only on the year 2030. No other near-time period was considered. Similarly, no time period after 2030 has been assessed.

Technical solutions are designed by considering the minimal and obvious workable choices that addressed the problem presented. Therefore, there remains room for further optimisation which would be dealt with as part of the normal network development process but is outside of the scope of this study. For example, studies are also not sufficiently detailed to confirm whether new circuits are to be designed as overhead lines or underground cables. Hence, where a need for a new circuit is identified it will not be specified if it is an overhead line or an underground cable.

Solutions for reactive compensation system needs have not been identified as part of the studies and new reactive compensation reinforcements are not listed. Solutions for reactive compensation needs in 2030 will be studied in more detail in the coming years as levels of certainty relating to the reactive capabilities of the evolving generation fleet, new HVDC interconnectors and storage technologies increases.

5.2.4 Planning and grid development assumptions

EirGrid and SONI are already committed to a number of grid infrastructure projects. These projects are critical and needed to maintain secure, reliable and economic power systems in Ireland and Northern Ireland.

Prior to commencing the transmission needs identification process, these projects were included in our network model. Therefore, the network model we analysed for 2030 consists of the transmission network as it is today plus these critical projects.

It is important to note that a number of these projects have received capital approval in the period between the consultation data freeze date (December 2019) and the data freeze date used for this final analysis (July 2021). As a result, the base network model used for the analysis of the four consultation approaches is different to the base network model used in in this final network development analysis – in essence there is additional transmission capacity in the network model used for our final approach compared to that used in the consultation approaches.

A full list of all projects that had received capital approval at the time of the data freeze (July 2021), and were therefore used in the base network model for the final network analyses, is provided in Appendix 4. Examples of new circuits which were assumed in service and included in our base network model include:

- North South 400 kV Interconnection Development;
- North Connacht 110 kV Reinforcement Project (Moy to Tonroe);
- Laois - Kilkenny Reinforcement Project;
- Cross-Shannon 400 kV cable;
- Kilpaddoge-Knockanure 220 kV Project;
- Kilpaddoge-Moneypoint 220 kV Project;
- Kildare-Meath 400 kV Grid Upgrade Project;
- Clashavoon-Dunmanway 110 kV Reinforcement Project;
- Cross Shannon 400 kV Cable Project; and
- Belcamp-Shellybanks 220 kV Reinforcement Project.

The following reactive compensation projects were assumed in service and included in our base network model:

- Series capacitors at Dunstown, Moneypoint & Oldstreet;
- STATCOMs at Ballynahulla, Ballyvouskil, Thurles, and Belcamp; and
- Reactors at Knockanure, Ballyvouskil, Tandragee, Tamnamore, & Castlereagh.

The grid developments identified as part of this Shaping Our Electricity Future Roadmap are in addition to these committed projects. We refer to these additional grid developments as candidate reinforcements. All candidate reinforcements identified as part of this initiative will need to enter EirGrid's Framework for Grid Development process or SONI's 3 Part Process for Developing the Grid. Both have their own detailed analysis requirements.

5.2.5 Planning and environmental considerations

This Roadmap is the output of the Shaping Our Electricity Future consultation. It identifies, at a high level, parts of the transmission system that are likely to need development over the decade. The Roadmap also sets out EirGrid's and SONI's approach to the planning and development of the grid that will be undertaken as the Roadmap progresses.

This Roadmap will also link with relevant Ireland and Northern Ireland Transmission Development Plans (TDP). The TDPs are plans for the development of the Irish and Northern Irish transmission networks over a ten-year period which both EirGrid and SONI publish annually in accordance with the terms of their respective licences. The TDP presents specific projects that are identified as necessary for the operation of the transmission network and discusses future needs for the transmission network that may drive future potential projects.

The Roadmap may in time supersede or update EirGrid Group's Grid Development Strategy published in 2016. That strategy had an accompanying Transmission Development Plan which was subject to full Strategic Environmental Assessment (SEA) including Appropriate Assessment (AA) in Irish and Northern Irish jurisdictions respectively.

The output of this Roadmap will also be subject to SEA and AA in due course in Ireland and Northern Ireland. EU Directive (2001/42/EC) on the assessment of the effects of certain plans and programmes on the environment, herein referred to as the 'SEA Directive', established the statutory requirement for SEA as part of the development of certain plans and programmes.

In Ireland, the enabling legislation is the European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations 2004 (SI 435/2004), as amended in 2011 by SI200/2011, and the Planning and Development (Strategic Environmental Assessment) Regulations 2004 as amended in 2011 (Irish SI 436/2004 and SI 201/2011).

The requirements of the SEA Directive are transposed into Northern Irish domestic law through the Environmental Assessment of Plans and Programmes Regulations (Northern Ireland) 2004 (SR280/2004).

It is EirGrid and SONI's commitment to provide for a high level of protection to the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development.

Each annual TDP in Ireland and Northern Ireland includes a formal Environmental Appraisal Report (EAR), which considers whether the TDP is in accordance with the SEA of the Implementation Plan. In short, the TDP is subject to appraisal to ensure its conformance with the provisions of the adopted SEA.

The Shaping Our Electricity Future Roadmap and the TDP will each provide a different level of scale and detail - from the long-term vision statements contained in the Roadmap, to the objectives and policies to implement the Strategy set out in the Implementation Plan, to the specific projects outlined in the TDP. This is set out graphically in Figure 13.

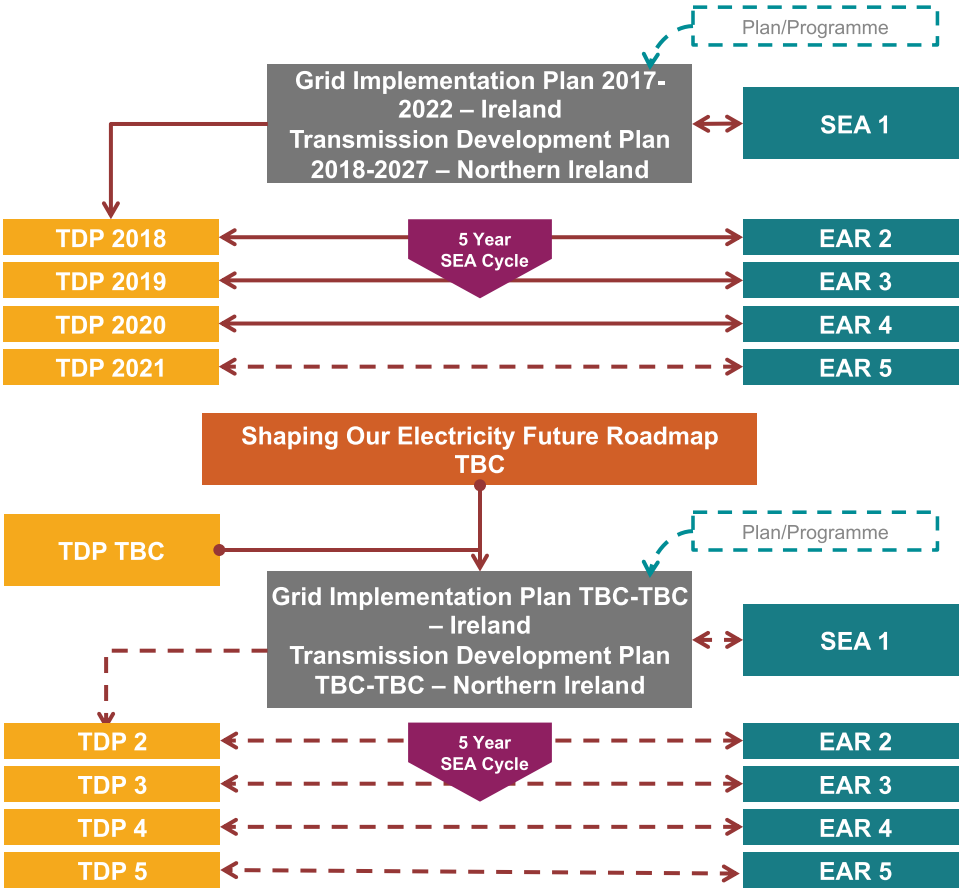


Figure 13: How Shaping Our Electricity Future and the TDP informs the grid implementation plan

5.3 Study assumptions

EirGrid and SONI use scenario planning to manage the uncertainty present in the medium and longer-term planning timeframes. In March 2021, we launched the Shaping Our Electricity Future consultation which made use of the Tomorrow's Energy Scenarios (TES) and Tomorrow's Energy Scenarios Northern Ireland (TESNI) datasets to help identify the scale of network development required to achieve the Renewable Ambition under four discrete approaches. These datasets and study assumptions have been updated to reflect the feedback received in the consultation, and the latest available information.

5.3.1 Demand

Ireland's demand is expected to grow significantly in the period to 2030, primarily driven by the connections of Large Energy Users (LEU), and the electrification of heat and transport. LEUs are not anticipated to develop at a similar scale in Northern Ireland, although a modest amount of such demand may occur by 2030.

In both Ireland and Northern Ireland, the transition away from fossil fuels in the heating and transport sectors will see some of those demands being met from electricity.

Demand assumptions are largely consistent with the high demand scenario contained in the Generation Capacity Statement 2021-2030[7]. We have assumed a high demand scenario to ensure that our reinforcement plan accommodates the need for increased transmission capacity driven by increased LEU, electric vehicles and heat pump demand. The spatial distribution of this additional demand is an important consideration in ensuring that the growth needs for specific regions are identified. This includes reinforcement needs for Dublin and the Mid-East which is forecast to see disproportionate demand growth compared to other regions in Ireland. The spatial distribution of demand is illustrated in Figure 14 and a subset of demand assumptions is shown in Table 14.

7 EirGrid Group, All-Island Generation Capacity Statement 2021-2030, 2021

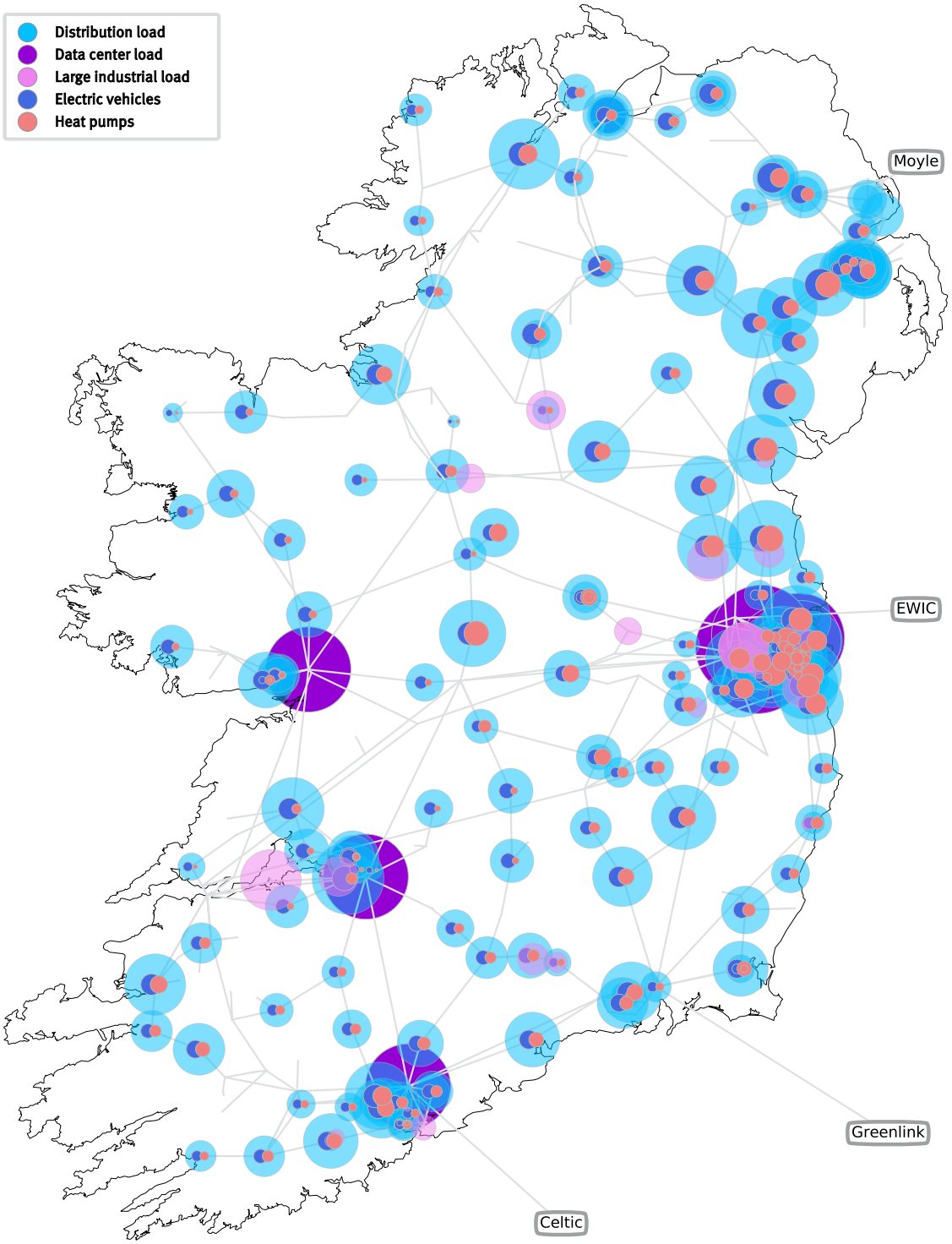


Figure 14: Demand spatial distribution, 2030.

Table 14: Summary of demand assumptions

Demand category	Units	Ireland	Northern Ireland
Total Electricity Requirement (TER)	TWh	46.5	10.1
TER peak demand	GW	7.01	1.85
Number of electric vehicles	1000s	936	273
Number of heat pumps	1000s	600	67
Large Energy User demand	MW	1,550	15

Achieving the Renewable Ambition relies on our ability to meet the majority of existing and new demand using renewable energy sources and doing so at the lowest cost with minimal levels of network congestion. We have responded to support for the Demand-Led approach by assuming that some growth in new LEU demand will occur outside of Dublin and the Mid-East in Ireland, and outside of Belfast in Northern Ireland. The locations for this new LEU demand are informed by a number of factors including network topology, available network capacity, proximity to renewable energy sources and connection applications.

Table 15 shows assumptions relating to new LEU demand outside of Dublin and the MidEast, and Belfast. This new LEU demand is expected in addition to already contracted LEU demand in Dublin and the Mid-East.

Table 15: Locations and size of LEU demand located outside of Dublin and the Mid-East, and Belfast

Node	Jurisdiction	Voltage (kV)	Demand (MW)
Cashla	Ireland	220	100
Coolkeeragh	Northern Ireland	110	15
Killonan	Ireland	220	100
Knockraha	Ireland	220	100

5.3.2 Energy efficiency

Energy efficiency improvements are an important part of climate and energy policies in Ireland and the United Kingdom. Both countries have adopted ambitious targets as a means of reducing greenhouse gas emissions. The EU's Clean Energy Package targets a 32.5% reduction of final use energy by 2030 compared to 2005.

Efficiencies in electricity use can be achieved using more efficient appliances in homes and businesses and through better insulation of buildings. Improvements in transport are achieved as electric vehicles, and other modes of electric transport, become more advanced over time. Assumptions relating to energy efficiency are based on TES 2019 and TESNI 2020 and are provided in Table 16.

Table 16: Annual energy efficiency improvements

Sector	Category	% annual improvement
Residential	Electrical appliances	1.0 – 1.2
Residential	Thermal	0.8 – 1.0
Commercial	Electrical appliances	1.2 – 1.5
Commercial	Thermal	0.8
Transport	Electric Vehicles	1.0 – 1.6
Industrial	Aggregated efficiencies	1.0

5.3.3 Conventional generation

Due to Clean Energy Package legislation on CO2 emission limits for capacity market payment eligibility[8], and planning decisions[9], it is expected that thermal generation using coal, peat and oil as their primary fuel will decommission by 2030. This capacity, and the capacity from other plant expected to retire out to 2030, is expected to be replaced by new gas-fired generation, battery energy storage, interconnection, and demand side units.

A summary of the assumed thermal generation capacity, rounded to the nearest 50 MW, is shown in Table 17.

8 SEM Committee, Capacity Remuneration Mechanism 2024/25 T-4 Capacity Auction Parameters and Compliance with the Clean Energy Package, 2020
9 ABP, West Offaly Power Station decision, 2019

Table 17: Assumed thermal power plant rated capacities in 2030, rounded to nearest 50 MW

Generator type	Ireland (MW)	Northern Ireland (MW)
Gas Turbine	5,800	1,900
Distillate Oil	300	250
Total	**6,100**	**2,150**

EirGrid Group is presently carrying out detailed analysis regarding the future conventional generation profile, taking into consideration system adequacy requirements. This includes detailed generator derating assessments. The results of this analysis will help inform future capacity market processes. The generation portfolio in the final network development approach has been deemed adequate for network analysis and provides enough derated capacity to satisfy assumed levels of demand.

A regional breakdown of the new thermal generation rated capacity in the final network development approach is listed in Table 18, rounded to the nearest 50 MW. A map illustrating the areas provided in Table 18 is shown in Figure 15. We recognise that based on Best Available Techniques (BAT) conclusions some new gas-fired generation technologies may be run hour limited in order to comply with the Industrial Emissions Directive.

Multi-shaft configuration CCGT provides unrestricted thermal capacity which is not subject to run hour limitations that are imposed on other gas-fired technologies such as Open Cycle Gas Turbines (OCGTs). We have assumed that some of the new gas-fired thermal plant are Multi-shaft configuration CCGTs.

Table 18: Rated capacities of new gas-fired thermal generation by area

Area	Rated capacity (MW)
Area C	400
Area D	300
Area G	150
Area I	300
Area J	1,100
NI SE	850
Total	**3,100**

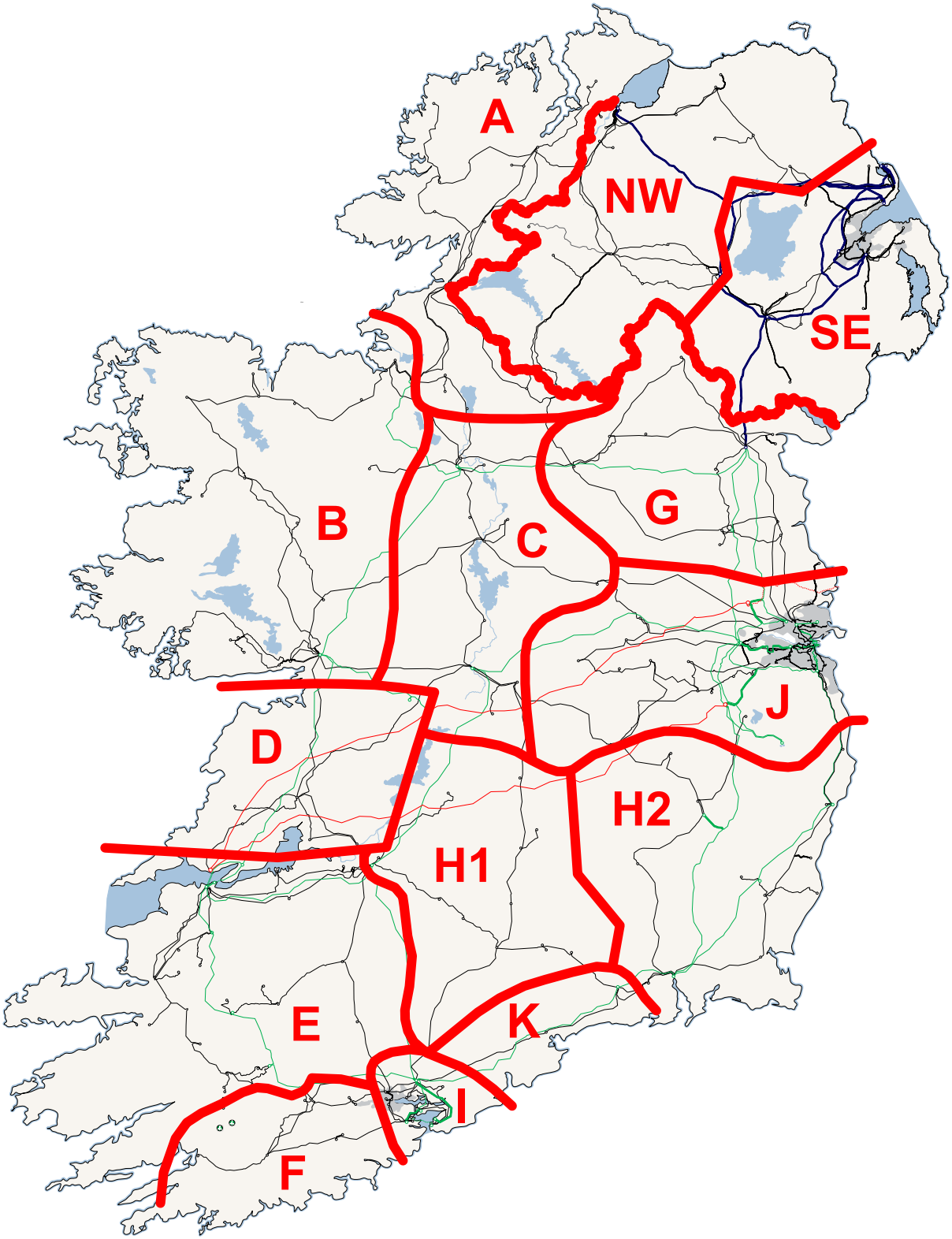


Figure 15: Study areas

5.3.4 Renewable generation

In the Shaping Our Electricity Future consultation, we presented four different approaches for meeting the Renewable Ambition. We received considerable feedback from both the public and industry; all of this feedback has ultimately helped influence the composition and location of new renewable generation capacity in the final network development approach.

There were some differences in the composition of the feedback in Ireland and Northern Ireland. A summary of how the feedback in each jurisdiction influenced the renewable generation portfolio in the final approach is provided below.

Ireland

In Ireland, the Generation-Led approach was strongly supported in the consultation feedback, with aspects of the other approaches also receiving support. In the final network development approach, significant growth in offshore wind is included.

Onshore wind continues to play a major role in delivering the Renewable Ambition with new capacity connecting in areas of the grid with relatively fewer network constraints. This responds to strong support for the Generation-Led approach which achieves benefits for consumers by reducing both network constraints, and the scale and quantity of network reinforcements required.

Solar PV generation is expected to develop significantly in Ireland over the next decade. In response to feedback seeking greater involvement for community-based renewables, some of this capacity is micro-PV. Section 5.3.5 provides further details on micro-generation.

The renewable generation portfolio in Ireland is influenced by the results of the recent RESS1 auction, with all successful participants assumed in our studies - including all successful community-based projects.

Northern Ireland

In Northern Ireland, the Generation-Led approach was viewed favourably in the public consultation; however, the industry feedback expressed concerns over the deliverability of significant quantities of offshore wind. Overall, there was balanced support of all the approaches in Northern Ireland. Taking all feedback into consideration means that the final network development approach sees a much-reduced quantity of offshore wind in Northern Ireland.

In response to the feedback, onshore wind continues to play a major role in delivering the Renewable Ambition; new capacity is mainly expected to connect to generation clustering substations.

As in Ireland, PV generation is expected to increase considerably; similarly, some of this capacity is expected to be micro-PV with further information available in Section 5.3.5.

Table 19 provides a summary of the major renewable generation capacities assumed to be in place in Ireland and Northern Ireland by 2030.

Table 19: Summary of assumed renewable generation capacities in 2030

Source	Ireland [MW]	Northern Ireland [MW]
Onshore Wind	5,700	2,450
Offshore Wind	5,000	100
Solar[10]	1,500	600
TOTAL	12,200	3,150

Shaping Our Electricity Future focuses on 2030, including the renewable generation capacities required to be in place to deliver the Renewable Ambition. Figure 16 and Figure 17 give an indicative example of how those capacities may be built out annually in Ireland and Northern Ireland respectively.

Delivery of onshore wind and solar PV see the renewable generation capacity increase at a steady pace in Ireland out to 2025. The anticipated delivery of offshore wind from 2026 onwards sees the renewable generation capacity increase at a faster pace in the second half of the decade. In Northern Ireland, steady growth of onshore wind and solar PV is assumed across the decade, with a small demonstration offshore wind project delivered in 2030.

The level of RES-E is indicated in both figures; both jurisdictions see a small increase out to 2025. In the latter half of the decade, RES-E increases year on year at a faster pace. A relaxation of operational rules following the assumed delivery of interconnection capacity enables this faster pace of change.

These graphs are for indicative purposes only. The trajectory of the delivery of renewable generation capacity is ultimately subject to many factors. These include the receipt of planning approval and the delivery of transmission network and interconnection capacity.

10 Includes micro-generation solar PV

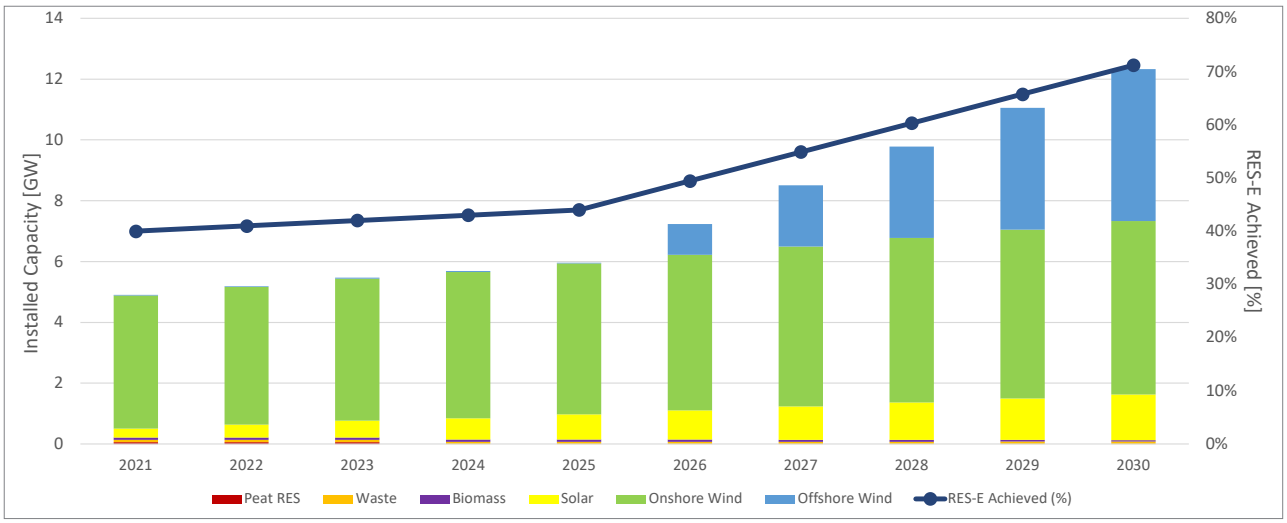


Figure 16: Projection for renewable generation growth and RES-E% levels in Ireland

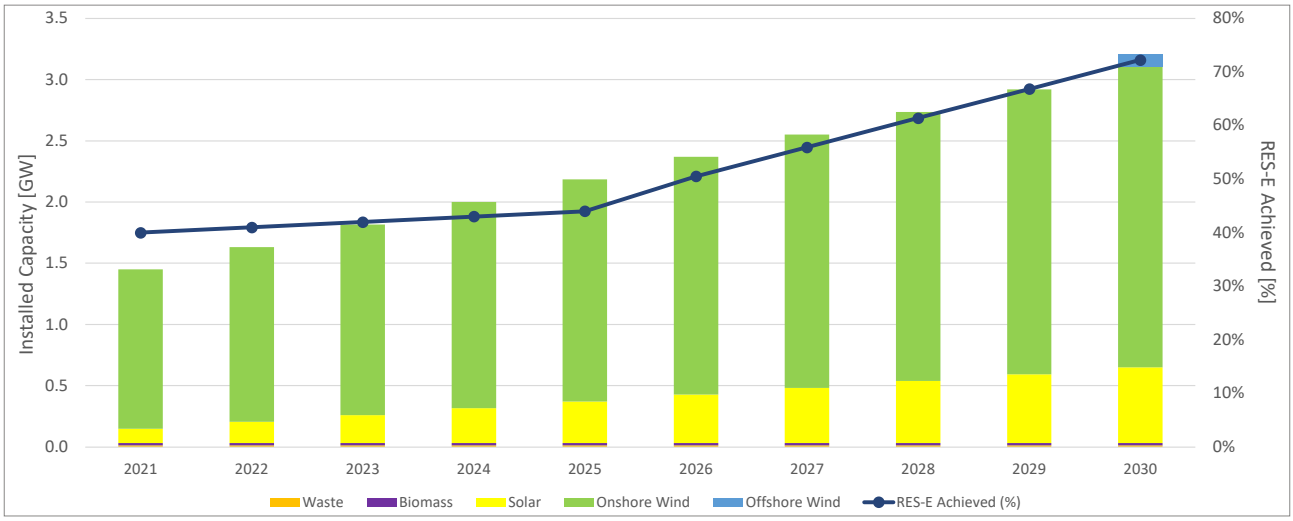


Figure 17: Projection for renewable generation growth and RES-E% levels in Northern Ireland

Table 20 provides a summary of renewable generation capacities by area in Ireland and Northern Ireland and Figure 18 shows the spatial of generation by 2030. The assumed locations for future connections of renewables are informed by a range of information sources such as consultation feedback, grid connection applications, outcomes of auctions and projections of available grid capacity. These locations are subject to change; they will be updated as part of future revisions of Shaping Our Electricity Future to reflect the best available information.

