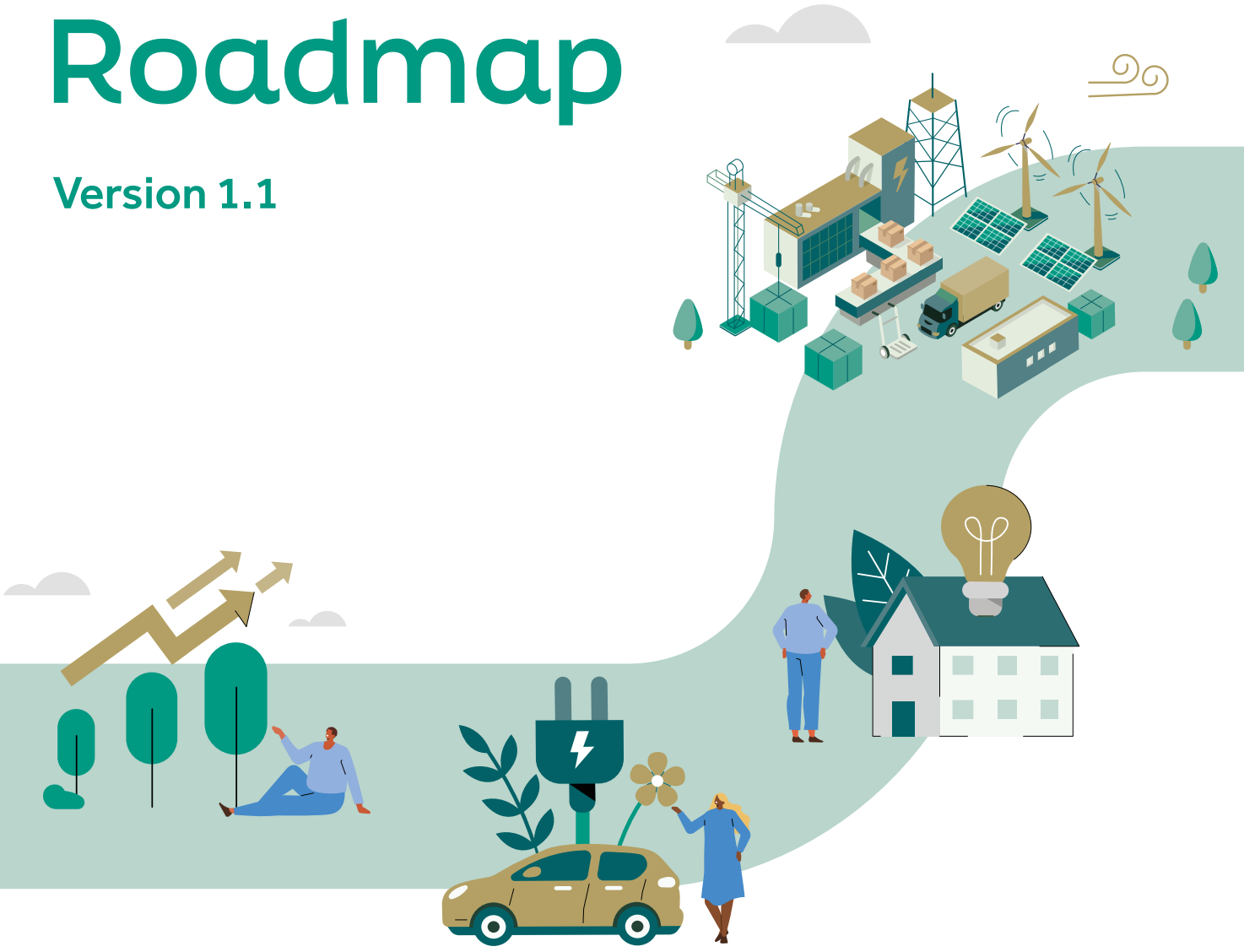
Shaping Our Electricity Future Roadmap

Version 1.1



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1. Executive summary

EirGrid operates and develops the electricity transmission system in Ireland and, more recently, has been mandated to operate, develop and own Ireland's offshore grid. SONI has responsibility for planning the development of the onshore electricity system in Northern Ireland.

We operate, implement changes and enhance the wholesale electricity market on the island of Ireland. EirGrid also develop and operate interconnections with neighbouring grids and enables third-party interconnectors. We send power from where it is generated to where it is needed.

1.1 Key messages

1. **As electricity can be generated and transmitted without carbon emissions, it will play a crucial role in our response to climate change.** The growth in clean electricity from low carbon and renewable sources will require a decade of change to the electricity system. The Ireland and Northern Ireland governments have asked EirGrid and SONI to develop a Roadmap to capture their elements of that challenge.

2. **This revised Roadmap, Shaping Our Electricity Future Version 1.1, builds on the original Roadmap** launched in November 2021 and outlines a pathway towards meeting enhanced 2030 government electricity ambitions in Ireland and Northern Ireland. It aims to do this in a manner which balances technical considerations, cost implications, environmental impacts, social acceptance, and deliverability. It also provides a foundation to support the broader transition to net zero by 2050.

3. **The scale of the challenge is without precedent. Whilst EirGrid and SONI have an important role to play, the entire electricity ecosystem also needs to deliver.**

   This includes but is not limited to:

   - Overarching, government led support on the need for the energy transition and visible support and enabling policy for the delivery of challenging infrastructure.
   - Delivery of renewable and conventional generation, and system services from new technologies in the context of a challenging supply chain environment.
   - Delivery of enabling solutions such as sources of system flexibility, demand side management, long duration storage, low carbon technologies amongst others.
   - Delivery of additional interconnection, to enhance system security at times of low output from renewable generation whilst also maximising the export potential when the output from renewable generation is higher than the demand for electricity in Ireland and Northern Ireland.
   - Planning decisions being made by the relevant consenting authorities in a timely manner.
   - Regulatory decisions and securement of funding and investment from regulators being made in both a timely fashion and a manner which incentivises investment in the sector.
   - Availability of the road network for the routing of underground cable infrastructure.

- Developers of new generation capacity and new demand responding to network availability when planning new connections to the system.
- In Ireland, developers working in partnership with the System Operators to develop renewable hubs in areas of the grid with realisable capacity by 2030.
- Evolution of the wholesale Single Electricity Market (SEM) by the SEM Committee in line with recommendations from EirGrid and SONI.
- Securing broad based understanding and support across the population in every county in Ireland and Northern Ireland for all elements of the energy transition.

4. **In Ireland, the ambitious sectoral carbon budget for the electricity sector presents a new and additional challenge and complexity for delivery.** Collectively, the power sector is no longer aiming to achieve an end of decade target, but now must also do so within prescribed carbon allowances across five-year blocks. The speed of roll-out and delivery of identified change is key across the decade.

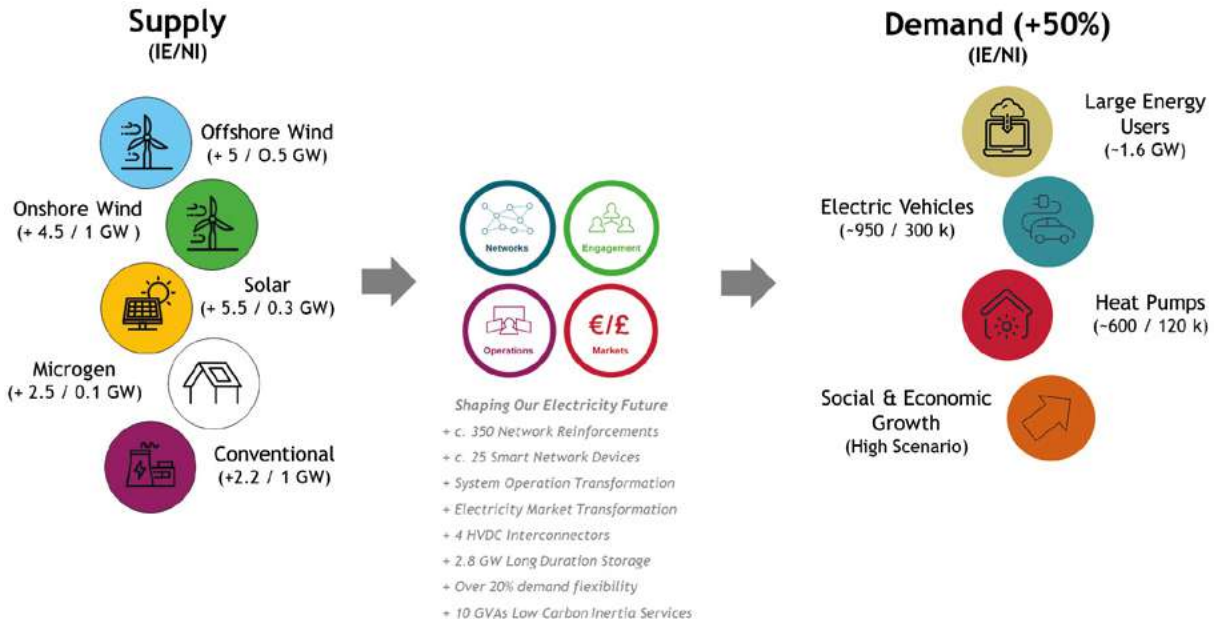


Figure 1: Whole of electricity system challenge

Networks

5. Since the publication of the last Roadmap, **EirGrid and SONI have overhauled our approach to delivering Infrastructure**, from how we engage with communities at the very early stages to the scale and the speed at which we hand over projects to our partners ESB Networks and NIE Networks. In the last two years we have initiated over €1 Billion per annum in projects making the Grid more resilient and ready to integrate the additional demand and generation, including renewables, as required to meet the targets.

6. **In Ireland, EirGrid believe meeting the challenge of the Climate Action Plan targets requires a change in our approach to how we collectively decarbonise the electricity sector.** The power sector must transition from a developer led approach to a plan led approach. The developer led approach has served Ireland well in meeting and exceeding our 2020 renewable electricity targets. However, as we transition to higher levels of renewables, the changing realities of the electricity system, balancing the needs of society as a whole, the wishes of communities and the energy citizen all require a different approach to ensure delivery. As well as continuing to focus on factors such as cost competitiveness and innovation, we must factor in macro level constraints – in particular, grid capacity as we plan towards 2030.

   EirGrid believe the developer-led approach, where every project is progressed irrespective of the grid capacity consumes valuable resources across the electricity industry and adds additional costs. We need to prioritise those areas which contribute most towards meeting our renewable ambition and focus our efforts as an industry in delivering these.

   A plan-led approach allows stakeholders to work together collaboratively, ensuring that the resources required to deliver Climate Action Plan targets are deployed in the most efficient and effective manner possible, while also improving our ability to deliver by 2030. This does not mean in the future that those developer-led projects will not be connected.

7. **Additional network infrastructure must be built to achieve the Renewable Ambition.** Our studies identify a significant number of network reinforcement projects to modernise the grid capability so that the Renewable Ambition can be fully delivered. 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 immensely challenging to deliver even in the context of a plan-led approach and all parts of the electricity ecosystem must be optimised to reduce delivery time.

8. **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 dynamic power flow controllers and dynamic line rating can help manage network congestion and maximise existing network capacities. This approach also assists in mitigating challenges associated with building new transmission infrastructure such as societal acceptance and prolonged outages of key existing infrastructure.

9. **In Ireland, the Roadmap outlines several renewable hubs in the midlands and southeast**. Renewable hubs permit the gathering together of renewable projects in a geographic area into a new collector substation and injecting power onto the grid where there is realisable capacity. The existing 'cluster' arrangements are expected to continue in Northern Ireland.

10. **The Roadmap recognises the strategic deployment of energy storage technologies in constrained regions of the network.** This approach works to somewhat reduce constraint of renewable generation, by taking in excess generation during hours of constraint.

11. **Surplus renewable generation is a key feature of this Roadmap and happens when renewable generation supply exceeds market demand plus interconnector exports. Surplus renewable generation also represents a significant opportunity for innovative energy usage in Ireland and Northern Ireland.** Timely implementation of incentives and frameworks which appropriately and effectively exploit this surplus renewable generation require careful consideration and focus by policy makers, regulators, and industry players. Other significant power systems in Europe, the US etc. are not expected to experience similar surplus renewables levels until well into the next decade and thus Ireland and Northern Ireland will be at the forefront of this emerging space.

12. **Where these incentives and frameworks are not implemented, over 20% of available renewable generation could be surplus to the demand requirements in 2030.** It should be noted that further new interconnection along with aggressive assumptions around long duration storage and demand side flexibility help mitigate and utilise renewable surpluses and have been assumed to be in place in this revised Roadmap. EirGrid and SONI acknowledge implementation of these by 2030 is extremely ambitious.

13. **Significant infrastructural and technological solutions are required to support the implementation of the Renewable Ambition** and, even with optimistic assumptions on the roll-out of these, the report shows the scale of the challenge in electrifying and decarbonising our economy by 2030. Because surplus renewables is a key feature of the future power system, additional renewables is one of a number of measures to meeting targets.

Engagement

14. **Public acceptance is central to the delivery of electricity infrastructure.** 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, 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.

15. **Stakeholders believe the transformation of EirGrid's and SONI's approach to engagement needs to be sustained, iteratively evolved, and be supported by consistent and targeted communications at local, regional and national level**. At every opportunity, stakeholders have reiterated to us 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.

16. **Only with the support of stakeholders will Ireland and Northern Ireland 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. When 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.

17. **Communities deserve 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.

Operations

18. **Continued secure operation of the power system is critical.** We are currently operating the power system with System Non-Synchronous Penetration (SNSP) levels of up to 75% and trialling Rate of Change of Frequency (RoCoF) up to 1.0 Hz/s. Satisfactory completion of this RoCoF trial will form the basis of further changes to our operational practices to achieve our 2030 targets.

19. **Operating the future power system with fewer conventional synchronous generators will be technically challenging.** To deliver on government renewable energy policies in Ireland and Northern Ireland, it will be necessary to have the ability 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 but not insurmountable challenges, many of which have not been experienced by other synchronous power systems to date and will not be experienced until well after they have been experienced in Ireland and Northern Ireland.

20. **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 essential to address the technical and operational challenges arising from the need to operate with SNSP levels up to 95% by 2030, which underpins achieving the renewable targets in Ireland and Northern Ireland.

21. 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 80% RES-E and facilitate electrification of the heat and transport sectors while maintaining power system security. An effective regulatory driven demand side 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.

22. **In the short to medium term, the system adequacy position in Ireland will be challenging.** 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. Over the coming decade, demand is forecast to increase, aging and carbon-intense capacity will have exited the market, new capacity will enter and the reliability of the residual generation fleet is expected to deteriorate. A secure transition and the orderly coordination of these factors is crucial to maintaining system reliability over the coming decade. The situation in Northern Ireland is more stable but requires careful monitoring.

Markets

23. The electricity market recommendations are the Market Operators' and Transmission System Operators' view of the actions required to enable Ireland and Northern Ireland to meet the 80% renewables targets and also the carbon emission reduction targets in Ireland. **The SEM Committee is ultimately responsible for the electricity market design and we will implement their decisions.**

24. **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 UK and EU policy.

25. **Since the publication of the original Roadmap in late 2021, there has been a paradigm shift in market dynamics due to the war in Ukraine.** A number of short-term changes have been necessitated to minimise the impact of high energy costs to consumers. It is important that the longer-term plan outlined in this Roadmap is progressed and not impacted by the ongoing shorter-term actions.

26. **The updated 2030 renewables targets and the carbon emission reduction targets has required a re-evaluation of the required capacity needed to maintain power system reliability while meeting these ambitious targets**. The analysis has shown that a balanced power system portfolio of different technologies is critical.

    There is an urgent requirement to ensure that there are no investment gaps in delivering on this. For example, long duration storage has been shown to be a crucial component of the balanced portfolio.

27. **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, this includes renewable fuel ready generation plants.

28. **Energy efficiency improvements are an important part of climate and energy** policies in Ireland and Northern Ireland and need to be a focus for the CRU and UR demand strategies.

29. **EirGrid and SONI recognise cost is a key concern in a secure transition and we are committed to working with government and regulatory authorities to help ensure a safe, secure, reliable but also affordable electricity system out into the future.** As regulated entities, we acknowledge the responsibilities of our regulators in ensuring that customers and network users receive value for money while providing the appropriate investment signals to enable the just transition in the most secure, reliable and effective manner. Those investments go towards the efficient operation, development, and maintenance of the power system and markets.

1.2 Context

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 where it is generated 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, reliable and sustainable 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 the electricity ecosystem and society can respond to limit the damage and therefore protect our planet for current and future generations.

The original Shaping Our Electricity Roadmap, (version 1.0 published in November 2021), reflected the electricity policy context of Ireland and Northern Ireland at that time. However, due to a myriad of factors, electricity policy has rapidly changed since then.

This updated Shaping Our Electricity Roadmap, (version 1.1) captures these changes to electricity policy and informs a pathway to achieving energy and climate ambitions and objectives across both jurisdictions. It builds on the previous Roadmap and plans for an electricity system that can deliver up to 80% RES-E by 2030 in both Ireland and Northern Ireland. It also considers how the electricity system in Ireland complies with the requirements set out in the sectoral emissions ceilings for electricity to 2030. In this roadmap these objectives are referred to as the Renewable Ambition.