Table 20: Summary of onshore wind, offshore wind and solar PV by area

Area	Onshore Wind (MW)	Offshore Wind (MW)	Solar PV (MW)
IE AREA A	820	0	140
IE AREA B	890	390	60
IE AREA C	190	0	70
IE AREA D	310	0	30
IE AREA E	1,520	0	80
IE AREA F	210	0	20
IE AREA G	240	370	160
IE AREA H1	550	0	90
IE AREA H2	430	990	300
IE AREA I	2	350	90
IE AREA J	480	2,900	410
IE AREA K	60	0	50
NI SE	340	100	450
NI NW	2,110	0	150

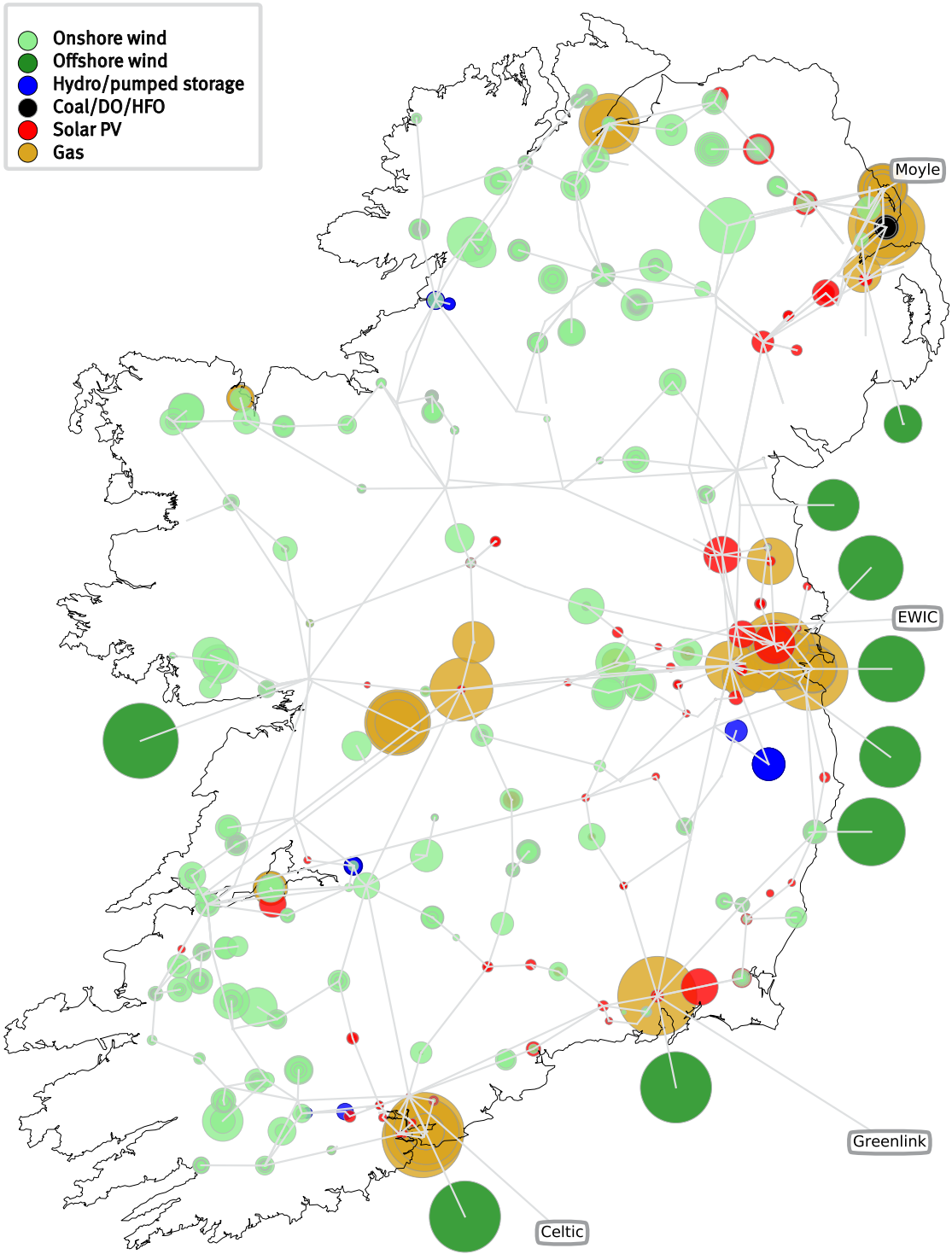


Figure 18: Generation spatial distribution, 2030.

5.3.5 Micro-generation

Micro-generation is an important aspect of the renewable transition offering energy consumers and community groups the opportunity to produce, supply and use renewable electricity. The EU's Clean Energy Package requires member states to offer such opportunities to citizens and to leverage smart metering technologies to facilitate participation.

In Ireland, micro-generation is defined as a generator that produces less than 5.75 kW (single phase) or 11 kW (3 phase) of electrical power[11]. In Northern Ireland, the Micro-NIRO mechanism encouraged the use of renewable generation with a capacity of less than 50 kW to connect to the grid as part of the Northern Ireland Renewable Obligation (NIRO) scheme.

There are many different types of micro-generation in both jurisdictions such as wind turbines, solar PV, hydro, biomass CHP and biogas. Significant growth in solar PV micro-generation out to 2030 is expected in Ireland and Northern Ireland. The Micro-NIRO helped rooftop solar PV become one of the most prominent forms of micro-generation in Northern Ireland, leading to an installed capacity of around 100 MW. This is assumed to double by 2030 resulting in 200 MW of installed capacity.

In Ireland, growth of micro-generation solar PV has been relatively slow compared to Northern Ireland. We have assumed a step-change in uptake of rooftop solar PV resulting in 500 MW by 2030. The volume of homes with solar PV installed is shown in Figure 19 for 2019 and 2030, in Ireland and Northern Ireland.

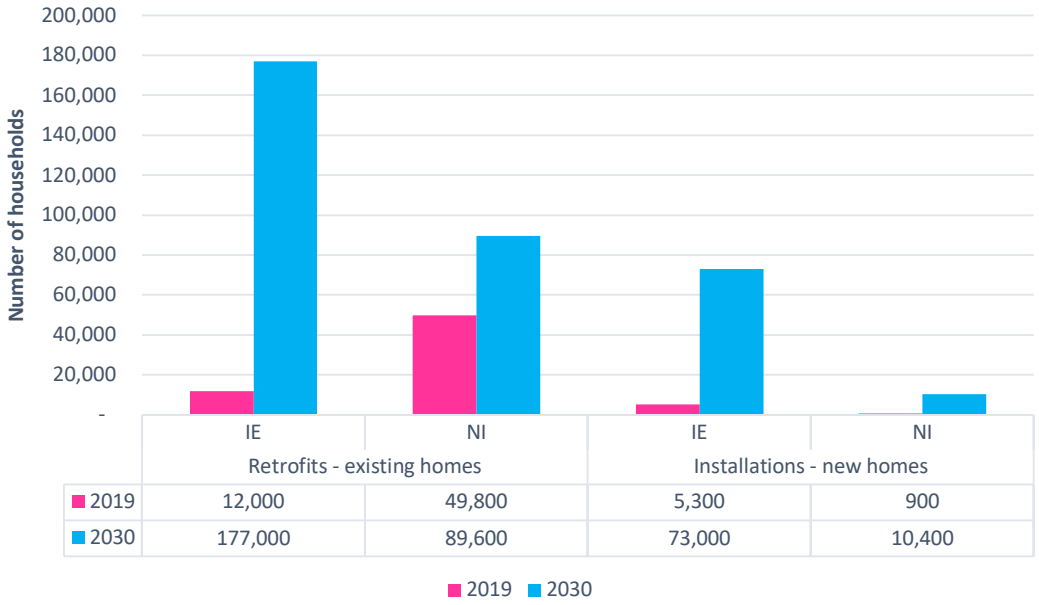


Figure 19: Solar PV micro-generation by existing and new homes

11 SEAI, Connecting Micro-generation to the Electricity Network, 2009

5.3.6 Interconnection

Our studies assume that the following new interconnectors are in service according to their stated schedule, which precedes 2030. These are:

- The 2nd North-South Interconnector – an alternating current (AC) interconnection between Ireland and Northern Ireland (ENTSO-E TYNDP project 81);
- Celtic Interconnector – a HVDC interconnection between Ireland at Knockraha station and the northern transmission network of France (ENTSO-E TYNDP project 107); and
- Greenlink – a HVDC interconnection between Ireland at Great Island station and a transmission station in western Wales (ENTSO-E TYNDP project 286).

In our studies, no further interconnections such as the Renewable Integration Development Project (ENTSOE TYNDP project 82), the MARES Organic Power Interconnector (ENTSO-E TYNDP project 349) or LirIC (ENTSO-E TYNDP project 1040) were assumed before 2030. EirGrid and SONI will continue to monitor development of these projects.

5.3.7 Storage and demand side units

We have assumed that existing pumped hydro energy storage (PHES) will continue to operate in Ireland by 2030, and that there will be growth in demand side units (DSU) and battery energy storage capacities (BES) is also expected in both jurisdictions.

Table 21 lists the storage and DSU capacity assumed connected by 2030.

Table 21: Assumed storage and DSU capacities in 2030

Technology type	Ireland (MW)	Northern Ireland (MW)
Demand Side Unit (DSU)	600	200
Battery Energy Storage	1,700	300
Pumped Hydro Energy Storage	300	0
Total	**2,600**	**500**

The large scale Silvermines hydro project (ENTSOE TYNDP project 1025), which has also been deemed a PCI project by the European Union, has not been included in our analysis. EirGrid will continue to monitor development of this PCI project and it may be included in future studies when appropriate.

Battery energy storage (BES) technologies are required in 2030 for reserve provision, capacity adequacy and to assist with congestion management. It is assumed that the energy-to-power ratio of the battery fleet will increase over the period to 2030 with mostly reserve-only batteries expected before 2025 followed by longer duration batteries capable of providing capacity, flexibility and reserve. The assumed BES fleet is provided in Table 22; installed capacities are rounded to the nearest 50 MW.

Table 22: Annual battery energy storage capacities in 2030

Jurisdiction	Category	Average of Duration [h]	Installed capacity [MW]
Ireland	**Energy and Reserve**	1.9	800
	Reserve-Only	0.5	350
	Long Duration	6.0	550
Northern Ireland	**Energy and Reserve**	2.0	250
	Reserve-Only	0.5	50

5.3.8 Operational constraints

In order to achieve the Renewable Ambition changes to how we ensure operational security during the generation dispatch process are required. Operational security is achieved using operational constraints. These operational constraints must evolve over time to cater for planned changes to the all-island power system such as integration of high levels of non-synchronous generation. The operational constraints assumed in our studies are shown in Table 23.

Table 23: All-island operational constraints

Constraint	Unit	Value
SNSP upper limit	%	95
Inertia lower limit	MWs	15,000
RoCoF upper limit	Hz/s	1
Minimum number of conventional units, Ireland	#	2
Minimum number of conventional units, Northern Ireland	#	2

5.4 Results

5.4.1 System needs

The final network development approach is subject to a system needs assessment, which identifies the elements of the transmission system that do not meet the required performance levels in tests selected from the TSSPS for Ireland and Northern Ireland. This helps inform selection of the final set of network reinforcements required to deliver the 70% Renewable Ambition for 2030.

The generation and demand from the final network development approach is modelled on the transmission network. The transmission network configuration used in the analysis is based on the network as it is today, but with a number of approved reinforcements included.

Figure 20 illustrates the needs identified using the final network development approach in Ireland and Northern Ireland. The severity of the need is indicated using the colour coding described in Table 24.

The volume and scale of transmission elements that performed outside of the planning standards indicates that the transmission network does not have sufficient capacity to integrate the levels of RES needed to achieve the Renewable Ambition. This is in spite of the inclusion of a number of approved reinforcements.

Consequently, if no further transmission network development occurs, additional RES capacity will need to be installed to offset the RES dispatch-down associated with maintaining transmission elements within their ratings, lest the Renewable Ambitions in both jurisdictions be missed. Lack of transmission network investment will also create challenges for future power system operational planning and operations, for example outage scheduling and voltage control.

Table 24: Severity of overloading indicated in system needs assessment

Indicator	Risk of overloading
	Marginal risk of overloading – circuit loaded up to 101% thermal rating for 1% of the year.
	Small risk of overloading – circuit loaded up to 105% thermal rating for 5% of the year.
	Moderate risk of overloading – circuit loaded up to 110% thermal rating for 10% of the year.
	Heavy risk of overloading – circuit loaded up to 120% thermal rating for 20% of the year.
	Severe risk of overloading – circuit loaded up to 130% thermal rating for 30% of the year.
	Extreme risk of overloading – circuit loaded in excess of 130% for over 30% of the year.

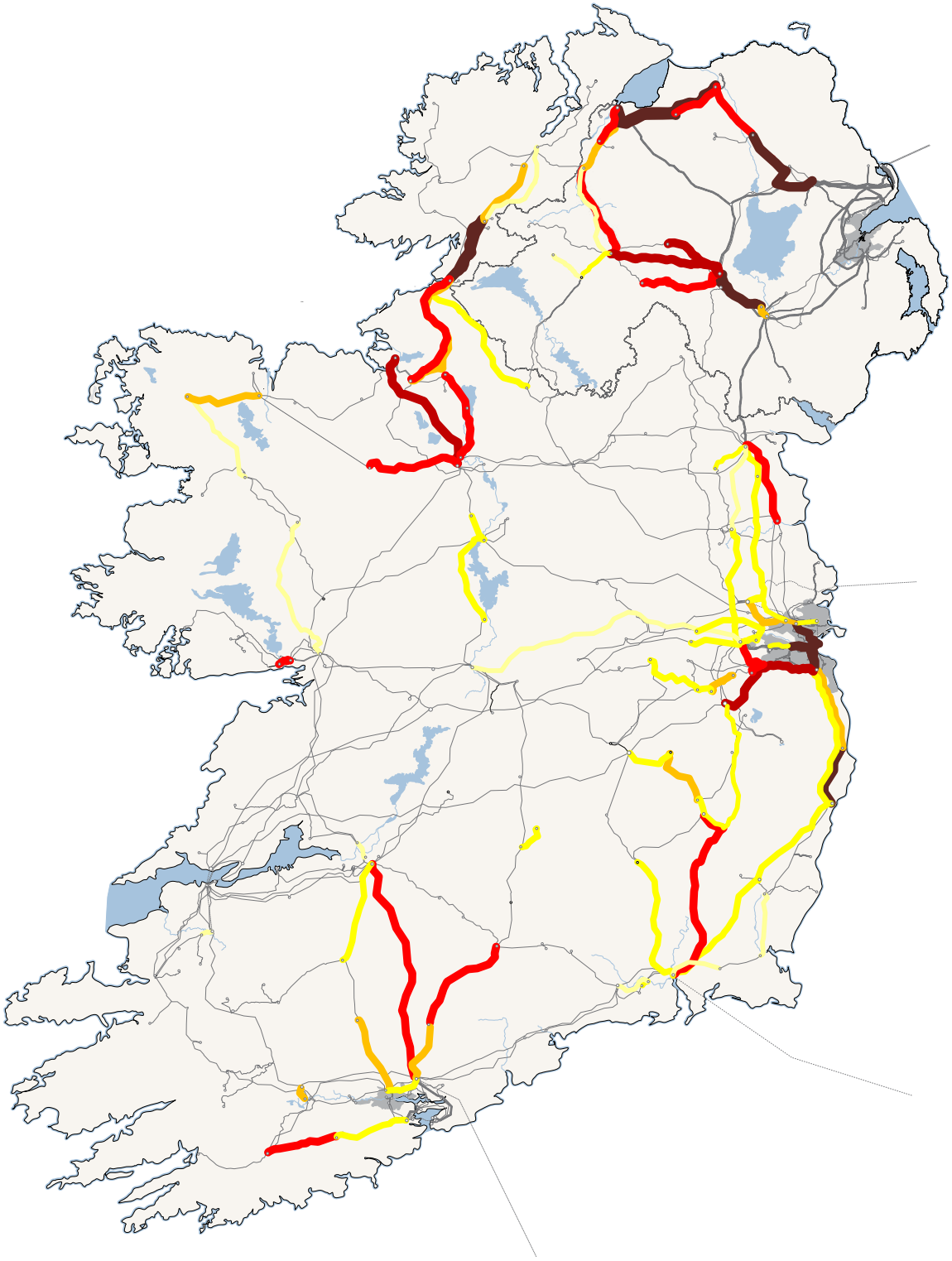


Figure 20: Needs arising from system needs assessment

Many 110 kV circuits in the north-west area of Northern Ireland see a significant risk of overloading, driven by the large increase in onshore wind generation in the area. The eastern side of Northern Ireland sees little to no risk of overloading, given the strong transmission network in this area.

In a similar manner, 110 kV circuits in the north west of Ireland, in particular in counties Donegal and Sligo, see a high risk of significant overloading. Again, this is primarily driven by a large capacity of onshore wind generation in the area.

Figure 21 shows the risk overloading within the greater Dublin city area. The 220 kV network within Dublin city is subject to some of the highest risk of significant overloading observed in the analysis. This is a result of load growth in Dublin and the Mid-East regions, large demand growth from large energy users and the connection of offshore wind generation located along the east coast.

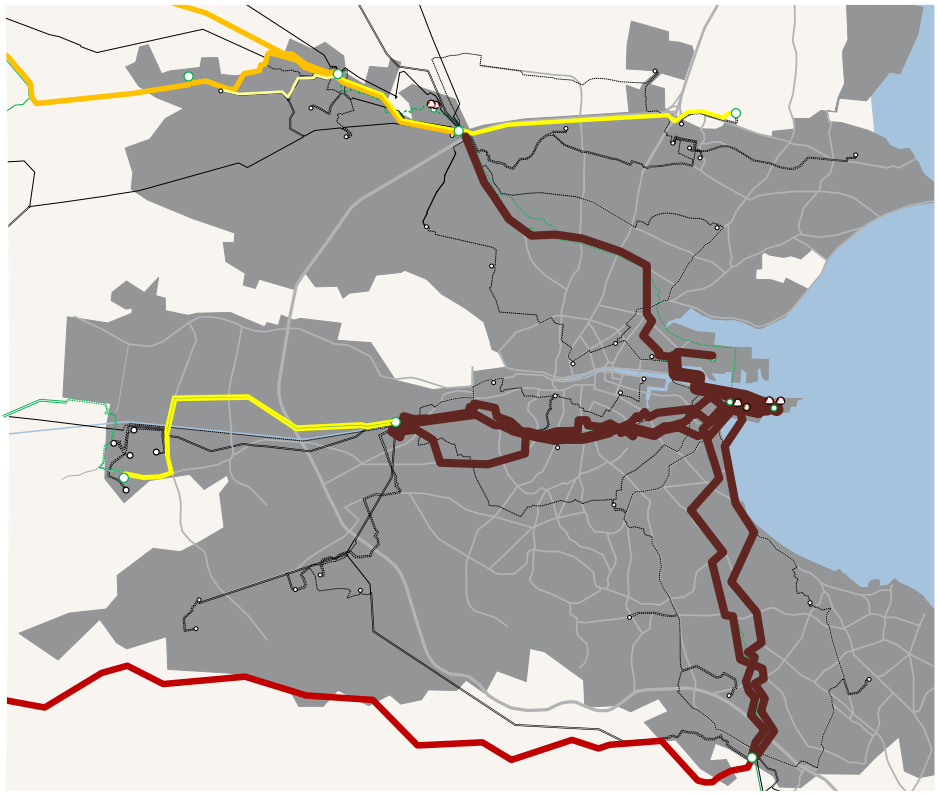


Figure 21: Focus on needs in Dublin city area

5.4.2 Candidate reinforcements

We have identified a number of candidate reinforcements that are required in order for the Renewable Ambition to be met in both jurisdictions. These reinforcements are required in addition to other committed projects that are already progressing through the respective grid development frameworks. The reinforcements are indicated in Figure 22.

In Northern Ireland, new circuit capacity is required between Kells and Rasharkin, and in the area between Rasharkin, Coleraine and Limavady. Within the north-west area, many 110 kV circuits are required to be uprated to provide additional capacity, on the corridors between Coleraine and Coolkeeragh, Coolkeeragh and Strabane and Strabane and Omagh.

Some upvoltaging is required on the corridor between Omagh and Tamnamore, with an associated reconfiguration of the connection of some generation clustering substations in the area. The 110 kV circuits between Drumnakelly and Tamnamore are also required to be uprated.

Two Dynamic Line Ratings (DLR) schemes facilitate the connection of additional wind generation at clustering substations in the west of Northern Ireland.

In Ireland, several new projects are required to address new renewable generation in the north-west area. In the Donegal area, additional capacity is delivered with the North West Project, uprating of the Clogher to Drumkeen circuit and some reconfiguration of the network. Additionally, several Power Flow Controllers (PFC) are used to manage flows around the local 110 kV transmission network.

South of Donegal, a 220 kV upvoltage solution between Flagford and Srananagh, along with a number of PFC and 110 kV circuit uprates are required to facilitate the additional power flows from the north-west area. Towards the west, two DLR schemes are required in the Mayo area to manage power flows at times of high wind generation output. In Galway, additional transmission capacity is needed between Galway and Salthill to enable to connection of additional wind generation west of Galway.

In line with a Demand-Led approach, it is assumed that some Large Energy User (LEU) demand is incentivised to locate outside Dublin and Mid-East. One site selected in the analysis is at Cashla, and this helps mitigate the risk of severe thermal overloading by making use of abundant renewable energy resources in the area, including a new offshore wind farm.

In the north-east area, a combination of new offshore wind generation and a need to enable larger power flows between Ireland and Northern Ireland sees the uprating of the Louth to Woodland 220 kV and the Louth to Drybridge 110 kV circuits.

The connection of large wind and solar generators in the Midlands, combined with a large increase in demand from LEUs, sees a considerable number of projects required in the greater Dublin area. Four 110 kV circuits around Maynooth are required to be uprated and additional transmission capacity is needed between Woodland and Finglas. A combination of DLRs and circuit uprating are required on 110 kV circuits in the area around Newbridge.

Significant quantities of offshore wind generation along the east coast to the south of Dublin see a need for the upvoltaging of the Arklow to Ballybeg to Carrickmines 110 kV circuit to 220 kV, which includes the requirement to develop a 220/110 kV station at Ballybeg.

Power flows from Great Island towards the greater Dublin area, driven by both new interconnection and new renewable generation connections in the south, see uprating required on the Athy to Carlow 110 kV circuit and the Great Island to Kellis 220 kV circuit. Similar drivers result in an overload risk in the Knockraha area; one uprate and several PFC are proposed to mitigate the overload risk.

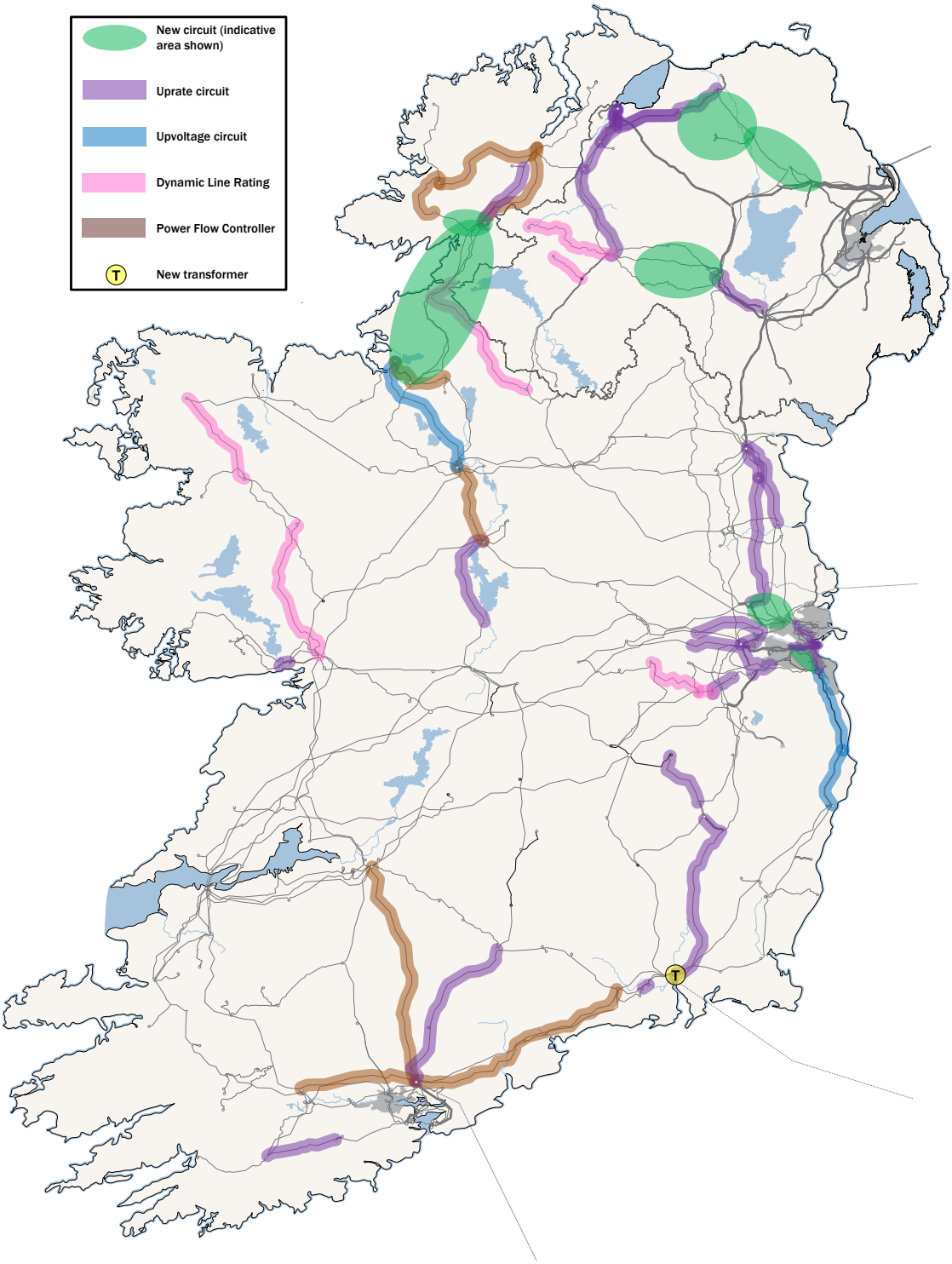


Figure 22: Identified candidate reinforcements

Within Dublin city, the risk of significant and severe overloading due to large connections of new renewable generation and demand in the area sees five 220 kV cables required to be replaced, and new capacity required between Inchicore and Carrickmines. Candidate reinforcements within the Dublin city area are shown in Figure 23.

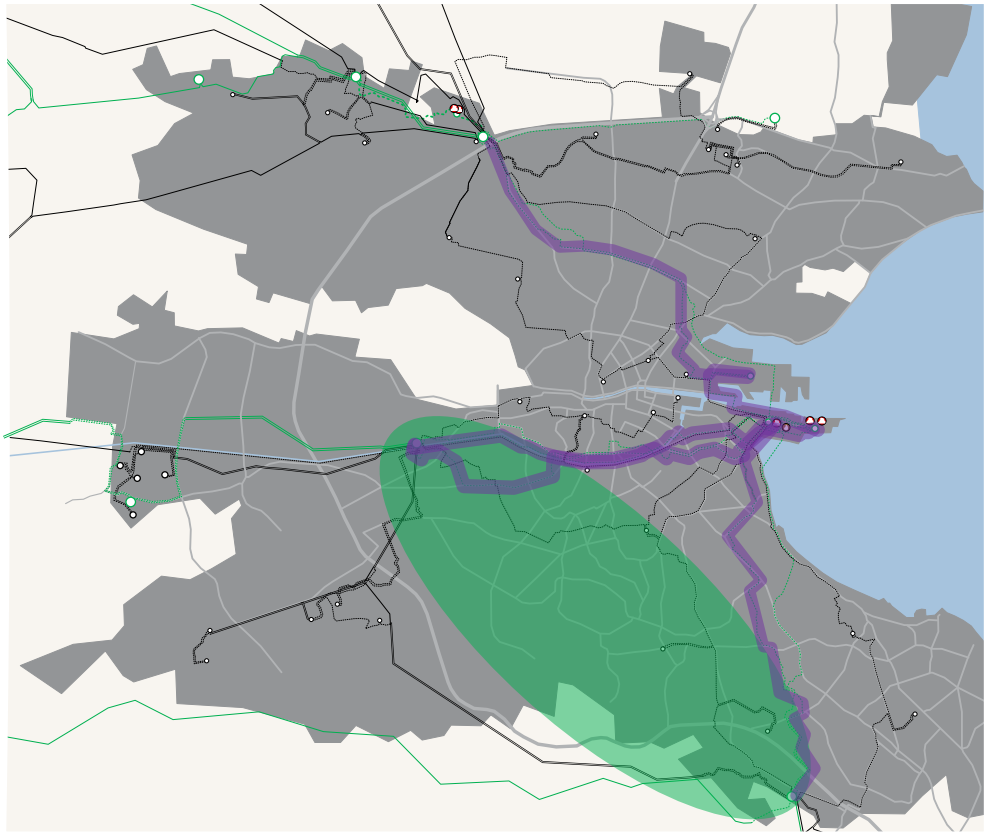


Figure 23: Candidate reinforcements in Dublin city area

A summary of the quantity and types of candidate reinforcements is provided in Table 25. A full list of all candidate reinforcements can be found in the Appendix 3.

Table 25: Quantities of candidate reinforcements by type and jurisdiction

Reinforcement Category	Ireland	Northern Ireland
New circuits	4	3
Uprate existing circuits	17	7
Replace existing circuits	5	-
Upvoltage existing circuits	2	-
New transformer	1	-
Power flow controllers	6	-
Dynamic line ratings	5	2
Total	**40**	**12**

5.4.3 Costs

The estimated capital expenditure (CAPEX) costs of candidate reinforcements are shown in Table 26 for Ireland and Northern Ireland. The estimated capital costs are calculated using standardized unit costs for networks in Ireland and Northern Ireland respectively. These costs are based on the final development approach which reflects stakeholder feedback received as part of the consultation. The final development approach results in a programme of work that meets the Renewable Ambition by leveraging new technologies and maximising the use of the existing grid. This strategic programme of work reduces network investments costs and mitigates deliverability risks by minimising the need for additional grid infrastructure.

Table 26: Estimated CAPEX by reinforcement type per jurisdiction

Reinforcement Category	Ireland (€M)	Northern Ireland (£M)
New circuits	554	105
Uprate existing circuits	187	25
Replace existing circuits	197	-
Upvoltage existing circuits	122	-
New transformer	5	-
Power flow controllers	30	-
Dynamic line ratings	8	4
Total	**1,103**	**134**

The costs of the candidate reinforcements identified as part of Shaping Our Electricity Future are considered in the context of the wider programme of capital investment in transmission infrastructure. Combining SOEF costs with EirGrid and SONI's current and future programme costs indicates the total transmission CAPEX required by 2030.

Current programme costs reflect price control decisions for the period 2021 to 2025 in both Ireland and Northern Ireland. Future programme costs reflect CAPEX forecasts in the period 2026 to 2030, and are subject to regulatory approval. The future programme estimates in Ireland cover a number of project types including system reinforcements, connections and asset refurbishments.

Table 27: Estimated total transmission CAPEX by 2030 by jurisdiction and pipeline category

Category	Ireland (€M)	Northern Ireland (£M)
Current and future programme	2,117	140
Shaping Our Electricity Future	1,103	134
Total	3,220	274

5.4.4 Economic benefits of candidate reinforcements

A number of metrics are used to assess the economic performance of the final network development approach. This is consistent with the methods used to compare performance of the four draft approaches as part of the consultation. The economic performance metrics considered in the assessment of the final network development approach are:

- Change in production costs;
- Reduction in CO2 emitted from fossil fuel fired generation, measured in tonnes;
- RES-E achieved, measured in percentage of estimated gross final consumption of electricity;
- Reduction in renewable generation constraint, i.e. the RES spillage savings measured in gigawatt-hours (GWh); and
- Reduction in grid losses, measured in gigawatt-hours (GWh).

The first four benefits are estimated as the difference between security-constrained unit commitment and economic dispatch simulations that have the candidate reinforcements included and excluded. Grid losses are taken from the intact AC power flow simulations. A full year of expected operation is simulated for the selected scenario-year, i.e. 2030.

It should be noted that the estimated benefits reflect the assumptions outlined in Section 5.3 and assume that all reinforcements listed in appendix 3 and 4 are in place by 2030. The accuracy of the estimated benefits is also affected by limitations of the market simulation models used which assume perfect foresight and competition.

The economic performance is assessed for the year 2030:

- The RES-E levels that are expected exceed the ambitions of both Ireland and Northern Ireland.
- Generators are economically dispatched, leading to the optimal dispatch and hence the optimal production costs as a result.
- Assuming that the generation connects as expected, and that the reinforcements are in place by 2030, the levels of constraint will be minimised. For 2030, this is expected to be of the order of 5% and will correspond to approximately 1,750 GWh. At an average compensation rate of €85/MWh[12], this corresponds to a constraint cost of €148 million.
- System losses are expected to reduce by 135 GWh each year once the reinforcements are in place, relative to the transmission system containing only those reinforcements that have received capital approval. This translates to a combined reduction in the cost of losses for Ireland and Northern Ireland of approximately €7 million per annum, assuming an average annual Day-Ahead Market Price of €50/MW.

The estimated benefits, calculated in Euros, are shown in Table 28.

12 Cost of compensation determined based on assumed strike prices of €67/MWh for onshore wind; €73/MWh onshore solar PV; and €119/MWh for offshore wind. Assumed strike prices are calculated based on the weighted average strike prices and amount of successful capacity per technology type from the RESS 1 auction. For offshore wind, the estimated strike price is based on average LCOE estimates.

Table 28: Estimated all-island benefits shown in Euros

Metric	Volume	Monetisation (€m)
Production cost change p.a.	Generators are optimally dispatched due to the removal of network constraints	Optimised production cost per annum
CO2 emission reduction t p.a.	Minimum level of CO2 due to running most efficient plant	Minimised CO2 cost due to the minimised level of CO2 emissions
RES-E achieved in 2030	c. 71.36%	
Renewable generation Constraint p.a.	1,750 GWh c. 5%	148
Grid losses change p.a.	-135 GWh	7

5.5 Transmission interface station capacity needs

EirGrid, as the Transmission System Operator of Ireland, and ESB Networks, as the Distribution System Operator of Ireland, work collaboratively to ensure that needs of transmission and distribution connected customers are met. This includes planning development of transmission interface stations. A transmission interface station is a point of connection between the transmission and distribution system or directly connected transmission customers. A primary function of these stations is to facilitate power flows between the transmission and distribution systems.

As part of feedback to the consultation the DSO has highlighted to EirGrid emerging needs for additional transformer capacity at transmission interface stations in the Dublin area. This capacity is needed to accommodate forecast growth of electricity demand in the distribution network. This projected demand growth is driven by a number of factors including large energy users, electrification of heat and transport and growth in commercial connections.

A summary of emerging needs at transmission interface stations is as follows:

- New North County Dublin Bulk Supply Point Station with two additional 250 MVA transformers and associated grid connection;
- New Dublin City Centre Bulk Supply Point Station with two additional 250 MVA transformers and associated grid connection;
- New West County Dublin Bulk Supply Point Station with two additional 250 MVA transformers and associated grid connection;
- Carrickmines: One additional 250 MVA transformer; and
- Corduff: One additional 250 MVA transformer (underway)

Further studies are required before optimal solutions to these needs are developed and before a process of wider engagement and consultation begins. EirGrid will continue to work with the DSO, and to incorporate plans for transmission interface stations into broader plans for development of the transmission network.

6. Shaping Our Electricity Future Roadmap – Multi-Year Plans

The Shaping Our Electricity Future Roadmap was prepared by EirGrid and SONI in consultation with stakeholders across society, government, industry, market participants and electricity consumers. This section sets out multi-year plans or recommendations for the evolution of our transmission network, engagement approach, system operation and markets.

6.1 Network Infrastructure

6.1.1 Context

Between now and 2030, there needs to be a transformational step change in the volume of network reinforcement delivered across the transmission network. This is required to support the delivery of the Renewable Ambition in an efficient and effective manner.

The objective of the networks element of Shaping Our Electricity Future is to describe how the transmission network in Ireland and Northern Ireland needs to evolve out to 2030. This follows detailed consultation with government, regulators, industry participants, stakeholders and the general public where we used scenario-based analysis to identify an optimal transmission network roadmap. The future evolution of the power system beyond 2030 is also implicitly considered in delivering on ambitions to be carbon neutral before 2050.

This plan sets out the key strategic enablers for delivery of electricity infrastructure.

6.1.2 High level summary

There are a number of key strategic enablers that have been identified as being fundamental for infrastructure delivery within the required timeframes out to 2030. These have been identified based on a combination of project delivery experience, engagement with stakeholders and communities. These enablers are described below:

1. **Public Acceptability –** fundamentally, public acceptance is at the heart of our approach to grid delivery in Ireland and Northern Ireland. We will continue to embed this approach in our projects and work with stakeholders and communities to deliver the grid solutions of the future. Early engagement with stakeholders from councils, landowners and impacted communities will enable solutions to be identified and delivered effectively and efficiently. Detailed engagement/communications plans will be developed for specific projects and programmes of work as required.[13] Further details of our engagement approach is covered off in the engagement section of this report.

2. **Optimal programme delivery of projects (TSO/TAO/TO Joint Delivery Approach) –** there is a significant programme of grid development work identified as part of Shaping Our Electricity Future. This programme also includes some non-wire reinforcements (flexible network devices). This is in addition to the system reinforcement projects already committed to or in progress and which are at various stages of the Framework for Grid Delivery in Ireland and the 3 Part Process in Northern Ireland. Furthermore, there will be additional network required to support the connection of new generation on to the power system in Ireland and Northern Ireland. We will work closely with our partners in ESBN/NIEN to deliver on these reinforcement solutions out to 2030.

13 EirGrid, EirGrid to Engage with Public on Route Options for Kildare-Meath Grid Upgrade, 2021

- In Northern Ireland, significant work has already been completed by SONI and NIEN to update the existing processes that underpin the Transmission Interface arrangements.[14] A more streamlined approach is being developed to project delivery which includes earlier joint engagement and development of key joint processes. Further work on grid delivery arrangements (Need Case, Option Appraisal, Route Corridors, Route Alignment) are close to being finalised.
- The programme of work in Ireland is significant and EirGrid and ESBN will look at ways to streamline how we work, incorporating learnings from previous projects with a view to optimising the overall joint delivery approach. For example, early engagement by EirGrid and ESBN on scope and approach (including procurement, site investigations, construction approach etc.) will be adopted where appropriate for key projects due to complexity and risk to delivery timeline. This has already commenced for a number of current projects. The Dublin region has also been identified as a particular region where there is value in working closely with ESBN to derive an overall holistic programme of work. This is due to the complexity and volume of work required in the region.

3. **Transmission Outages –** the availability of sufficient outages is a fundamental part of the programme of works for delivering network reinforcements across Ireland and Northern Ireland. This is a key constraint that has to be managed both before and during project delivery.
    - In Ireland, based on experience of outage constraints, early consideration of the outage requirements has been identified as a key enabler for project delivery. This means that outages will feed into the decision making and "optioneering" for projects in terms of deliverability. Therefore, the outage review and transformation process will include a review of outage requirements and durations during construction as well as consideration of outages during project initiation and decision making. This process will seek to minimize the requirement for outages during construction where possible. EirGrid and ESBN will continue to work closely to deliver the outage programme and in turn the grid delivery programme as effectively and efficiently as possible.
    - In Northern Ireland, to manage the uprate programme of works that are required, there will be a need to carefully schedule the transmission outage programmes of work in the North West region over the years out to 2030. SONI and NIEN will continue to work closely to deliver the outage programme and in turn the grid delivery programme as effectively and efficiently as possible.
4. **Incentivising Location** – there are advantages to locating new demand outside of congested parts of the grid i.e. Dublin and the Mid-East. In Ireland, a total of 300 MW of new LEU demand has been assumed to connect by 2030, split equally across three 220 kV nodes in Cork, Galway and Limerick. In Northern Ireland, 15 MW of new LEU demand is assumed to connect at Coolkeeragh. Locating new demand in close proximity to renewable generation can help minimise the scale and quantity of network reinforcements required. Similarly, there are advantages to connecting new renewable generation capacity in areas of the network with relatively higher available grid capacity. By optimally locating connections of new demand and generation overall costs can be reduced due to a need for fewer reinforcements and lower levels of network constraints.

14 TIA amendments have been agreed between SONI and NIEN and are with UR for approval

5. **Planning Consents -** for many grid reinforcement projects, a key part of the project programme is obtaining the necessary planning consents in a timely manner. We will continue to work with the relevant consenting authorities in Ireland and Northern Ireland, as well as all relevant prescribed bodies to submit the necessary planning applications to deliver on the projects and to do this in the optimal manner possible. We will continue to work at a strategic level to identify our projects as part of national and regional and local planning policy focussing on established development plan structures.

6. **Technology Toolbox –** consideration has been given to identifying and implementing mechanisms, tools and processes, in addition to network build, to relieve network congestion in order to facilitate additional renewable connections and allow export of generation on to the system. As part of the analysis carried out, a number of flexible network technologies have been identified in both Ireland and Northern Ireland to relieve network congestion. These will be rolled out to specific parts of the network in the years out to 2030. A key part of this will be the development of a flexible network strategy to ensure that flexible technologies installed on the system are leveraged to maximise their benefit. We will work closely with ESBN and NIEN to deliver on these flexible technologies over the coming years.

Other key enablers include the use of the public road network in scenarios where a decision has been taken to install underground cable following an assessment of various options. This use of the road network is a key enabler for timely project delivery and to minimise routing constraints.

6.1.3 Multi-year plan

6.1.3.1 Ireland

Table 29: Networks - Ireland multi-year plan

Project Name	Description	Parties	Start Date	Finish Date
Incentivising Location	Government and regulatory policies in place to support locating generation and large energy users where electricity grid capacity is available or where it will be available in the future.	DECC, EirGrid, CRU	Q4 2021	Q2 2023
Planning Consents	Engagement with planning authorities at a strategic level to enable expeditious delivery of strategic electricity infrastructure, e.g. development of grid masterplans at regional and local authority levels and enhanced multi-level engagement by planning and environmental experts with consenting authorities, prescribed bodies and other relevant stakeholders.	EirGrid, DECC, DHPLG, local and regional authorities	Q4 2021	Q4 2022
Optimal Joint Programme Delivery (TSO/TAO)	Implementation of an end – end TSO/TAO joint approach to optimise programme delivery time of electricity infrastructure[15]	EirGrid, ESBN, CRU	Q4 2021	Q4 2022
Transmission Outage Review and Transformation	Implementation of a transmission outage review and transformation programme	EirGrid, ESBN	Q4 2021	Q4 2023
Technology Toolbox	Deliver electricity grid Technology Toolbox solutions for enhanced flexible network operation[16].	EirGrid, ESBN	Q4 2021	Q4 2026
Flexible Network Strategies	Develop flexible networks strategy for deployment of "non-wires" electricity grid technologies[17]	EirGrid	Q4 2021	2023/24 /25/26
Future Capacity Dublin Region	Work with ESBN (TAO and DSO) to derive a delivery plan for Dublin region (including station works, new Bulk Supply Nodes, refurbishments and any new build requirements)	EirGrid, ESBN	Already commenced	2022
Road Networks	Leverage the public road Network for delivery of electricity infrastructure. Public roads are a key enabler for delivery of network infrastructure where an underground cable has been selected as the preferred option following multi criteria decision making.	EirGrid, ESBN, TII, Local authorities,	Already commenced	Project Specific

15 Some additional regulatory supports may be required here to support accelerated joint delivery of projects.
16 and 17 Examples of new technologies in tables below

6.1.3.2 Northern Ireland

Table 30: Networks - Northern Ireland multi-year plan

Project Name	Description	Parties	Start Date	Finish Date
End-End TSO/ TO Approach to delivery	Work is underway to develop joint processes, and relevant amendments to subsidiary documents to support this. (i.e. Transmission Interface Arrangements). Moving into implementation.	UR, SONI, NIEN	Already commenced	Q1 2022
Technology Toolbox	Deliver electricity grid Technology Toolbox solutions for enhanced flexible network operation	SONI, NIEN	Q4 2021	Q4 2026
Flexible Network Strategy	Develop flexible network strategy for deployment of “non-wires” electricity grid technologies	SONI, NIEN	Q4 2021	2024/25/26

6.2 Stakeholder Engagement

6.2.1 Context

EirGrid's work to transform the electricity system is a critical component of the Government's Climate Action Plan. SONI is working with partners to prepare the Northern Ireland electricity system to support the forthcoming Department for the Economy's energy strategy.

EirGrid and SONI together with governments, regulators, the DSOs and industry will both lead and underpin the island's response to climate change in the electricity sector. It is EirGrid's and SONI's role to get the grid ready for the 2030 renewable energy ambitions of each jurisdiction. For this to happen, EirGrid and SONI need to make an evolutionary shift in how we engage with the public: we need to evolve our public engagement strategy.

EirGrid and SONI now have their own strategies to transform public engagement in each jurisdiction that builds upon extensive work over the past decade.

This must continue to be a process of continuous improvement.

Only with the support of all stakeholders will we be able to achieve the scale of change required in the next few short years. The scale of this challenge is enormous.

When we work together, we make better decisions. If we can collaborate with the public, with communities and with landowners to find a shared solution, then together we can create a better future for generations to come.

6.2.2 High Level Summary

In the next decade, we will need to develop new grid infrastructure. More than ever before, it's important that we gain the support of individual landowners, their neighbours, and their wider communities.

We must acknowledge the challenges of what we ask from individuals and communities for the benefit of the entire population. If we don't engage successfully with those affected by grid development plans, we won't achieve climate action targets.

In response, EirGrid and SONI are making community engagement and participation a core part of this Roadmap. Our aim is to develop a cohesive approach that reflects and is framed by the energy transition – and by the urgent context of climate action. As we improve the way we engage with the public, we must recognise and reconcile the impact of these changes on existing projects.

Among the list of engagement initiatives which will support delivery of stakeholder acceptance and collaboration in the delivery of a secure, reliable and economic transmission network by 2030 are:

1. **Enhance Community Benefits*** – Since 2014, EirGrid has offered community benefit funds for major projects. This recognises the vital role that local communities make in accepting new grid infrastructure.
   This model showed promise in smaller projects but needs scale to reflect the greater disruption of larger works. To reflect this, EirGrid is increasing community benefit funding from spring 2021. Our new approach sees local areas gain from a fund that benefits communities, sustainability and biodiversity. The decisions on how these funds are distributed are open, participatory and inclusive. The setup of community forums on major projects ensures there is even greater community ownership of these funds.

***This is an Ireland only initiative**

2. **Deliver ambitious education and information campaigns** – Our new approach to public engagement aims to find project solutions that are more acceptable to affected communities. Alongside this, we are seeking to increase levels of public acceptance for new grid infrastructure. We know from our collaborations with communities to date, that when there is a shared understanding of what we do, and why we do it, they are generally more supportive of new grid infrastructure.

3. **Expand our public engagement toolkit** - By toolkit, we mean the ways we engage with stakeholders. We acknowledge the need to increase the rate of participation in our public engagement processes. The COVID-19 pandemic has accelerated our trials of remote and virtual solutions. These include video conferencing, interactive online maps, a consultation portal, co-design initiatives and participative processes. We are continuing these tests to expand the breadth and reach of our public engagement virtually and physically.

4. **Work with key stakeholders on a multi-partner campaign about climate action to support public policy* –** Our engagement with our stakeholders shows that the public do not understand EirGrid's and SONI's role in responding to climate change. In addition, most people are unaware of the role of electricity in climate action plans. Given this, there is a need for a widespread, cross-organisation campaign to inform the public about the changes needed in the next decade. We are now collaborating with key stakeholders to align messaging on this topic. This is an essential step to inform the public we engage with on the fundamental and urgent need for new grid infrastructure

*** This is an Ireland only initiative**

5. **Support and encourage the energy sector to work together more effectively** - Given the scale of change required in the next decade, all in the sector need to continue to work collaboratively together. This is particularly necessary to strengthen public engagement. We also need to work more closely with large-scale users of electricity in the industrial and high-tech sectors. The aim in all cases should be to increase collaboration, dialogue and shared insights for mutual support and to achieve common goals.

6. **Strengthen relationships with community organisations** - EirGrid and SONI need to increase our presence and visibility in local communities. We typically only come to the attention of local areas when a route or site for new grid infrastructure is proposed. This is too late to build trust and have an open dialogue. In response, we are rolling out a community information programme on the needs and benefits of the electricity grid. In doing so, EirGrid and SONI are building our understanding of communities that host grid infrastructure. This helps us gain a deeper internal knowledge of their priorities and perspectives. More broadly, we are also developing closer relationships with a range or organisations and groups including farming and business organisations, Public Participation Networks in Ireland, local Councils in Northern Ireland and Sustainable Energy Communities. EirGrid has also commenced rolling out independent community led forums across all major grid development projects.

7. **Renew and develop new alliances with enabling organisations** - EirGrid and SONI on their own cannot deliver the clean grid that the island needs to respond to climate change. We are now identifying and developing new partnerships with organisations that share our challenges and goals. We will review this on an ongoing basis for continuous improvement. This will allow us to reflect new developments in our sector as the pathway to 70% renewables becomes clearer.

Table 31: Engagement - Ireland multi-year plan

Project Name	Description	Parties	Start Date	Finish Date
UN COP26	Host an event in partnership with the Department of Energy, Climate and Communications at COP26. This event will showcase Ireland's Renewable Integration story.	EirGrid, DECC	Q4 2021	Q4 2021
Engage for Better Outcomes for All	Embed Consultation and engagement toolkit within the Framework for Grid Development – "Putting Communities at the Heart of Grid Development."	EirGrid	Q1 2022	2025
Continue the Rollout of Community Forums Across All Projects	To ensure communities remain at the heart of our approach to grid development, we will continue to rollout independent community forums across all major projects. These will be set up as early as possible in the framework for grid development.	EirGrid, NGO partners	Q2 2021	Ongoing
Regional Energy Citizen's Assemblies	Modelled on Ireland's Citizens Assembly but at local level liaising with NGOs and Civil Society.	EirGrid	Q2 2022	Ongoing
Local Authority Roll-Out	Follow up with individual local authorities on future grid needs in their area, including Climate Action Regional Offices (CARO). Engage more proactively with regional assemblies (EMRA, SRA, NWRA).	EirGrid	Q1 2022	Ongoing
Regional Master Planning	Supporting the delivery of grid masterplans at regional level through comprehensive engagement and communications strategies.	EirGrid	Q4 2021	Q4 2022
Partner with AILG on future conference. (Association of Irish Local Government)	Host Future Energy Conference for elected public representatives across Ireland creating a platform for discussion with key stakeholders and policy makers.	EirGrid, Partners	Q4 2022	Q4 2022
Youth Activation / Sponsorship Partnership	Partner with schools / a national youth organisation with regional reach to deliver awareness programmes/initiatives on transitioning Ireland to a cleaner greener energy future.	EirGrid, Other	Q4 2022	Annual

Our Energy Future Project	Partnership with RGI and Friends of the Earth with the objective of the successful implementation of the energy transition through the delivery of 10 partnership modules.	EirGrid, RGI, Friends of the Earth	Q4 2021	Q3 2024
Community Benefit Fund	EirGrid is rolling out its Community Benefit Fund this year as part of new Infrastructural Projects. EirGrid will explore with partners the introduction of a 4th Strand of Funding for micro-generation to support landowners and communities in transitioning to a cleaner greener energy future. This strand is in addition to our existing strands on Community/ Sustainability/Biodiversity.	EirGrid, Partners	Q2 2022	Q4 2024
Deliver Energy Advocates / Champions	Foster energy champions / advocates / leaders / allies emerging from stakeholder engagement activity in 2022.	EirGrid	Q1 2023	Ongoing
Community Energy Collaboration Roadshow / Knowledge Hub	Coordinate and host regional knowledge hub initiatives that support communities with the practical information and tools to commence their community energy journey.	EirGrid, Partners	Q3 2022	Annual
Landowner Engagement	Continue engagement with landowner representative groups. Support landowner workshop series on transitioning to a clean green energy future and roll out a biodiversity support programme.	EirGrid, Landowner Rep Org	Q4 2021 (phased)	Ongoing
EirGrid Sponsored Apprenticeships – Upskilling in Renewable Development	Liaise with Skillnet Ireland, Education and Training Board Ireland (ETBI) and SOLAS to investigate employment opportunities in Renewable Development.	EirGrid, Partners	Q2 2022	Q4 2022
EirGrid Young Energy Citizen Initiative	Provide a platform to amplify the work of young people across a range of competencies, culminating in acknowledging significant contributors to energy innovation or advocacy.	EirGrid, NGOs	Q4 2022	Annual
Energy Tourism Initiative	Collaborate with a local authority on a pilot scheme supporting energy tourism initiatives.	EirGrid	Q1 2022	Q4 2022

6.2.3 Ireland Engagement Strategy

EU Collaboration	Increase collaboration with EU bodies and neighbours on delivery of sector leading engagement activities. Explore the setup of a TSO Engagement working group with EU counterparts. Identify opportunities to influence policy and frameworks.	EirGrid, EU Counterparts	Q1 2022	Ongoing
EirGrid Awareness Raising Campaign	Develop the EirGrid brand to incorporate/lead as a Business to Public (B2C) approach.	EirGrid		Q4 2022
EirGrid Knowledge Hub	As part of the wider redevelopment of the EirGrid website: Develop a knowledge hub for communities to explore topical queries in relation to the grid such as EMF, underground cabling, overhead lines, cost of the grid, how EirGrid is funded, how wind energy works, smart technologies, operations, sustainability and climate etc.	EirGrid	Q4 2022	Ongoing

6.2.4 Northern Ireland Engagement Strategy

Table 32: Engagement - Northern Ireland multi-year plan

Project Name	Description	Parties	Start Date	Finish Date
Engage for Better Outcomes for All	Embed SONI's enhanced 3 part process and Consultation and engagement toolkit within NI project delivery – "Putting Communities at the Heart of Grid Development."	SONI	Q4 2021	Ongoing and subject to annual review
Council Roll out	Engage elected representatives' CEOs, Planning officials – complete a biennial cycle of council engagement on key topics such as SOEF, TDPNI and individual project and how we engage. Including annual workshop with council planners; and regular updates to SOLACE. Supported by colleagues in NIE Networks as appropriate.	SONI, Local Councils, SOLACE Committee and NIE Networks	Q1 2022	Biennial Cycle subject to regular review
SOEF Updates	Support as and when required with cost-effective engagement programme with earned and organic media.	SONI	Q4 2021	Until project end
SONI Knowledge Hub	As part of the wider redevelopment of the SONI website: Develop a knowledge hub for communities to explore topical queries in relation to the grid such as EMF, Underground Cabling, Overhead Lines, Cost of the grid, how SONI is funded, How wind energy works, etc.	SONI	Q4 2022	Ongoing
Support SONI Thought Leadership and Awareness	Support SOEF – via cost effective key influencer engagement, platform opps and earned media	SONI	Q4 2021	Ongoing

6.2.5 Industry Engagement Plan

Table 33: Engagement - Industry multi-year plan

Project Name	Description	Parties	Start Date	Finish Date
Engage for Better Outcomes for All	Establishment of Shaping Our Electricity Future Advisory Council.	TSOs	-	Q1 2022; Every 4 Months
	Industry briefing webinar	TSOs	-	Every 4 Months
	Coordinate regular Shaping Our Electricity Future Industry Forum	TSOs	-	Every 6 Months

6.3 System Operations

6.3.1 Introduction

In order to deliver on government renewable energy policies in Ireland and Northern Ireland, it will be necessary to accommodate unprecedented penetrations of variable non-synchronous RES such as offshore wind, onshore wind, and solar whilst keeping curtailment levels to a minimum.

This will require a significant evolution of the operation of the power system and for EirGrid and SONI to deal with unique challenges that will not be faced in larger more heavily AC interconnected power systems for years to come.

In the following sections, the key messages associated with the transition of system operations are explained along with a detailed approach highlighting how the challenges of the transition will be overcome and the ambition of at least 70% RES-E will be facilitated from a system operations perspective.

6.3.2 High level summary

1. Continued secure operation of the power system is critical. We are currently trialling operation of the power system with System Non-Synchronous Penetration (SNSP) levels of up to 75% and Rate of Change of Frequency (RoCoF) up to 1.0 Hz/s. Satisfactory completion of these trials (expected in Q1 2022) to demonstrate our capability to operate the power system securely at these levels will form the basis of further changes to our operational practices to achieve our 2030 targets.

2. Operating the future power system with fewer conventional synchronous generators will be technically challenging. In order to deliver on government renewable energy policies in Ireland and Northern Ireland, it will be necessary to accommodate large penetrations of variable non-synchronous RES such as offshore wind, onshore wind, and solar, whilst keeping curtailment levels to a minimum. This will require us to be able to operate the power system with SNSP levels of up to 95% and with significantly reduced numbers of conventional units online. However, operating at such SNSP levels is unprecedented and poses several technical challenges, many of which have not been experienced by other synchronous power systems to date.

3. In response to these challenges, we have developed a programme of work which will enable us to enhance our power system operational capability out to 2030. This all-island programme of work will build upon the programme of activity that was carried out, and the extensive knowledge, learnings and experience developed, as part of EirGrid's and SONI's "Delivering a Secure Sustainable Electricity System (DS3)" Programme which was a key enabler in achieving the 2020 RES-E target of at least 40%.

4. System services will play a key role in managing the resilience of the power system. The new system services arrangements introduced in 2016 were key to achieving 40% RES-E by 2020. New system service capabilities from low carbon sources are required to address the technical and operational challenges arising from the need to operate with SNSP levels up to 95% by 2030.

5. Service providers connected to the distribution network and partnerships between the Transmission System Operators (TSOs) and Distribution System Operators (DSOs) are required to help release the full potential of demand-side flexibility. Demand side flexibility will be critical to ensuring we can enable the transition to 70% RES-E and facilitate electrification of the heat and transport sectors while maintaining power system security. A demand side management strategy covering the participation of demand side resources in the energy, capacity and system services markets is required to incentivise the necessary behaviours and flexibility.

6. The current maximum SNSP level facilitated by existing system operations capability is 75%[18]. By 2030, we are planning to be able to operate at SNSP levels up to 95%, to have a reduced Inertia Floor (reduction from the current floor of 23,000 MWs), to have implemented a secure RoCoF limit of 1 Hz/s (an operational trial is currently underway and expected to run until Q1 2022) and to have a significantly reduced Minimum Number of Large Synchronous Units requirement (the current requirement is to keep 8 large conventional synchronous units synchronised across the island). The purpose of evolving these, and other, operational metrics is to facilitate a reduction in the minimum level of conventional synchronous generation (in MW terms) required on the system. In Q2 2022, we intend to publish an "Operational Policy Roadmap to 2030" which will set out our plan for evolving operational policy across a range of these key metrics. This roadmap will be reviewed and updated every two years.

18 A 75% SNSP trial commenced on 22 April and is expected to run until Q1 2022.

7. While there will be a wide-ranging programme of work required to enhance our power system operations capabilities, the following activities will be key to safely and securely increase the instantaneous amount of variable non-synchronous RES that can be accommodated on the power system:

    a. On-going studies and analysis on technical challenges and potential solutions;

    b. Setting and clarifying operational standards, including grid codes and system services protocols, and subsequently monitoring performance against these standards;

    c. Enhancing the system services arrangements to introduce new services and facilitate service provision by new and innovative low carbon technologies;

    d. Removing barriers to entry and enabling the integration of new technologies at scale;

    e. Continued evolution of operational policies e.g. minimum number of large synchronous units;

    f. Developing new and enhanced control centre tools and systems;

    g. Working in collaboration with other TSOs to share learnings and potential solutions; and

    h. Working in partnership with the DSOs to coordinate and deliver for consumers.

8. Network and market developments will also drive changes to how we operate the power system. New HVDC interconnectors, a second North-South tie-line, as well as on-shore and off-shore grid expansion will add to the breadth and complexity of transmission system operations. Evolution of the SEM and developments with neighbouring markets (Great Britain and Europe) will drive changes to our scheduling and dispatch processes. Development of tools and capability to accommodate these changes will be required and are factored into our programme of work.

6.3.3 Overview of operational programme

The System Operations strand of Shaping Our Electricity Future is divided into four main workstreams:

- **Operational Policy:** The objectives of this workstream are to undertake operational studies and analysis and develop operational policies to facilitate the transition to 70% RES-E by 2030;
- **Standards and Services:** The objective of this workstream is to ensure we have the right operational standards and appropriate system services frameworks to support investment in required capability;
- **Operational Tools:** The objective of this workstream is to identify and oversee the delivery of enhanced and new integrated control centre technologies and tools that are required to operate the system securely and efficiently with increasing levels of variable non-synchronous RES; and
- **Technology Enablement:** The objective of this workstream is to facilitate the development and integration of new technologies and innovations on the power system to enable them to operate efficiently and effectively.