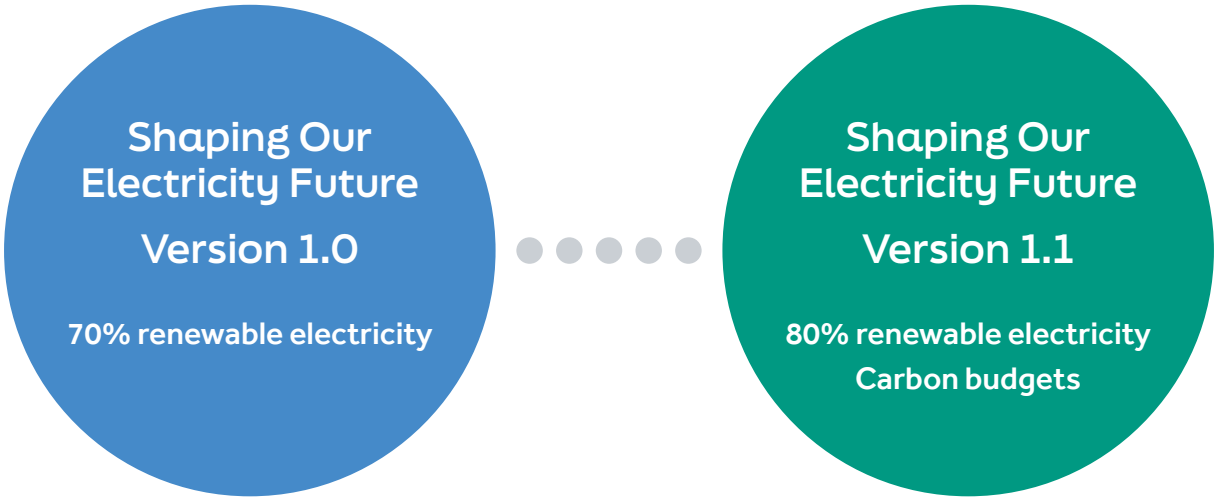


Figure 2: Update of Shaping Our Electricity Future (SOEF) to reflect evolving electricity policy

1.3 Scope and objectives

Shaping Our Electricity Future takes a whole of system approach and considers transmission network development, public and stakeholder engagement, evolution of system operations and appropriately incentivising electricity markets.

Figure 3: Integrated roadmap – Shaping Our Electricity Future

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 required is without precedent and the current approaches to network planning, public and industry engagement, electricity system operation and electricity markets need to be further transformed if the Renewable Ambition is to be achieved.

The key objectives of the Shaping Our Electricity Future are to:

- Support the delivery of the renewable electricity (onshore and offshore) and related flexibility targets as detailed in latest Ireland and Northern Ireland government policy.
- Identify any problems, gaps, opportunities, potential for synergies, or any areas of duplication in the deployment of renewable electricity projects and the supporting infrastructure.
- Identify opportunities for accelerated delivery of short and medium-term outcomes.
- Support the identification and resolution of potential regulatory, administrative and/or legal barriers to the accelerated deployment of renewable electricity projects.
- Increase alignment across the energy sector to support the delivery of renewable electricity generation projects and supporting infrastructure, electricity markets, and policy development.
- Recommend an appropriate investment climate for electricity projects as part of a system-wide approach to decarbonising the electricity system – at least cost to consumers while maintaining strong investment signals.
- To support the policy makers in engaging society so we all deliver a just transition.

1.4 Extensive public and industry engagement

EirGrid and SONI first commenced engaging on Shaping Our Electricity Future in March 2021. This document leans into the extensive and continuous public and industry stakeholder engagement over the last 2+ years.

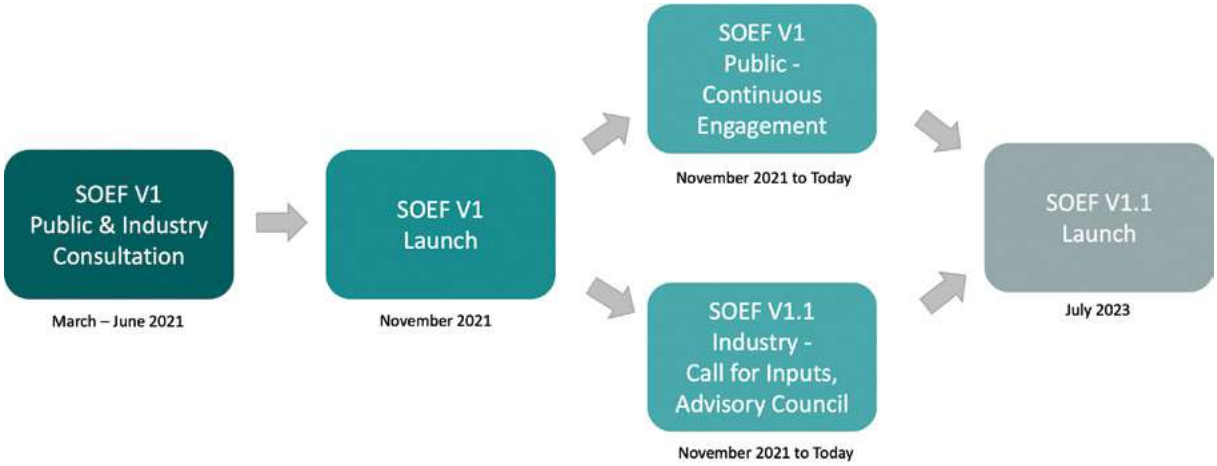


Figure 4: Summary of public and industry engagement on Shaping Our Electricity Future (SOEF) since early 2021

1.4.1 Shaping Our Electricity Future Version 1 – public and industry engagement

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.

EirGrid and SONI conducted a range of engagement and participation activities over the course of a 14-week consultation – 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.

Public engagement feedback summary

- 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 at 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.
- 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 summary

- 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 – this 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 was 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.

The above public and industry consultation feedback formed the basis of the original version of Shaping Our Electricity Future (version 1) published in November 2021.

1.4.2 Shaping Our Electricity Future Version 1.1 – public and industry engagement

Public engagement

Since November 2021, through the implementation of the engagement pillar in Ireland and Northern Ireland, there has been continuous engagement with the public on delivering on the Renewable Ambition.

- In Ireland, this engagement has included (amongst many other initiatives) Energy Citizen roadshows across the country, partnership with Young Social Innovators and partnership with Friends of the Earth and the Renewables Grid Initiative.
- In Northern Ireland, this included (amongst many other initiatives) convening the Northern Ireland Energy Forum with Northern Ireland Chamber of Commerce and establishment of a Citizen Sounding Board for the mid-Antrim project.

The feedback in both jurisdictions as part of this continuous engagement was very consistent with the public feedback in 2021 as part of the original Shaping Our Electricity Future development. Key changes included:

- Increased support for solar mini-gen and micro-gen in Ireland.
- Increased focus on reducing energy costs in Ireland and Northern Ireland in light of the Ukraine crisis.

Industry and academia engagement

Similar to public engagement, there has been continuous engagement with the industry and academia over the last 2 years. This included a Call for Inputs over summer 2022 and regular engagement with the Shaping Advisory Council (approx. 30 subject matter experts representing various sectors of the electricity industry in Ireland, Northern Ireland and further afield).

Again, the feedback in both jurisdictions as part of this continuous engagement was very consistent with the industry feedback in 2021 as part of the original Shaping Our Electricity Future development. Focussing specifically on the summer 2022 Call for Inputs, key feedback included:

- Renewable targets – support for increased renewable targets, need for much greater focus on carbon emissions, modelling of multiple scenarios and building onshore wind and solar as early as possible.
- Timeframe – need a version of Shaping Our Electricity Future with a longer-term view beyond 2030 and any network reinforcements should be future proofed.
- Costs – reduce grid connection costs and minimise costs to all electricity consumers.
- Networks – build required grid as quickly as possible, consider non-wire/new technology options and review outage practices.
- Markets – must evolve to support investment in a high renewables environment and need locational signals, congestion products and long duration storage.
- Operations – target 100% SNSP and no minimum generation requirement, upgrade the renewable dispatch tool and remove barriers to hybrid connections.
- Resourcing – EirGrid/SONI requires the funding to implement the programme of work.

The public and industry engagement feedback over the last 2 years formed the basis of this updated version of Shaping Our Electricity Future (version 1.1).

1.5 Multi-year plans overview

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

1. Network Infrastructure,
2. Engagement,
3. System Operations, and
4. Electricity Markets.

1.5.1 Network infrastructure

Context

Between now and 2030 there needs to be a 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 builds on detailed consultation with government, regulators, industry participants, stakeholders and the general public.
The future evolution of the power system beyond 2030 is also implicitly considered in delivering on ambitions to be net zero by 2050.

Scenario overview

The following is a high-level summary of the Shaping Our Electricity Future power system vision for Ireland and Northern Ireland. The values in the table are the additional capacities compared to the year 2023.
All figures are rounded to nearest 100 MW.

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

	Ireland	Northern Ireland
Demand	45.1 TWh (~Median GCS Scenario)	10.8 TWh (~Median GCS Scenario)
Offshore Wind	+5,000 MW +2,000 MW for hydrogen production	+500 MW
Onshore Wind	+4,500 MW	+1,000 MW
Solar PV	+8,000 MW (including 2,500 MW small scale)	+400 MW (including 100 MW small scale)
Short Duration Storage	+100 MW	+50 MW
Long Duration Storage	+2,400 MW	+350 MW
De-rated Gas Capacity	+2,000 MW	+900 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's 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 using the grid development processes for Ireland or Northern Ireland to determine the optimum path forward. Engagement is at the heart of these grid development frameworks.

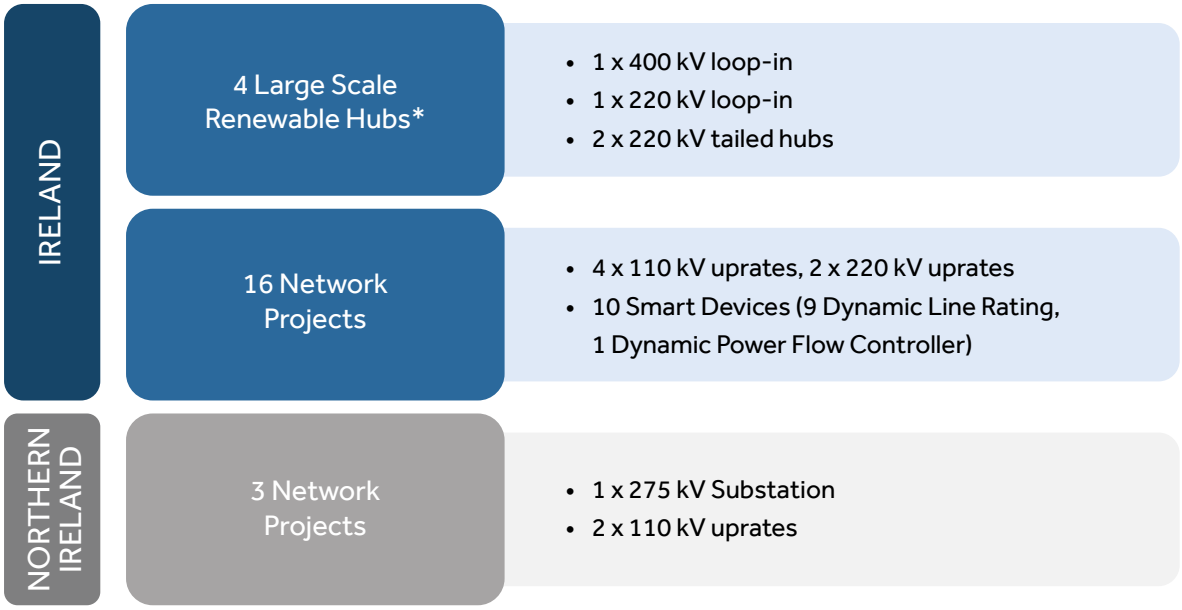
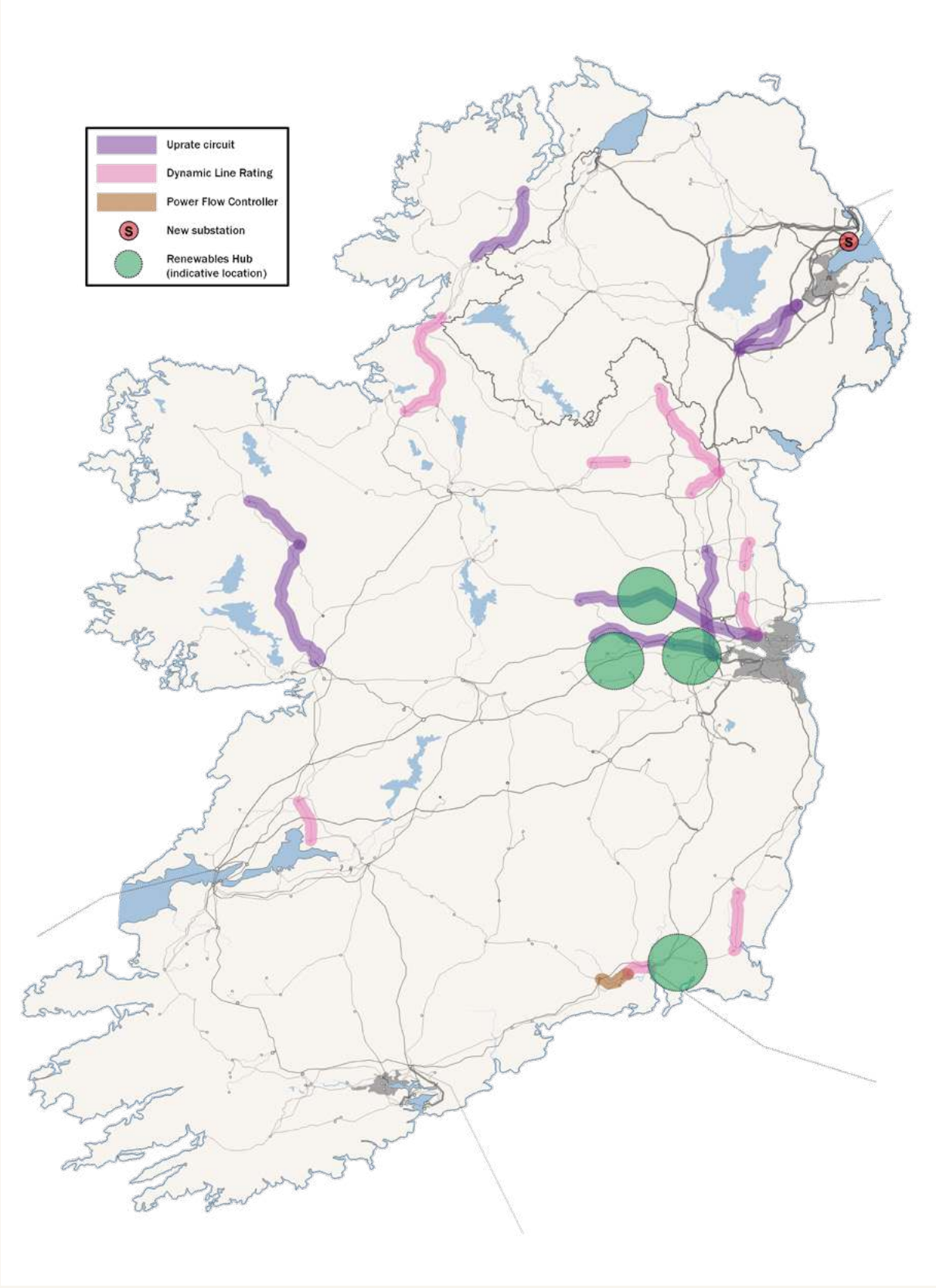


Figure 5: Networks analysis candidate network project[1]

1 A renewable hub is where renewable projects in a geographic area are gathered into a new transmission sub-station. These can be built by renewable developers according to EirGrid functional specifications.

Figure 6: Map of Ireland and Northern Ireland detailing reinforcements



Network enablers

There are a number of key strategic enablers that have been identified as being fundamental for infrastructure delivery. These have been identified based on a combination of project delivery experience, and through engagement with stakeholders and communities.
These enablers are described below.

Table 2: 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. • Timely planning decision by the consenting authorities. • Supply chain challenges to be understood and resolved by appropriate third party. • 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 in line with international best practice. • Deliver an electricity grid Technology Toolbox solution and application of this toolbox for enhanced network operation. • Implementation plan for flexible network devices. • Leverage of public road network[2] for delivery of infrastructure.
Northern Ireland	Enablers include: • Implementation of an end–end TSO/TO joint approach to optimise programme delivery time of electricity infrastructure. • Deliver an electricity grid Technology Toolbox solution for enhanced network operation. • Implementation plan for flexible network devices.

2 Some projects, notably the North South Interconnector, must be built above ground for technical reasons.

1.5.2 Engagement

EirGrid and SONI together with the governments, regulators, DSOs, the 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.