Figure 24: System Operations Workstreams

The four workstreams are underpinned by a holistic TSO-DSO partnership.

In the following section, further information on the TSO-DSO partnerships and work programmes in Ireland and Northern Ireland is provided. For each of the four System Operations workstreams, a high-level plan and key objectives are detailed in Section 6.3.4.

TSO-DSO

With so many of the future generators and system service providers expected to be connected to the distribution system, jointly with the DSOs in Ireland and Northern Ireland respectively, we have entered into jurisdictional joint system operator work programmes to ensure that the needs of both distribution and transmission systems, and ultimately the needs of consumers, are met.

In these work programmes, in recognition of the need for co-operation and interaction between system operators, EirGrid with ESB Networks and SONI with NIE Networks have committed to progressing the following:

- Establishing a TSO-DSO operating model, defining the vision, roles and responsibilities, and ways of interaction;
- Developing TSO-DSO interfaces that enable the sharing of data and coordination in decision making; and
- Working together to manage changes on the distribution network and how those changes impact the operation of the transmission network (and vice versa).

The TSOs and DSOs are working together to ensure that, where appropriate, we have complementary work streams and approaches. While there will be separate programmes of work which reflect the differences in the electricity sector arrangements in Ireland and Northern Ireland, we are seeking to ensure alignment in the approaches taken across the two jurisdictions in so far as possible.

In the following sections, the ongoing work between EirGrid and ESB Networks in Ireland and between SONI and NIE Networks in Northern Ireland to establish and deliver joint TSO-DSO work programmes is set out.

SONI-NIE Networks Partnership

SONI and NIE Networks have been working closely together and have developed a TSO-DSO joint programme of work. The current joint scope of work covers the following areas:

- Flexibility Trial,
- Technology Enablement,
- Network Capacity Allocation Platform,
- Nodal Controller,
- Future Arrangements for System Services, and
- TSO-DSO Operating Model

Work is currently underway across these areas and the plan is subject to continuous refinement.

The workstream plans included in Section 6.3.4 include a subset of the SONI-NIE Networks joint projects / initiatives. We envisage that, as these TSO-DSO plans are delivered, there will be opportunities for stakeholder engagement with SONI and NIE Networks on the various initiatives being planned.

EirGrid-ESB Networks Partnership

In early 2021, EirGrid, in its role as TSO, and ESB Networks, in its role as DSO, established a Joint System Operator Programme to ensure that we are working together in a collaborative and effective manner to jointly address electricity system and customer needs, and to deliver whole-of-system solutions.

During 2021, we progressed the 2021 work programme submitted to CRU in January and put in place the necessary programme management and governance structures to develop and deliver the plan.

In October 2021, we launched a consultation on a joint 2022-2026 work plan. The plan reflects areas where the TSO and DSO must work in partnership to enable new technology on the transmission and distribution systems participate in new solutions, apply whole-of-system approaches to resolving system needs, and work collaboratively to reduce dispatch down of renewable generation and enhance security of supply.

The multi-year plan comprises four work streams that are focused on outcomes as defined in the CRU PR5 Incentive framework, as follows:

- Whole-of-System Approaches;
- Facilitating New Technology;
- Reducing Dispatch Down of Renewables; and
- Security of Supply.

The plan will be finalised after taking into account the consultation feedback received from stakeholders. The workstream plans included in Section 6.3.4 include a subset of the EirGrid-ESB Networks joint projects / initiatives.

FlexTech

Through the Shaping Our Electricity Future initiative, EirGrid and SONI are integrating our broader 2030 networks, markets, engagement and system operations plans into a single overarching programme of work with associated governance arrangements. In addition, we have developed and are continuing to refine separate committed programmes of work with ESB Networks in Ireland and with NIE Networks in Northern Ireland.

In that context, we consider that delivery of the strategic priorities identified in the 2020 FlexTech Response to Consultation would be better achieved by integrating the various FlexTech activities into these and other established programmes as set out in Figure 25. For clarity, while we will no longer manage activities under the FlexTech governance arrangements nor use the FlexTech brand, we remain firmly committed to delivering on FlexTech's objective of removing barriers to the integration of new technologies at scale.

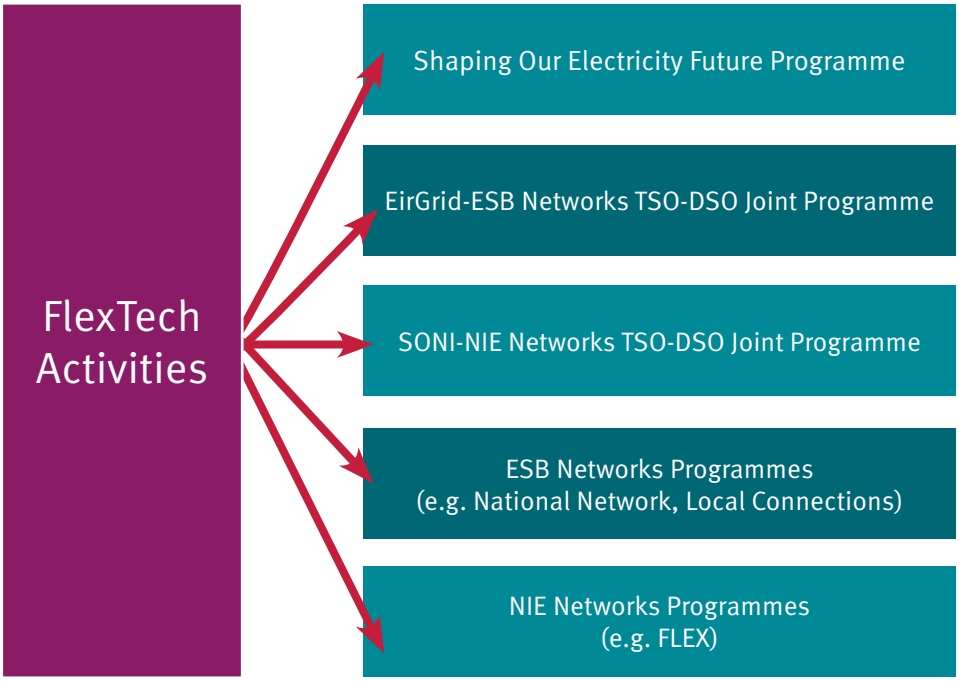


Figure 25: Integration of FlexTech activities into established programmes of work

6.3.4 Multi-year plans

In this section, a high-level plan and key objectives are detailed for each of the four System Operations workstreams. This integrated set of plans covers mandatory activities (e.g. items linked to deeper integration with Europe) as well as initiatives which we consider to be essential if we are to develop the capability to operate the power system with SNSP levels of up to 95% and with significantly reduced numbers of conventional units online.

These initiatives inform the path to achieve the renewable transition and therefore may be updated or revised in the future, for several reasons, such as EU directives, governmental policy in Ireland and Northern Ireland, regulatory decisions (including those related to funding of initiatives), and socio-economic requirements. In the event of notable changes, EirGrid and SONI will refresh the roadmap and communicate the revised initiatives and timelines to relevant stakeholders.

6.3.4.1 Operational policy workstream

The objectives of the Operational Policy workstream are to undertake operational studies and analysis and develop operational policies to facilitate the transition to 70% RES-E by 2030. We will achieve this by:

- Identifying technical scarcities and operational needs – both now and projected for the future.
- Developing operational protocols, policies and procedures for new Interconnectors.
- Completing system studies to facilitate the transition of key operational metrics including, but not limited to, SNSP, inertia and minimum number of sets.
- Revising and developing operational policies to assist in operating the power system with new system services provision capabilities and the new operational systems and tools.

Table 34: System Operations - Operational Policy workstream

Project Name	Description	Parties	Start Date	Finish Date
Close-out of on-going DS3 Programme operational trials	Complete the ongoing 75% SNSP trial and its transition to enduring operational policy	TSOs	Q2 2021	Q1 2022
	Complete the ongoing 1 Hz/s RoCoF trial and its transition to enduring operational policy	TSOs	Q2 2021	Q1 2022
	Complete the ongoing Nodal Controller Trial in Ireland	DSO (ESBN) / TSO	ongoing	Q1 2022
	Complete the ongoing Nodal Controller Trial in Northern Ireland and determine next steps	DSO (NIEN) / TSO	ongoing	Q4 2022
Operational Policy Roadmap to 2030	Develop an "Operational Policy Roadmap to 2030" to set out our plans for evolving operational policy. This roadmap will set out target timelines for: • Increasing SNSP from 75% to 95% in 2030; • Reducing the minimum number of large conventional units from 8 to 4 or less in 2030; • Lowering the inertia floor from 23,000 MWs to 17,500 MWs in 2030.	TSOs	Q4 2021	Q2 2022
	Update the Operational Policy Roadmap to 2030 every two years	TSOs	-	Review every two years

Detailed studies and analysis to support progress towards the 2030 targets	Conduct long-horizon studies and analysis to identify technical challenges and potential mitigations to achieve 2030 targets. The studies completed to date will be reviewed for robustness every two years.	TSOs	-	Review every two years
	Conduct ongoing short-horizon operational studies to ensure a secure power system with increasing levels of renewables as we transition to 2030 Note: A comprehensive suite of studies is undertaken before making any significant operational policy change.	TSOs	-	Ongoing
Reduction of the operational constraints related to the minimum number of large synchronous units and the system inertia floor	Undertake suite of studies to identify the capability to reduce the minimum number of large synchronous units from 8 to 7 and the inertia floor from 23,000 MWs to 20,000 MWs	TSOs	Q3 2021	Q2 2022
	Develop interim operational policy for operation with a minimum of 7 large synchronous units / 20,000 MWs inertia floor	TSOs	Q2 2022	Q2 2022
	Conduct an operational trial of this interim policy of a minimum of 7 large synchronous units / 20,000 MWs inertia floor	TSOs	Q2 2022	Q1 2023
	Implement enduring operational policy for operation with a minimum of 7 large synchronous units / 20,000 MWs inertia floor	TSOs	Q2 2023	Q2 2023
	Transition to system operation with 4 large conventional units or less (the interim steps will be described in the "Operational Policy Roadmap to 2030" as set out earlier in this plan)	TSOs	Q3 2023	2030

Greenlink Operational Procedures	Develop Joint Operating Agreement (JOA) for the Greenlink Interconnector Note: This development is dependent on regulatory agreement and decision (from CRU and Ofgem) on the operating model.	TSOs / GIL / NGESO	2022	2023
	Develop TSO processes and procedures related to operation of the Greenlink Interconnector (subject to the agreed operating model)	TSOs	2022	2024
Transition to 85% SNSP	Complete final studies and checks prior to the increase in the SNSP limit to 85%	TSOs	2024	2025
	Develop operational policy for operation at 85% SNSP	TSOs	2025	2025
	Conduct operational trial with a SNSP limit of 85%	TSOs	2025	2025
New North-South Interconnector	Review and implement operational policy changes related to the new North-South Interconnector	TSOs	2024	2025
Celtic Operational Procedures	Develop Joint Operating Agreement (JOA) for the Celtic Interconnector Note: This development is dependent on regulatory agreement and decision (from CRU and CRE) on the operating model.	TSOs / RTE	2021	2022
	Develop TSO processes and procedures related to the operation of the Celtic Interconnector (subject to the agreed operating model)	TSOs	2023	2026

Probabilistic Operations	Develop operational policy and standards to align with the transition to probabilistic operations	TSOs / TAOs	2022	2027
Transition to 95% SNSP	Complete final studies and checks prior to the increase in the SNSP limit to 95%	TSOs	2029	2030
	Develop operational policy for operation at 95% SNSP	TSOs	2030	2030
	Conduct operational trial with a SNSP limit of 95%	TSOs	2030	2030
SONI-NIEN Partnership Activities	General SONI-NIEN partnership activities as reflected in the joint programme	TSO / DSO (NIEN)	-	-
EirGrid-ESBN Partnership Activities	General EirGrid-ESBN partnership activities as reflected in the joint programme	TSO / DSO (ESBN)	-	-

6.3.4.2 Standards and services workstream

The objective of the Standards and Services workstream is to ensure we have the right operational standards and appropriate system services frameworks to support investment in required capability. This will help ensure we achieve 70% RES-E and 95% SNSP by 2030. We will achieve this by:

- Clarifying the system technical needs, both now and projected for the future;
- Reviewing the Grid Code (and where appropriate, working with the DSOs in relation to the Distribution Code) and bringing forward modifications as appropriate;
- Developing the technical requirements for the new commercial framework for procurement of system services, taking effect from 1 May 2024;
- Publishing the standards that service providers will need to adhere to and monitoring the performance of service providers against these standards on an ongoing basis; and
- Developing a framework for flexible network management that will seek to incentivise the supply and demand sides to provide flexible network services and alleviate network congestion.

Table 35: System Operations - Standards and Services workstream

Project Name	Description	Parties	Start Date	Finish Date
Low Carbon Inertia Services	Share a plan for the identification of requirements and procurement of Low Carbon Inertia Services with stakeholders	TSOs	Q4 2021	Q4 2021
	Undertake studies to identify the technical and locational requirements considering inertia, reactive power and short circuit level	TSOs	Q3 2021	Q1 2022
	Undertake a public consultation on the technical and locational requirements, develop a proposed decision paper and submit it to the Regulatory Authorities for approval	TSOs	Q1 2022	Q2 2022
	Undertake a public consultation on the fixed term contracts, develop a proposed decision paper and submit it to the Regulatory Authorities for approval	TSOs	Q3 2022	Q4 2022
	Undertake a procurement process leading to award of contract(s) Note: Commencing this process is dependent on a decision by the Regulatory Authorities.	TSOs	Q4 2022	Q2 2023
	Review and modify Grid Codes Note: This development is dependent on regulatory approval of Code modifications (by CRU and UR).	TSOs	Q4 2021	Q2 2023

System Services Future Arrangements - Technical Requirements and Volumes Note 1: The plan for the broader detailed design and implementation of the Future Arrangements is set out in the Markets Roadmap. Note 2: The timelines and approach are dependent on a SEMC decision on the high-level market design and governance by Q4 2021	High-level design of system services products for inclusion in the first Future Arrangements auction, including: - Review of the efficacy of the existing system services products - Redesign of the products as required	TSOs	Q1 2022	Q4 2022
	Develop methodology and process for: (i) determining system services auction volumes (day/week ahead, dependent on regulatory design decisions) (ii) forecasting longer-term system services requirements (e.g. year-ahead horizon)	TSOs	Q2 2022	Q4 2023
	Implement: (i) auction volume determination process ahead of first system services auction (ii) forecasting process for longer-term system services requirements (e.g. year-ahead horizon)	TSOs	Q4 2023	Q2 2024
	Ongoing review of efficacy of the system services arrangements and introduction of new services as required (e.g. congestion product)	TSOs	Q2 2024	2030

Grid Code Evolution to Support the 2030 70% RES-E Ambition	In order to ensure timely delivery of Grid Code changes that provide clarity to developers and support the future needs of the power system, we will review our processes for identifying, planning, coordinating and implementing Grid Code changes.	TSOs	Q4 2021	Q1 2022
	Subject to appropriate approvals, use these processes, identify and initiate the first phase of Grid Code changes to be progressed during 2022. This will include working with the DSOs to consider any related Distribution Code changes.	TSOs / DSOs	Q2 2022	Q4 2022
	Ongoing identification and implementation of Grid Code changes as required. This will include working with the DSOs to consider any related Distribution Code changes.	TSOs / DSOs	Q1 2023	2029
Enhanced Performance Monitoring	Establish new performance monitoring arrangements to enable enhanced performance monitoring of Grid Code compliance and system services provision	TSOs	Q4 2022	Q2 2024
SONI-NIEN Partnership Activities	General SONI-NIEN partnership activities as reflected in the joint programme	TSO / DSO (NIEN)	-	-
EirGrid-ESBN Partnership Activities	General EirGrid-ESBN partnership activities as reflected in the joint programme	TSO / DSO (ESBN)	-	-

6.3.4.3 Operational tools workstream

The objective of the Operational Tools workstream is to identify and oversee the delivery of enhanced and new integrated control centre technologies and tools that are required to operate the system securely and efficiently with increasing levels of variable non-synchronous RES. We will achieve this by:

- Identifying the needs for enhanced and new tools driven by factors such as increasing levels of variable non-synchronous RES, increasing demand and new demand categories, new transmission network including flexible devices, new interconnectors, and new scheduling and dispatch processes driven by market and system services changes;
- Developing the IT, data management and physical infrastructure required to support these developments;
- Ensuring that relevant interfaces and data exchanges are in place with the DSOs and other stakeholders; and
- Ensuring appropriate training in the use of tools.

Table 36: System Operations - Operational Tools workstream

Project Name	Description	Parties	Start Date	Finish Date
Implementation / Enhancement of already planned / existing control centre tools	Go-Live of enduring Ramping Margin Tool (RMT)	TSOs	-	Q4 2021
	Go-Live of Voltage Trajectory Tool (VTT)	TSOs	-	Q4 2021[19]
Control Centre of the Future - Operational Tool Development Plan	Develop a delivery plan for the tools and capability we need to operate the power system to 2030. This will include, but is not limited to, tools to: • Interface with the DSOs on visibility, management and forecasting of DER • manage congestion • control new network devices • improve models • enable probabilistic operations This plan will also cover the development of associated IT, data management and physical infrastructure to support the tools. Note: A separate integrated programme of work covering enhanced scheduling and dispatch solutions is included in the Markets roadmap.	TSOs	Q1 2022	Q4 2022
Operation of Devices within the Grid Technology Toolbox	Development of the capability to model and operate new grid technologies (such as Dynamic Line Rating and Power Flow Controllers) which will enhance our capability to maximise the use of existing transmission grid infrastructure. These developments will evolve as the technology arrives.	TSOs	Q4 2022	2029

19 Following identification of some issues and gaps in functionality in Factory Acceptance Testing of the Voltage Trajectory Tool, a period of re-design work is currently taking place. This will be followed by a re-planning exercise that will revise the timeline if required.

HVDC Interconnector Integration	Develop and deliver systems and interfaces for the integration of Greenlink Interconnector into our operational systems. Note: This development is dependent on regulatory agreement and decision (from CRU and Ofgem) on the operating model.	TSOs / GIL, NGESO	2022	2024
	Develop and deliver systems and interfaces for the integration of Celtic Interconnector into our operational systems. Note: This development is dependent on regulatory agreement and decision (from CRU and CRE) on the operating model.	TSOs / RTE	2022	2026
Future Arrangements for System Services	Develop the operational tools necessary to implement the future System Services arrangements Note: Identification of specific tool changes is dependent on a SEMC decision on the high-level system services market design and governance by Q4 2021	TSOs	2022	2024
Enhanced European Integration	Regional Coordination Centre (RCC) Services – identification of operational requirements and development of solutions Note: The wider European integration work is set out in the Markets roadmap.	TSOs	2023	2026

6.3.4.4 Technology enablement workstream

The objective of the Technology Enablement workstream is to facilitate the development and integration of new technologies and innovations on the power system to enable them to operate efficiently and effectively. We will achieve this by:

- Enabling hybrid connections and arrangements with a view to optimising use of existing infrastructure;
- Addressing the challenges associated with the integration of large-scale storage technology;
- Facilitating the provision of system services from new and existing RES as well as small-scale flexible generation;
- Enabling DSM to maximise its potential;
- Engaging with large energy users to investigate the potential for large energy users to contribute to system flexibility; and
- Proactively engaging with industry and academia to review and evaluate emerging technologies which are not covered by the other work streams.

Table 37: System Operations - Technology Enablement workstream

Project Name	Description	Parties	Start Date	Finish Date
Demand Side Strategy	Develop a Demand Side strategy that aims to have industrial (including large energy users), commercial and residential demand fully participating in meeting the needs of the system with high levels of renewable generation.	TSOs	Q3 2021	Q2 2022
Residential Demand Response Trial in Ireland	Plan for and conduct a trial for system services provision from residential demand response (planned pilot being led by the DSO).	TSO / ESBN	Q1 2023	Q4 2024
Hybrids – Framework for Multiple Legal Entities (MLEs) in Ireland	Agree contractual framework approach to accommodate Multiple Legal Entities behind a single connection point[20]. Note: This is dependent on a CRU decision post-submission of a recommendations paper to CRU by EirGrid and ESB Networks.	TSO / ESBN / CRU	Q1 2021	Q1 2022
Hybrids - Review of Over-Install Policy in Ireland	Undertake a review of the Over-Install Policy in Ireland and submit a recommendations paper to CRU setting out any proposed changes.	TSO / ESBN	Q3 2021	Q2 2022
Hybrids - Trading of MEC behind a single connection point in Ireland	Scoping of work package for trading of Maximum Export Capacity (MEC) in Ireland	TSO / ESBN	Q4 2021	Q1 2022
	Technical assessment of options for trading of MEC behind a single connection point	TSO / ESBN	Q2 2022	Q4 2022
Hybrids - Review of Over-Install Policy in Northern Ireland	Undertake a review of the Over-Install Policy in Northern Ireland and submit a recommendations paper to UR setting out any proposed changes	TSO / NIEN	Q3 2021	Q2 2022

20 Offshore projects will require further consideration.

Qualification Trial Process	Conduct annual QTP process to facilitate the integration of new technologies, for example: • Hydrogen-based technology; and • Grid forming technology Note: Current regulatory funding mechanism is in place until Q2 2024.	TSOs	-	Annual
	Review the QTP process and develop a plan for the transition to the System Services Future Arrangements. Note: This is dependent on a SEMC decision on the high-level market design and governance by Q4 2021	TSOs / CRU / UR	Q4 2021	Q4 2022
	Establish new QTP process to align with the launch of the System Services Future Arrangements. Note: This is dependent on a SEMC decision on the high-level market design and governance by Q4 2021	TSOs / CRU / UR	Q1 2023	Q2 2024
Technology Enablement - Code Modifications	Ongoing implementation of code modifications (e.g. Trading and Settlement Code, Capacity Market Code, SEMOpx Code) to facilitate Technology Enablement. Note: The plan for evolution of the Grid Codes is set out in the Standards and Services workstream of this System Operations plan.	TSOs	-	2029
Energy Storage Power Station (ESPS) – Evolution of Arrangements	Evolution of arrangements for integration of Energy Storage Power Stations (ESPS) (e.g. codes and operating protocols) Note: Systems and tools changes for ESPS are covered in the Markets roadmap	TSOs	Q4 2021	Q2 2023
Low Carbon Inertia Services – Development of Arrangements	Development of arrangements for integration of Low Carbon Inertia Services (e.g. codes and operating protocols) Note: System and tools changes for Low Carbon Inertia devices are covered in the Markets roadmap. Procurement of services from Low Carbon Inertia devices is covered in the Standards and Services workstream of this System Operations plan.	TSOs	Q4 2021	Q2 2023

Protection Settings for Our Largest Customers	Formalise arrangements for coordination of the protection settings of our largest customers to ensure that system security is maintained. This will involve engagement with our customers. Note: In Northern Ireland, we will coordinate with NIE Networks for distribution-connected customers, where applicable, in the future. Note: In Ireland, we will co-ordinate with ESB Networks for distribution-connected customers. For further information on our plans in Ireland, please see the Joint System Operator Programme plan.	TSOs / DSOs	Q4 2021	Q4 2022
Understanding DER Behaviour	Develop greater understanding of the performance of Distributed Energy Resources (DER) during system events (voltage and/or frequency deviations) to ensure that system security and safety is maintained as the power system diversifies and decentralises. Note: This initiative will involve co-ordination between the TSOs and DSOs. Note: For further information on our plans in Ireland, please see the Joint System Operator Programme plan.	TSOs / DSOs	Q1 2023	Q4 2023

New Innovation and Research strategy	EirGrid Group recognises that we need to improve our innovation maturity to not only deliver on our ambitions to achieve the 70% RES-E targets by 2030, but to ensure that we can achieve net zero carbon by 2050. To facilitate this ambition, we kicked off the development of a new Innovation and Research strategy in early 2021. The process we are undergoing is to look at our current state, where we want to get to and finally what we need to do to get there. We are currently still working through this strategy and implementation plan. We will be publishing this in Q1 2022 to get feedback from our stakeholders. The Innovation and Research strategy covers the full scope of EirGrid Group's roles and responsibilities. It is included in this Technology Enablement workstream as the delivery of this strategy will be key to enabling the integration of new technologies.	TSOs	Q2 2021	Q1 2022
SONI-NIEN Partnership Activities	General SONI-NIEN partnership activities as reflected in the joint programme.	TSO (SONI) / DSO (NIEN)	-	-
EirGrid-ESBN Partnership Activities	General EirGrid-ESBN partnership activities as reflected in the joint programme	TSO / DSO (ESBN)	-	-

6.4 Electricity Markets

6.4.1 Scope

The Single Electricity Market (SEM) will play an integral role in providing the necessary incentives for third-party investment and the financial support needed for renewable assets. This is key for the procurement of necessary energy and system services needed to operate the power system at 70% Electricity from Renewable Energy Sources (RES-E). Achieving this goal will require industry stakeholder commitment and extensive engagement with governments, Regulatory Authorities, market participants, consumers, and other interested parties to agree, develop and approve the market rules, process and market system changes needed to achieve the Renewable Ambition by 2030.

The current market design already enables a high level of generation on an annual basis from renewables as illustrated below:

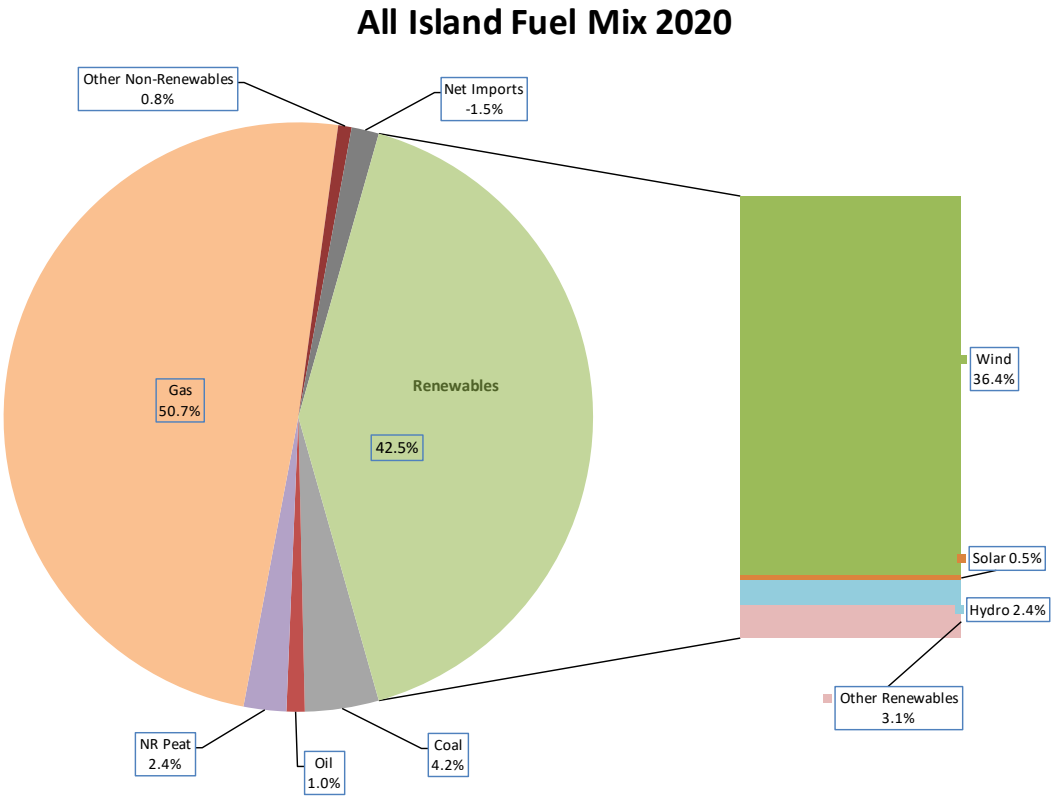


Figure 26: All island fuel mix 2020

During 2020, an All-Island RES-E of 42% - the percentage of electricity demand supplied by renewables, was achieved for the year, with 36% supplied from wind generation. Over the course of a year, output from renewable resources can vary between periods of low and high supply. For example, wind generation provided a maximum output of 4,472 MW in February 2021. These levels of renewable supply have been made possible by the implementation of innovative operating policies and the DS3 System services market over the past decade.

To achieve the higher levels of renewable supply mandated in the Renewable Ambition, will require additional system and adequacy services to be available to ensure we can meet demand requirements securely with close to 95% non-synchronous generation. There is a growing need to ensure that sufficient generation adequacy is available to meet consumer demand during periods of low renewable generations supply. This will require incentives that promote the right third-party investment in new generation, demand side and system support assets to achieve a resilient power system at 70% RES-E and allow the reliable and secure operation of the power grid.

The market reviews conducted by EirGrid and SONI as part of the DS3 and Shaping Our Electricity Future programmes, identified that over the next decade there will be between €40 to €50 billion invested by third parties in the necessary generation, demand and system services assets. The alignment between the energy, capacity, system services markets, and related investment drivers with operational requirements is essential. Failure to do so may increase the risk of inefficient investment resulting in higher than necessary costs to the consumer and the risk of falling short of the Renewable Ambition.

The timelines outlined in the programme below are driven by the need for timely and appropriate investment decisions to meet the Renewable Ambition, a range of obligations arising out of European legislation, combined with specific directions from Regulator Authorities. The obligations for non-priority dispatch of renewable (Article 12) and compensation of dispatch down of renewable resources (Article 13) are required under current European regulations and have an effective date of 1st January 2020. Failure to comply with these regulations may undermine the investment decisions for new renewable plant. This increases the risk of material impact to successful RESS1 capacity auction participants in 2023 when they commence connecting to the power system.

On Future Arrangements, there is a growing need to drive new investment to meet the technical challenges of managing real time operations of over 95% SNSP by 2030. The suggested introduction of a new system services market design will need a number of years to mature to deliver the necessary investment in the required services. From prior experience, it can take up to 4 years for market participant confidence and knowledge to reach a level where a new market can deliver real investment results.

The plan we have proposed has significant project implementation risks. These potential risks include the need for timely and appropriate regulatory decisions, both market design and programme resourcing, as well as a complimentary application of resources by EirGrid and SONI in delivering to these challenging timelines. This can only be achieved with a coordinated and focused industry working together to successfully achieve the Renewable Ambition.