Table 3: Summary of engagement workstreams

Workstream	Description
Ireland	Enablers include: • Continue to rollout independent participative forums across all major projects. • Collaborate with local and national stakeholders through EirGrid Energy Citizen roadshows. • Continue development of participative forums across major grid development projects. • Preparation and publication of Regional Strategic Framework for Planning and Environment documents. • Continue to enhance youth participation opportunities to deliver and leverage awareness among young people. • Review and update Community Benefit Policy every three years. • Landowner engagement – enhance our approach on an ongoing basis in relation to earlier engagement, optioneering, route selection, site investigations and land acquisition. • Undertake a process to co-design EirGrid's practical approach to engagement and consultation with offshore stakeholders. • Explore opportunities to partner with education providers to deliver upskilling in the Energy Ecosystem for local communities.
Northern Ireland	Enablers include: • Further evolve SONI's enhanced three-part process and Consultation and engagement toolkit within NI project delivery through the creation of new project engagement roadmaps. • Engage with key agricultural stakeholders on Shaping Our Electricity Future v1.1 to develop refreshed SONI landowner engagement charter to support Shaping Our Electricity Future delivery. • Engage elected representatives', CEOs and planning official in a strategic roundtable series. • Develop a knowledge hub for communities to explore topical queries in relation to the grid.
Industry	Enablers include: • Regular hosting of Shaping Our Electricity Future Advisory Council. • Coordinate regular Shaping Our Electricity Future industry forums.

1.5.3 System operation

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 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 more heavily AC interconnected power systems for years to come.

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

1. Operational Policy: undertake operational studies and analysis and develop operational policies to facilitate the Renewable Ambition.
2. Standards and Services: ensure we have the right operational standards and appropriate system services frameworks to support investment in required capability.
3. Operational Tools: 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.
4. Technology Enablement: facilitate the development and integration of new technologies and innovations on the power system to enable them to operate efficiently and effectively.

The four workstreams are underpinned by a holistic TSO-DSO partnership. Many of the future generators and system service providers are expected to be connected to the distribution system, jointly with the DSOs in Ireland and Northern Ireland respectively.

We have therefore entered into jurisdictional joint system operator work programmes to ensure the needs of distribution and transmission systems, and the needs of consumers, are met.

Figure 7: System Operations workstream

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

Table 4: 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 80% RES-E by 2030: • Identifying technical scarcities and operational needs – both now and projected for the future. • Developing operational protocols, policies and procedures. • Complete system studies to facilitate the evolution of key operational metrics including, but not limited to, SNSP, inertia, minimum number of units and system strength. • 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 frameworks to support investment in required capability. This will help ensure we achieve 80% 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. • Publishing the standards that service providers will need to adhere to 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.
Operational tools	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. • 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. We will achieve this by: • 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 flexibility 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.

1.5.4 Electricity markets

Through Shaping Our Electricity Future, EirGrid, SONI and SEMO have made recommendations on how the electricity market could evolve to efficiently achieve the Renewable Ambition. These recommendations are our view of the actions required to enable Ireland and Northern Ireland to meet the 80% RES-E targets and the carbon emission reduction targets in Ireland.

The SEM Committee (SEMC) is ultimately responsible for the electricity market design, and we will implement decisions from the SEMC.

The key changes to help 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 energy, and system services markets to provide aligned incentives for third-party investment in resources that will provide the necessary balanced portfolio, energy and system services to meet dynamic demand requirements and physically operate the power system at 80% RES-E and be compliant with carbon emission reduction targets. This also includes wider aspects that influence third party investment such as renewable auction 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 comply with EU legislation, best utilise interconnection, to improve the economic outcomes for 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 the market in Great Britain they have been impacted by Brexit. Even prior to Brexit the SEM 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 of interconnection between SEM and the rest of the EU.

   - 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.
   - Full trading arrangements between SEM and Great Britain market
     With the withdrawal of the UK from the EU on 1st January 2021, the SEM 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.

Under these two pillars the Roadmap recommends a pathway of markets initiatives, key decision points, milestones, and implementation timelines to inform how to achieve the Renewable Ambition in a secure, sustainable, 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 from the SEM Committee in a timely coordinated fashion.

Table 5: 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. Changes to Generation Capacity Statement to align with the European Adequacy Assessment report methodology.
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 for system services	Auction design and proposed procurement mechanisms for the system services needed to operate the power system with high renewables. Development of an overarching commercial and legal framework to drive necessary third-party investment to meet challenges of high renewables.
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 Market of Great Britain and SEM: • Re-establishing day-ahead electricity trading arrangements between Ireland, Northern Ireland and Great Britain.
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.

1.6 Security of supply

Electricity is a necessity to maintain our quality of life and the success of every aspect of our economy. EirGrid and SONI have an extremely low risk appetite for disconnecting demand temporarily to maintain power system security within standard. Power system reliability standards are set by the competent authority – for Ireland this is the regulatory authority and in Northern Ireland this is the local government department.

For Ireland, the recent Generation Capacity Statement indicates a risk of capacity shortfalls over the study horizon. Through previous Generation Capacity Statements, we forecasted increases to demand and the closure of conventional plant due to age, financial viability and environmental legislation as factors contributing to the capacity shortfalls. The increased risk to security of supply in recent capacity statements is driven by deteriorating plant performance and challenges associated with the delivery of new capacity awarded long term contracts through the capacity market.

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.

Whilst CRU has ultimate responsibility for security of supply in Ireland, EirGrid is working with CRU and DECC 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 and ensure investment in new capacity can support the Renewable Ambition through a secure transition.

For Northern Ireland, the recent Generation Capacity Statement indicates a risk of capacity shortfalls over short to medium term as existing older generation retires and new gas capacity comes online. Current analysis and projections indicate there is sufficient capacity expected to deliver to meet the long-term needs of the Northern Ireland power system. SONI continue to monitor the Northern Ireland adequacy position by carrying 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.

1.7 Transition to net zero beyond 2030

EirGrid and SONI recognise 2030 is a milestone on the ultimate journey to a net zero energy system. To that end, EirGrid and SONI have commenced development of the next iteration of Tomorrows Energy Scenarios – this will consider credible pathways for the evolution of the power system in 2035, 2040 and 2050.

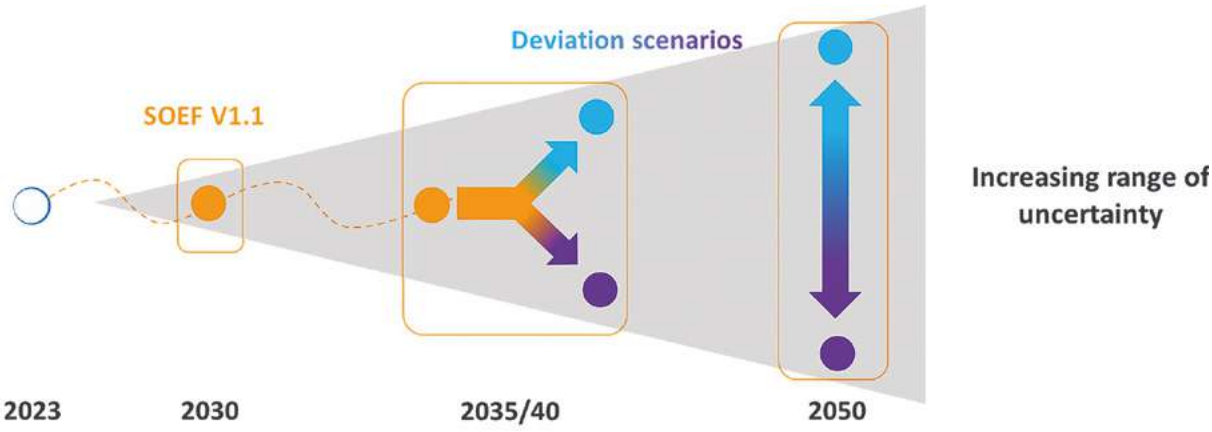


Figure 8: Deviation of scenarios across the decades

A consultation on Tomorrows Energy Scenarios, which will be benchmarked against energy scenario developments in other jurisdictions, will take place in summer 2023.

EirGrid and SONI are also working with colleagues around Europe on the evolution of both onshore and offshore energy systems to 2050. EU countries have agreed on new, ambitious long-term goals for the deployment of offshore renewable energy up to 2050 in each of the EU's five sea basins, with intermediate objectives to be achieved by 2030 and 2040.

These agreements build on strong regional cooperation instruments and tools established by the revised Regulation on trans-European energy networks (TEN-E Regulation). By going beyond national approaches, EU countries are laying the framework for a trans-European method which allows for a cost-effective expansion of grids needed to incorporate the expected offshore renewable generation with least environmental impacts and tackle internal bottlenecks. EirGrid and SONI, along with colleagues in ENTSO-E are combining this with information on maritime spatial planning and will propose strategic integrated offshore network development plans. This will give visibility to grid promoters, investors, and the supply chain on what offshore grids to expect for each sea basin by 2050.

1.8 Shaping Our Electricity Future – next steps

The Shaping Our Electricity Future Roadmap will be updated approximately every two years in response to the latest technology, economic, policy and system developments. We will continue to work together with governments and regulators and in consultation with industry stakeholders and the public in making our energy system safe, affordable, secure, reliable and sustainable. It should be noted the anchor year for the analysis in the future will likely change from 2030.

2. Engagement – industry and public

EirGrid and SONI first commenced engaging on Shaping Our Electricity Future in March 2021. This document leans into the extensive and continuous public and industry stakeholder engagement over the last 2+ years.

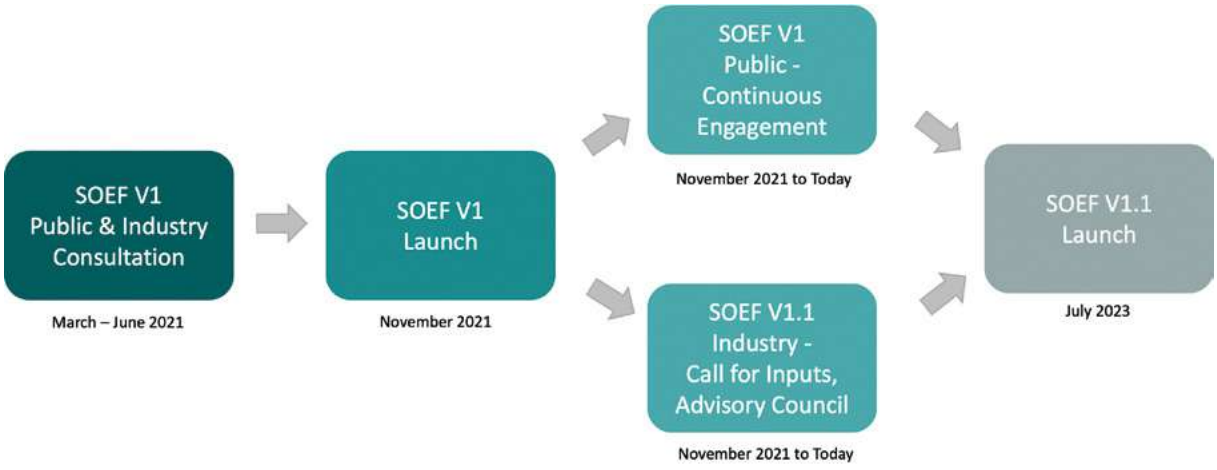


Figure 9: Summary of public and industry engagement on Shaping Our Electricity Future (SOEF) since early 2021

2.1 Shaping Our Electricity Future Version 1 – public and industry engagement

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.

EirGrid and SONI conducted a range of engagement and participation activities over the course of a 14-week consultation – 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.

2.1.1 Public engagement feedback summary

- 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.
- 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.

2.1.2 Industry feedback summary

- 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 – this 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 was 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.

The above public and industry consultation feedback formed the basis of the original version of Shaping Our Electricity Future (version 1) published in November 2021.

2.2 Shaping Our Electricity Future Version 1.1 – public and industry engagement

2.2.1 Public engagement

Since November 2021, through the implementation of the engagement pillar in Ireland and Northern Ireland, there has been continuous engagement with the public on delivering on the Renewable Ambition.

- In Ireland, this engagement has included (amongst many other initiatives) Energy Citizen roadshows across the country, partnership with Young Social Innovators and partnership with Friends of the Earth and the Renewables Grid Initiative.
- In Northern Ireland, this included (amongst many other initiatives) convening the Northern Ireland Energy Forum with Northern Ireland Chamber of Commerce and establishment of a Citizen Sounding Board for the mid-Antrim project.

The feedback in both jurisdictions as part of this continuous engagement was very consistent with the public feedback in 2021 as part of the original Shaping Our Electricity Future development. Key changes included:

- Increased support for solar mini-gen and micro-gen in Ireland.
- Increased focus on reducing energy costs in Ireland and Northern Ireland in light of the Ukraine crisis.

2.2.2 Industry and academia engagement

Similar to public engagement, there has been continuous engagement with the industry and academia over the last 2 years. This included a Call for Inputs over summer 2022 and regular engagement with the Shaping Advisory Council (approx. 30 subject matter experts representing various sectors of electricity industry in Ireland, Northern Ireland and further afield).

Again, the feedback in both jurisdictions as part of this continuous engagement was very consistent with the industry feedback in 2021 as part of the original Shaping Our Electricity Future development. Focussing specifically on the summer 2022 Call for Inputs, key feedback included:

- Renewable targets – support for increased renewable targets, need for much greater focus on carbon emissions, modelling of multiple scenarios and building onshore wind and solar as early as possible.
- Timeframe – need a version of Shaping with a longer-term view beyond 2030 and any network reinforcements should be future proofed.
- Costs – reduce grid connection costs and minimise costs to all electricity consumers.
- Networks – build required grid as quickly as possible, consider non-wire/ new technology options and review outage practices.

- Markets – must evolve to support investment in a high renewables environment and need locational signals, congestion products and long duration storage.
- Operations – target 100% SNSP and no minimum generation requirement, upgrade the renewable dispatch tool and remove barriers to hybrid connections.
- Resourcing – EirGrid/SONI requires the funding to implement the programme of work.

The public and industry engagement feedback over the last 2 years formed the basis of this updated version of Shaping Our Electricity Future (version 1.1).

2.3 Structure

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

An overview of the summer 2022 call for inputs and detailed responses to feedback received can be found in Appendix 2.

3. Shaping Our Electricity Future – progress so far

In 2021, EirGrid and SONI launched the Shaping Our Electricity Future initiative which set out the changes needed to the electricity system to deliver a target of at least of 70 % RES-E in Ireland and Northern Ireland. Scenario-based analysis and a wide stakeholder consultation was conducted across the whole electricity system which resulted in the Shaping Our Electricity Future Roadmap. The Roadmap was published in November 2021 and provided an outline of the key developments to enable the delivery of the 70% RES-E target and support the transition to net zero carbon emissions by 2050.

3.1 What did Shaping Our Electricity Future V1.0 do?

The key components of the roadmap were grouped under the following four workstreams:

1. Network Infrastructure,
2. Engagement,
3. System Operations, and
4. Electricity Markets.

For each workstream, the Roadmap set out a multi-year plan or recommendations for the evolution of our transmission network, engagement approach, system operation and electricity markets.

3.1.1 Network Infrastructure – key achievements

Ireland

A different approach to transmission network delivery has been adopted given the scale of grid works required. This change in approach has focussed on identifying different ways of working across the end–end life-cycle of programme and project delivery and investigating and implementing ways to optimise and accelerate programme schedules. Key areas of change and progress include the following.

Progressing network 'candidate reinforcements'

During 2022 significant work has been undertaken to progress some of the indicated 'Candidate reinforcements' listed in Appendix 3 of the Shaping Our Electricity Future v1.0 roadmap.

In 2022, EirGrid progressed nine (9) of the listed candidate reinforcements into either Step 2 or 3 of the framework.

In addition, a number of projects which are not listed in the candidate reinforcement list, such as busbar ratings, station refurbishment and reinforcements associated with specific connections with signed connection agreements (Site Related Connection Equipment, SRCE) were also progressed. In total during 2022, seven (7) of these types of projects (including the three Bulk Supply Point projects) were progressed into Step 2 or 3 of the Framework for Grid Development.

Project/Programme progress

Significant progress has been made on specific projects and programmes during 2022. This progress is published via the National Delivery Portfolio (NDP) and will continue to be updated quarterly.

Renewable connections

2022 saw a record number of renewable transmission substations connecting to the grid facilitating upwards of 600 MW of renewables on to the system. The first batch of the Government's Renewable Energy Support Scheme (RESS-1) projects connected in the summer months and a total of 6 TSO RESS-1 projects connected by the end of the year. 3 of which were onshore wind farms project and 3 solar farm projects marking the first transmission connected Solar farms to date on the transmission system.

Early engagement with ESBN as TAO

A new process was jointly developed by ESBN and EirGrid to facilitate early engagement ahead of what the existing IA (Infrastructure Agreement) process would ordinarily allow for on network delivery programme projects. This new process enables early collaboration and decision making on programme validation, constructability, route investigation, outages, planning, site investigation and procurement. It fosters greater sharing of information and earlier familiarisation which benefits subsequent IA processes and also de-risks the construction programmes. A continued agile approach to delivery between the TSO and TAO is fundamental to accelerate network delivery and ensure projects are viable for the construction phase.

Site investigations

Site investigation (SI) for planning and construction are now being completed by EirGrid where there are programme schedule benefits. Normally the construction SI activity would be completed by ESBN post planning consents and only then used to input into the contractor procurement phase. EirGrid is completing this activity earlier and in parallel with the existing planning consenting processes with the objective to avoid later ESBN duplication, reduce the overall programme duration and ensure the projects (and associated routes) are viable projects for construction. Example projects are Kildare Meath CP0966, North Connacht CP0816, East Meath North Dublin CP1021 and the Dublin projects.

Outages

Transmission Outages are a fundamental part of the programme of works for delivering network reinforcements and connections across Ireland and Northern Ireland. In Ireland, the required outages are now a key input in the early project optioneering and decision making for projects in terms of ultimate construction schedules and associated timelines. This approach has been applied within the Dublin programme in terms of the Dublin cable replacements and will be the basis for all projects going forward. This process will seek to minimize the requirement for outages during construction where possible.

Outages has been identified as a key risk to grid programme delivery out to 2030. In order to mitigate this, a fundamental review of outage processes and methodologies is underway including an international review of best practices for outages.

In Ireland, the need for a Transmission Outage Planning (TOP) market product was identified during 2022. The purpose of this is that additional capacity is available to assist with maximising the outage availability to be granted by the TSO and help resolve operational bottlenecks on the transmission system. EirGrid is engaging with the CRU in relation to options around procuring such a market product.

Different approach in Dublin

The successful delivery of the Dublin Programme relies on doing things differently – the delivery of the replacement cables projects requires a change in approach. With over 50 km of cable to be replaced throughout the city the need for close engagement with all utility companies has never been more important. To facilitate this collaboration the Dublin Infrastructure Forum was established. Benefits are already being realised, for example the agreement reached with Dublin City Council to enable the delivery of 4 km of advance ducting when they are installing cycle lanes along the Royal Canal for Waterways Ireland.

Taking advantage of this opportunity was made possible by a change in the project delivery process which allowed the agreement of part of a cable route before the whole route has been finalised. In addition, to ensure that the routes identified are feasible, EirGrid will procure specialist site investigation services to prove the validity of the proposed route. Furthermore, where SI is undertaken in certain areas EirGrid will consider installing ducts at the same time to secure the route. We will continue to look at different ways to optimise delivery of this substantial programme of work during 2023.

Significant engagement with ESBN as DSO

The Shaping Our Electricity Future roadmap highlighted the need to progress development of transmission interface stations with the Distribution System Operator (DSO) in the Dublin region. These interface stations are also called Bulk Supply Points (BSP) and are essential for accommodating forecasted growth of electricity demand in the distribution network. It is important to note that these BSP are not just stations – they will also require high voltage transmission circuits to connect them into the wider network.

In 2022, three BSPs and associated connecting circuits were progressed into Step 3 of the Framework for Grid Development for further feasibility assessment and associated optioneering:

1. The North County Dublin Bulk Supply Point Station with two additional 250 MVA transformers and associated grid connection.
2. Dublin City Centre Bulk Supply Point Station with two additional 250 MVA transformers and associated grid connection.
3. West County Dublin Bulk Supply Point Station with two additional 250 MVA transformers and associated grid connection. This was progressed as a combined and optimised solution for South Dublin incorporating one of the Shaping Our Electricity Future v1.0 candidate reinforcements.

Programme approach

There has been a significant ramp in capability in project and programme resources through the life cycle of projects in EirGrid. We are working closely with partners with expertise in large scale programme delivery along with international experts in power system delivery and design. Opportunities for further acceleration of programmes is under constant review from a stakeholder, design, and construction perspective. We will continue to look at ways to streamline how we work and incorporate learnings from previous projects/ sectors with a view to optimising the overall joint delivery approach.

Use of public roads

A High Voltage Interface Forum has been established to work through the technical details of how to put high voltage underground cables down public roads. This group includes representatives from TII, CCMA, DECC, CRU, DoT, ESB and EirGrid. This forum is about delivering pragmatic engineering solutions to enable the overall optimisation of the national infrastructure (roads) with underground cables to ultimately deliver on the Climate Action Plan in an accelerated fashion.

Northern Ireland

Progressing network 'candidate reinforcements'

During 2022 significant work has been undertaken to progress some of the indicated 'Candidate reinforcements' listed in Appendix 3 of the Shaping Our Electricity Future roadmap. All 12 of the listed candidate reinforcements have been progressed through various stages of part 1 (identifying the optimum solution and what area may be affected) of the SONI grid development process. In addition, essential analysis and progression of five other reinforcements which are not listed in the candidate reinforcement list, such as station improvements and reinforcements that will address security of supply for the DNO, have continued in 2022.

Joint TSO/TO approach In Northern Ireland

Significant work has already been completed by SONI and NIE Networks to update the existing processes that underpin the Transmission Interface Arrangements. A more streamlined and collaborative approach is being developed to project delivery which includes earlier joint engagement and development of key joint processes. This collaborative approach has enabled both organisations to identify and respond to any stakeholder concerns early in the project's life cycle. In addition, SONI will continue to explore future opportunities to utilise innovative approaches to community engagement, such as community forums and citizen sounding boards for relevant network projects.

Energising Belfast

Energising Belfast is currently in Part 2 (identifying where the project will be built) of the SONI 3 Part grid development process. The first round (of a planned three stages) of public consultation was completed in 2022 which introduced the project to the general public and local stakeholders. Constraint mapping is underway to identify potential substation sites and cable routes which will be brought to the next stage of consultation in late 2023.

Mid Antrim upgrade

Mid Antrim Upgrade project is currently in Part 2 (identifying where the project will be built) of the SONI 3 Part grid development process. The first round (of a planned three stages) of public consultation was completed in 2022 which introduced the project to the general public and local stakeholders. Constraint mapping is underway to identify potential switching site options as well as Overhead Line route options. The next stage of public consultation is planned for late 2023.

3.1.2 Engagement – key achievements

Ireland

Hosted an Event at COP26

'Delivering a Cleaner Energy Future: Government, Energy Sector and Civil Society' coinciding with the launch of Shaping Our Electricity Future Roadmap. This event, which was live streamed, explored engaging citizens on the actions required to address climate change including requiring greater understanding, participation and acceleration globally. The discussion considered how citizens can be better engaged and involved in this transition. The session highlighted the need for all parties across the global energy spectrum to devise better ways of working with wider civil society to enable development of large-scale renewable and transmission infrastructure to accelerate decarbonisation. This high-level event was moderated by Marie Donnelly, Chair of Ireland's Climate Change Advisory Council with the panel consisting of: Eamon Ryan T.D., Minister for the Environment, Climate and Communications, Leonore Gewessler, Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Austria, Mark Foley, CEO of Ireland's Transmission System Operator, Eirgrid plc, Mair Kelly, Youth Activist, National Youth Council of Ireland and Tom Howes, Head of Energy and Environment Division, International Energy Agency.

EirGrid Energy Citizens Roadshows

In May 2022, we commenced our programme of Energy Citizen Roadshows across the country, delivering roadshows in Donegal, Sligo, Wicklow, Westmeath, Cork, Dublin and Kildare. The roadshows engage local communities on Shaping Our Electricity Future and our plans to future-proof the electricity grid and support communities in considering the role of energy and taking steps locally. These events have been supported by SEAI and ESB Networks as well as local and regional development authorities and indeed members of the local communities.

Young Social Innovators

In February 2022, we launched a partnership with non-profit organisation, Young Social Innovators (YSI). The partnership saw EirGrid become the new Climate Action and Energy partner to YSI for a three-year period and involved the launch of a new Climate Action and Energy Award. This new award recognises young people's efforts to innovate efforts around climate action and energy to create a more sustainable world. In 2022, there were 29 projects selected for the Climate Action and Energy Award category with 378 young people participating. The inaugural award was presented to Commotion in the Ocean from Abbey Vocational School in Donegal Town. Commotion in the Ocean brings awareness on how people can reduce their carbon footprint and reduce the amount of pollution that is entering into our seas and oceans, damaging marine life.

Friends of the Earth and the Renewables Grid Initiative

In December 2021, we launched a joint project to engage communities and groups around the country on Ireland's energy transition with Friends of the Earth Ireland and the Renewable Grid Initiative. The first dialogue was held in June 2022 with a focus on energy poverty, a second dialogue was held in November 2022 with a focus on the co-existence of biodiversity protection and delivery of renewable energy infrastructure. This partnership facilitates an opportunity to support open and honest conversations with stakeholders about Ireland's energy future.

EU collaboration

We have been active in the promoting practice across the EU with our counterparts through the Renewable Grid Initiative. This includes a practice exchange which took place in October 2022 in Würzburg as well as a series of online stakeholder engagement roundtables. These activities contribute to capacity building and innovation both in EirGrid and our counterparts across Europe.

Redevelopment of strategic brand communications strategy to reflect a more public facing approach

During 2022, we undertook a review of the existing brand communications. To inform this work, we engaged with internal and external stakeholders and following appropriate consultation, internally and externally, defined the brand strategy to ensure that our messaging, approach and means of communicating was effective and resonating with the public and other key stakeholders. We then reviewed and evaluated proposed brand strategy with key internal stakeholders. The outcome was a revised and refreshed focus on our communications channels and our messaging.

EirGrid visual identity

Following on from the redevelopment of the brand strategy we reviewed and audited our existing visual identity. The aim was to create a more appealing, sustainable, and relevant visual identity for our communication with the public and stakeholders. This was reviewed and evaluated with internal and external stakeholders and feedback was incorporated. In January 2023 this new visual identity was rolled out and embedded across the organisation.

Pilot of social and digital 'Always on' awareness campaign

A social media 'Always On' campaign began in August 2022 to explain EirGrid's role through a relatable and more public facing lens with a focus on how the electricity grid, network and market operate to provide power to people's homes. The 'Always On' campaign ran across multiple social media channels in late 2022, speaking to all the citizens of the Republic of Ireland. In the campaign, EirGrid was portrayed as a team of passionate people, who were always thinking about finding innovative solutions for Ireland's long-term energy needs. Learnings from this campaign are being utilised for a future campaign.

EirGrid knowledge hub

In line with the visual identity, work has started on developing a new website for EirGrid. Included in this is a reframing of how content is produced and shared to make our information more accessible for the public and key stakeholders and industry. Contained within the new website will be knowledge hubs to bring key information together in a more user-friendly way.

Northern Ireland

The Northern Ireland Energy Forum

SONI has continued to work with the Northern Ireland Chamber of Commerce to convene the Northern Ireland Energy Forum. Taking place quarterly, the Forum brings together key strategic energy stakeholders across Northern Ireland to facilitate a whole system approach to addressing the opportunities and challenges in delivering Northern Ireland's Energy Strategy.

SONI's first citizen Sounding Board

In 2022, SONI devised and delivered the organisation's first Citizens' Sounding Board for our Mid Antrim upgrade project. As a further evolution of SONI's three-part engagement process, we worked with community empowerment charity INVOLVE NI to facilitate a diverse and representative forum to inform Part 2a of our Mid Antrim upgrade project. The process received unanimously positive feedback and will continue throughout Part 2b of the project.

A stakeholder advocacy approach to energising Belfast

SONI's Energising Belfast project is a transformational upgrade that will power Belfast's sustainable growth agenda in the future. To support the project, SONI worked closely with Belfast City Council and a wide range of business representative organisations to build a network of informed, enthusiastic project advocates. Through a programme of innovative partner communications, which included a high-profile multi-partner launch event in Belfast City Centre, SONI successfully collaborated with key city economy partners to communicate the transformative impacts of the project.

SONI knowledge hub

Through the SONI website, the organisation continues to upload a wide range of information and educational content pertaining to our core role as the Transmission System Operator for Northern Ireland and in relation to each of our projects. In addition, the SONI Consultation Hub has transformed how we engage with local communities by making engagement with our projects more accessible and inclusive.

3.1.3 System operations – key achievements

EirGrid and SONI have worked to deliver initiatives across the four main System Operations workstreams of Operational Policy, Standards and Services, Operational Tools and Technology Enablement. The following highlights progress made and key achievements since Shaping Our Electricity Future v1.0 was launched in 2021.

Achieved operation at 75% SNSP

The System Non-Synchronous Penetration (SNSP) limit sets a restriction on the amount of wind and solar generation (which are non-synchronous sources of generation) that we can accommodate on the power system at any instant in time. A focus of our System Operations programme of Shaping Our Electricity Future is to increase this SNSP limit so that we can accommodate more wind and solar generation on the power system. In 2022 we successfully concluded our trial of operation with an increase in the SNSP limit from 70% to 75% and this increased limit became operational policy on 31st March 2022. In 2022, we operated above 70% SNSP for 359 hours, approximately 10 hours of which were at the 75% limit. Today we operate with one of the highest levels of non-synchronous generation in the world which allows us to accommodate more renewable generation on the system. Further increases in SNSP are planned in coming years as set out in our System Operations programme.

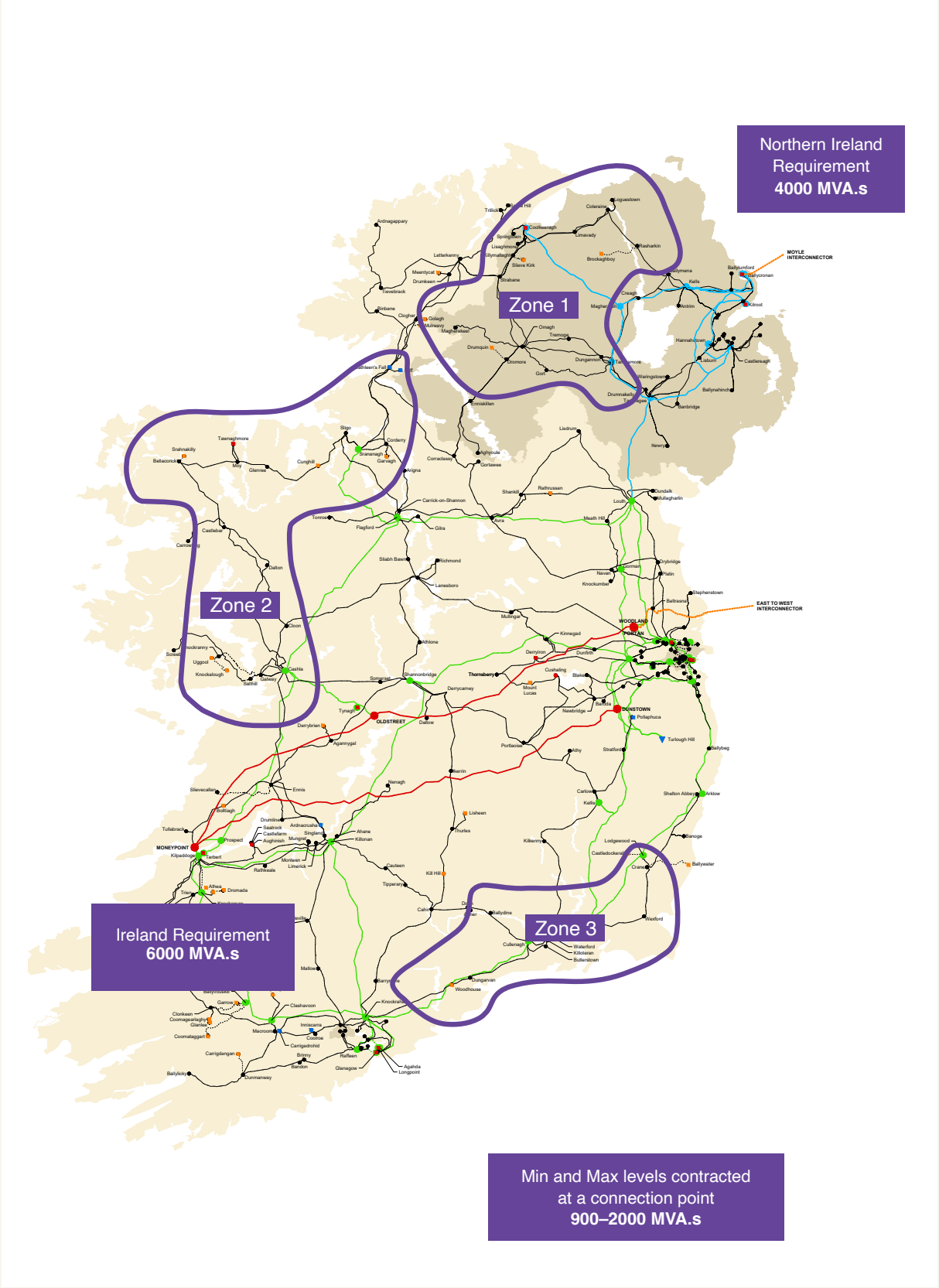
Developed arrangements for procurement of low carbon inertia services

In addition to increasing the SNSP limit (as described above) we are seeking to reduce our operational requirements for running conventional, carbon-intensive, thermal generation on the power system. As well as providing energy, conventional generation also provides a range of System Services that are required for the secure operation of the power system. These System Services include inertia and reactive power capability.

In 2021, we commenced a detailed technical study on our requirements for alternative 'low carbon' technology sources of inertia (with reactive power and short circuit contribution capability) that could assist in reducing our dependency on conventional thermal generation. In 2022 we consulted on technical requirements for these 'Low Carbon Inertia Services' and obtained approval from the Regulatory Authorities to proceed to the next stage of the process which is a consultation on the contractual arrangements that will govern the provision of these services. This consultation commenced in April 2023 and, following completion of this consultation and approval of the Regulatory Authorities, we expect to conclude procurement of Low Carbon Inertia Services in late 2023.