Based on the Shaping Our Electricity Future detailed technical market review and the industry and public consultations, EirGrid and SONI recommend many of the key market initiatives needed to evolve the current design to achieve the Renewable Ambition. These key initiatives can be categorised under the following high-level groupings each of which could result in significant changes to the existing electricity market design, processes, and systems. It is acknowledged that EU legislation determines the overall structure of much of the current and future market design, and that Regulatory Authorities and the SEM Committee have an oversight and legal role in the development of any new SEM rules and processes. The initiatives in this Roadmap inform the transition to achieve the Renewable transition and therefore may be updated or revised in the future, for several reasons, such as EU directives, Government policy, regulatory decisions, and socio-economic requirements. In the event of notable changes, EirGrid and SONI will refresh the roadmap and communicate the revised initiatives and timelines to relevant stakeholders. Specifically, the suggested key changes that might inform the evolution of the market design to support the Renewable Ambition are grouped under two pillars:

1. **Aligning markets to the operational challenges of high RES-E –** evolving the design of the energy, and system services markets to provide aligned incentives for third-party investment in resources that will provide the necessary energy and system services to meet dynamic demand requirements and physically operate the power system at 70% RES-E. This also includes wider aspects that influence third party investment such as RESS design, network tariff design and Transmission loss adjustment factors.

2. **Full trading arrangements between SEM in the Great Britain and EU markets** – evolving the market structures to best utilise interconnection - to improve the economic outcomes for SEM consumers and to facilitate the export and import of large volumes of renewable energy efficiently and effectively. While there are working practices today between SEM and Great Britain they have been impacted by BREXIT. In addition, prior to BREXIT the SEM market was not coupled with Europe in the Intraday or Balancing timeframes. These are central components of the European market design and if not addressed could materially undermine the efficacy interconnection between SEM and EU. There are two main workstreams in this pillar:

   Full trading arrangements between SEM and Great Britain market – with the withdrawal of the UK from the EU on Jan 1, 2021, EirGrid and SONI no longer has a Day-ahead market with GB and the broader EU markets. The intraday trading facilities between SEM and GB are still in effect.

   The Trade and Cooperation Agreement between the EU and UK provides that any new arrangements for trading and capacity calculation between SEM and GB must be approved by the new UK/EU Specialised Committee of Energy. It is expected that new trading arrangements will be developed through this approval process for all trading periods between SEM and GB.

   Full SEM integration into EU market – The integration of the SEM into EU electricity markets to allow the cross-border trading of energy and services will be required when the SEM has a direct physical interconnector with the continental European systems. To achieve full integration is a significant programme of work that will encompass integration into the EU platforms for intraday and balancing timeframes. It may also require strong consideration within the SEM of the appropriateness of central dispatch and ex-post imbalance price setting philosophies. The proposed changes in market design, market operating procedures, market management systems and settlement are complex and will require detailed industry engagement and leading-edge innovative solutions

Under these two pillars the Roadmap proposes a pathway of markets initiatives, key decision points, milestones, and implementation timeline to inform how to achieve the Renewable Ambition in an affordable, effective, and timely manner. This multi-year plan is a starting point for discussion with our industry colleagues to debate the needs and challenges in achieving the Renewable Ambition and come to the appropriate design decisions in a timely coordinated fashion.

As highlighted above, these suggested market design changes are informative only - market design and rules changes are subject to approval by the Regulatory Authorities. EirGrid and SONI will collaborate with the relevant Regulatory Authorities, SEM Committee (SEM-C) and ACER on the detailed evaluation, design, and planned implementation of these proposed changes, as much of the market design is set by EU Legislation, SEM rules and post Brexit UK /EU developing market arrangements.

The markets approach to The Roadmap has 2 pillars with related workstreams

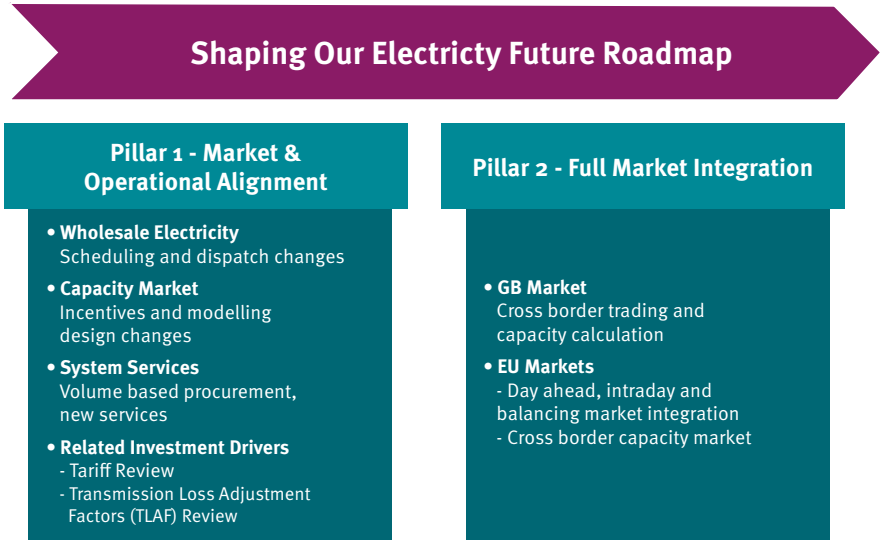


Figure 27: Markets approach

6.4.2 Pillar 1: Aligning markets and operational challenges in high-RES world

The complexity and challenges of operating the power systems at high levels of RES-E are considerable. These challenges are two part; replacing the technical capabilities that conventional plant inherently provide that are displaced by renewable resources. These capabilities now need to come from other technologies such as, renewable energy resources, demand side resources and new support technologies. The second part are new and emerging technical and operational scarcities as the power system transitions to operating with very high levels of RES-E. These areas can be summarised as

- With the expectation of fewer conventional units running in the future, there is a growing need to replace the systems services that these resources provide such as inertia, electromagnetism, reserves, and reactive power, from other technologies

- High levels of renewable supply make the power system more susceptible to weather conditions. This risk of weather dependency can impact real time RES-E of forecast accuracy result in temporal scarcity related to large weather fronts as well as low renewable periods when resource adequacy is a significant issue.

In the absence of the energy market actively recognizing the challenges of high levels of renewables for operations, the financial schedule that is an output of electricity market trades will diverge from how the system will actually operate in real time. There is an increased risk of inefficient market outcomes where there is a significant divergence between the physical operating schedules and financial market schedules. These inefficiencies can impact short term costs and skew long-term investment.

The impact of this divergence is compounded as the energy schedule is currently used as a baseline and reference for other markets including capacity, system services markets, renewable supports, and compensation for non-market redispatch. Current analysis on these impacts has estimated that additional costs to consumers could be as high as €2.5 billion if not addressed appropriately.

Energy markets have traditionally been designed based on a portfolio of conventional synchronous generation plant. While the SEM has already integrated a large volume renewable energy resources, to achieve the Renewable Ambition will require additional investment in renewables. Consequently, the SEM will need to operate effectively at high levels of RES-E in real time as well as cover the periods when there is low RES-E. The proposed growth in renewable generation from our existing high levels suggested in the Roadmap highlights the requirement for a much more flexible power system, increases the need for system services that cover those previously supplied by conventional connected plant, for example inertia, and those now emerging as the power system is being driven by a weather dependent portfolio.

Aligning these requirements will necessitate work across the main market segments including energy, capacity, renewable supports, and system services. In addition, there are alignment challenges in other related investment drivers including network tariffs, Transmission TLAFs , renewable energy resource support mechanisms in how they need to support good long-term market discipline and how oversupply should be treated.

Wholesale electricity markets

Electricity wholesale market - Alignment and implementation (Oct 2021 – June 2023)

Energy market

Currently, the day-ahead market delivers a market schedule that does not account for an on-island network or the operational constraints, which drives re-dispatch actions. As the power system becomes more decentralised, the markets and market systems will be required to deliver more realistic operational schedules and ensure that market participants are incentivised to actively contribute to the flexibility requirements of the power system.

A key consideration of this paradigm is the removal of priority dispatch status from new renewables from 1st Jan 2020. This EU mandated ruling requires that new windfarms and solar arrays are dispatched to a distinct individual position rather than an aggregated position. This allows new renewable resources to respond to market prices, deciding, for example, not to run if there is a low or negative energy price. Currently, priority dispatch plant is dispatched to maximise their output subject to system security irrespective of the price and generally receive make-whole payments through the current support mechanism. New renewable resources connecting to the power system will not do so.

The ruling for distinct dispatch of new renewable resources requires the ability to schedule them for reserves and systems services within the operational and market systems. In addition, there will be a need to remove some windfarms from the aggregated process that we use for all priority dispatch plant today as units come out of support and take full market risk. This goes to changes at the core of the market and operational systems today and will also need consideration for other new technology such as battery storage.

The workstream will need to include these functional areas

- **Dispatch and logging and real-time control:** Processes and systems for issuance of dispatch instructions including service provision will require the ability to allow for non-priority dispatch renewable resources and batteries to be given a distinct MW and service dispatch base point. This would require changes to existing power system and market management systems such as Electronic Dispatch Instruction Logger (EDIL), the Marker Management System (MMS), the Electricity Management System (EMS) and the existing wind dispatch tool.

- **Security constrained unit commitment - operating schedule:** there may be changes to the to the calculations for generation unit set points and scheduling of reserves. All new renewable generation units will now be schedulable and dispatchable for services including reserves – not included in priority dispatch.

- **Bid/Offer management:** changes may be required for the bidding management processes and systems, including submissions of commercial and technical offer data.

- **Settlement and billing**: changes to market rules to accommodate the dispatch and compensation for curtailment of new units may need to be reflected in the settlement formulae, processes, and systems for the market

The suggested changes would need to be considered through an open and transparent process with industry with approval and oversight by the Regulatory Authorities.

System services

EirGrid and SONI have previously demonstrated the fundamental need to enhance the System Services market to drive investment to solve a range of technical challenges arising out of the need to regularly operate the power system at higher levels of RES-E in real time. Our analysis of the challenges to operate up to 70% RES-E in real time shows that additional investment is required, and the operational challenges are more advanced than today where there is a real time operational limit of three quarters of the generation within the SEM coming from RES-E.

The existing system services arrangements are designed to meet the 2020 renewable targets of 40% RES-E and will not be sufficient to deliver the needed capability to achieve the Renewable Ambition for 2030. Attracting investment and procuring sufficient volumes of system services capability from both existing service providers and new prospective providers, will be critical to meeting the Renewable Ambition. In addition, the procurement of system services will be subject to Regulatory Authority approval and needs to be compatible with EU regulations.

The design and implementation of a new market is complex, and it takes time for the rules to developed, agreed, and approved. Investors need time to understand how to operate and manage risk in the new construct. In our experience this process can take four years from inception to delivery of new investment. It will therefore be imperative to have an agreed design for future procurement arrangements delivered by the EirGrid and SONI and Regulatory Authorities as soon as possible to meet the Renewable Ambition by 2030. Such a design will need to specify the core functional requirements for future system services procurement and be flexible to allow the integration of services when required.

The Regulatory Authorities' programme of work on System Services is divided into three main parts:

Part 1: Develop and implement a system services daily auction platform – develop the central daily auction platform with supporting financial and operational systems, contracts, and processes to procure needed services linked to the Day ahead energy market schedule. These services should be augmented these with long-term procurement for products not in the daily auction. This project will re-design the System Services Framework to meet the Renewable ambition. Subject to Regulatory Authority approval, the design will potentially include system services auctions or other competitive procurement processes, depending on suitability. The framework may include the following considerations:

- **Procurement -** the procurement process redesign from the current mode of price regulation to one of volume regulation in which services are procured on a competitive basis. The earlier that clarity can be provided to industry on which services are suitable for daily auction and which are not, the lower the risk for investors.
- **Volume –** the required system services volume requirements will change as the generation mix evolves. EirGrid and SONI will forecast volume needs over different planning timeframes for example years, months, and weeks
- **Type -** the type of system services required will evolve with changing system needs. Possible new services are those that address issues such as congestion and oscillation.
- **Distribution system -** close co-ordination with the Distribution system operator will be necessary to facilitate the participation of distribution connected energy resources in system services
- **EU integration** - the arrangements should be designed with a view to meeting all the EU regulations with respect to services

Part 2: Fixed term contract for zero carbon inertia – the objective of this this project is to procure inertia system services from resources that are suitable for a low carbon power system.

Part 3: Expanding the system services daily auction platform –the purpose of this initiative should evolve the daily procurement (for example through a daily auction) to expand on required reserves, ramping capability, and procure the reactive power reserves and synchronous Inertia response, needed to manage a power system operating with high penetrations of variable renewable generation.

Capacity markets and renewable supports

Purpose of capacity markets and renewable supports - electricity markets need to maintain a minimum level of generating capacity to ensure the reliability and security of the of the power system. Traditionally the energy market was the main driver of generator investment if a unit did not run that often in the energy market it may not be able to earn sufficient revenue to cover both its operational and capital expenses. Within current operational processes and with the increase of renewables sometimes a number of conventional plants are required to be available during low renewable periods but without a guarantee of earning sufficient revenues in the energy market alone. To this end this required generation to meet our overall demand needs was awarded capacity contracts dimensioned on a probabilistic assessment of what additional generation was required to maintain a desired loss of load expectation. This capacity support mechanism defacto provided the “missing money” to make them financially complete. This support structure is allowed by the EU and must meet strict criteria and gain approval from the EU Commission under State Aid regulations.

Renewable supports are somewhat similar. In recent years the public policy of higher renewable penetration has led governments to support renewable technologies to meet long-term policy objectives. This support is necessary because the energy market on its own cannot not deliver the required investment in renewable resources. The renewable supports are designed to pay these technologies the difference between their market returns and sufficient investment rate of return - “missing money”, to secure the investment. At low levels of renewable penetration, these supports have a small impact energy market outcome. At the levels of renewable penetration in the SEM today and planned as per f the Renewable Ambition, the potential impact of on market outcomes could be considerable.

It should be noted that electricity capacity markets require both Regulatory Authority and European State Aid approval. The current State Aid approval extends to the end of 2027. Beyond 2027 there may be an opportunity for the Regulatory Authorities to reassess and redesign the capacity market construct, if needed, to better fit the changing generation mix on the power system.

Suggested existing capacity market changes - the current capacity market design has worked well to deliver the traditional adequacy requirements needs of the power system. The current design focuses largely on incentives to retain or retire existing plant and incentivise the construction of new generation resources in an efficient and coordinated fashion to meet demand growth. There is a need to evolve the current capacity market design to better deliver against the Renewable Ambition and operate the power system with up to 70% RES-E by 2030. This transition will be complex and will require simultaneously reducing the utilisation of high emitting generation resources such as fossil fuel generation and attracting investment and construction of renewable generation and new efficient technologies while maintaining a reliable supply of electricity for consumers. An orderly sequencing of retirements and new generation connections would be critical to maintaining a reliable a secure supply.

Enhancements to the current capacity market design are proposed to increase investment in adequacy resources that can better manage the more complex nature of long-term supply adequacy given the planned change in generation mix.

The suggested enhancements could be implemented in two phases

- **Phase 1 - 2022-2026** – implementing capacity market design changes to improve incentives for existing Capacity providers consistent with the Renewable Ambition. These changes could include:

    - **Improved market modelling** – enhance the current market models to assess the adequacy contribution of renewable resources. The specific characteristics that the enhanced market model should include are, for example intermittent energy sources and energy or run hour limited resources.

    - **Appropriate capacity -** ensure that adequacy procured through the capacity market is appropriate to address the technical needs of the power system in relation to system security and reliability.

    - **Strengthening performance incentives** – improving the alignment of capacity payments with the actual delivery of energy and performance of resources from all providers when dispatched.

- **Phase 2 - Beyond 2027 (implementation timeline - 2022-2027) –** electricity capacity markets require both Regulatory Authority and European State Aid approval. The current State Aid approval extends to the end of 2027. Beyond 2027 there is a need to reflect the changed circumstances of the power system. By 2027 we will be well on the way to 70% RES-E. This means that the challenges of real time operation at high RES-E levels will have to be addressed. While the responsibility of a new capacity mechanism design and application for state aid approval rests with the relevant Government departments and the Regulatory Authorities and SEM Committee we outline below our understanding of the work that would enhance the capacity market design:

    - Assess resource adequacy in line with the required EU regulations and our evolving power system

    - If a resource adequacy gap is identified progress an application for a new European Capacity Market State Aid approval. This would include

        - A robust cost benefit assessment and justification based on its contribution to the Renewable Ambition and benefits to consumers

        - ensuring that the new capacity arrangements remain appropriately technology neutral but recognising that "missing money" support can be targeted to distinct technologies through state aid

        - new capacity is addressing a proven technical scarcity to meet demand through sustained (days) periods of low renewable output

- payment is for measurable physical attributes to provide adequacy which is a function of real time availability, dispatchability and forecasting of future services provision from day ahead to multi year ahead; and

- payment is zero at the marginal point at which the scarcity is fully addressed by the volume of the service provided.

The scope and details if these changes to be led by the Regulatory Authorities in consultation with market participants and relevant stakeholders.

Related investment drivers

Renewable support schemes

Renewables support schemes are expected to continue to support the necessary investment in renewable generation needed to achieve the Renewable Ambition. The current renewable support scheme for Ireland is the Irish Government RESS scheme, which is the direct responsibility of the Department of Environment, Climate and Communications (DECC). With the advent of the NI Energy strategy, we await confirmation of whether a renewables support scheme is to be established to accompany a renewable target in Northern Ireland. The introduction of a renewable support scheme in Northern Ireland is a key enabler to achieving the Renewable Ambition.

It is suggested, based on trends in industry and regulatory practices, that modifications could be made to the present renewable support scheme to achieve the Renewable Ambition in a more cost-effective manner. Any such enhancements would be subject to DECC approval. Renewable support schemes in other jurisdictions have traditional placed emphasis on bolstering energy revenues to generators. With the forecasted change in generation mix, energy revenues paid to generators is set to diminish as the penetration of zero marginal cost renewable generation increases. In addition, the importance of non-energy services, such as capacity and system services is increasing to support power system operations. It is suggested that the structure of renewable support schemes may need to adapt to recognise the growing importance of capacity and system service revenue streams and provide the investment incentives to encourage the appropriate renewable generation investments.

Treatment of oversupply

The European Clean Energy Package has mandated the compensation of renewable generation resources for curtailment in non-market redispatch arrangements. This market requirement could increase the risk of inefficient market outcomes by providing incentives to invest in generation resources, that can earn support payments but fail to effectively contribute to meeting consumer demand. In addition, there is a potential risk of increasing electricity costs due to payment for oversupply. At times when there is a surplus renewable generation – more generation than the market needs to meet consumer demand, including exports, this oversupply cannot be not utilised. EU Clean Energy Package recognises that the generation owners need to make sufficient revenues to remain economically viable and therefore oversupply, should be compensated. The question of how, and who pays for oversupply should be considered in terms of ensuring appropriate investment signals to renewable generators and the potential impact on affordability of electricity in the transition to a low carbon future.

Demand Transmission Use of System (DTUoS) tariffs

The magnitude of change that is expected in the electricity industry in the coming years is unprecedented. It is recommended that the current framework of Transmission Use of System tariffs, introduced in the year 2000, should be reassessed and modified where necessary as we move towards a more dynamic and decentralised electricity power system. There is a growing need to consider the appropriate tariffs for demand customers on a power system operating with over 90% of instantaneous generation coming from variable renewable sources and reviewing the overarching tariff principles.

Future tariffs may need to consider power system operational issues such as congestion, curtailment and the changing nature of system costs such as non-market based redispatch costs. In addition, the basis for calculating demand tariffs such as energy consumed, connection location, connection capacity may need to be reviewed to ensure the allocation cost allocation method is equitable. An area of particular importance because of its potential to provide additional renewable resources is residential demand side participation. With increased digitalisation, data accessibility and other tools the options for tariffs and tariff structures is much greater than it was historically. There is an opportunity to utilise demand tariff structures to send signals to system users to influence their electricity consumption behaviours and the choices they make in the context of the electricity system transition.

EirGrid and SONI are engaged with the relevant Regulatory Authorities in relation to their specific review of DTUoS tariffs and have committed to providing qualitative analysis and modelling to support this important initiative.

Generation Transmission Use of System (GTUoS) and Transmission Loss Adjustment Factors (TLAFs)

GTUoS relates to the charges by transmission infrastructure owners to electricity generators for the transportation of bulk power across the transmission system. Due to electrical resistance, when electrical current travels on the transmission system, some energy is dissipated in the form of heat and is deemed to be lost. TLAFs allocate these losses to generators based on factors such as their point of connection on the transmission system and the distance generation plant from consumer load.

GTUoS and TLAFs have the potential to send signals to generators on where best to locate on the power system. This attribute could promote a more efficient use of the current transmission system and support the Renewable Ambition. The current GTUoS and TLAFs methodologies assume that additional transmission infrastructure can be built to accommodate new generation resources and alleviate transmission constraints. This underlying assumption is being challenged as it becomes less socially acceptable to construct large infrastructure assets above ground. The transition to lower emissions, and the expected engineering challenges of increased congestion and constraints on the power system ad demand increases, suggests that the methodology and required outcomes from the application of GTUoS and TLAFs may need to be reassessed.

In combination with the broader tariff review that EirGrid and SONI is suggesting under this programme, any changes should be considered in relation to their impact across all system charges. For example, the costs attributed to generation and demand is currently based on a 25%:75% split. Consequently, any changes proposed under the DTUoS mechanism would need to keep in mind the interactions with proposed changes to locational signals within GTUoS. As well as considering the demand: generation split for recovering TUoS, the postage stamp versus locational split of 70%:30% in GTUoS should also be reviewed. How total losses on the transmission systems in Ireland and Northern Ireland are calculated may warrant review.

Pillar 1: Multi-year plan

Electricity markets and power system operational alignment

Table 38: Markets - Pillar 1 multi-year plan

Project Name	Recommendation	Date
Electricity wholesale market **Alignment and Implementation** **Scheduling and Dispatch** **Alignment of the energy market with high penetration of renewable generators - leading to scheduling and dispatch changes to ensure all market technologies and participants have equal access and opportunities**	Regulatory Authority approval of principles and concept – This allows the commencement of a programme of work including industry consultation, detailed design, implementation planning - including resourcing and timeline	2021 - 2026
	High Level Design Decisions in respect to the treatment of non-priority dispatch renewable generators (Article 12)	
	Workshop concepts and issues for scheduling and dispatch tool changes with industry relating to Article 12 and other consulted and agreed changes	
	Develop Detailed Design and Programme Plan on dispatch and scheduling changes to include: • Treatment of new non-priority dispatch renewable generation • Wind dispatch tool enhancements • Energy Storage Power Station (ESPS) capability • Low carbon inertia services capability • Fast frequency response capability • Reserve services capability dispatch and scheduling from new providers	
	Solution architecture and detailed design to inform required vendors selection for scheduling and dispatch changes	
	Regulatory Authority approval for Detailed Design implementation including resourcing and timeline following consultation	
	Implementation and go live of detailed design system changes.	
	High level design decision on Compensation for redispatch down of renewables (Article 13) and other settlement impacts	
	Develop a detailed design for on Compensation for redispatch down of renewables (Article 13) in dispatch and settlement systems following consultation and workshops with industry.	
	Regulatory Authority approval for Detailed Design and implementation plan including resourcing and timeline following consultation	
	Solution Architecting the detailed design to inform required vendors selection - Compensation for redispatch down of renewables (Article 13)	

	Implementation and go live of detailed design system changes.	
Capacity Market alignment with a high-RES world and system requirements	Regulatory Authority approval of principles and concept – This allows the commencement of a programme of work including industry consultation, detailed design, implementation planning - including resourcing and timeline	2021 - 2026
	High Level Design of Capacity Market Modelling changes and associated changes to the capacity market including strengthening incentives for physical performance	
	Implement changes with benchmarked performance on new modelling approaches against previous and future scenarios - following consultation with industry	
Re-integration Design and Resource adequacy considerations post 2027 **In the context of the expiry of the existing State Aid approved capacity mechanism in 2027 any new resource adequacy support will have to be developed along the following milestones**	Regulatory Authority approval of principles and concept – This allows the commencement of a programme of work including industry consultation, detailed design, implementation planning - including resourcing and timeline	2021 - 2026

	Assess resource adequacy for post 2027 in line with the required EU regulations and our evolving power system and if a resource adequacy gap is identified progress an application for a new European Capacity Market State Aid approval. This would include • A robust cost benefit assessment and justification based on its contribution to the Renewable Ambition and benefits to consumers • ensuring that the new capacity arrangements remain appropriately technology neutral but recognising that "missing money" support can be targeted to distinct technologies through state aid • new capacity is addressing a proven technical scarcity to meet demand through sustained (days) periods of low renewable output • payment is for measurable physical attributes to provide adequacy, which is a function of real time availability, dispatchability and forecasting of future services provision from day ahead to multi year ahead • payment is zero at the marginal point at which the scarcity is fully addressed by the volume of the service provided. Cross border participation in capacity mechanisms with neighbouring Member States is facilitated	
Future Arrangements **Phase 1 New Daily Auction**	High Level Design Decision for Future Arrangements following consultation and workshops with industry	2022 - 2024
	Detailed Design development: Auction design and design of procurement mechanisms for non-auctioned services	
	Regulatory Authority approval for implementation and enduring operation including resourcing and timeline following consultation	
	Development of an overarching commercial and legal framework to drive necessary 3rd party investment to meet challenges of high RES-E including as required Future Arrangements Codes, Industry Governance arrangements.	
	Market Trial of Future Arrangements daily auction.	
	Go-live of Future Arrangements	
Future Arrangements **Phase 1: Transition from DS3 System Services to Future Arrangements**	Review of existing services' suitability for mitigating scarcities in extended period.	2022 - 2024

	Consultation with Regulatory Authorities and Industry Stakeholders on detail of future procurement arrangements	
	Introduction of Fixed Term layered procurement approach for products not immediately suitable for the Daily Auction.	
	Develop a migration approach from DS3 SS to FA for all products including valuation of this and proposed mechanism to access this value.	
	Termination of existing agreements and establishment of System Services Review Panel	
Future Arrangements **Phase 2: Fixed Term Contracts for zero carbon**	Plan provided as part of the Operations Multi-year plan	2022 - 2025
Future Arrangements **Phase 3: Development of new services and longer-term risk management of Future Arrangements**	The design and procurement of additional system services and addition of locational weighting, where appropriate and longer-term risk management. It will be predicated on whether the Daily Auction consists of all or a subset of needed products. Includes the development of new system service products to address the challenges of the future systems for 2030. These may include Congestion, Frequency Regulation, Oscillations and long-term ramping. For those products inside the daily auction there will be a need to determine longer term contracts for differences and locational scalars to incentivise good behaviour. For those outside the daily auction competitive tenders will need to be developed. In all cases funding will need to be identified to procure these services.	2024 - 2027
CRU Demand Transmission Use of System review	Provide input to CRU on their approach to DTUoS review and feedback to their subsequent Call for Evidence paper Carryout qualitative analysis to identify leading tariff options to model. These tariffs need to be focused on the challenges of the renewable, digital world we will be in when they come into operation. Support qualitative analysis and build overarching tariff model	2022 - 2025
	Implement settlement system changes to accommodate the new DTUoS tariff design policy	
Transmission Loss Adjustment Factors (TLAF) review	Review of the existing TLAF methodology and calculations used by the Transmission System Operators to ensure appropriate design is in place to deliver the 2030 renewable ambition	2026

6.4.3 Pillar 2: Full Integration of the SEM into GB and EU markets

SEM-GB - Brexit has decoupled the SEM and GB markets from the European day-ahead market and capacity calculation process and as a result, there is no longer any day-ahead trading on the SEM-GB border. The pre-existing (interim) intraday arrangements between SEM-GB are still active, which enables trading across the two interconnectors in this time frame.

Under the Trade and Cooperation Agreement (TCA) between the GB and EU, new arrangements will be required for day-ahead capacity allocation and capacity calculation. The proposed capacity allocation process that is being examined at present is based on multi region loose volume coupling (MRLVC) for the day-ahead time frame with an associated capacity calculation process. This work is being progressed in a co-ordinated approach between the GB TSOs, EU TSOs and ENTSO-E. Guidance on the final technical procedures will be agreed upon by the GB/EU Specialised Committee on Energy (SCE). The initial high-level timeline for implementation of the day-ahead arrangements is April 2022; however, this may be subject to amendment based on more detailed assessments by the relevant parties.

Work on the technical procedures for other timeframes (intraday, forwards or balancing markets) will be undertaken in the medium term as required.

Arising out of BREXIT the SEM has been effectively locked out of the pan EU coupled day-ahead markets for now and progress for full participation of the SEM in the EU single intraday coupled markets (SIDC), and the Balancing Platforms (TERRE and MARI) has been suspended given our isolated status from EU systems. This means work has to be done in the near term to try to establish new Day ahead arrangements between SEM-GB and work is already established in this area, with GB TSOs and EU TSOs progressing developments. Separately we need to ensure that, in time for the planned Celtic interconnector go live, we have completed all preparatory work that will enable full integration into the pan EU Day ahead, intraday and balancing markets, and have fully established market related services from the regional coordination centre ; Coreso

Full integration into EU day-ahead and intraday markets - When the Celtic Interconnector becomes operational, the SEM will have to reintegrate with the electricity markets of continental Europe. This will require full compliance with the electricity market network codes which are currently not fully applicable due to Brexit, including the integration of the pan EU Intraday and balancing trading processes.

The purpose of the project is to assess the changes required to the existing market design to best achieve this. However, considering the nature of the existing EU Balancing platforms (PICASSO, TERRE and MARI) fundamental market and dispatch design issues need to be contemplated. In particular, self-versus central dispatch and ex-ante versus ex-post balancing price determination are necessary considerations before designing the changes required. The first piece of work will require us to work with our EU TSO colleagues to establish an appropriate capacity calculation region (CCR) as this will determine how we re-integrate into the pan EU markets and who we have to achieve agreement with.