Subsequent delivery of these services will reduce our dependency on conventional thermal generation, facilitate the further integration of renewable generation and contribute towards achieving the 2030 Renewable Energy Source (RES) targets set in both Ireland and Northern Ireland.

Figure 10: Planned transmission system 400 kV, 275 kV, 220 kV and 110 kV December 2029



Developed an 'Operational Policy Roadmap to 2030'

The EirGrid and SONI Operational Policy Roadmap to 2030, published in Q4 2022, represents the completion of a key initiative in the multi-year plan published in Shaping Our Electricity Future v1.0. The roadmap sets out the key actions in the operational policy space that will be required to deliver on climate action targets while continuing to securely operate the electricity system. It outlines the context, drivers, timelines, milestones, actions, and stakeholder impacts that are needed in each operational policy area. The operational policy roadmap will be reviewed and updated if required, every two years.

The Operational Policy Roadmap is divided into three policy areas:

1. Dynamic Stability,
2. Reserves and Ramping, and
3. Operational Security.

The roadmap for the Dynamic Stability area, which includes SNSP and inertia, is shown in the figure below as an example of the contents of the Operational Policy Roadmap.

Key Changes				Greenlink HVDC			LCIS		North South Interconnector Celtic HVDC				Offshore Wind			Potential Further Interconnection	
Policy	**22H2**	**23H1**	**23H2**	**24H1**	**24H2**	**25H1**	**25H2**	**26H1**	**26H2**	**27H1**	**27H2**	**28H1**	**28H2**	**29H1**	**29H2**	**2030**
Inertia	23 GWs	20 GWs (All Island)		20 GWs (All Island)			Regional Inertia		~ 20 GWs (Regional or All Island)	~ 20 GWs (Regional or All Island)						~ 20 GWs (Regional or All Island)
RoCoF	1 Hz/s	1 Hz/s														1 Hz/s
System Strength						New EirGrid & SONI Policy									Updated EirGrid & SONI Policy	Enduring System Strength Policy
SNSP	75%			~ 80%	~ 80 %			Constraint Relaxed ~ 85%	Constraint Removed			~ 90%				~ 95%
MUON	8 (5 in IE, 3 in NI)	7 (All Island)		7 (All Island)					Constraint Relaxed ~ 6	Constraint Removed ~6	~ 5 (All Island)		~ 4 (All Island)			~ 3 (All Island)

Figure 11: Operation Policy Roadmap dynamic stability milestones to 2030

Hybrid technology enablement

The introduction of 'Hybrids' presents an opportunity for both market participants and system operators to optimise the use of grid infrastructure by increasing the overall capacity factors of connected entities, with the potential for improving security of supply. EirGrid and SONI are working closely with ESB Networks and NIE Networks respectively to unlock the potential for these developments.

In Ireland, jointly with the DSO (ESB Networks), EirGrid has submitted three separate papers to CRU covering the following:

1. A suggested contractual framework approach to facilitate Multiple Legal Entities behind a single connection point (June 2022);
2. Recommendations on revisions to the over-install policy (October 2022); and
3. A technical assessment for sharing of Maximum Export Capacity (MEC) behind a single connection point (January 2023).

We are engaging with CRU and, once clarity on next steps emerges, we intend to include relevant actions on future versions of this roadmap.

In Northern Ireland, SONI has jointly undertaken a review of the over-install policy with the DSO (NIE Networks) and have engaged with the Utility Regulator on recommendations.

Control centre tool implementation – Ramping Margin Tool

The Ramping Margin Tool (RMT) was successfully developed and tested in 2021. In February 2022 it was operationally rolled out to the TSOs' Control Centres. RMT is used by grid controllers to calculate generation ramping reserve requirements and to monitor ramping reserve availability. It is used in conjunction with the scheduling and dispatch process to manage generation profiles with increasing amounts of variable generation, especially during times of forecast uncertainties.

Completed system studies analysing the impact of reducing the minimum number of units constraint

EirGrid and SONI completed a suite of studies to identify the capability to reduce the minimum number of large synchronous units from eight to seven. Relaxing this constraint will facilitate higher levels of renewables on the system and a reduction in carbon emissions from non-renewable generation. The scope of the studies included evaluation of ramping capability, system strength, voltage and dynamic stability of the future power system where the operational policy constraint related to the Minimum Number of Units ON (MUON) is relaxed from eight to seven units, with RoCoF constraint of 1 Hz/s. The study outcomes are proceeding through internal approvals, ahead of commencing an operational trial in 2023.

Nodal controller trial in Ireland

The nodal controller trial was developed to assess the utilisation of distribution connected windfarms to provide voltage support for the transmission system. The nodal controller trial was developed in collaboration between the DSO and TSO. A three-month trial in real-time operations was conducted with a cluster of windfarms in Tipperary and was carried out between December 2021 and February 2022. The nodal controller trial provided valuable insights and learnings to be taken forward into future developments by the TSO and DSO.

TSO-DSO joint programmes

EirGrid and SONI have continued to develop the TSO-DSO partnerships, via the jurisdictional joint system operator work programmes with the DSOs in Ireland and Northern Ireland respectively. With so many of the future generators and system service providers expected to be connected to the distribution system, we have been working closely together with the DSOs to ensure that the needs of both distribution and transmission systems, and ultimately the needs of consumers, are met.

Since the publication of Shaping Our Electricity Future, in recognition of the need for co-operation and interaction between system operators, EirGrid with ESB Networks and SONI with NIE Networks have worked closely across a broad range of areas (see above for descriptions of the work done to progress hybrid technology and the nodal controller, for example). A core focus of the TSO-DSO joint programmes in both Ireland and Northern Ireland has been work towards the ongoing development of the future TSO-DSO operating model.

Joint Operating Agreement (JOA) for the Celtic Interconnector

Key technical and financial agreements for Celtic Interconnector were signed on 25th November 2022 including the Joint Operating Agreement (JOA) signed by EirGrid and RTE. The JOA is a legal document outlining how the TSOs will work together to deliver key operational, market and maintenance protocols in advance of the commercial operation of Celtic Interconnector. Development of these operating protocols and procedures will commence in 2023. A joint EirGrid RTÉ Operations and Maintenance Committee was initiated in March 2023, to oversee joint deliverables and the approval of any protocols.

Publication of the new innovation and research strategy

In December 2021, EirGrid and SONI published our Innovation and Research Strategy. The strategy sets out a roadmap to delivering increased levels of innovation and identifies a number of innovative programmes in a co-ordinated and prioritised manner across a ‘now, next, beyond lens’, building on the success of our in-flight programmes, such as those planned as part of the Shaping Our Electricity Future Roadmap.

3.1.4 Electricity markets – key achievements

The following highlights progress made and key achievements since Shaping Our Electricity Future v1.0 was launched in 2021.

Future arrangements for system services

In April 2022 the SEM Committee published SEM-22-012, a decision paper outlining the High-Level Design (HLD) for Future Arrangements for System Services (FASS). The Regulatory Authorities (RAs) also took the lead role in establishing engagements with industry to develop the detailed design of the new arrangements.

The TSOs put in place a dedicated project team to deliver on the SEM Committee requirements. The project was divided into a number of phases as follows:

- Phase 1 – Analysis & Planning.
- Phase 2 – Detailed Requirements & Design.
- Phase 3 – Implementation.
- Phase 4 – Readiness & Rollout.
- Phase 5 – Support.

As part of phase 1, one of the initial tasks was to develop a detailed project plan. Due to the level of complexity in the HLD the plan indicated a 3.5-year implementation project. This plan was shared with the RAs and also with Industry.

The HLD design also contained a number of areas where further clarification was required to enable the delivery of a detailed design. We therefore engaged our strategic partners to develop proposals. These were initially presented to Industry at an RA led workshop in November 2022. We held further bilateral meetings with Industry throughout January 2023 to gain further feedback on this proposal.

In January 2023, the RAs requested the TSOs to prioritise work on interim arrangements for FASS i.e. arrangements to be put in place in advance of the enduring arrangements. This was due to the level of complexity and the timeframes involved with the enduring arrangements. The RAs proposed that interim arrangements would comprise an auction for reserve services. The TSOs provided input to the RAs by developing a number of options to deliver on their requirements, detailed implementation plans and costs. Our understanding is that the SEM Committee will publish a consultation paper on the RAs' interim arrangements proposals in Q2 2023, with a decision in Q3 2023.

Scheduling & dispatch

In their proposed decision paper, SEM-21-027, the SEM Committee made proposals in relation to the treatment of new variable non-priority dispatch renewable generators in the SEM. This necessitated significant market system changes for the TSOs, MO and also market participants. At the time there were also a number of additional engagements with industry around market changes to enable more optimal scheduling and dispatch of the system.

It was considered that it would be more efficient to package a number of changes together into a larger programme, thus leading to the scheduling and dispatch programme. This was outlined to industry during a workshop held by the TSOs and MO on article 12 and 13 of the Clean Energy Package in July 2021. This outlined the scope of the scheduling and dispatch programme which would include:

1. Operation of non-priority dispatch of renewables.
2. Energy Storage Power Station (ESPS) integration.
3. Fast Frequency Response (FFR.)
4. Wind & Solar dispatchability improvements.
5. Reserve services scheduling and dispatch.
6. Synchronous condenser scheduling and dispatch.

The TSOs and MO put in place a dedicated project team to deliver on this new programme.

A significant amount of bilateral industry engagement took place throughout Autumn 2022 to outline proposed solutions under development for the initiatives included within the scope of the Scheduling & Dispatch programme. This culminated in a joint workshop with Industry in November 2022 where the details of the solutions being progressed into the next phase of the programme were outlined.

The project was divided into a number of phases as follows:

- Phase 1 – Analysis & Planning.
- Phase 2 – Detailed Requirements & Design.
- Phase 3 – Implementation.
- Phase 4 – Readiness & Rollout.
- Phase 5 – Support.

During Phase 1, the TSOs and MO developed high level requirements covering the six initiatives within this project and solution pathways outlining possible approaches for implementation. A functional explanation document, outlining the proposed interim solution for the treatment of variable non-priority dispatch generators, was developed, and submitted to the Regulatory Authorities in March 2023.

The scheduling & dispatch programme contained some initial funding from the respective RAs through the relevant price controls. These allowances were however not sufficient to further continue to work through Phases 2–5. A joint funding application to progress with the detailed requirements and design phase was submitted to the Regulatory Authorities in April 2023. This funding application also included very rough order of magnitude costs for Phases 3–5.

During Phase 2, the TSOs and MO will determine the optimal solution pathway and this will help inform on what market releases the various initiatives will be deployed to. Further industry engagement will take place for the remainder of this programme.

Renewable electricity support schemes

In Ireland the Department of the Environment, Climate and Communications (DECC) introduced a Renewable Electricity Support Scheme (RESS) and requested EirGrid to administer this. EirGrid delivered an auction platform to deliver on the DECC approved terms and conditions. Two full RESS auction cycles have been completed so far delivering total contracts of 3.1 GW. A number of RESS1 projects are also connected onto the transmission system in Ireland and are exporting renewable electricity. RESS3 is scheduled to be complete by the end of 2023.

DECC also introduced an Offshore RESS (ORESS) to enable delivery of the government targets. EirGrid was also tasked with the administration of this scheme. The preliminary auction results for the first offshore RESS auction were published in May 2023. The auction cycle is due to be complete in mid-2024.

A key outcome of the initial Shaping Our Electricity Future document was in relation to a need for a more coordinated plan led approach to grid development. To deliver on this EirGrid has developed a solution for locational signals for inclusion in future RESS auctions. Note that this is dependent on the final decision from DECC on the RESS auction design.

In Northern Ireland, there is currently no support scheme in place, however in April 2023 SONI responded to the Department for the Economy (DfE) consultation on a support scheme for renewables in Northern Ireland. SONI welcomes this engagement and looks forward to providing any necessary support to the DfE in respect of this.

EU/GB market integration

To date we have carried out a number of initial tasks including:

- We have engaged with EU TSOs to review potential Capacity Calculation Regions, completed a qualitative analysis and will be making a submission for regulatory approval later in 2023.
- Industry engagement has also commenced in relation to certain aspects of this work and proposals for the design of the ex-ante market are in development and have been shared with industry through bilateral engagements.
- In April 2023 we put in place a dedicated programme team to manage this work.

As the programme becomes established, we expect a significant level of industry engagement around the detailed scope and implementation plan.

Long duration energy storage

A key output of the new iteration of Shaping Our Electricity Future is that there is a need for Long Duration Energy Storage (LDES). industry feedback is that there is a remuneration gap for investors to develop LDES. To investigate this the TSOs and MO have commenced work, which will feed into a future expected decision by the SEM Committee, on this matter.

The tasks undertaken include:

- We have put in place a dedicated manager and team to look at this issue;
- Engagement has been taking place with industry representative bodies, government agencies, the Distribution System Operators and the Regulatory Authorities throughout early 2023;
- Shaping Our Electricity Future indicates the volume, durations and locations for LDES. We are also investigating further studies to look at the impact of not being able to deliver LDES, to support any regulatory submissions around the needs case;
- We have engaged a strategic partner, who has significant developer experience, to advise on the costs an investor would incur to develop LDES. This will support us in developing the remuneration needed to incentivise LDES; and
- Work has been ongoing on the market options available to incentivise LDES. The options could include existing mechanisms such as the Capacity Remuneration Market or System Services. Equally it could be a new mechanism such as a support scheme, similar to the Renewable Electricity Support Scheme (RESS) in Ireland. We will engage and consult with industry on these options, prior to making a formal recommendation to the RAs.

Further industry engagement will take place during 2023 in relation to this new product.

Demand Transmission Use of System (DTUoS) review for Ireland

This is a CRU led project in Ireland and is supported by EirGrid and ESB Networks. This work was due to commence in 2022, however the CRU requested EirGrid to pause work in this due to other priorities. EirGrid has put in place external support and we have completed initial qualitative analysis on tariff options for modelling and scenarios. In April 2023 we have recommenced engagement with CRU and ESB Networks to progress this work.

4. Climate and energy policy

Since the launch of the Shaping Our Electricity Future Roadmap in November 2021, there have been significant developments to electricity policy at European level, in the United Kingdom and in both Ireland and Northern Ireland.

4.1 Europe

From a European perspective, the EU and its member states continue to be at the forefront of international climate and energy policy with the aim of carbon neutrality by 2050 as set out in the Regulation on the Governance of the Energy Union and Climate Action (EU/2018/1999) and the European Green Deal.

The 2030 Climate and Energy Framework set out binding targets for the EU. As part of this, member states are required to produce National Energy and Climate Plans from 2021 to 2030 and a Long-Term Strategy to reduce Greenhouse Gases to 2050.

In December 2020, the European Council committed to increasing the EU emissions reduction target to at least 55% by 2030 in the Fit for 55 package. The package aims to update EU legislation and put in place new initiatives to ensure that EU policies are in line with the climate goals agreed by the Council and the European Parliament.

The package included a proposal for a revision of the Renewable Energy Directive (RED III) increasing the current EU-level target and on 30 March 2023, the European Parliament and the Council reached a provisional agreement and set a binding renewable energy target of a minimum 42.5%, but aiming for 45%, for 2030. Once this process is completed, the new legislation will be formally adopted and enter into force.

The revision of the directive also introduces new measures to complement the already existing building blocks established by the 2009 and 2018 directives to ensure that all potentials for the development of renewable energy are optimally exploited and accelerated, which is a necessary condition to achieve the EU's objective of climate neutrality by 2050.

Furthermore, measures in the REPowerEU Plan respond to the ambition of reducing dependency on Russian gas and oil through energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy to replace fossil fuels in homes, industry and power generation.

4.2 United Kingdom and UK withdrawal from the EU

In 2019, the UK updated its Climate Change Act to bring into law a requirement for net zero emissions by 2050. The UK was the first country to set carbon budgets; the fifth carbon budget, covering the period 2028 to 2032, limits the total greenhouse gas emissions in the UK to an average 57% reduction in emissions relative to 1990.

Energy policy is devolved to Northern Ireland, so how the country contributes to the carbon budgets and delivers net zero emissions will be set by the devolved administration.

The Brexit transition period ended on 31st December 2020 and the Ireland/Northern Ireland Protocol to the Withdrawal Agreement has provided the basis for the continued operation of the Single Electricity Market (SEM) and trade of wholesale electricity across the island of Ireland and in Northern Ireland after 1 January 2021.

Under the Free Trade Agreement (FTA), new SEM-GB trading arrangements for the Day-Ahead electricity market were to be established, agreed, and implemented by April 2022. However, a policy decision in relation to these trading arrangements is still being discussed between the UK and the EU.

4.3 Ireland

In line with the EU ambition, the Climate Action and Low Carbon Development (Amendment) Act 2021 commits to achieving a 51% reduction in Ireland's overall Greenhouse Gas emissions by 2030 relative to 2018 emission levels, and to achieving a climate neutral economy no later than 2050.

Overall carbon budgets for the periods 2020–2025, 2025–2030 and 2030–2035 were came into effect in April 2022 and sectoral emissions ceilings were announced in July 2022.

Climate Action Plan 2023 (CAP23) was published in December 2022 and explicitly sets out updated emission reductions aligned with carbon budgets and sectoral emissions ceilings.

These include targets for electricity of:

- Carbon Budget 1: 2020-2025: 40 $MtCO_2$ equivalent.
- Carbon Budget 2: 2025-2030: 20 $MtCO_2$ equivalent.
- Reduce electricity sector emissions to 3 $MtCO_2$ equivalent per annum.
- 80% of electricity demand generated from renewable sources.
- 9GW of onshore wind capacity (6GW by 2025).
- 8GW of Solar PV capacity (up to 5GW by 2025).
- At least 5GW of offshore wind capacity.
- At least 2GW new flexible gas plant.
- At least 500 MW of community based renewable energy projects.
- Ensure that 20-30% of system demand is flexible by 2030 (15-20% by 2025).
- Delivery of three new transmission grid connections or interconnections to Northern Ireland, Great Britain, and the EU and explore further interconnection.

The targets in the Climate and Low Carbon (Amendment) Act 2021 and the CAP23 place an onus on EirGrid to both enable and deliver elements of the greatest change on the power system since the rural electrification project during the 1940's to the 1970's. This transformation will feed into major changes in how both business and society behave and operate.

We will be working with our various stakeholders in order to implement the relevant revisions to the RED III once the revision process has been concluded. The revision adopts additional measures to accelerate the development of renewable connections and associated infrastructure. We are also working with CRU and the DSO in order to account for the increased ambition in CAP23 in the Enduring Connection Policy.

The Renewable Electricity Spatial Policy Framework is currently being prepared and will stand as the Government's policy for onshore renewable electricity, informing the regional development and distribution of onshore wind and solar PV generation. This framework will translate the national renewable electricity targets, as set out in the Climate Action Plan 2023, to Ireland's three Regional Assemblies. It will allocate regional spatial and renewable generation capacity targets, with supporting principles and polices, which together shall establish a framework within which all relevant stakeholders should operate in order to achieve the national climate objective.

The development of onshore renewable electricity in Ireland should align with the targets, principles, and polices set out in this policy framework.

In relation to offshore, the Policy Statement on the Framework for Phase Two Offshore Wind which was published in March 2023 is a key milestone in achieving our offshore targets for 2030 as outlined in CAP23. In addition, public consultation on the Second Offshore Renewable Energy Development Plan (OREDPII) concluded in April 2023 and the outcome of this and associated developments will be a key building block towards our enduring plan-led approach to developing offshore renewable energy.

4.4 Northern Ireland

In December 2021, The Northern Ireland Executive published its Energy Strategy 'Path to Net Zero Energy'. The new strategy outlines a roadmap to 2030 aiming to deliver a 56% reduction in energy-related emissions, on the pathway to the 2050 vision of net zero carbon and affordable energy. A key component of this is to meet at least 70% renewable electricity by 2030.

In January 2022, the Northern Ireland Executive released an Action Plan for the year which includes the aim of developing a plan to deliver 1GW of offshore wind from 2030. An Action Plan for 2023 was published in March 2023.

In June 2022, the Climate Change Act (Northern Ireland) came into force. This legislation commits Northern Ireland to achieving emissions reductions of 48% from 1990/1995 level by 2030 and net zero carbon emissions by 2050. Part of this legislation updated the requirements of the Energy Strategy in setting a new target of achieving at least 80% RES-E in Northern Ireland by 2030. The legislation also requires Northern Ireland to introduce carbon budgets, with the first budget to cover the period 2023 to 2027, and also requires that Northern Ireland publish a Climate Action Plan by June 2024. SONI understands that this will be consulted on during 2023.

In relation to offshore, the consultation on the Offshore Renewable Energy Action Plan (OREAP)[3] concluded in March 2023 as the first step towards delivering on the ambition of deploying 1GW of offshore wind from 2030 in Northern Ireland waters.

3 https://www.economy-ni.gov.uk/consultations/draft-offshore-renewable-energy-action-plan

4.5 Policy summary

Given the updated legislation, we now need to plan for an electricity system that can deliver up to 80% RES-E power system by 2030 in both Ireland and Northern Ireland, 51% reduction in greenhouse gas emissions by 2030 relative to 2018 and carbon neutral electricity system by 2050 in Ireland (hereafter referred to as the Renewable Ambition). We also need to consider how the electricity system in Ireland complies with the requirements set out in the sectoral emissions ceilings for electricity.

During this significant electricity system transition we will need to deliver the Renewable Ambition 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 electricity supply, new technologies 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 for their electricity supply.

The main objective of the Shaping Our Electricity Future initiative is to outline a blueprint for a secure transition to deliver the Renewable Ambition.

5. Security of supply

Maintaining security of supply in the power system means ensuring that there is a balanced portfolio of generation to meet both the demand and the operational requirements to run the electricity system securely for each and every hour across the year. Delivering a balanced portfolio of generation, interconnection, storage, renewables and demand response will ensure the lowest possible emissions from the fleet to meet 2030 objectives and beyond.

5.1 System adequacy

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. Ireland and Northern Ireland, under the SEM, are to the forefront of experience with respect to the technical and economic challenges associated with the transition, due to our limited interconnection and high non-synchronous renewable generation integration. 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.

It is 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 generation 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 energy storage, demand side units and flexible generators have entered capacity market contracts as a result. Interconnection also plays a role by providing access to capacity 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 Commission for Regulation of Utilities in Ireland and the Department for the Economy in Northern Ireland. 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 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.

5.2 Short-medium term adequacy assessment

In recent years, there have been a number of system alerts in Ireland. They indicate that capacity margins are tight, and a loss of a generator could mean difficulty in meeting demand.

Previous experience shows a combination of factors such as very low wind, poor plant performance and the possibility of cold snaps in winter can result in increased likelihood of a system alert.

As reported in the Generation Capacity Statement 2022–2031, a number of factors are contributing to capacity challenges in Ireland and Northern Ireland:

Availability

Performance of existing generation capacity continues to deteriorate in Ireland and Northern Ireland and this is reflected in our adequacy assessments. Furthermore, technical challenges associated with aging plant can reduce units' contribution to capacity adequacy, in some cases even forcing early retirement of capacity.

Forecasted new generation failed to materialise

In recent years, over 700 MW of previously awarded capacity has terminated their capacity market contracts and accordingly paid their termination charges. This means that a large proportion of new capacity expected to come online has now been withdrawn by the developers.

Capacity auctions

New capacity has come forward through the capacity market auctions. EirGrid and SONI have introduced enhanced deliverability reporting of these projects, which includes engagement with the developers and other state agencies to support a timely process. The output of this deliverability assessment has been used to determine a realistic view of when this new capacity will deliver.

Annual run hour limitations on new units

EirGrid and SONI understand that new Open Cycle Gas Turbines (OCGTs) coming through capacity auctions may be subject to annual run hour limitations due to restrictions outlined in their planning applications or environmental legislation. There is uncertainty around the application of run hour limitations, therefore we assume the application of run hour limits on new units based on the latest available information at the time. As new information regarding the applicability of run hour restrictions becomes available, subsequent analysis will be updated accordingly.

Demand

EirGrid include the latest social and economic growth projections and also the latest information on the growth of New Tech Load users and data centres within their contracted demand allowance. EirGrid observed trends in the data centre sector that showed demand levels around 450 MW higher by 2030, as the sector continues to grow towards their contracted demand levels. Growth of new data centres is an area of ongoing review by EirGrid, CRU and government. The Climate Action Plan 2023 outlined specific targets for the electrification of heat and transport. Full implementation of these targets is now a part of the central median scenario. SONI's assessment considers the long-term demand growth in Northern Ireland is relatively stable, reflecting an increase due to the electrification of heat and transport.

Operational requirements

As part of the reliability assessments, EirGrid and SONI account for system operational requirements. This is in line with the relevant Transmission System Security and Planning Standards (TSSPS) and Operating Security Standards in each jurisdiction and reflects the realities of operating a power system. This approach is consistent with the capacity market volumes identified by EirGrid and SONI.

In Ireland, over the short term EirGrid expects the margins will be tighter over the coming winters as old capacity retires and demand increases. Approximately 1,500 MW of rated capacity is currently planned to exit the market over the coming years.

To address the challenge and to ensure the transition is managed in a secure manner, EirGrid has been working with CRU and DECC to implement a programme of work[4] 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 programme of work includes:

241 MW of temporary emergency generation to be in place for Winter 2023, with a further 412 MW to be in place by Winter 2024. This generation is expected to remain in place until the necessary replacement capacity has been secured. Furthermore, this capacity will only be called up in the event of a shortfall and where system alerts are likely.

Retention of existing units which are set to retire will continue to be an option, where possible, until enduring measures are in place.

There are additional actions, led by the CRU, to enhance the responsiveness of demand side units and develop additional demand side capacity.

In Northern Ireland, there is a risk of capacity shortfalls over the short to medium term as existing fired generation closes and new gas capacity comes online. 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.

4 https://cruie-live-96ca64acab2247eca8a850a7e54b-5b34f62.divio-media.com/documents/CRU202317_Electricity_Security_of_Supply_Programme_of_Work_Update_February_2023.pdf

5.3 Long term adequacy

An adequate portfolio of capacity is required to meet our long-term operating needs. This portfolio will include long duration energy storage, 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 fuel, (gas liquid or other) ready generation 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.

6. Transmission network analysis

Timely and efficient development of electricity transmission networks is crucial to delivery of the Renewable Ambition. In the Shaping Our Electricity Future v1.0 roadmap, we outlined a set of candidate reinforcements required to deliver 70% RES-E in Ireland and Northern Ireland.

6.1 Network development approach

In this update, we have performed a comprehensive set of network planning studies to determine what additional projects are potentially needed to further increase the capability of the transmission system and ensure the Renewable Ambition is delivered in both jurisdictions. The network planning studies have also identified network connected projects and equipment that help meet the Renewable Ambition by adding flexibility to respond to the variability of renewable generation but that do not add capacity to the network.

These potential projects are candidate solutions that 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 candidate 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 candidate 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 candidate 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.

6.2 Methodology

The analysis of the transmission network makes use of well-established methods and techniques that are described in both the Ireland and Northern Ireland Transmission System Security and Planning Standards (TSSPS). The final network development approach is built upon that in the Shaping Our Electricity Future v1.0 roadmap and includes updated government policy, feedback received from the Call for Inputs 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 beyond those identified in the v1.0 roadmap. 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. The creation of hourly generator dispatch schedules for the year 2030 that realise the Renewable Ambition of both jurisdictions. PLEXOS market simulation software is used to prepare these schedules.
2. Testing the performance of the transmission system for each of the hourly generator dispatch schedules using PSS/E power flow analysis software. Given the strategic nature of the analysis, the performance is assessed according to requirements set out in the TSSPS for a single contingency event only. The results are used to identify the needs of the transmission network.
3. Selection of a set of transmission network reinforcements that satisfy the identified needs of the transmission system. These candidate reinforcements ensure that the Renewable Ambition is met and are designed to maximise the use of the existing transmission network, therefore minimising the need for new infrastructure.

6.2.1 Scheduling analysis

We use PLEXOS market simulation software to create a credible hourly generation and demand schedule for the whole of the study year. A number of assumptions regarding future operational rules are used to inform 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.

The scheduling analysis is also used to estimate dispatch-down requirements in the study year. Dispatch down consists of three main components:

1. Curtailment, due to taking operational rules, set out above, into account in the dispatch of generation;
2. Constraint, which is due to network congestion; and
3. Surplus renewable generation, which occurs at times when there is more generation than the market needs to meet consumer demand, including exports.

6.2.2 Transmission network connected surplus renewable generation management

The scheduling analysis indicated that delivery of the Renewable Ambition could result in a significant quantity of generation dispatch-down relating to surplus renewable generation. In response to this, the scheduling analysis tools and methods were also used to identify transmission network connected technologies that can exploit and utilise the surpluses of renewable energy. Further details of this assessment are provided in Appendix 3.

Surplus renewable generation occurs at times when there is more generation available than the market needs to meet consumer demand, including exports. This surplus is an opportunity which could be exported, stored for later use, or used by demand consumers that can respond to variability in supply.

Technologies that can help manage surplus renewable generation are those that are flexible and can respond to the changes in variable renewable generation output. Flexible technologies identified to have the greatest benefit at utilising the opportunity around surplus renewable generation in the 2030 study year include:

- Further interconnection (beyond Celtic and Greenlink) to neighbouring transmission networks;
- Long duration storage; and
- Flexible demand.

By managing surplus renewable generation, the amount of installed variable renewable generation capacity that is needed to meet the Renewable Ambition can be minimised. The analysis aims to identify those technologies that contribute most to managing renewable surpluses. By combining these with sufficient installed capacities of renewable generation, we aim to minimise the installation of renewable generation whilst still delivering the Renewable Ambition.

Timely implementation of incentives and frameworks which appropriately and effectively drives the utilisation of this surplus renewable generation require careful consideration and focus by policy makers, regulators, and industry players.

6.2.3 Transmission network needs identification

Each hourly snapshot of the generation and demand schedule is modelled in PSS/E power flow analysis software. The performance of the transmission network for every hour of the year 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.

6.2.4 Network development principles

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.

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.

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. 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 not sufficiently detailed to confirm whether new circuits are to be designed as overhead lines or underground cables. Similarly, the availability of outages to upgrade existing circuits has not been evaluated. This may result in additional scope added to circuit uprate or up-voltage projects.

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, Low Carbon Inertia systems, new HVDC interconnectors and storage technologies increases.

6.2.5 Planning and grid development assumptions

To carry out the network analysis, a base network model containing all network assumptions for 2030 is required. The base network model consists of the transmission network as it is today and includes all new transmission network developments assumed to be complete in 2030.

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.

In Ireland these projects form the Network Delivery Portfolio (NDP)[5]. This portfolio is updated and published quarterly. Approved projects in the NDP are included in the base network model. In Northern Ireland these projects are listed in the Transmission Development Plan Northern Ireland (TDPNI).

Shaping Our Electricity v1.0 identified candidate solutions and these are becoming committed projects as they work their way through EirGrid's Framework for Grid Development process or SONI's three-part Process for Developing the Grid. The grid developments identified as part of this Shaping Our Electricity Future v1.1 Roadmap are in addition to the committed projects and solutions in Shaping Our Electricity Future v1.0.

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 processes have their own detailed analysis requirements.

6.2.6 Planning and environmental considerations

The Shaping Our Electricity Future v1.1 Roadmap builds on the roadmap developed in Shaping Our Electricity Future v1.0 and the consultation carried out, along with input and feedback received in the Call for Inputs from industry and academia in August 2022.

It identifies, at a high level, parts of the transmission system that are likely to need development over the next decade and beyond. 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 is inter-related with relevant Ireland and Northern Ireland Transmission Development Plans (TDP). The TDPs are project-specific 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. In short, 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. These projects derive from the Shaping Our Electricity Future Roadmap.

5 https://www.eirgridgroup.com/customer-and-industry/general-customer-information/network-delivery-portfoli/

The Roadmap continues to emphasise and build upon the three statements of EirGrid's Grid Development Strategy 2016 – 'Your Grid, Your Tomorrow':

1. Inclusive consultation with local communities and stakeholders will be central to our approach.
2. We will consider all practical technology options.
3. We will optimise the existing grid to minimise the need for new infrastructure.

The 2016 Strategy and the 2016 TDP formed the substance for EirGrid's 'Grid Implementation Plan 2017-2022 for the Electricity Transmission System in Ireland' which was subject to Strategic Environmental Assessment (SEA) including Appropriate Assessment (AA). A Plan was also prepared and subject to SEA in Northern Ireland.

The output of this Roadmap and relevant TDP will form the basis for the forthcoming next five-year Implementation Plan and both SEA and AA in Ireland; a similar SEA and AA is also being undertaken in Northern Ireland in parallel with the drafting of the Transmission Development Plan for Northern Ireland (TDPNI).

The undertaking of SEA for EirGrid and SONI plans is in accordance with 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', which 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 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.

This approach will also apply to any other Regional Plans and/or Local Plans (focussed on substation nodes) that EirGrid might produce over the 5 year lifetime of the SEA.

The Shaping Our Electricity Future v1.1 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 and any Regional Plans or Local Plans. This is set out graphically in Figure 12.