The scope includes:

- Consideration of the application of self-dispatch philosophy to the SEM as well as moving to an ex-ante imbalance price determination;
- Determination of an appropriate capacity calculation region (bespoke CCR or joining the CORE CCR France- Romania) and relevant regulatory approval.
- Alignment to or amendment of CORE methodologies or the development of new ones (dependent on CCR decision)
- Development of systems and processes to integrate with the pan-EU intraday auctions and platforms.
- Development of systems and processes to integrate with the pan-EU balancing platforms.
- Development of systems and processes to enable full-service capability from CORESO, the Regional Coordination Centre (RCC)

At a programme level this will require the TSOs to engage with the industry and seek RA decision on:

- An examination in detail our current scheduling and dispatch practices.
- Benchmark study against other scheduling and dispatch arrangements in place across Europe
- Consider the changes to the portfolio of plant expected to connect in Ireland and Northern Ireland over the coming years.
- Review "Straw Man" options previously developed for integrating a central dispatch arrangement onto the Balancing platforms.
- Complete a detailed analysis of options available, make recommendations and get full agreement on a proposed solution.
- Develop a comprehensive multiyear, multi-vendor programme to deliver necessary changes with regulatory approval and oversight and proactive and open engagement with industry at all stages for Celtic interconnector go-live.
- Systems to support market reintegration, balancing platform participation and dispatch
- Procedures, processes, Licence conditions updates to reflect these changes
- Training and market participant engagement
- Market and Operational system trialling
- Go live procedures in place for EU Market participation including RTE-EirGrid Celtic operational procedure and practice in place.

Pillar 2: Multi-year plan

Full trading agreement between the SEM into GB and EU markets

Table 39: Markets - Pillar 2 multi-year plan

Project Name	Milestone	Date
Post Brexit SEM/GB Day ahead Capacity allocation arrangements	Appropriate approval of principles and concept – from Regulators to allows the commencement of a programme of work Guidance by Specialised Committee on Energy (SCE) on development of capacity allocation options examining Cost benefit assessment conducted in 2021.	2025
	GB/EU Transmission System Operator Capacity allocation technical procedure development - to follow the outcome of the Cost benefit assessment and SCE guidance	
	Opinion by GB Regulatory Authorities and ACER	
	Possible amendments required by GB/EU specialized Committee on Energy	
	Final recommendation to adopt the and EU/GB day-ahead capacity allocation technical procedure	
	Possible new systems design, test and go-live	
Post Brexit SEM/GB Day ahead Capacity calculation arrangements	Appropriate approval of principles and concept – from Regulators to allows the commencement of a programme of work Guidance by Specialised Committee on Energy on development of capacity calculation technical procedures	2021-2025
	Day-ahead Capacity Calculation technical procedure GB/EU Transmission System Operator development of a day-ahead capacity calculation to link with the capacity allocation process	
	Opinion by GB Regulatory Authorities and ACER	
	Possible amendments required by GB/EU specialized committee on Energy	
	Final recommendation to adopt an EU/GB day-ahead capacity calculation technical procedure	
	New SEM/GB capacity calculation process detailed system design, test and go-live	

Post Brexit SEM/GB – Future market timescales work	Appropriate approval of principles and concept – from Regulators to allows the commencement of a programme of work	2021 -2025
	Possible GB/EU technical procedures for other electricity market timeframes - Intraday, Forwards, balancing – development of methodologies and implementation	
Full integration with EU Capacity Calculation Region (CCR) In advance of Celtic interconnector operations, the SEM will have to establish a new CCR or join an existing one (CORE CCR for example).	Engage with EU Transmission System Operators to review potential CCR options	2022-2026
	Agree with All EU Transmission System Operators to amend the Capacity Calculation Region (CCR) determination	
	Develop and submit for regulatory approval for a new EU CCR proposal	
	Receive regulatory approval of CCR	
Full EU Integration Design The SEM will be required to implement a number of obligations under EU law that cannot be met today, which will precipitate significant design changes	Develop paper on Scoping options and requirements to inform industry discussion	2022-2026
	Consultation paper delivered setting out the areas for review	
	Develop issues and options for scoping including ex-ante and ex-post pricing, self-dispatch and central dispatch, Regional Coordination Centres (RCC) operations and cross border services	
	Develop new methodologies with relevant EU TSOS for integration into EU Forwards, Intraday, Day ahead and Balancing markets	
	Propose, consult and decide on High Level Design of Re-integration	
	Develop Detailed Design and Programme Plan	
	Industry readiness preparation for re-integration and new market design	
	Over-arching governance of new market design including Rules Working Group, Technical Liaison Group and Business Liaison Group	
	Procurement of Vendor new system/ Change request current systems	
	Build and deploy enhanced SEM (SEM 4.0) to address self/central-ex ante, ex post	

7. Key Dependencies

EirGrid and SONI believe that the Renewable Ambition can be delivered while maintaining the stability of the power grid. This Roadmap is informed by stakeholder and general public engagement feedback, comprehensive modelling and analysis of network reinforcements and detailed reviews of market operations and system operations.

The scale of the transition is very challenging and the current approaches to network planning, public and industry engagement, electricity system operation and electricity markets need to be transformed if the Renewable Ambition is to be achieved.

The following are some of the key dependencies for successful delivery of the Renewable Ambition.

Table 40: Key dependencies for successful delivery of the Renewable Ambition

Dependency	Description
Governmental support	There is an effective policy and enabling framework in Ireland and Northern Ireland to support delivery of the Renewable Ambition.
Regulatory support	EirGrid and SONI are appropriately funded, and there is an effective regulatory framework in place, to deliver on Renewable Ambition. It is assumed that Regulators will have capacity to make timely decisions relating to same.
Delivery of network reinforcement programme	There needs to be a step change in the volume of network reinforcements that needs to be delivered between now and 2030. It is assumed enablers are in place to facilitate this step change and deliver the necessary network reinforcements.
Public Acceptance for energy infrastructure	Public acceptance is at the heart of our approach to grid delivery in Ireland and Northern Ireland and critical to the success of the transformation.
Unknown technical challenge	Operating a power system with the forecasted level of non-synchronous generation will present unique challenges. It is assumed that all technical challenges that arise during the transition can be overcome.
Sufficient investment signals	Industry/market participants respond to existing and new investment signals to enable the transition. This is balanced against the need for consumer affordability.

8. Further Analysis

The planning horizon for the Shaping Our Electricity Future Roadmap is the remaining years to 2030. Given the relatively short planning horizon, the Roadmap must provide a deliverable, technically and economically feasible, dynamic and transparent roadmap that maintains consumer affordability and delivers system reliability while meeting our Renewable Ambition.

To inform this Roadmap, we have conducted detailed technical reviews of current market operations, system operations and network infrastructure scenario-based modelling that incorporated expected changes in consumer demand, trending technology innovation, and economic growth.

Given the significant range of possible scenarios, it is not possible in a planning study to explore every potential future outcome or technology development and consequently EirGrid and SONI consulted widely with industry and the public to select scenarios and approaches that were broadly considered the most useful in developing this roadmap. The insights from the technical reviews together with the feedback from our consultation engagements have served as valuable inputs to Shaping Our Electricity Future Roadmap. The Roadmap serves the obligation placed on EirGrid and SONI to identify deliverable projects to technically and economically meet the Renewable Ambition as well as the broader obligation of informing market participants, investors, policy decision makers and consumers of investment opportunities and proposed market and operational changes.

Based on our current technical reviews, stakeholder feedback and planning assumptions, it is technically and economically feasible to achieve the Renewable Ambition on the Ireland and Northern Ireland electricity power system by 2030. The transition is complex and there is always a degree of uncertainty to scenario analysis and therefore will require ongoing stakeholder engagement as well as continued refreshing of the assessments of market operations, network infrastructure planning and electricity system operations to identify what updates might be needed to the Roadmap. This could be driven by many factors (e.g. policy changes, technology improvements, economic changes, mitigation of implementation risks) while continuing to maintain a reliable electricity system and providing the most economical and deliverable solution.

EirGrid and SONI plan to refresh the Shaping Our Electricity Roadmap at least every 24 months. In the next 24 months EirGrid and SONI also plan to also develop an equivalent net zero electricity system roadmap – this is expected to follow an intensive consultation and engagement process.

Appendix 1 – Glossary and Key Concepts

Term	Abbreviation	Description
Alternating Current	AC	Alternating current is an electric current which periodically reverses direction and changes its magnitude continuously with time in contrast to direct current (DC) which flows only in one direction.
Appropriate Assessment	AA	An assessment of the potential adverse effects of a plan or project (in combination with other plans or projects) on Special Areas of Conservation and Special Protection Areas.
Association of Irish Local Government	AILG	The national representative body that represents and supports the role of the 949 elected Councillors across Ireland.
Battery Energy Storage	BES	Capture of energy at one time to use at a later time using battery technology.
Capacity Calculation Region	CCR	Geographic area in which coordinated capacity calculation is applied.
Capacity Market	CM	Auctions four years, two years and one year in advance of physical supply of the electricity.
CO2 emissions	CO2	Carbon dioxide emissions or CO2 emissions are emissions stemming from the burning of fossil fuels and other manufacturing processes. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels as well as gas flaring.
Commission de régulation de l'énergie	CRE	The energy regulator in France.
Commission for Regulation of Utilities	CRU	Ireland's independent energy and water regulator.
Constraint		Constraint (either up or down) refer to a change to any generator's output from the planned "market schedule" due to transmission network limitations or operating reserve requirements.
CORE Capacity Calculation Region	CORE CCR	Sixteen TSOs combined the regional initiatives of former Central Eastern Europe and Central Western Europe to the create the enlarged European Core region.
Curtailment		Curtailment refers to the dispatch-down of wind for system-wide reasons (where the reduction of any or all wind generators would alleviate the problem).
Demand Side Management	DSM	The modification of normal demand patterns, usually using incentives and/or control actions.
Demand Side Unit	DSU	Consists of one or more Individual Demand Sites that can be dispatched by the Transmission System Operator (TSO) as if it was a generator.
Demand Transmission Use of System	DTUoS	Tariff designed to recover the costs associated with the development, maintenance and operation of the transmission system in Ireland. Apply to all demand customers on the transmission and distribution network.

Term	Abbreviation	Description
Department of Environment, Climate and Communications	DECC	Department of Environment, Climate and Communications
Department of Housing, Local Government and Heritage	DHPLG	Department of Housing, Local Government and Heritage
Direct Current	DC	Direct current is an electric current which flows only in one direction, in contrast to alternating current (AC) which periodically reverses direction and changes its magnitude continuously with time.
Distributed Energy Resources	DER	Small scale energy resources connected to the distribution network.
Distribution System Operator	DSO	The Distribution System Operator is the designated authority responsible for the operation of the distribution system.
Dynamic Line Rating	DLR	Tool that applies a real time rating to an overhead line throughout the year by assessing the prevailing weather conditions and determining the maximum power flow that can be accommodated at that time.
Eastern and Midland Regional Assembly	EMRA	One of three regional structures that strengthen the development of Ireland's regions in a co-ordinated, strategic manner.
Education and Training Board Ireland	ETBI	ETBs are active in local communities through the direct provision of training and education programmes delivered in training centres, colleges and other training and educational settings.
Electric and Magnetic Fields	EMF	These are invisible areas of energy which occur naturally – the earth itself has natural electric and magnetic fields. EMFs can also be created artificially – an example would be electricity power lines. EMFs can create electrical currents in nearby materials that can conduct electricity.
Energy Management System	EMS	Network of computer servers and workstations used to monitor and control the Grid.
Electricity Supply Board Networks	ESBN	A subsidiary within ESB Group, ESB Networks is the licensed operator of the electricity distribution system in the Republic of Ireland and owner of all transmission and distribution network infrastructure.
Electronic Dispatch Instruction Logger	EDIL	Communication platform between TSO and Units, used to issue dispatch instructions.
Energy Storage Power Station	ESPS	A specific type of unit registered with EirGrid - classified as Power Park Modules (PPM) under the Grid code.
Environmental Appraisal Report	EAR	Considers whether the Transmission Development Plan is in accordance with the Strategic Environmental Assessment of the Implementation Plan.
European Network of Transmission System Operators for Electricity	ENTSO-E	The European Network of Transmission System Operators, represents 43 electricity transmission system operators from 36 countries across Europe.

Term	Abbreviation	Description
Fast Frequency Response	FFR	A DS3 System Services product that incentivises the fast provision active power within 2 seconds following the frequency disturbance.
Future Arrangements	FA	System Services FA project was formally launched by the SEM Committee in July 2020.
Generation Transmission Use of System	GTUoS	TUoS applied to Generators.
Gigawatt	GW	Unit of power
Greenlink Interconnector Limited	GIL	The developer of the Greenlink HVDC interconnector between Ireland and Great Britain.
High-Voltage Direct Current	HVDC	HVDC electric power transmission system uses direct current for the bulk transmission of electrical power.
Infrastructure		Structures and facilities of a region or country, such as buildings, roads, bridges and the electrical grid.
Joint Operating Agreement	JOA	The arrangements between the interconnector operator and connecting TSOs related to the operation of the interconnector.
Large Energy User	LEU	Customer connected to the grid that uses a significant amount of energy.
Manually Activated Reserves Initiative	MARI	European implementation project for the creation of the European manual Frequency Restoration Reserve platform.
Market Management System	MMS	System used to monitor and control the markets.
Maximum Export Capacity	MEC	The maximum export value (MW) provided in accordance with a generator's connection agreement. The MEC is a contract value which the generator chooses as its maximum output and is used in the design of the Transmission System.
Mega Volt Ampere	MVA	Unit of apparent power. MVA ratings are often used for transformers, e.g. for customer connections.
Megawatt	MW	Unit of power
Micro-generation		Offers energy consumers and community groups the opportunity to produce, supply and use renewable electricity.
Multi Region Loose Volume Coupling	MRLVC	Proposed solution to allocate capacity on the interconnectors to GB in the day-ahead market timeframe according to the TCA
National Energy and Climate Plan	NECP	Regulation on the governance of the energy union and climate action to meet the EU's 2030 energy and climate targets for each member state
National Grid ESO	NGESO	National Grid is the electricity system operator for Great Britain.
Non-Governmental Organisation	NGO	A non-governmental organisation (NGO) is a non-profit group that functions independently of any government.
Northern and Western Regional Assembly	NWRA	One of three regional structures that strengthen the development of Ireland's regions in a co-ordinated, strategic manner.

Term	Abbreviation	Description
Northern Ireland Electricity Networks	NIEN	NIE Networks owns the electricity transmission and distribution network and operates the electricity distribution network which transports electricity to customers in Northern Ireland.
Northern Ireland Renewable Obligation	NIRO	NIRO is the main policy measure for supporting the development of renewable electricity in Northern Ireland. NIRO is closed for applications.
Power Flow Controller	PFC	A device installed on a transmission circuit to allow control over how power is directed along that circuit and neighbouring circuits.
Price Review 5	PR5	The Commission for Regulation of Utilities (CRU) review and decision on allowable revenues for the 2021 to 2025 period.
Production Cost		Is the total generation cost including fuel, variable operations and maintenance costs, start and shutdown costs and emissions costs. It is measured in euro and typically over the period of a year.
Projects of Common Interest	PCI	Is a category of projects that the European Union has identified as a key priority for interconnecting Europe 's energy system infrastructure.
Pumped Hydro Energy Storage	PHES	Capture of energy at one time to use at a later time using flow of water technology.
Qualification Trial Process	QTP	The EirGrid and SONI mechanism for trialling of new technologies to provide System Services on the system.
Ramping Margin Tool	RMT	The EirGrid and SONI control centre tool to ensure sufficient Ramping Margin System Services.
Rate of Change of Frequency	RoCoF	The Rate of Change of Frequency defines the maximum rate at which system frequency should change following an event on the power system. As such it defines the rate of change for which generators and demand should be able to withstand and remain connected to the power system.
Regional Coordination Centres	RCC	These are to be introduced after the Winter Energy Package as an institutional framework to enhance regional coordination between transmission system operators across the EU.
Regulatory Authority	RA	Authorities with obligations to regulate utilities in the public interest.
Renewable Ambition		At least 70% of electricity from renewables by 2030.
Renewable Energy Sources	RES	Sources of electricity generation that use renewable processes, such as wind, solar radiation, tidal movement etc. to produce electricity.
Renewable Energy Sources for Electricity	RES-E	Electricity from renewable energy sources, i.e. the electricity generated from clean energy sources such as photovoltaic, hydro, tidal or wave, wind, geothermal, and renewable biomass.
Renewable Energy Support Scheme	RESS	Scheme will provide for a renewable electricity (RES-E) ambition of up to a maximum of 70% by 2030 in Ireland, initially announced via the Government Climate Action Plan 2019. Subject to determining the cost-effective level which will be set out in the National Energy and Climate Plan (NECP).

Term	Abbreviation	Description
Renewables Grid Initiative	RGI	The Renewables Grid Initiative is a collaboration of environmental and social NGOs and transmission system operators from across Europe. We promote transparent, environmentally sensitive grid development to enable the further steady growth of renewable energy and the energy transition.
Réseau de Transport d'Électricité	RTE	Electricity transmission system operator of France.
Single Electricity Market	SEM	This is the wholesale market for the island of Ireland.
Single Electricity Market Committee	SEMC	Decision making authority for the Single Electricity Market on the island of Ireland.
Single intraday coupled markets	SIDC	The facilitation of a single EU cross-zonal intraday electricity market.
Society of Local Authority Chief Executives	SOLACE	Acts as the professional voice for local government in Northern Ireland.
SOLAS		State agency. Its mandate is set out in the Further Education and Training Act 2013.
Southern Regional Assembly	SRA	One of three regional structures that strengthen the development of Ireland's regions in a co-ordinated, strategic manner.
Specialised Committee on Energy	SCE	Specialised Committee on Energy as established under the UK/EU Trade and Cooperation Agreement – a decision making body for energy arrangements between the UK and EU.
Strategic Environmental Assessment	SEA	Defined by the Environmental Protection Agency as the process by which environmental considerations are required to be fully integrated into the preparation of plans and programmes prior to their final adoption.
System Marginal Price	SMP	The System Marginal Price is the price set for each half hour of Single Electricity Market trading by the bid of the last generator that must be despatched to meet demand in that settlement period. All generators receive the SMP regardless of their bid.
System Non-Synchronous Penetration	SNSP	System Non-Synchronous Penetration is a real- time measure of the percentage of generation that comes from non-synchronous sources, such as wind and HVDC interconnector imports, relative to the system demand.
System Services	SS	Ancillary services which ensure that the system operates securely and efficiently, while facilitating higher levels of renewable energy.
Technology Readiness Level	TRL	Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology.
Tomorrow's Energy Scenarios	TES	Scenario plans for Ireland.
Tomorrow's Energy Scenarios Northern Ireland	TESNI	Scenario plans for Northern Ireland.

Term	Abbreviation	Description
Total Electricity Requirement	TER	The sum of annual electricity demand for residential, tertiary, transport, industrial sectors, including electricity produced by privately operated and owned micro-generators, as well as losses.
Trade and Cooperation Agreement	TCA	New framework for law enforcement and judicial cooperation in criminal and civil law matters between the EU and UK.
Trans European Replacement Reserves Exchange	TERRE	European implementation project for exchanging replacement reserves.
Transmission Asset Owner	TAO	The entity that owns the transmission assets. In Ireland ESB Networks owns the transmission assets and in Northern Ireland NIEN owns the transmission assets.
Transmission Loss Adjustment Factor	TLAF	Electricity (Power) can be lost through the transmission system as it travels. To ensure that the wholesale market is settled correctly, the transmission losses are allocated to generators this way.
Transmission Owner	TO	The entity that owns the transmission assets. In Ireland ESB Networks owns the transmission assets and in Northern Ireland NIEN owns the transmission assets.
Transmission System Operator	TSO	License entity that is responsible for transmitting electricity from generators to regional or distribution operators.
Transmission System Security Planning Standards	TSSPS	Set of standards that the grid is designed to meet. These standards are a licence obligation and are approved by the Commission for Regulation of Utilities.
Transport Infrastructure Ireland	TII	Provides transport infrastructure and services.
Underground cable	UGC	An underground cable is a cable that is buried below the ground and is used to convey electrical power.
United Nations Conference of the Parties	UN COP	The United Nations Climate Change Conferences are yearly conferences held in the framework of the United Nations Framework Convention on Climate Change (UNFCCC). They serve as the formal meeting of the UNFCCC Parties (Conference of the Parties, COP) to assess progress in dealing with climate change.
Utility Regulator for Electricity and Gas for Northern Ireland	UR	Responsible for regulating the electricity, gas, water and sewerage industries in Northern Ireland.
Voltage Trajectory Tool	VTT	The EirGrid and SONI control centre tool to ensure that reactive power sources are managed efficiently to maintain a healthy and secure voltage profile.

Appendix 2 – Feedback and Responses

Overview of public consultation and stakeholder engagement

EirGrid and SONI, as the operators of the electricity transmission systems in Ireland and Northern Ireland, will play a key role in delivering at least 70% renewable energy by 2030. EirGrid and SONI cannot deliver this without support. We sought the views of the public, industry and civil society, so we could refine and improve our proposed approaches to preparing the grid to reach this goal.

EirGrid and SONI worked with a range of partners to help stakeholders have their say and engage directly with us. This included working with local authorities, chambers of commerce and rural communities across Ireland and Northern Ireland, engaging and deliberating at grassroots level with the stakeholders who ultimately facilitate, deliver and benefit from the work of EirGrid and SONI.

In addition to this, EirGrid and SONI directly facilitated engagement events in Ireland and Northern Ireland including stakeholder workshops, civil society fora, a deliberative dialogue and a youth assembly. These engagements were designed around informing and discussing the four draft approaches to Shaping Our Electricity Future. This included exploring the costs, likelihood of success and unique infrastructural features of each approach. Gathering this feedback was done at unprecedented scale and was the largest public consultation and engagement programme undertaken in this sector.

From this programme of consultation and engagement, EirGrid and SONI produced a range of consultation and engagement reports which have been considered and published online:

- Independent Public Consultation and Engagement Report (EirGrid)
- Independent Public Consultation and Engagement Report (SONI)
- National Youth Council of Ireland Youth Assembly Report
- Chambers Ireland Regional Engagement Report
- Irish Rural Link Rural Engagement Report

The feedback and inputs from public and civil society stakeholders was analysed and used to inform the final Shaping Our Electricity Future Roadmap. Specifically, the feedback was used to:

- influence the network/generation modelling that we have based our studies on;
- develop the Network Infrastructure Roadmap;
- develop the Stakeholder Engagement Roadmap; and
- more broadly, influence and reinforce EirGrid and SONI's overall approach to Public Engagement.

The activity undertaken by EirGrid and SONI throughout this consultation and engagement process has uncovered significant support from stakeholders for the necessity and objectives of Shaping Our Electricity Future.

We want to…

Understand, consider and respond to stakeholders' views on EirGrid's and SONI's draft approaches for ensuring that at least 70% of Ireland and Northern Ireland's electricity comes from renewable sources by 2030.

To do that we need to…

- Understand, consider and respond to stakeholder views on and preferences for the draft approaches
- Understand and consider what influences these views, including underlying assumptions, risk profiles for the different approaches, and trade-offs that stakeholders make in gauging their preferences.

So the full programme must be designed to answer…

Research questions

- What do stakeholders think about each approach?
- Which approach do they prefer, and why?
- What is the conditionality of their views? What values, motivators, and messaging influence their views, and how?

To have informed views, participants need to have information on…

- High level view of the climate change challenge.
- The policy context of the targets.
- Current/potential energy sources, with a focus on clean electricity generation options.
- The energy landscape in Ireland and Northern Ireland now and in the future (i.e. demand and supply).
- What is the grid and how does it work.
- The role of energy generation in responding to climate change, and the implications for the grid.
- Roles, responsibilities, and authority across different organisations in the electricity landscape.

We will use the findings to…

- Inform future development strategies for development of the transmission grid in Ireland and Northern Ireland.
- Inform and enable future communication and engagement on the development of the transmission grid in Ireland and Northern Ireland.

Public feedback and responses

This section explores the most common themes arising from this programme of engagement and consultation and provides a response from EirGrid and SONI.

Agriculture

Feedback

There was widespread participation from the agricultural communities across the engagement processes. A key concern was the recognition and protection of landowner rights where infrastructural development takes place on farmland. These stakeholders highlighted poor engagement in past projects but also recognised a shift in approach.

Response

EirGrid and SONI is actively engaging with relevant agricultural bodies and stakeholders. We have been building our landowner team over the last number of years and have dedicated agricultural liaison officers who are engaging on the ground with landowners on our projects. These teams are continually listening and responding to feedback from landowners. This informs our approach to developing and improving our overall engagement approach on an ongoing basis.

Cost

Feedback

Cost was a consistent concern raised by public and civil society stakeholders. These stakeholders are seeking further information on how this will impact the consumer in terms of electricity bills, levies and other taxes. There is no appetite for the cost of electricity to rise in the transition to 2030 and views expressed emphasised the need to protect vulnerable consumers.

While stakeholders acknowledged both SONI's and EirGrid's roles as policy implementers, they also asserted that as implementers, EirGrid and SONI should be able to forecast costs at wholesale level and model the impact on consumer prices. Stakeholders believe that a culture of cost mitigation in the decarbonisation of the system must be sustained and reinforced – across all actors who have a role in the electricity system.

Cost in relation to the delivery of the grid infrastructure was generally understood as necessary and acceptable.

Response

EirGrid and SONI recognise cost is a key concern in a secure transition and we are committed to working with governmental and regulatory stakeholders to help ensure a secure, reliable but also affordable electricity system out into the future. As regulated utilities we acknowledge the responsibilities of our regulators in ensuring that customers and network users receive value for money while we earn a fair return on our activities to make the necessary network investments. Those investments go towards the efficient operation, development and maintenance of the networks. Based on the experience of other jurisdictions, EirGrid and SONI believe it will be challenging to maintain electricity prices at current levels. However the cost of not carrying out this transition to a low carbon electricity system is considerable and could include increasing carbon taxes; cost associated with climate change mitigation and; higher exposure to volatile international oil and gas prices such as we have seen in recent times.

EirGrid and SONI roles

Feedback

It was clear from the consultation that the general public were not fully aware of EirGrid and SONI's respective roles in relation to the electricity grid. Similarly, this was the case across broad civil society. However, when they gained an understanding of EirGrid and SONI's roles, there was a general sense of support.

Where stakeholders were aware of EirGrid and SONI, this was generally due to existing relationships, experience on projects or sectors of civil society that would be more aware of the energy sector.

In the case of EirGrid, stakeholders perceived it in having a role in the delivery of micro-generation capacity, the awarding of planning permission and the development of Government policy. It was sometimes confused with being a private developer of electricity generation also.

Stakeholders did feel it is important that EirGrid and SONI continue to promote and reinforce their roles, and raise awareness of this across a broader spectrum of society.

Response

EirGrid and SONI utilised the engagement and consultation opportunity on Shaping Our Electricity Future to raise awareness about their roles in the electricity systems in Ireland and Northern Ireland.

EirGrid and SONI continue to make efforts to clarify their roles in the electricity system, and this process has assisted in achieving that. Both organisations will use their positions as key stakeholders in the electricity system to pass on the feedback they hear from stakeholders in relation to issues beyond the direct control of EirGrid and SONI.

Electricity demand and economic development

Feedback

There was repeated reference to the need for rural communities to share in any economic upturn as a result of the implementation of a roadmap with major Renewable Ambition. This includes balancing the infrastructure modelling across the island, encouraging large energy users to locate in regional cities and balance the requirement of offshore and onshore generation, in order to sustain and attract jobs and investment. Feedback also suggested that the provision of quality energy infrastructure as essential to underpin the economic development of the regions and the unlocking of new and evolving economic opportunities.

Response

New large energy user demand outside of Dublin and the Mid-East regions of Ireland was not originally modelled for the Developer-Led, Generation-Led, and the Technology-Led approaches. In Ireland, the final roadmap includes the locating of 300 MW of new large energy user demand in regional cities – across Cork, Galway and Limerick. In Northern Ireland, the final roadmap includes the locating of 16 MW of new large energy user demand.

EirGrid and SONI acknowledge the significant role of our local authorities, chambers of commerce and community stakeholders in the regions in the achievement of national renewable energy targets and are dedicated to continuing to build and improve relationships with these key stakeholders.

Energy storage

Feedback

Energy storage was a consistent topic of interest across engagements and submissions. Stakeholders feel this should play a meaningful role in facilitating renewable energy on the grid, in addition to contributing to security of supply.

Response

In response to support for industrial scale electricity battery storage in Ireland, the final roadmap includes 1.4 GW of battery storage, a significant increase on draft modelling of 0.45 GW. In Northern Ireland, battery storage will stay the same as modelled at 0.3 GW.

Offshore electricity generation

Feedback

In Ireland, a large amount of feedback supported offshore generation. Many stakeholders felt that offshore generation has a less negative environmental and visual impact. A few stakeholders pointed out that there is less opposition to the construction of offshore than onshore projects. In addition to this, stakeholders expressed the view that there should be much more offshore on the West coast of Ireland, utilising the Atlantic Ocean.

In Northern Ireland, some respondents felt offshore turbines would be preferable to building infrastructure onshore. A few people also felt increasing offshore production of renewable energy would be more environmentally sustainable than building new infrastructure onshore. A few respondents said that offshore wind development will take a long time and would mean that sufficient generation would not be in place by 2030.

Response

In response to support for offshore electricity development in Ireland, the final roadmap includes 5 GW of offshore renewable electricity. The draft approaches had modelled between 1.8 GW to 4.5 GW. In addition to this, EirGrid have assumed limited capacity for offshore wind development off the South and West Coast. Offshore wind development in the short term remains to be predominantly focused on the East Coast.

In response to the evolving policy scenario and capability in Northern Ireland, the final roadmap includes 0.1 GW of offshore renewable electricity. The draft approaches had modelled between 0.35 GW to 0.7 GW.

It is not expected that the technology for offshore wind will be developed maturely enough to facilitate large scale offshore wind on the west coast in the short term. The East Coast of Ireland has shallower waters, making offshore a more viable option in the short term.

Onshore electricity generation

Feedback

Wind energy was widely considered and accepted as a solution to support the decarbonisation of the grid. However, in Ireland the public generally had a preference for solar and expressed acceptance challenges around the facilitation of onshore wind infrastructure.

Response

In Ireland, the final roadmap includes an additional 1.3 GW of new onshore renewable electricity on 2020 levels. The draft approaches had modelled between 0.1 GW to 3.9 GW of new onshore capacity.

In Northern Ireland, the final roadmap includes 1 GW of new onshore renewable electricity on 2020 levels. The draft approaches had modelled between 0.16 GW to 0.76 GW.