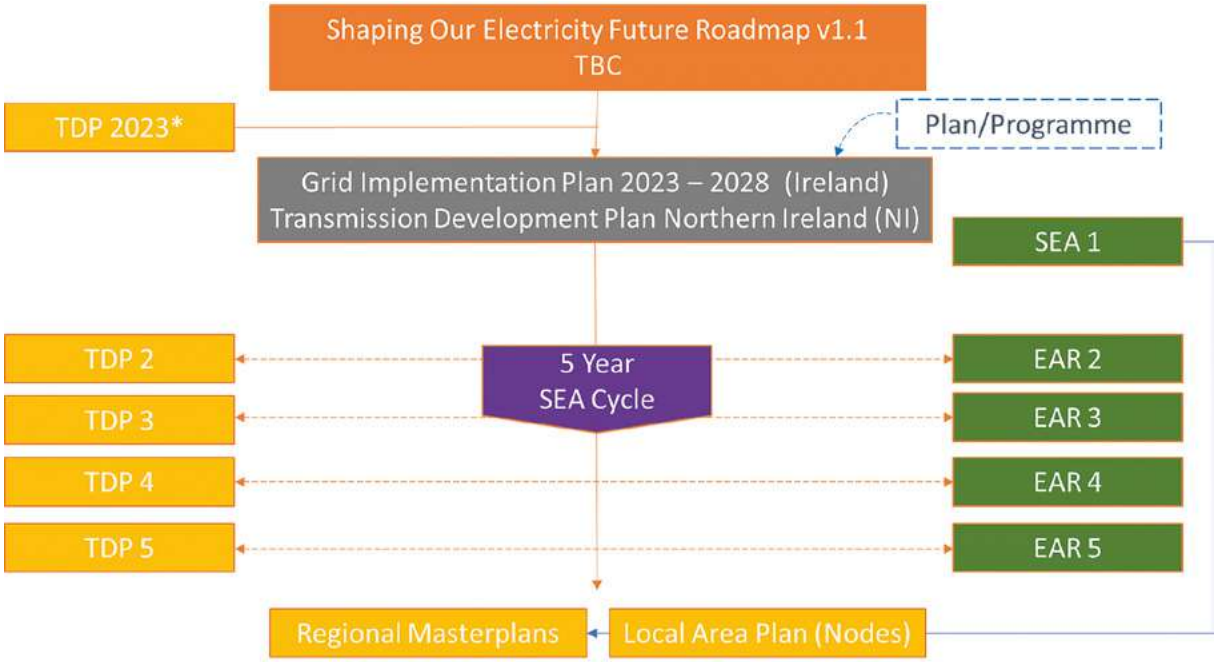


Figure 12: How Shaping Our Electricity Future and the TDP informs the grid implementation plan

6.3 Study assumptions

EirGrid and SONI use scenario planning to manage the uncertainty present in the medium and longer-term planning timeframes. In November 2021, we launched the Shaping Our Electricity Future v1.0 Roadmap following a period of consultation and analysis 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. For the Shaping Our Electricity Future v1.1 roadmap these datasets and study assumptions have been updated to reflect changes to government policy in Ireland and Northern Ireland, the feedback received in the Call for Inputs received in August 2022, and the latest available information.

6.3.1 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 median demand scenario contained in the Generation Capacity Statement 2022-2032[6]. This scenario assumes significant demand growth, in line with that assumed in Shaping Our Electricity Future v1.0, 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 13 with the main demand assumptions set out in Table 6.

6 https://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf

Figure 13: Demand spatial distribution, 2030

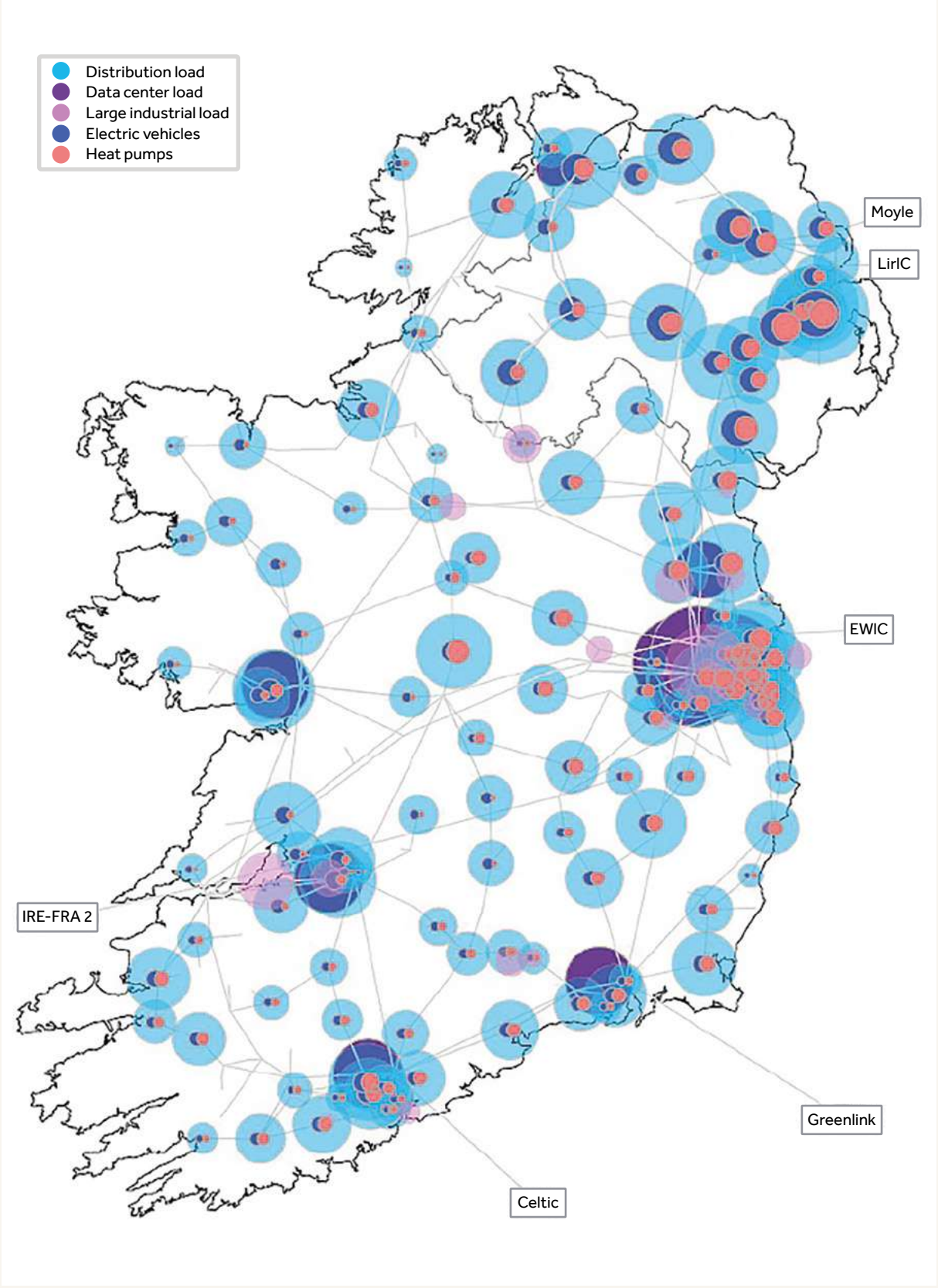


Table 6: Summary of main demand assumptions			
Demand category	**Units**	**Ireland**	**Northern Ireland**
Total Electricity Requirement (TER)	TWh	45.1	10.8
TER peak demand	GW	6.78	2.17
Number of electric vehicles	1000s	936	300
Number of heat pumps	1000s	600	120
Large Energy User demand	MW	1,550	20

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. In this Shaping Our Electricity Future v1.1 roadmap we responded to support for the Demand-Led approach in the original 2021 consultation, and to the Call for Inputs feedback, 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 7 shows assumptions relating to new LEU demand outside of Dublin and the Mid-East, and Belfast. This new LEU demand is expected in addition to already contracted LEU demand in Dublin and the Mid-East.

Table 7: Locations and size of assumed LEU demand located outside of Dublin and the Mid-East, and Belfast			
Node	**Jurisdiction**	**Voltage (kV)**	**Demand (MW)**
Cashla	Ireland	220	75
Coolkeeragh	Northern Ireland	33	20
Killonan	Ireland	220	75
Knockraha	Ireland	220	75
Great Island	Ireland	220	75

6.3.2 Flexible demand

Demand flexibility is an important contributor to managing surplus renewable generation by consuming the surplus when it is available. Additionally, the ability to reduce demand when renewable generation output is reduced can aid overall improvements in utilising renewable generation.

In both Ireland and Northern Ireland, over 20% of the demand in 2030 is assumed to be flexible. This flexibility is made up of Demand Side Units and price responsive Electric Vehicle charging.

The response of demand to available renewable generation is dependent on appropriate signals and tariffs being in place.

Table 8 sets out our demand flexibility assumptions.

Table 8: Flexible demand assumptions

Technology type	Ireland (MW)	Northern Ireland (MW)
Demand Side Unit (DSU)	1,200	380
Price Responsive EV charging	400	120
Total	**1,600**	**500**

6.3.3 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 Energy Efficiency Directive sets a binding collective EU target of 39% for energy savings. It reinforces the principle of energy efficiency first, i.e. prioritising energy saving across all sectors, by making it a legal obligation.

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 provided in Table 9.

Table 9: 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

6.3.4 Conventional generation

Due to Clean Energy Package legislation on CO_2 emission limits for capacity market payment eligibility[7], and planning decisions[8], 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, long duration energy storage, new interconnection capacity and demand side units.

A summary of the assumed thermal generation capacity in 2030, rounded to the nearest 50 MW, is shown in Table 10.

Table 10: Assumed thermal power plant rated capacities in 2030, rounded to nearest 50 MW

Generator type	Ireland (MW)	Northern Ireland (MW)
Gas Turbine	5,750	2,050
Distillate Oil	200	250
Total	5,950	2,300

EirGrid and SONI have carried out detailed analysis regarding the future conventional generation profile, taking into consideration system adequacy requirements – including detailed generator derating assessments. The generation portfolio 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 11, rounded to the nearest 50 MW. A map illustrating the areas provided in Table 11 is shown in Figure 14.

Since the data freeze date for inputs to the analysis for Shaping Our Electricity Future v1.1 the T4 2026/27 capacity auction has been completed.

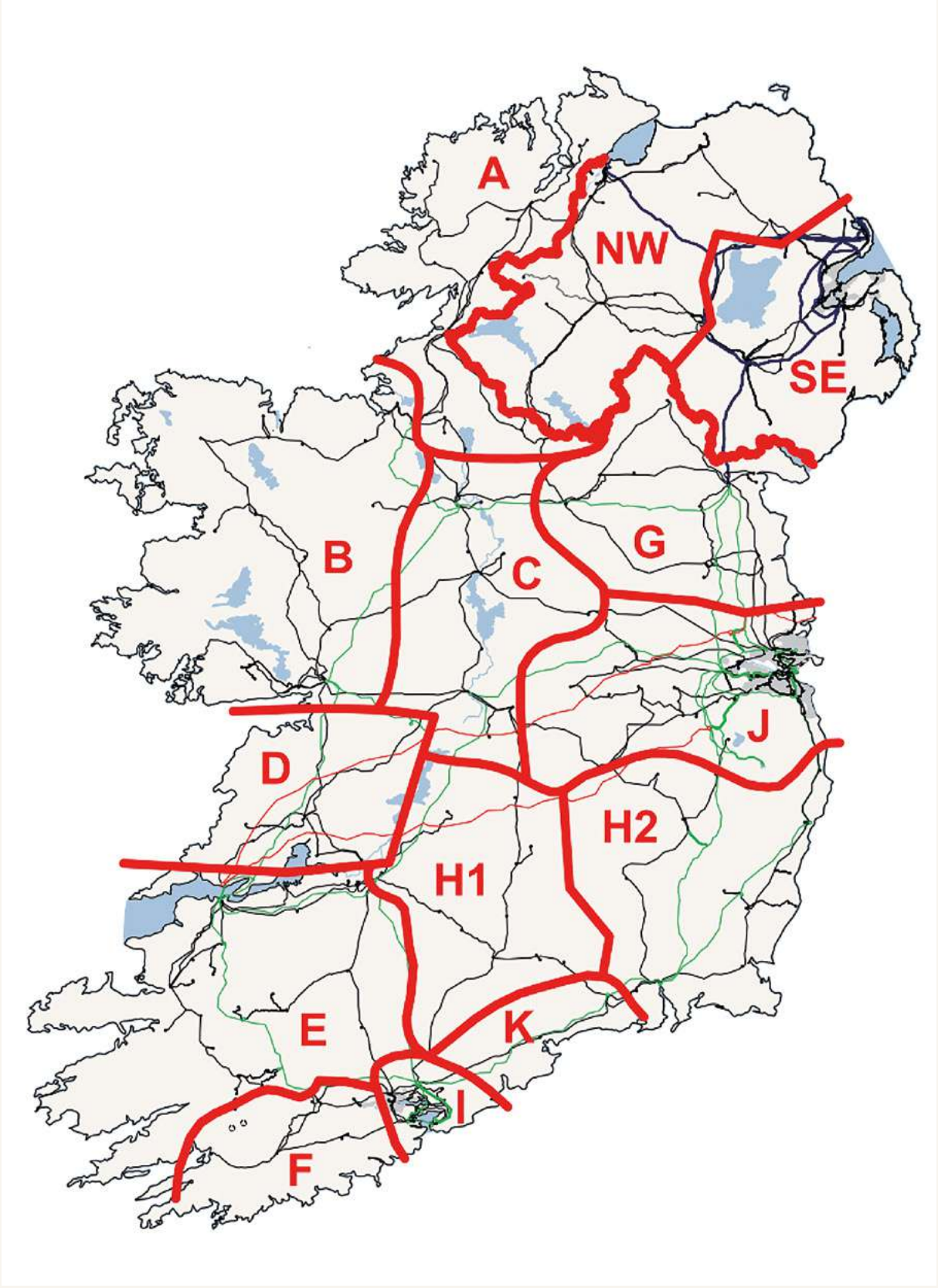
The total new capacity to be delivered by the auction matches the forecast in the Shaping Our Electricity Future v1.1 analysis; however, the assumptions around totals of Combined Cycle Gas Turbines (CCGT) and Open Cycle Gas Turbines (OCGT) is different. This is due to changes to the understanding of run-time limits on OCGTs.

Table 11: Assumed rated capacities of new gas-fired thermal generation by area

Area	Rated capacity (MW)
Area C	550
Area D	150
Area J	1,150
NI SE	1,000
Total	**2,850**

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

Figure 14: Study areas



6.3.5 Renewable generation

Ireland

The renewable generation quantities assumed in Ireland are informed by the Climate Action Plan 2023 which was published in December 2022. Based on these national targets, the Government's upcoming Renewable Electricity Spatial Policy Framework will set targets for each Regional Assembly for the development of onshore wind and solar PV, which will then form the basis under which specific targets at local authority level will be established and subsequently planned for. It is expected that the geographical allocation of renewables set out below in Shaping our Electricity Future v1.1 are broadly consistent with these targets.

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 approach achieves benefits for consumers by reducing both network constraints, and the scale and quantity of network reinforcements required.

Offshore wind is expected to emerge as a key contributor to delivering the Renewable Ambition. Strong progress is being made to set the required regulatory frameworks and connection principles and methods in place. The initial focus leading up to 2030 is on developments on the east coast which places the generation close to the largest centre of demand, again reducing 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, and based on targets in Climate Action Plan 2023, a considerable share of this capacity is small scale and micro-PV. Section 6.3.6 provides further details on micro-generation.

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

Northern Ireland

In Northern Ireland, the renewable generation portfolio in the Shaping Our Electricity Future v1.0 roadmap was heavily reliant on new onshore renewable generation capacity, given feedback expressing concerns over the deliverability of significant quantities of offshore wind by 2030. The Energy Strategy, published by the Northern Ireland Executive shortly after the Shaping Our Electricity Future v1.0 roadmap, set a target of 70% RES-E by 2030 in Northern Ireland, and an ambition to deliver 1 GW of offshore generation from 2030.

The subsequent revised legal target of 80% RES-E in Northern Ireland by 2030 led to a recognition that offshore generation capacity would need to be delivered by 2030 to help achieve the target. Given the large portfolio of onshore renewable generation in Northern Ireland in the Shaping Our Electricity Future v1.0 roadmap, for this update we assume the additional renewable generation capacity required to meet the revised Renewable Ambition will be delivered by offshore wind.

Table 12 provides a summary of the major renewable generation capacities assumed to be in place in Ireland and Northern Ireland by 2030.

Table 12: Summary of assumed renewable generation capacities in 2030

Source	Ireland (MW)	Northern Ireland (MW)
Onshore wind	9,000	2,450
Offshore wind	5,000 (+ 2,000 MW assigned to hydrogen production)	500
Solar[9]	8,000	600
Total	**22,000**	**3,550**

Focus on: 2 GW offshore wind for green hydrogen in Ireland

The Ireland Climate Action Plan 2023 includes a target for green hydrogen production from an additional 2 GW of offshore wind as part of the 2031-2035 measures for electricity.

For Shaping Our Electricity Future v1.1, this additional offshore wind has not been included in the network model as, based on engagements with DECC, the working assumption was made was that the demand for hydrogen production will not be supported by the wider transmission network when the output of the 2GW is below the demand of the hydrogen facilities.

There is scope for the concept of energy parks to emerge around the combined offshore wind and hydrogen production systems. A separate policy for such energy parks would need to consider green hydrogen accounting rules as per draft provisions under the EU Renewable Energy Directive.

It is recognised this is an emerging space which will require careful consideration as the sector progresses.

9 Includes micro-generation solar PV.

Table 13 provides a summary of assumed renewable generation capacities by area in Ireland and Northern Ireland and Figure 15 shows the assumed spatial distribution of generation by 2030.