Micro-generation of electricity

Feedback

Micro-generation was a popular theme that arose consistently across all stakeholder segments throughout the consultation in Ireland. Communities are eager to get involved in this aspect of the electricity system and believe micro-generation should have a relatively significant role in attaining the Renewable Ambition. Stakeholders also challenged EirGrid and SONI to advocate for developments in this area in relevant arenas and increasing the amount of micro-generation included in modelling to support the setting of targets, in order to accelerate adoption. In Ireland, stakeholders felt that this area is in real need for development.

Response

Micro-generation is an important aspect of the renewable transition offering energy consumers and community groups the opportunity to produce, supply and use renewable electricity. To support and encourage this, EirGrid has increased our modelling assumptions of micro-generation capacity to 500 MW by 2030. The draft approaches originally assumed between 100 MW and 400 MW.

In Northern Ireland, where micro-generation programmes are more developed, capacity is modelled to be 200 MW by 2030 which is unchanged from the draft approaches.

Public engagement processes

Feedback

Stakeholders highlighted that infrastructural development creates debate among all elements of society especially the communities or region hosting the infrastructure. Stakeholders were adamant that it must be real engagement and the "token" engagement of the past needs to be eliminated.

Stakeholders acknowledged both EirGrid's and SONI's evolution in their approach to engagement, and the accelerated speed at which this has happened. Stakeholders believe this needs to be sustained, iteratively evolved and be supported by consistent and targeted communications at local and national level.

At every opportunity, stakeholders reinforced that engagement should be open, transparent and consistent across the board. It is particularly important that stakeholders are empowered and respected in their engagement with EirGrid and SONI. Stakeholders continually stated that engagement needs to be fundamental to the work of EirGrid and SONI.

In addition to this, they wanted to see greater evidence of a plan to include communities in key decisions over the next decade.

Response

EirGrid and SONI acknowledge the challenges of what we ask from individuals and communities for the benefit of the entire population. If we don't engage successfully with those affected by grid development plans, we won't achieve climate action targets.

In response, EirGrid and SONI are making community engagement and participation part of the core SOEF Roadmap.

In relation to including communities in key decisions, EirGrid has commenced the roll out of Community Forums across all major grid development projects. These forums are chaired independently by national NGOs with a core competence in community development with the intent of incorporating co-design principles in the delivery of projects. In Northern Ireland have reviewed our Public Engagement process on grid infrastructure projects and subject to appropriate regulatory funding, would seek to pilot a Community Forum model on a major project in 2022/23. SONI would potentially roll out the model on all major grid development projects following a review of the pilot.

Public acceptance / licence

Feedback

In order to enable the delivery of energy infrastructure and system services, the consultation process clearly identified and reinforced the need for 'public acceptance' or a 'social licence'. It was highlighted that this must also be achieved by energy infrastructure developers in order to enable delivery of renewable energy generating infrastructure.

In Ireland, some stakeholders highlighted a mistrust between government, developers and local communities, which was particularly evident in the midlands in relation to renewable energy and the south east in relation to Grid Link. Similarly, some stakeholders highlighted opposition to overhead line projects, such as the North South Interconnector.

As outlined elsewhere in this report, there was widespread acceptance of and support for the decisions which must be made and the changes which those decisions will entail. There was also a degree of realism that objections to planning, and NIMBYism overall could lead to major problems in the implementation of any initiative on the scale required to meet the challenges ahead. in Ireland, this issue did leach into other comments about EirGrid's remit, particularly in relation to an envisaged disconnect between the aims laid out by EirGrid and the government overall, and the abilities of the planning service to meet those challenges.

In Northern Ireland, many participants did feel that SONI need to carry out further engagement, in particular with communities who might be impacted by future projects required in order to meet future renewables targets.

Response

Social licence / acceptance is achieved when stakeholders feel they can trust EirGrid's and SONI's approaches to the planning of infrastructure. Trust is something that must be built over time and can only be gained through continuous and transparent engagement.

It is also important to acknowledge the range of stakeholders involved in the delivery of electricity infrastructure and the parameters that guide the delivery of that infrastructure too. It is imperative that a 'whole of sector' approach is taken to delivering best practice engagement.

Each grid development project is assessed under a multi-criteria assessment. The multi-criteria assessment includes technical, economic, environmental, socio-economic and deliverability factors, including the feedback of all stakeholders. This process determines the technical solution and route for each project.

EirGrid and SONI are committed to achieving this. Read more about this and the practical actions we propose to take in the Engagement Multi-Year Plan.

Community ownership of renewables

Feedback

In Ireland, consultation and engagement feedback communicated a strong desire that communities should be supported and incentivised to develop RESS-scale community owned renewable projects. Many stakeholders believed a community-led approach to renewable project development would provide significant community benefit, support acceptance of energy infrastructure and demonstrate a grassroots contribution to achieving climate action targets. However, stakeholders strongly communicated that systems need to be put in place to foster and encourage ideas in this area becoming a reality.

In Northern Ireland, feedback called for greater community involvement in the future of energy production and decisions making regarding generation projects. Some participants talked about the community in relation to decentralising the grid and there was several suggestions about micro-generation or community generation of energy.

Response

EirGrid and SONI consider the active participation of communities to be integral part of the energy transition. Ultimately, it is the many communities and businesses in Ireland and Northern Ireland that the electricity system is there to serve and we believe that communities should be empowered and engaged participants in the decarbonisation of the economy and society. We believe this is a key requirement in the power system transition and expect policy will evolve in this area. Read more about this the Engagement Multi-Year Plan.

New technology / future proofing

Feedback

Stakeholders highlighted a range of feedback that can be grouped in the technology and future proofing space. This includes aspects such as ensuring the grid is fit for purpose beyond 2030, that the grid utilises technology to minimise new grid infrastructure. There were a few suggestions of other renewable generation approaches such as hydrogen, nuclear, wave, biomass carbon capture and smart energy.

Response

The achievement of at least 70% renewable electricity by 2030 is just the first step towards a net zero energy system by 2050. EirGrid and SONI are committed to this as underlined by Government policy in Ireland and the UK. Climate and energy policy is evolving at a fast pace, and we will continue to monitor policy and technology developments and modify our roadmap to suit.

EirGrid and SONI believe the activities outlined in this report document a sustainable transition, including the best use of appropriately mature technology.

Security of supply and data centres

Feedback

Security of supply and the impact of data centres on demand was raised across several of the responses, mainly from civil society organisations in Ireland. Some respondents saw the relocation of data centres as a possible aid to economic development in the regions while alleviating the pressure on the Greater Dublin Area. In addition to this some respondents felt supply insecurity may result in lost investments opportunities.

In Northern Ireland a small number of respondents stated that security of energy supply is an important consideration in reaching the renewables target, saying that there have been amber alerts on the transmission system in the recent past.

Some responses in Ireland and Northern Ireland highlighted the increasing occurrence of amber alerts over the past number of years.

Response

Maintaining security of supply and system stability throughout the power system transition is of paramount importance to both EirGrid and SONI. It is essential that the transition to 70% RES-E and to a net zero power system is achieved in an orderly fashion. Over the short term, EirGrid and SONI will continue to maintain security of supply by planning and operating the transmission systems in line with our planning and operational standards. We will continue to identify and communicate the adequate levels of generation capacity required to meet growing demand in each jurisdiction whilst supporting SEMO in efficient operation of the markets that deliver such capacity.

Over time our planning and operational policies and standards must evolve to accommodate the transition - EirGrid and SONI will continue to engage and consult stakeholders as these changes are designed and implemented. The markets must evolve too so that the right technical capabilities are available when they are needed.

Security of supply also relies on the ability of the transmission network to reliably transport energy from generators to demand sources. EirGrid and SONI will work to identify the most appropriate network reinforcements required to maintain appropriate levels of network performance and reliability as the power system transitions whilst engaging with customers and stakeholders as projects progress through the respective grid development processes.

In Ireland there a generation adequacy challenge over the next number of years. EirGrid are collaborating with colleagues in CRU and DECC on an appropriate response. This is discussed in more detail in the Security of Supply chapter of this document.

Environment

Feedback

Feedback received on environmental issues received was minimal and non-technical.

Support in achieving at least 70% renewable electricity on the grid by 2030 was generally supported. Many stakeholders were passionate about the urgency for success in relation to this. There was general support for reducing reliance on fossil fuels as a necessary initiative given concerns around climate change overall.

Of the feedback received, many felt that environmental considerations should be prioritised when considering which of the four draft approaches should be adopted. Nearly all participants and respondents recognised the need for urgent action to mitigate the worst effects of climate change.

There was concern about how the outcome of Shaping Our Electricity Future would impact on the landscape across Ireland and Northern Ireland, including coastal views in the context of offshore renewables.

Ireland and Northern Ireland's emission output relative to the rest of the world raised queries from stakeholders in relation to the benefit of decarbonising.

Some stakeholders raised the issue of natural tourist attractions in Northern Ireland and UNESCO Geoparks in Ireland and the potential impact of renewable energy generation and grid infrastructure on these.

Response

The output of the Roadmap will be subject to a Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA) in due course in Ireland and Northern Ireland. The SEA will address the feedback received during the public consultation and ensure the significance of any impacts are mitigated. There will also be a statutory consultation period for the SEA to seek feedback on specific concerns of the final plan/programme.

It is EirGrid and SONI's commitment to provide for a high level of protection to the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development.

Each annual Transmission Development Plan (TDP) in Ireland and Northern Ireland includes a formal Environmental Appraisal Report (EAR), which considers whether the TDP – deriving from the governing document expected from Shaping Our Electricity Future – is in accordance with the SEA. In short, the TDP is subject to appraisal to ensure its conformance with the provisions of the adopted SEA.

The Shaping Our Electricity Future Roadmap and the TDP will each provide a different level of scale and detail – from the long-term vision statements contained in the roadmap, to the objectives and policies to implement the SEA to the specific projects outlined in the TDP.

Industry feedback and responses

This section of the report focuses on the industry stakeholder engagement and details responses to feedback received. The feedback and responses are grouped by:

- Feedback common to networks, system operations and markets;
- Networks;
- System operations; and
- Markets.

Feedback from the industry was broadly consistent across Ireland and Northern Ireland – any jurisdictional differences are noted as appropriate.

Feedback common to networks, system operations and markets

Cost

Feedback

Many industry respondents noted that the cost included in the consultation report related to the capital expenditure on the transmission network. Respondents believed that this did not reflect the true cost of the overall cost and potential impact on consumers.

Response

The consultation report provided costs associated with reinforcements to transmission networks needed in addition to those already progressing through the grid development frameworks in EirGrid and SONI. In this final roadmap document, we also include costs of currently committed projects in Ireland and Northern Ireland.

EirGrid and SONI recognise cost is a key concern in a secure transition and we are committed to working with governmental and regulatory stakeholders to help ensure a secure, reliable but also affordable electricity system out into the future. As regulated utilities we acknowledge the responsibilities of our regulators in ensuring that customers and network users receive value for money while we earn a fair return on our activities to make the necessary network investments. Those investments go towards the efficient operation, development and maintenance of the networks. Based on the experience of other jurisdictions, EirGrid and SONI believe it will be challenging to maintain electricity prices at current levels. However the cost of not carrying out this transition to a low carbon electricity system is considerable and could include increasing carbon taxes; cost associated with climate change mitigation and; higher exposure to volatile international oil and gas prices such as we have seen in recent times.

Increased renewable targets

Feedback

Many industry respondents stated the achievement of the Renewable Ambition should be considered as a step toward the goal of net zero emissions from the power system by 2050 and that this stretch goal should be the basis for the Shaping Our Electricity Future Roadmap.

Response

EirGrid and SONI are committed to achieving net zero power systems in both Ireland and Northern Ireland in line with Ireland's Climate Action Bill 2021 and the United Kingdom's Climate Act 2008 respectively.

We acknowledge that delivery of the 2030 Renewable Ambition is a stepping stone toward achieving the ultimate goal of net zero greenhouse gas emissions in both jurisdictions. We have included additional commentary in this document in relation to the pathway to net zero. We believe that the activities outlined in this Roadmap document provide a robust foundation for achieving the net zero ambition and that achieving this ambition is contingent upon implementation of many of the activities outlined. Climate and energy policy is evolving at a fast pace and we will continue to monitor policy developments and modify the Roadmap to suit.

Shaping Our Electricity Future advisory council

Feedback

Many industry respondents suggested setting up of a SOEF Advisory Council like the DS3 Advisory Council. The purpose of the council is to provide a forum to discuss ideas and issues that may impact the achievement of the Renewable Ambition. Members of the council should be experts from across the power industry including representatives from academia and industry across Ireland and Northern Ireland

Response

EirGrid and SONI assessed potential options for facilitating ongoing industry engagement on the issues, challenges and activities set out in the Roadmap. Delivery of the Renewable Ambition relies on effective communication and coordinated efforts of many stakeholders in our industry. We have decided to respond to this feedback by expanding the remit of the existing DS3 advisory to include activities related to Shaping Our Electricity Future and delivery of the Renewable Ambition. This is reflected in the industry workstream of the Engagement multi-year plan.

Resourcing of the Transmission System Operator

Feedback

Several industry respondents stated that achieving the Renewable Ambition will result in a substantial increase in workload for EirGrid and SONI. They stated that EirGrid and SONI are currently resourced to meet their obligations as TSOs - including infrastructure planning, system operations and market operations. Respondents highlight that is essential that EirGrid and SONI are appropriately resourced to maintain current system and market operations and to implement the initiatives needed to achieve the Renewable Ambition.

Response

Achieving the Renewable Ambition requires significant changes in how we plan, operate and develop the electricity transmission system and electricity markets. We believe that adequate resourcing of the TSOs in Ireland and Northern Ireland is central to achieving the Renewable Ambition.

The scale of the ambition requires a step change in delivery of many TSO functions in, Ireland and Northern Ireland, as we transform the power systems whilst ensuring that security of supply is maintained along the way. EirGrid and SONI have identified a number of improvements which are needed to supplement our existing team resources in terms of both numbers and levels of experience. These improvements are already underway as we add depth and experience to our delivery teams.

EirGrid and SONI, as regulated TSOs, will continue to evolve and develop plans in line with our license obligations ensuring that these plans are consistent with the relevant climate and policy objectives in each jurisdiction. These plans will be informed by the recommended activities contained within this report. Resourcing of such plans is achieved through defined regulatory frameworks in Ireland and Northern Ireland, designed to ensure that adequate allowances are provided in regard to operational and capital expenditure.

Long-term Security of Supply

Feedback

Some industry respondents stressed the importance of maintaining security of supply throughout the transition to 70% renewables by 2030. Long-term security of supply is viewed as critical for all electricity customers to economic activity and competitiveness.

Response

Maintaining security of supply and system stability throughout the power system transition is of paramount importance to both EirGrid and SONI. It is essential that the transition to 70% RES-E and to a net zero power system is achieved in an orderly fashion. Over the short-term, EirGrid and SONI will continue to maintain security of supply by planning and operating the transmission systems in line with our planning and operational standards. We will continue to identify and communicate the adequate levels of generation capacity required to meet growing demand in each jurisdiction whilst supporting SEMO in efficient operation of the markets that deliver such capacity.

Over time our planning and operational policies and standards must evolve to accommodate the transition - EirGrid and SONI will continue to engage and consult stakeholders as these changes are designed and implemented. The markets must evolve too so that the right technical capabilities are available when they are needed.

Security of supply also relies on the ability of the transmission network to reliably transport energy from generators to demand sources. EirGrid and SONI will work to identify the most appropriate network reinforcements required to maintain appropriate levels of network performance and reliability as the power system transitions whilst engaging with customers and stakeholders as projects progress through the respective grid development processes.

In Ireland there will be a generation adequacy challenge over the next number of years. EirGrid are collaborating with colleagues in CRU and DECC on an appropriate response. This is discussed in detailed in the security of supply chapter of this document.

Coordinated planning

Feedback

Some industry respondents commented that to achieve the Renewable Ambition, planning for the development of the transmission and distribution system must be coordinated between the TSO and DSO. Transmission reinforcement may result in additional distribution reinforcements to ensure system reliability.

Response

Close partnerships between the TSOs and DSO of Ireland and Northern Ireland will be required to achieve the Renewable Ambition. Such partnerships are embedded within the structure of the operational roadmap to 2030 as the four programme work streams are enclosed by a holistic TSO-DSO Partnership. This reflects our view that TSO-DSO interaction underpins all aspects of operations - a view formed by detailed scoping of the workstream plans, interaction with the DSOs and consultation feedback. With so much of the future generation and system service providers expected to be connected to the distribution system as the portfolio decentralises and diversifies, we will need to partner with the DSOs to ensure that the needs of both distribution and transmission systems, and ultimately the needs of consumers are met.

TSO-DSO collaboration is also an essential aspect of network planning in the context of the Renewable Ambition. Visibility of grid development needs and planned reinforcements on the distribution and transmission networks assists in coordinating the design and implementation of grid development projects. The transmission development plans in Ireland and Northern Ireland provide detailed information relating to transmission reinforcements that are progressing through the grid development processes in Ireland and Northern Ireland. EirGrid and SONI welcome all feedback in relation to draft versions of these documents which are produced on an annual basis. EirGrid and SONI also produce long-term planning scenarios for use in identifying the long-term development needs of the transmission networks in Ireland and Northern Ireland. EirGrid and SONI, consult on the assumptions and data used to develop these scenarios, known as Tomorrow's Energy Scenarios, and welcome feedback from a range of stakeholders including the DSOs.

The TSOs and DSO also work collaboratively to address needs associated with bulk supply points or transmission interface stations. Section 5.5 of this report discusses emerging transformer capacity needs at transmission interface stations in Dublin and EirGrid's commitment to work along with the DSO to address these needs through a process of detailed investigation.

TSO and DSO collaboration is integral to the operations and markets multi-year plan detailed in this Roadmap.

Stakeholder engagement

Feedback

Some industry respondents stated that ongoing cross-societal engagement will be required throughout the energy transition to ensure stakeholders are kept informed and continue to contribute to the implementation process.

Response

A core element of Shaping Our Electricity Future roadmap will be the ongoing engagement with all sectors of society as we deliver this programme over the next decade. Public acceptance must be at the heart of our approach to grid delivery in Ireland and Northern Ireland and critical to the success of the transformation. We also recognize that engagement should not be limited to those directly affected by grid development plans, and that every energy citizen should have opportunities to give their views on how EirGrid and SONI are contributing to delivery of the Renewable Ambition and the ultimate net zero ambition.

In response to the feedback on engagement, EirGrid and SONI are making community engagement and participation part of the core Shaping Our Electricity Future roadmap. EirGrid and SONI expect that industry will also continue to improve public engagement practices and take a whole of sector approach in building improved community relations.

Network infrastructure feedback and responses

A summary of feedback and responses relevant to network infrastructure is provided in this section.

Maximise the use of existing grid

Feedback

Many industry respondents stated their support for maximising the current grid infrastructure and the build out of the network and interconnectors to allow the maximum number of renewables to be connected to the power system. These initiatives are deemed essential to facilitate firm access for projects to progress from RESS auctions to energisation.

Response

EirGrid and SONI's commitments to maximising the use of the existing grid are set out in their respective 5 year plans[21] [22]. The goal of both TSOs is to achieve the required increase in renewables while minimizing the addition of new infrastructure. This can be achieved by increasing the capacity of existing infrastructure, or by using new technologies, depending on the requirements and circumstances in each case. EirGrid and SONI build new infrastructure only when this is the right solution, and will work with industry partners, technology innovators and with other transmission system operators to identify, research and trial possible innovations.

Non-wire alternative technologies

Feedback

Several industry respondents raised the possibility of using technologies such as synchronous condensers, dynamic line rating, series compensation, and longer duration storage options. Some industry respondents advised caution with using new non-wire technologies that are unproven in the field and where their potential impact on system reliability is uncertain.

Response

Achieving the Renewable Ambition is assisted by technologies which help provide stability to the system and/or reduce network constraints allowing the output of renewable generators to be increased. EirGrid and SONI recognize that a number of technologies can assist with this and have been exploring such technologies in recent years. EirGrid and SONI's technology toolbox provides a governance framework for the investigation of existing and new technologies and supports delivery of these technologies as validated grid solutions that can be used to address system needs. EirGrid's multi-year plan includes an initiative to revise the Technology Toolbox solution to ensure that it is suitable for enhanced network operation.

EirGrid and SONI's network analyses performed as part of SOEF have identified a number of candidate reinforcements using power flow controllers and dynamic line rating equipment whilst a number of series compensation projects are currently progressing through EirGrid's framework for grid development. Further to this, our studies also employ the use of synchronous condensers which provide inertia to the system helping with system stability. Our assumptions in relation to the use of synchronous condensers are informed by projects that are currently being developed by third parties. Long-duration storage battery energy storage systems are also assumed in the generation portfolio for SOEF capable of providing capacity, flexibility and reserve.

The Toolbox defines the Technology Readiness Levels (TRL) for each technology type as a means of determining suitability for deployment to the grid. Only technologies that are proven to work in its final form and under expected conditions qualify for widespread deployment to the grid, effectively mitigating any potential impacts to system stability or reliability.

21 EirGrid Group, Strategy 2020-25, 2019
22 SONI, Strategy 2020-25, 2020

Progression of existing and new grid projects

Feedback

Several industry respondents highlighted the need for a step change in pace in planning, approval, and implementation of existing and new infrastructure projects to achieve the Renewable Ambition.

Response

Between now and 2030 there needs to be a transformational step change in the volume of network reinforcements delivered across Ireland and Northern Ireland in order to support the Renewable Ambition in an efficient and effective manner. This is reflected in the quantity of reinforcement projects highlighted in the Roadmap.

A number of key strategic enablers have been identified as fundamental for network delivery within the required timeframes out to 2030. These have been identified based on a combination of project delivery experience and engagement with stakeholders and communities. This is the essence of the networks multi-year plan.

Underground cable

Feedback

Several industry respondents recommend the undergrounding of transmission cables where feasible to mitigate public acceptance risk and minimise environmental impact.

Response

EirGrid and SONI consider a range of technology options when examining potential solutions for a system need. These assessments are performed as part of the grid development processes in each jurisdiction. For complex projects a multi criteria assessment is performed to determine the best performing solution for a specific need. Each solution is assessed in terms of:

- Technical performance;
- Economic performance;
- Environmental impact;
- Society and social acceptability; and
- Deliverability.

By assessing a range of solutions against the criteria above it is possible to determine the best performing solution. If an underground cable is identified as the best performing solution for a specific system this solution will progress in the grid development process.

Long-term proactive planning

Feedback

Several industry respondents highlighted the need for robust long-term planning of network reinforcements. Given the scale of the transmission network projects needed to deliver the Renewable ambition, several industry respondents identified implementation of transmission infrastructure projects as the greatest challenge facing the Shaping Our Electricity Future initiative.

Response

The transformation of our energy system introduces many variables and uncertainties, particularly in the longer-term. EirGrid and SONI use scenario planning to help manage the risks of these uncertainties. Scenario planning allows a range of credible futures to be assessed and for the emerging needs associated with each scenario to be identified. Identifying emerging long-term needs is an important aspect of the grid development process in EirGrid and SONI and can inform us of the relative scale of grid development required for a given scenario. This information can help inform policy makers in regard to climate and energy policy development. The series of Tomorrow's Energy Scenarios[23] [24] publications provides more information in relation to EirGrid and SONI's scenario planning processes.

These scenarios formed the basis of the analysis for the Shaping Our Electricity Future consultation last spring. This Roadmap reflects the outcome of that consultation and charts activities required as part of a long-term network development plan.

Delivery of offshore wind in Northern Ireland

Feedback

Several industry respondents commented that the delivery of offshore wind capacity in Northern Ireland by 2030 was not feasible.

Response

The development approaches used in the SOEF consultation assumed that installed capacities of offshore wind in Northern Ireland would range between 350 MW and 700 MW by 2030. Our stakeholders felt that these assumptions are too optimistic and that the required legislative changes may not be in place in time to support delivery of the assumed levels of offshore wind capacity by 2030. In response to this feedback we have reduced our assumptions in relation to offshore wind to 100 MW by 2030.

23 EirGrid, Tomorrow's Energy Scenarios 2019 Ireland, 2019
24 SONI, Tomorrow's Energy Scenarios Northern Ireland 2020

Regional development

Feedback

Some industry respondents stated that the development of the grid should be spread across more regions to aid regional development rather than focused in the eastern part of the island.

Response

In Ireland, we have changed our assumptions in relation to the growth of large energy users with 300 MW connecting outside of Dublin and the Mid-East. Similarly, in Northern Ireland we have assumed that 15 MW of LEU demand will connect in Coolkeragh. These developments would provide a range of benefits, creating jobs in the regions whilst alleviating congestion on the transmission system thereby helping to minimize the need for grid reinforcements and helping to achieve the Renewable Ambition.

Some respondents welcomed growth of renewable generation in specific regions of Ireland stating that such developments can help create jobs and mitigate challenges associated with recent or planned closures of existing conventional generation stations. We have assumed that some of these regions will see growth in renewable generation capacities where there are existing connection applications and/or there is adequate transmission capacity. In Ireland, we have assumed that all successful community-based projects in the recent RESS 1 auction will connect. We have also provided commentary in this document in relation to the importance of community participation in the renewable transition in Ireland and Northern Ireland.

Northern Ireland Demand and Generation-Led approach

Feedback

Some industry respondents highlighted the benefits of a blended Demand and Generation-Led approach for Northern Ireland.

Responses

SONI has incorporated feedback related to the network development approaches in the final network analysis assumptions. This has been achieved by incorporating aspects of each in the final network development approach assumed. Support for the Developer-Led approach is reflected in the assumed renewable generation portfolio with an additional 1,000 MW of onshore wind and an additional 500 MW of grid scale solar PV connecting by 2030. We have assumed 100 MW of offshore wind will connect in response to Generation-Led support and support for the demand-led approach has led to changes in our demand locations with 15 MW of LEU demand assumed to connect in Coolkeragh by 2030. We have included reinforcements using dynamic line rating in two locations in response to support for the Technology-Led approach.

System outages to accommodate reinforcements

Feedback

Some industry respondents questioned the operational impacts of outages needed to implement transmission system reinforcements.

Responses

EirGrid and SONI recognise that the scale and quantity of network reinforcements needed to achieve the Renewable Ambition will increase challenges related to management of planned outages and gaining access to the transmission network to perform works. The increased demand for reinforcement outages must be managed along with demands for maintenance driven outages. This will be especially challenging in Ireland, and EirGrid have developed initiatives to review existing transmission outage procedures and to develop an outage transformation programme to be delivered by 2023. EirGrid will work closely with the DSO and TAO to design and implement this programme ensuring that the operational security of the transmission and distribution systems are maintained. Work in this space is specifically called out in the Networks multi-year plan.

System operations feedback and responses

In order to deliver on government renewable energy policies, it will be necessary to accommodate unprecedented penetrations of variable non-synchronous RES such as offshore wind, onshore wind, and solar, whilst keeping curtailment levels to a minimum. This will require a significant evolution of the operation of the power system and for EirGrid and SONI to deal with unique challenges that will not be faced in larger power systems for years to come.

We have used all feedback received through this consultation to refine and improve our proposed system operations programme of work. In the following sections, we have described some of the key themes arising in the stakeholder feedback and our response to the feedback.

2030 Ambition (Min Gen and SNSP)

Feedback

Several stakeholder responses suggested that the system operational policy targets for 2030 should be more ambitious. The main suggestions focused on increasing SNSP to 100% and reducing the minimum number of fossil fuel based synchronous units on the all-island power system to zero by 2030.

Response

The target of 95% SNSP set out in the consultation will see the all-island power system operating at higher SNSP levels than any other synchronous power system in the world. This 95% SNSP limit will be a key enabler for the electricity sector to achieve 70% RES-E by 2030 as per current government targets.

The target for the minimum number of units limit in 2030 has not yet been determined. There will be a decrease on today's limit of 8 units, with the intention to start in 2022 with a trial of 7 units. However, it is likely that there will still be a need to operate the system with some large conventional units online for system stability and system security reasons in 2030. Reductions in the minimum number of units limit have a significant impact on system operation and must be done in a controlled and prudent manner. As highlighted in several consultation responses, system security must be maintained throughout the transition to 2030 and it may not be possible to reduce the minimum number of units to zero by 2030 while maintaining a stable and secure system. The Operational Policy workstream plan (within the System Operations programme of work) outlines the analysis and operational policy change plan to achieve our 2030 targets.

Grid forming

Feedback

A few consultation responses highlighted the potential of grid forming technology to support system stability and provide system restoration capability. The utilisation of wind generation, batteries and STATCOMs as possible sources of emulated inertia was highlighted along with the potential of these technologies to provide black start capabilities.

Response

Grid forming technology has significant potential from system stability and system restoration perspectives. However, to date the technology is relatively immature and further experience with the technology is needed before it can be adopted more widely as a source of system stability or system restoration.

Through our participation in the Global Power System Transformation initiative (of which we are a founding member), we are working very closely with other leading TSOs and research institutes to assess the needs of a future power system dominated by inverter-based resources, the models and tools needed to plan and operate such a system, and the potential role that grid forming technology can play. In addition, EirGrid is a member of an ENTSO-E Task Force on Strategic Implementation of Grid Forming Capabilities which aims to assess options for incorporating grid forming capabilities into European Grid Codes (RfG and HVDC NC) taking into consideration a range of different relevant aspects.

The Technology Enablement workstream (within the System Operations programme of work) will support the development, testing and integration of new technologies, such as grid forming technologies, onto the all-island power system.

Hydrogen

Feedback

A number of consultation responses highlighted the potential benefits of hydrogen technology as a renewable fuel for gas fired generation and also as a source of energy storage. The potential to mix hydrogen with natural gas as an interim measure before transitioning to 100% hydrogen fuel was highlighted. The ability of hydrogen to store excess energy generated at wind and solar farm sites, via electrolysis, was also highlighted.

Response

The use of hydrogen as a fuel source for gas fired power stations has the potential to increase RES-E on the all-island power system. From a system operations point of view, provided there is no material change in the operation of the gas fired power stations due to the use of hydrogen, this development would be welcomed. Where material changes to the operation of the gas fired power stations are needed, the Technology Enablement workstream in the Operations Pathway to 2030 Program will support the development, testing and integration of new technologies onto the all-island power system.

The use of hydrogen as a localised source of energy storage at wind and solar farm sites has potential benefits for both dispatch down and system security. However, to date the technology is relatively immature and further experience with the technology is needed before it can be adopted more widely on the all-island power system. The Technology Enablement workstream (within the Operations programme of work) will support the development, testing and integration of new technologies, such as hydrogen technology, onto the all-island power system.

Non-wire technologies

Feedback

A number of consultation responses highlighted the potential benefit of non-wire technologies to assist with the transition to 2030. Dynamic line rating, series compensation and long duration storage were all called out as having potential benefits.

Response

We recognise and agree with the potential benefits of non-wire solutions. We have committed to utilising the existing infrastructure on the all-island power system in the most effective way in order to minimise the development of new infrastructure where possible. Dynamic line rating, series compensation and long duration storage are all technology areas which we see potential in for supporting the transition to 70% RES-E. Further, these technologies contribute to increased utilisation of existing infrastructure which is a key focus of the Shaping Our Electricity Future Programme.

'Technology Toolbox' projects have been identified as part of the Networks plan of work. We have also included a task in the Operational Tools workstream plan (which is part of the System Operations programme of work) related to the integration of these new technologies into our operational systems as they arrive.

Synchronous condensers

Feedback

A number of consultation responses highlighted the potential benefits of synchronous condensers with their ability to provide inertia, reactive power and fault current. The ability of synchronous condensers to assist with the reduction in the minimum level of conventional generation required on the system and their potential economic benefit to the system as a whole was also highlighted.

Response

As per the SEMC SEM-21-021 System Services Future Arrangements - Decision Paper EirGrid Group has been asked to assess the potential benefit of 'zero carbon sources of inertia' on the all-island power system. Synchronous condensers would meet the criteria for a 'zero carbon source of inertia' and these types of devices have the potential to be of significant benefit to the transition to 2030.

Under our Standards and Services workstream plan (within the System Operations programme) we have set out a high-level plan of work to develop the technical requirements and commercial arrangements that would enable procurement of such devices.

Storage

Feedback

A number of consultation responses highlighted the potential benefits of energy storage systems for system security and generation adequacy. The utilisation of energy storage at variable renewable generation sites was mentioned as a potential method of reducing dispatch down at these sites. This stored energy could then be used at times of low variable generation to support generation adequacy.

Response

The use of energy storage has potential benefits for dispatch down, system security and generation adequacy. Energy storage is currently being utilised on the all-island power system primarily through the use of batteries as energy storage power stations. The Technology Enablement workstream (within the System Operations programme of work) will support the development, testing and integration of future sources of energy storage onto the all-island power system.

Renewable generation forecasting

Feedback

A number of consultation responses highlighted the importance of renewable generation forecasts. Improved renewable generation forecasts can reduce the level of reserve services which need to be maintained by conventional units and can increase the level of renewable penetration on the all-island power system.

Response

As the installed capacity of renewable generation on the all-island power system increases, the magnitude of renewable generation forecast errors will also increase. This creates challenges from a reserve provision and generation adequacy perspective. The TSOs are aware of this challenge and are taking proactive steps to address it. The introduction of the interim ramping tool in the EirGrid and SONI control centres in 2020 has provided the TSOs with increased visibility of potential forecast errors and ensures that sufficient generation capacity is maintained to manage potential forecast errors. A new enduring ramping tool will be in place by the end of 2021 and will support this effort further. The TSOs are also focusing on other aspects of renewable generation forecasting, one example of this is the recent procurement of small-scale unit forecasts from our forecasting vendors along with utility scale forecasts. The TSOs will continue to work with industry and other TSOs around the world to refine our renewable forecasting processes.

Development of our forecasting capability is envisaged under the Operational Tools workstream (within the System Operations plan of work), specifically as part of our Control Centre of the Future development plan.

Pace of change

Feedback

A number of consultation responses suggested increasing the pace of change on the all-island power system beyond what is envisioned in the consultation. The quicker changes are made, the greater potential benefits there are from a renewable generation point of view.

Response

There are a significant number of changes to the operation of the all-island power system planned over the coming years. The Operational Policy workstream (within the System Operations programme of work) sets out the main milestone changes to operation policy, particularly SNSP changes. We consider these milestones to be ambitious but achievable targets given the considerable programme of work required to achieve them. In delivering these changes we must ensure that system security is maintained. The importance of securely transitioning to 2030 was also highlighted in a number of consultation responses and in our view is a key factor in prudently setting the pace of change.

Electricity markets feedback and responses

The current market structures were designed to facilitate trading of electricity and system services and to provide investment signals based primarily on concepts developed for generation fleet that was predominantly conventional fossil fuel. The market review seeks to consider how best to evolve the market construct for wholesale electricity, capacity, system services, and related investment drivers to accommodate high levels of renewable penetration while maintaining power system security and reliability.

A summary of feedback and responses relevant to Electricity Markets is provided in this section.

Holistic market design

Feedback

Many respondents agreed that a more holistic approach to market design is required to deliver the correct incentives and system changes to achieve 2030 targets, with many highlighting that if a holistic approach was not taken that inefficiencies could occur, and investment signals would be weakened.

Response

We welcome this feedback and aim to ensure that all market design changes are considered and applied in a holistic manner.

Concepts of alignment, clarity, and commitment

Feedback

Many respondents agreed that alignment between the markets is critical and that transparency and clarity on revenue opportunities, incentives, penalties and risk levels will be critical to ensure investment is possible and delivered in an economic affordable manner. Furthermore, respondents did agree that financial commitment was a necessary requirement to long-term investment particularly as it related to risks outside their control including oversupply, constraint and curtailment.

Response

We welcome the responses received and have proposed workstreams in this document that aim to ensure that any market reforms achieve these concepts of alignment, clarity and commitment.

Alignment with operations

Feedback

Several industry respondents have responded negatively to the suggestions of ensuring alignment between market schedules and operational requirements and have interpreted this as a proposal to introduce an SNSP limitation in the ex-ante markets in relation to the implementation of Articles 12 and 13 of CEP EU Regulation 2019/943. Other industry respondents supported this proposal. The majority of respondents highlighted that progress on this issue in terms of a final solution and implementation needs to be prioritised to ensure clarity for investors.

More widely some respondents have stated that changes to market systems that undermine investor confidence and certainty of income may lead to overall increased cost and lack of investment in the necessary technologies to achieve the transition. Other respondents have indicated that it will be critical to publish in the final roadmap a plan for the delivery of key market interfaces, which will allow all generation/demand actors to be able to fully participate within the market.

Response

We did not propose as part of the consultation any specific measures to aligning power system operations at high RES with electricity market design. However, we recognize that separately our response to a SEMC consultation on Article 13 does highlight a specific proposal on capping ex-ante markets to SNSP. We believe respondents to this consultation included their objections to that proposal.

We recognize that any approvals for specific proposals in these matters require extensive industry and regulatory engagements. Many industry respondents do not consider an operational limit on the non-synchronous generation appropriate. We respect these views but are concerned that if not appropriately managed there will not only be inefficiencies in the energy market (DBC increases would likely outweigh the reduction in ex ante energy market costs) but that other costs including higher RES support costs, Article 13 compensation, System Services inefficiencies will increase. Our analysis on these impacts has estimated that these additional costs to consumers could be as high as €2.5 billion over the decade which would be unlikely to be offset by any reduction in RESS bid prices. We consider that these additional costs need to be factored into any long-term solution in these matters. We look forward to engaging with the industry and Regulatory Authorities further on the solution to these challenges in the coming months. Our programme of work allows for this engagement in the Scheduling and Dispatch workstream.

More widely we recognize the need to prepare significant changes to market systems and processes to allow for full alignment between our markets and those of the EU markets in time for re-integration to EU balancing, intraday and day- ahead markets and have outlined work in this regard in the roadmap.

Capacity market review

Feedback

Many industry respondents provided views on the current capacity market design, with some supporting changes to provide better incentives and investment signals for renewable resources. Some respondents have indicated that the capacity market needs to evolve quickly and in a manner that incentivises and rewards low carbon generation, including supporting the change to the Cost of New Entrant (NET CONE) plant and enabling the market as a whole to align with the 2030 carbon budgets and eventual 2050 net zero objectives. Several respondents highlighted their concerns on the emerging security of supply issues and indicated that the capacity market is not delivering given the current situation and requested urgent changes to the capacity market to help address this.

Response

The Roadmap assumes minor changes to the Capacity Market in the next 2 years, with a more fundamental review to occur before the state aid approval of the current regime expires at the end of 2027. However, we recognise that there is an increasing risk of supply adequacy shortfalls on the Ireland power system this winter and these shortfalls are forecasted to increase through 2025/2026 as generation plant retires and demand increases. An additional section on Security of Supply, has been included in this Roadmap in response to this feedback.

Any proposed changes to the capacity market design are subject to Regulatory Authority approval. EirGrid and SONI will continue to work closely with our industry stakeholders and the regulators to identify and progress the design changes needed to ensure the capacity market delivers efficient outcomes.

System services update

Feedback

Several industry respondents commented on the expanded role for system services and the need for electricity market design changes and incentives to ensure delivery of system services to balance high levels of renewables. Many see this as an important investment driver and necessary to achieve the Renewable ambition. There was a high level of support for the need to increase system services and respondents requested clarification on the pace of implementation to allow them to plan their investment strategies. There was some specific feedback on product design including whether there is a need for negative reserve products.

Response

We are pleased to confirm the almost unanimous agreement from respondents that the evolution of system services is critical to achieving the Renewable Ambition. We actively urge all interested respondents to partake in the high-level consultation on system services that the SEMC is currently undertaking. We look forward to engaging with industry on these matters in the coming months, including aspects of product design.

Network tariff review

Feedback

Some industry respondents recommend a review and redesign of network tariffs to better reflect charges for use of system.

Response

On consideration we think there is merit to the issues surrounding network tariffs and recommend a review of these as part of the Roadmap.

Investor risks outside their control

Feedback

Many respondents raised their concern that on top of the risks that we had identified outside their control of oversupply, constraints and curtailment that there were also TUoS charges and Transmission Adjustment Loss Factors (TLAF). Specifically, Network tariff locational signals have been suggested as only relevant up to the point of operation and should be fixed afterwards for a period of time. Industry believe that existing generators cannot react to these after they have built. Some respondents commented that an element of cap and floor may be appropriate to mitigate this risk.

Response

On consideration we think there is merit to the issues surrounding the relative volatility of the current locational signals resulting from TLAFs and have recommended a review of these as part of the Roadmap

With respect to the long-term changes that evolve through TUoS charges we do not consider these are, or should be, considered a barrier to investment nor fixed or made invariant in the long-term. TUoS is a cost of doing business in the SEM environment and have adequate controls to ensure the costs to the consumers are balanced and efficient. The proportionate and appropriate allocation of TUoS is the responsibility of the Regulatory Authorities and we will continue to provide input into their oversight process

Remove market barriers

Feedback

Some industry respondents recommend that the electricity market design needs to be enhanced to eliminate any barriers to new technologies entering the market. In particular Demand Side Units (DSUs) have raised many issues relating to energy market payments in the capacity market.

Response

We are fully supportive of identifying and removing barriers to new technologies that can support the Renewable Ambition. These barriers are two-fold; the technical modalities to effectively operate these new technologies on the system and the financial incentives needed to appropriately compensate them.

On the technical modalities we have a detailed section in the Operations section of the RoadMap that deals directly to these barriers and we are working closely with our distribution system operators to mitigate these issues. On the financial incentives we consider aligning the markets to the operational challenges of high RES world will need to consider all these barriers and propose principled but pragmatic solutions on these matters. We look forward to engaging with the industry and regulators on these matters in the coming months.

Markets supporting renewable gas and hydrogen

Feedback

Some industry respondents have recommended that new conventional generation should be renewable gas and hydrogen ready. Others have suggested the carbon cost of market (energy and non-energy) actions and aligning market design to deliver on national carbon budgets to ensure that the power system can decarbonise in time support of other sectors such as decarbonisation of transport and heat through electrification.

Response

EirGrid and SONI are engaging with other stakeholders across other industry sectors, including Gas TSOs, Government Departments, ENTSO-E and Regulatory Authorities to ensure that there is a coordinated and holistic approach to decarbonisation across industry sectors.

The direction of future energy, climate and economic development policy will directly influence our approach to power system operations and market design. To the extent emerging policy drives the adoption of renewable gas and hydrogen, we will monitor progress and adapt our approach accordingly.

Appendix 3 - Candidate Reinforcements

Table 41: Reinforcements in Ireland and Northern Ireland

No.	Component	Voltage (kV)	Path	Domain	Class	Region
1	Mid Antrim Upgrade	110	New	Circuit	HVAC	Northern Ireland
2	Coolkeeragh - Strabane 110 kV circuit 1	110	Uprate	Circuit	HVAC	Northern Ireland
3	Coolkeeragh - Killymallaght 110 kV circuit 1	110	Uprate	Circuit	HVAC	Northern Ireland
4	Coolkeeragh - Limavady 110 kV circuit 1	110	Uprate	Circuit	HVAC	Northern Ireland
5	Omagh - Strabane 110 kV circuit 2	110	Uprate	Circuit	HVAC	Northern Ireland
6	Drumnakelly - Tamnamore 110 kV circuit 2	110	Uprate	Circuit	HVAC	Northern Ireland
7	Coleraine - Coolkeeragh 110 kV circuit 1	110	Uprate	Circuit	HVAC	Northern Ireland
8	Mid-Tyrone Project	275	New	Circuit	HVAC	Northern Ireland
9	Bandon - Dunmanway 110 kV circuit 1	110	Uprate	Circuit	HVAC	South-West
10	Athy - Carlow 110 kV circuit 1	110	Uprate	Circuit	HVAC	South-East
11	Rinawade - Dunfirth Tee 110 kV circuit 1	110	Uprate	Circuit	HVAC	Mid-East
12	Drybridge - Louth 110 kV circuit 1	110	Uprate	Circuit	HVAC	Mid-East
13	Maynooth - Timahoe 110 kV circuit 1	110	Uprate	Circuit	HVAC	Mid-East
14	Maynooth - Rinawade 110 kV circuit 1	110	Uprate	Circuit	HVAC	Mid-East
15	Galway - Salthill 110 kV circuit 1	110	Uprate	Circuit	HVAC	West
16	Inchicore - Carrickmines 220 kV circuit 1	220	New	Circuit	HVAC	Dublin
17	Poolbeg - Carrickmines 220 kV circuit 1	220	Uprate	Circuit	HVAC	Dublin
18	Finglas - North Wall 220 kV circuit 1	220	Uprate	Circuit	HVAC	Dublin
19	Poolbeg South - Inchicore 220 kV circuit 1	220	Uprate	Circuit	HVAC	Dublin
20	Poolbeg South - Inchicore 220 kV circuit 2	220	Uprate	Circuit	HVAC	Dublin
21	North Wall - Poolbeg 220 kV circuit 1	220	Uprate	Circuit	HVAC	Dublin
22	Louth - Oriel 220 kV circuit 1	220	Uprate	Circuit	HVAC	Mid-East
23	Woodland - Oriel 220 kV circuit 1	220	Uprate	Circuit	HVAC	Mid-East
24	Great Island - Kellis 220 kV circuit 1	220	Uprate	Circuit	HVAC	South-East
25	Arklow - Ballybeg - Carrickmines 220 kV circuit 1	220	Upvoltage	Circuit	HVAC	South-East
26	Killoteran - Waterford 110 kV circuit 1	110	Uprate	Circuit	HVAC	South-East
27	Athlone - Lanesboro 110 kV circuit 1	110	Uprate	Circuit	HVAC	Midlands
28	Woodland - Finglas 400 kV cable cct	400	New	Circuit	HVAC	Dublin
29	Kilteel - Maynooth 110 kV circuit 1	110	Uprate	Circuit	HVAC	Mid-East
30	Baroda - Monread 110 kV circuit 1	110	Uprate	Circuit	HVAC	Mid-East
31	Drumkeen - Clogher 110 kV circuit 1	110	Uprate	Circuit	HVAC	North-West
32	Flagford – Sliabh Bawn – Lanesboro 110 kV lines	110	New	Static device (PFC)	HVAC	Midlands
33	Sligo – Srananagh – Corderry 110 kV lines	110	New	Static device (PFC)	HVAC	North-West
34	Letterkenny – Tievebrack - Binbane 110kV lines	110	New	Static device (PFC)	HVAC	North-West
35	Letterkenny – Cathaleen's or Letterkenny – Clogher 110 kV lines	110	New	Static device (PFC)	HVAC	North-West
36	Killonan – Knockraha 220kV line	220	New	Static device (PFC)	HVAC	South-West
37	Clashavoon – Knockraha or Cullenagh – Knockraha 220 kV lines	220	New	Static device (PFC)	HVAC	South-West
38	Baroda - Newbridge 110 kV circuit 1	110	New	Static device (DLR)	HVAC	Mid-East
39	Bellacorrick - Castlebar 110 kV circuit 1	110	New	Static device (DLR)	HVAC	West
40	Cashla - Dalton 110 kV circuit 1	110	New	Static device (DLR)	HVAC	West
41	Cathaleen's Fall - Coraclassy 110 kV circuit 1	110	New	Static device (DLR)	HVAC	North-West
42	Cushaling - Newbridge 110 kV circuit 1	110	New	Static device (DLR)	HVAC	Mid-East
43	Binbane - Clogher - Cathaleen's Fall - 110 kV Clogher tie in	110	New	Circuit	HVAC	North-West
44	Clogher - Srananagh 220 kV circuit 1	220	New	Circuit	HVAC	North-West
45	Magherakeel - Omagh circuit 1	110	New	Static device (DLR)	HVAC	Northern Ireland
46	Curraghmulkin - Dromore circuit 1	110	New	Static device (DLR)	HVAC	Northern Ireland
47	North West of NI 110 kV reinforcement	110	New	Circuit	HVAC	Northern Ireland
48	Great Island 220/110 kV transformer No.3	220/110	New	Transformer	HVAC	South-East
49	Knockraha - Cahir 110 kV circuit 1	110	Uprate	Circuit	HVAC	South-West
50	Flagford - Srananagh 110 kV circuit 1	110	Upvoltage	Circuit	HVAC	North-West
51	Sligo - Srananagh 110 kV circuit 3	110	Uprate	Circuit	HVAC	North-West
52	Drumnakelly - Tamnamore 110 kV circuit 1	110	Uprate	Circuit	HVAC	Northern Ireland

Appendix 4 - Base Case Reinforcements

Table 42: Reinforcements that are scheduled to complete by 2030. These reinforcements have been modelled in the 2030 base case models used for studies in this document

No.	Component	CP	Voltage (kV)	Path	Domain	Class	Type	Region
1	Dunstown Series Capacitor	CP0968	400	New	Static device	HVAC	Series Capacitor	Dublin
2	North South 400 kV Interconnector - RoI	CP0466	400	New	Circuit	HVAC	OHL	North-East
3	Oldstreet Series Capacitor	CP0969	400	New	Static device	HVAC	Series Capacitor	North-West
4	Galway Station Redevelopment Project	CP0871	110	Uprate	Station	HVAC	GIS	North-West
5	North Connacht 110 kV Project	CP0816	110	New	Circuit	HVAC	Cable	North-West
6	Lanesboro Station Redevelopment Project	CP0919	110	Uprate	Station	HVAC	GIS	North-West
7	Cashla - Salthill circuit 1	CP1168	110	Uprate	Circuit	HVAC	OHL	North-West
8	Castlebar 110 kV station busbar	CP0771	110	Uprate	Station	HVAC	Busbar	North-West
9	Castlebar-Cloon circuit 1	CP0848	110	Uprate	Circuit	HVAC	OHL	North-West
10	Corderry - Srananagh circuit 1	CP0942	110	Uprate	Circuit	HVAC	OHL	North-West
11	Moy 110 kV Station reconfiguration and busbar uprate	CP0839	110	Uprate	Station	HVAC	Busbar	North-West
12	North South 400 kV Interconnector - NI	CP0884	400	New	Circuit	HVAC	OHL	Northern Ireland
13	Coolnabacky Station – New Station & Associated Lines & Station Works	CP0585	400	New	Station	HVAC	GIS	South-East
14	Great Island - Kilkenny circuit 1	CP0945	110	Uprate	Circuit	HVAC	OHL	South-East
15	Coolnabacky - Portlaoise circuit 1	CP0835	110	Uprate	Circuit	HVAC	OHL	South-East
16	Moneypoint Series Capacitor	CP0967	400	New	Static device	HVAC	Series Capacitor	South-West
17	Ballyvouskill 220/110 kV Station - Statcom	CP0935	220	New	Static device	HVAC	Static Compensator	South-West
18	Ballyvouskill - Ballynahula - Knockanure	CP0883	220	Uprate	Circuit	HVAC	OHL	South-West
19	Thurles Station - Statcom	CP0933	110	New	Static device	HVAC	Static Compensator	South-West
20	Ballynahulla Station - Statcom	CP0934	220	New	Static device	HVAC	Static Compensator	South-West
21	Aghada Station Busbar Reconfiguration	CP0794	220	Uprate	Station	HVAC	Busbar	South-West
22	Kilpaddoge - Knockanure cable	CP0726	220	New	Circuit	HVAC	Cable	South-West
23	Kilbarry GIS Station	CP0949	110	New	Station	HVAC	GIS	South-West
24	Distributed Series Reactors Project (Nationwide)	CP0990	110	New	Static device	HVAC	Series Reactors	Various
25	Knockraha Short Circuit Rating Mitigation	CP0973	220	Uprate	Station	HVAC	Protection	South-West
26	Clashavoon - Tarbert circuit 1	CP0763	220	Uprate	Circuit	HVAC	OHL	South-West
27	Knockraha station installation of additional couplers	CP0796	220	Uprate	Station	HVAC	AIS	South-West
28	Clashavoon - Macroom No. 1 & associated station works & 250 MVA transformer	CP0829	110	New	Circuit	HVAC	Cable	South-West
29	Knockanure Reactor	CP0936	220	New	Static device	HVAC	Reactor	South-West
30	Kildare-Meath 400 kV Grid Upgrade Project	CP0966	400	New	Circuit	HVAC	UGC	Mid-East
31	Kilpaddoge – Moneypoint 400 kV Project (Cross Shannon)	CP0970	400	New	Circuit	HVAC	UGC	South-West / Mid-West
32	Flagford - Sliabh Bawn circuit 1	CP0817	110	Uprate	Circuit	HVAC	OHL	North-West
33	Lanesboro - Sliabh Bawn circuit 1	CP1078	110	Uprate	Circuit	HVAC	OHL	North-West
34	Binbane - Cathaleen's Fall circuit 1	CP1079	110	Uprate	Circuit	HVAC	OHL	North-West
35	Arva - Carrick On Shannon circuit 1	CP0841	110	Uprate	Circuit	HVAC	OHL	North-West
36	Crane - Wexford circuit 1	CP1172	110	Uprate	Circuit	HVAC	OHL	South-East
37	Lanesboro - Mullingar circuit 1	CP1000	110	Uprate	Circuit	HVAC	OHL	North-West
38	Dalton busbar	CP0907	110	Uprate	Station	HVAC	Busbar	Midlands
39	Letterkenny busbar	CP1023	110	Uprate	Station	HVAC	Busbar	North-West
40	Moy - Glenree circuit 1	CP1155	110	Uprate	Circuit	HVAC	OHL	North-West
41	Derryiron - Kinnegad circuit 1	CP1144	110	Uprate	Circuit	HVAC	OHL	Dublin and Mid-East
42	Ballylumford - Eden 110 kV Circuit Uprate	CP1028	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
43	Coolkeeragh - Magherafelt 275 kV Circuits Refurbishment	n/a	275	Uprate	Circuit	HVAC	OHL	Northern Ireland
44	Omagh Main - Dromore Uprate	CP0993	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
45	Agivey 110/33 kV Cluster	CP1010	110	New	Substation	HVAC	AIS	Northern Ireland
46	Kells 110/33 kV Cluster	CP1033	110	New	Substation	HVAC	AIS	Northern Ireland
47	Reactive power support at Castlereagh, Tamnamore and Tandragee	CP1066	110	New	Static device	HVAC	Reactor	Northern Ireland
48	Gort second transformer	CP1098	110	New	Static device	HVAC	Transformer	Northern Ireland

Appendix 5 - Regional Data

This section outlines the assumptions regarding where generation technologies may connect by 2030. We have used the regions shown in Figure 28 to report installed capacities at the point of connection to the transmission grid for different technology types.

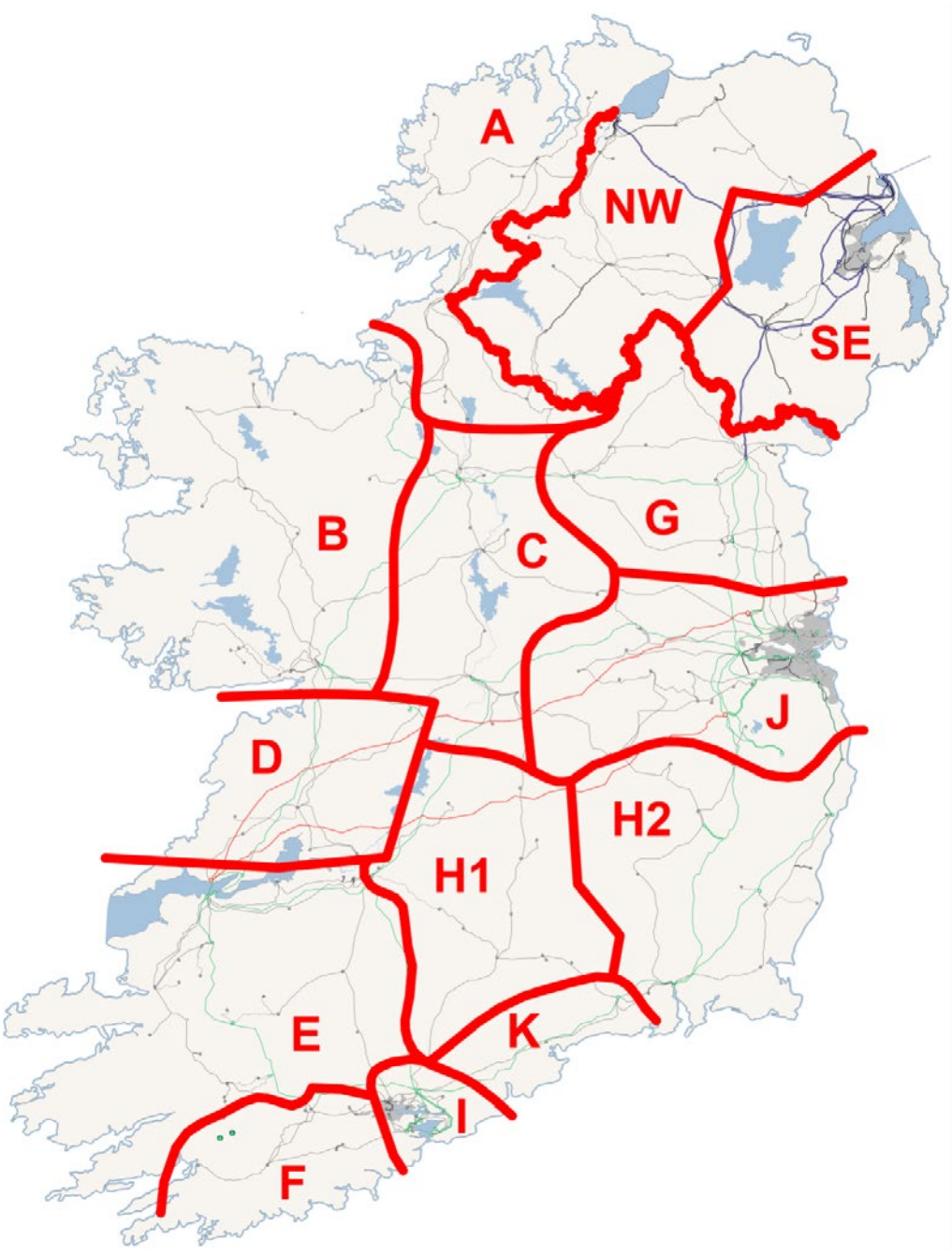


Figure 28: Study areas

Table 43: Table of RES source totals on a per area basis

Area	Onshore Wind (MW)	Offshore Wind (MW)	Solar (MW)
IE AREA A	820	0	140
IE AREA B	890	390	60
IE AREA C	190	0	70
IE AREA D	310	0	30
IE AREA E	1,520	0	80
IE AREA F	210	0	20
IE AREA G	240	370	160
IE AREA H1	550	0	90
IE AREA H2	430	990	300
IE AREA I	2	350	90
IE AREA J	480	2,900	410
IE AREA K	60	0	50
IE TOTAL	**5,700**	**5,000**	**1,500**
NI AREA NW	340	100	450
NI AREA SE	2,110	0	150
NI TOTAL	**2,450**	**100**	**600**

Table 44: Table of non-RES source totals on a per area basis

Area	Gas (MW)	Distillate (MW)	Battery (MW)	Pumped Storage (MW)	Hydro (MW)	Interconnection (MW)	Bio, CHP, Waste, Other Non-RES (MW)
IE AREA A	0	0	105	0	70	0	0
IE AREA B	0	100	120	0	0	0	0
IE AREA C	400	0	520	0	0	0	5
IE AREA D	700	0	0	0	90	0	0
IE AREA E	160	0	80	0	30	0	10
IE AREA F	0	0	0	0	0	0	5
IE AREA G	150	0	150	0	0	0	30
IE AREA H1	0	0	0	0	0	0	0
IE AREA H2	430	0	130	0	0	500	10
IE AREA I	1,360	0	180	0	0	700	2
IE AREA J	2,600	200	415	300	40	500	95
IE AREA K	0	0	0	0	0	0	2
IE TOTAL	**5,800**	**300**	**1,700**	**300**	**230**	**1,700**	**160**
NI AREA SE	1,470	250	250	0	3	450	75
NI AREA NW	430	0	50	0	4	0	55
NI TOTAL	**1,900**	**250**	**300**	**0**	**7**	**450**	**130**

The Oval, 160 Shelbourne Road,
Ballsbridge, Dublin D04 FW28
Tel: +353 (0)1 677 1700
www.eirgrid.com

Castlereagh House, 12 Manse Road,
Belfast BT6 9RT
Tel: +44 (0)28 9079 4336
www.soni.ltd.uk

Printed on recycled paper