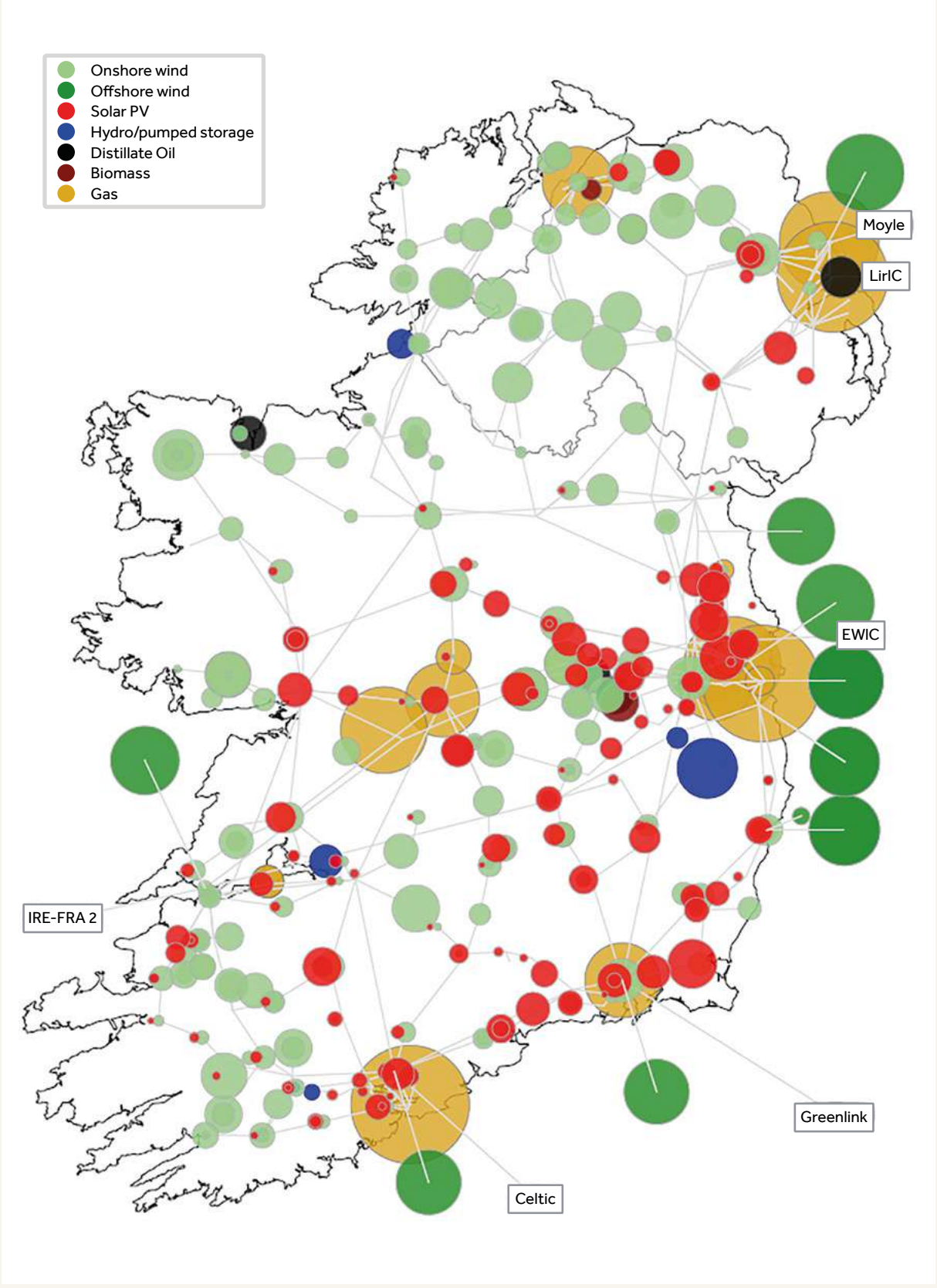
The assumed locations for future connections of renewables are informed by a range of information sources such as consultation feedback, grid connection applications, outcomes of auctions and projections of available grid capacity. These locations are subject to change.

Table 13: Summary of assumptions of onshore wind, offshore wind and solar PV by area

Area	Onshore wind (MW)	Offshore wind (MW)	Solar PV[10] (MW)
IE AREA A	1,150	0	150
IE AREA B	1,330	0	470
IE AREA C	630	0	520
IE AREA D	380	0	260
IE AREA E	1,830	390	560
IE AREA F	320	0	90
IE AREA G	370	370	490
IE AREA H1	630	0	450
IE AREA H2	860	1,170	1,260
IE AREA I	10	350	460
IE AREA J	1,380	2,720	2,940
IE AREA K	110	0	350
NI SE	450	500	450
NI NW	2,000	0	150

10 Includes micro-generation solar PV.

Figure 15: Generation spatial distribution, 2030.



6.3.6 Micro-generation and small scale 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 50 kW of electrical power. Small scale generators are those greater than 50 kW but less than those supported under the Renewable Electricity Support Scheme (RESS)[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 over 100 MW. We assume this will double by 2030 resulting in 200 MW of installed capacity, however, recent trends in the energy sector may drive this figure higher.

In Ireland, the Climate Action Plan 2023 has a requirement for 2,500 MW of non-new grid Solar PV capacity required by 2030. In response to interest from communities and individuals shown during consultation for Shaping Our Electricity Future and from the Energy Citizens Roadshows that EirGrid have been conducting in the last year, we have assumed that 2,500 MW of solar PV generation is small scale or micro PV that drives no new transmission network build.

As more small scale and micro PV generation is installed, its impact on ramping will become more prominent (a phenomenon often referred to as the 'duck curve'). In particular, the drop in PV generation output as the sun sets whilst the evening load increases could prove challenging to manage. This will require work between the TSO and DSO to develop systems and methods to manage the effects of self-supply of demand at peak small scale and micro PV output.

11 https://www.gov.ie/en/publication/b1fbe-micro-generation/#small-scale-generation

6.3.7 Interconnection

Further interconnection with neighbouring power systems, to add to the key system flexibility provided by existing interconnectors, has been identified as a component which can maximise the utilisation of surplus renewable generation and accommodate variable renewable generation.

It should be noted:

- Assumptions were made for new HVDC interconnection considering existing projects, projects with advanced proposals developed, diversity of supply and prospective new projects that are still at concept phase.
- The selection of assumed HVDC interconnection projects is indicative and is intended to demonstrate the benefit of additional interconnection and consider emerging policy in Europe.
- The assumptions are not endorsements of interconnection projects at any stage of development. EirGrid and SONI will continue to monitor development of interconnection projects and are/will be cognisant of emerging policy around interconnection.
- Interconnection projects are expected to play a key role out to 2050 as we look to further decarbonise the Ireland and Northern Ireland power system.

Taking this into account, our studies assume that the following new interconnectors are in service:

- 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).
- LirIC Interconnector – a HVDC interconnection between Northern Ireland at Kilroot substation and a transmission substation in south western Scotland (ENTSO-E TYNDP project 1040).
- A second Ireland – France HVDC interconnector. To minimise impact on network needs this new interconnector has been assumed to connect to the Moneypoint 400 kV busbar.

6.3.8 Storage

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 battery energy storage capacities (BES) is also expected in both jurisdictions.

Table 14 lists the storage capacity assumed connected by 2030.

The large scale Silvermines hydro project (ENTSOE TYNDP project 1025) has also been deemed a PCI project by the European Union, and has been included in our analysis.

Battery energy storage (BES) technologies are required in 2030 for reserve provision, capacity adequacy, to assist with congestion management, and to help manage surplus renewable generation while minimising the amount of renewable generation required to deliver the Governments' target. 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.

Table 14: Assumed storage installed output capability in 2030

Technology type	Ireland (MW)	Northern Ireland (MW)
Battery energy storage	3,225	625
Pumped hydro energy storage	600	0
Total	**3,825**	**625**

Table 15: Annual energy storage capacities in 2030

Jurisdiction	Category	Average of duration (h)	Installed capacity (MW)
Ireland	Energy and reserve	2.0	800
	Long duration	4.0	375
	Long duration	6.0	1,350
	Long duration	8.0	700
Northern Ireland	Energy and reserve	2.0	250
	Long duration	4.0	125
	Long duration	8.0	250

Table 16: Summary of assumed battery energy storage capacities by area

Area	Installed capacity (MW)	Storage duration breakdown (MW each duration)			
		2 hr	4 hr	6 hr	8 hr
IE AREA A	200	50	–	–	150
IE AREA B	200	100	–	100	
IE AREA C	450	150	–	200	100
IE AREA D	0	–	–	–	–
IE AREA E	200	50	150	–	–
IE AREA F	0	–	–	–	–
IE AREA G	125	25	–	100	
IE AREA H1	350	50	50	100	150
IE AREA H2	250	–	50	200	–
IE AREA I	400	150	–	250	–
IE AREA J	950	175	75	400	300
IE AREA K	100	50	50	–	–
NI AREA SE	625	250	125	–	250
NI AREA NW	0	–	–	–	–

6.3.9 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 17.

Table 17: All-island operational constraints

Constraint	Unit	Value
SNSP upper limit	%	95
Inertia lower limit	MWs	20,000
RoCoF upper limit	Hz/s	1
Minimum number of conventional units, Ireland	#	2
Minimum number of conventional units, Northern Ireland	#	1

6.4 Results of transmission network analysis

6.4.1 System needs

The model of the 2030 power system was subject to a system needs assessment – this identified the elements of the transmission system that do not meet the required performance levels in the basic TSSPS system reliability tests. This helped inform selection of the final set of candidate network reinforcements required to deliver the Renewable Ambition for 2030.

The generation and demand modelled on the transmission network has been set out in the Study Assumptions section. The transmission network configuration used in the analysis is based on the network as it is today, but with approved reinforcements included. The approved reinforcements come from the list of committed projects and those candidate projects identified in Shaping Our Electricity Future v1.0.

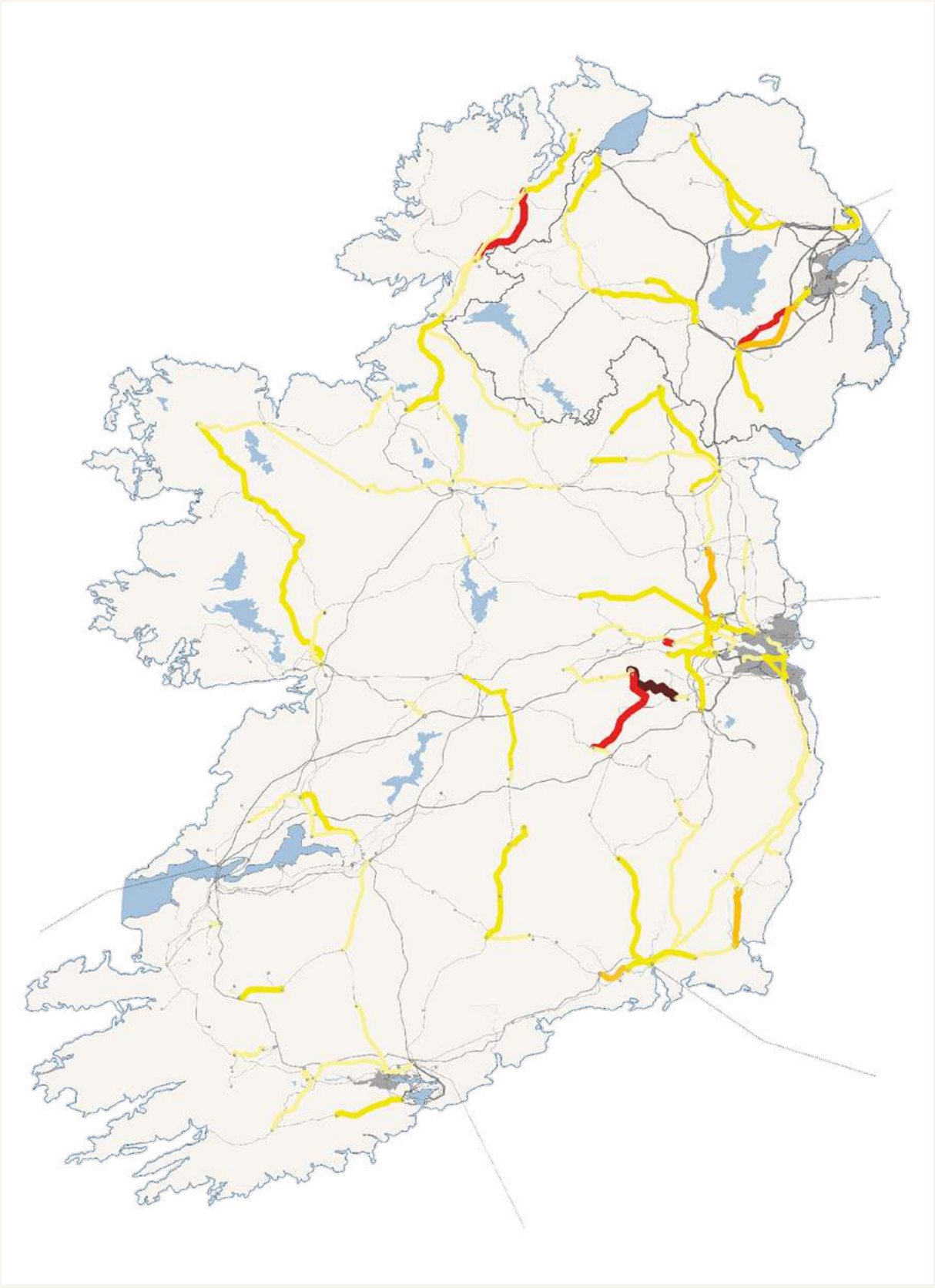
Figure 14 illustrates the network needs identified using the final network development approach in Ireland and Northern Ireland. The severity of the need is indicated using the colour coding described in Table 18.

As expected, the volume and scale of transmission network elements that performed outside of the planning standards indicated that the transmission network does not have sufficient capacity to integrate the levels of renewables needed to achieve the increased Renewable Ambition.

Table 18: 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 16: Needs arising from system needs assessment



In Northern Ireland, 110 kV circuits in the north-west area continue to see a significant risk of overloading, although the severity of the risk has reduced compared to Shaping Our Electricity Future v1.0 due to:

- The inclusion of the Mid Antrim reinforcement, a candidate reinforcement in Shaping Our Electricity Future v1.0, as a base case reinforcement this time around; and
- Updated assumptions regarding the location of new onshore wind connections.

Offshore wind generation of 500 MW is required to deliver the Renewable Ambition in Northern Ireland. This generation connects into the strong 275 kV network in the east of the country and consequently does not drive any significant risk of overloading.

The inclusion of 700 MW of additional interconnection capacity between Northern Ireland and Scotland sees a notable risk of overloading on 110 kV circuits between Lisburn and Tandragee during times of high exports to Scotland and high imports from Ireland into Northern Ireland.

In Ireland, additional needs compared to those identified in Shaping Our Electricity Future v1.0 were identified. These needs were created by the significant increase in assumed new renewable generation in the form of onshore wind and solar PV. In all parts of the network, more circuits are carrying more power more often. Some circuits were shown to experience overloads in the analysis.

The analysis sought to reduce the number of forecasted overloads by using renewable hub connection arrangements to gather and connect new generation to parts of the network that have realisable grid capacity by 2030.

In the southwest, the assumed second Ireland to France HVDC interconnector has been connected to the Moneypoint 400 kV station to help reduce loading on the circuits that traverse the country from west to east.

Long duration storage was used, where possible, to help minimise forecasted network overloads.

Remaining network overloads were considered for candidate reinforcement solutions.

6.4.2 Candidate reinforcements

We have identified a number of candidate reinforcements that are required in order for the increased 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 and are also additional reinforcements to those identified in the Shaping Our Electricity Future 1.0 roadmap. The candidate reinforcements are indicated in Figure 17.

In Northern Ireland, 110 kV circuits between Lisburn and Tandragee are required to be uprated to provide additional capacity. A new substation is required in South-East Antrim to facilitate the connection of several large projects which will provide significant flexibility to the transmission system.

In Ireland several new candidate reinforcement projects have been identified to address new renewable generation connections and demand growth across the country.

These new candidate reinforcements in Ireland are in addition to the projects with Capital Approval shown in the Q4 2022 Network Delivery Portfolio published in January 2023 and the candidate solutions identified in Shaping Our Electricity Future v1.0 listed in Appendix 4.

New renewable hub substations are proposed to be strategically located to allow significant quantities of new renewable generation in the geographic vicinity to connect into them. The renewable hub substations are then, in turn, connected to a part of the network that has the required realisable grid capacity to cope with the additional generation. This approach avoids multiple smaller-scale connections to the 110 kV grid with associated planned outage implications. Additional congestion on the 110 kV network is avoided which would drive further candidate reinforcements.

The concept of renewable hubs used in this analysis assumes they are built contestably by renewable generation developers as part of their connection method agreed with the TSO. At each of these renewable hubs it is assumed that new-build of substations and circuits can be minimised through co-location of onshore wind and solar PV generation in hybrid connection arrangements, in conjunction with long duration storage to capture variable renewable generation peaks and release that energy when network conditions allow.

The analysis has identified four new candidate large-scale renewable hubs for further consideration[12]. Three are to accommodate new renewable generation in the midlands, and one to accommodate renewable generation in the southeast:

1. A new 400 kV renewable hub collector substation looped-in to the Oldstreet – Woodland 400 kV circuit in the eastern Midlands;
2. A new 220 kV renewable hub collector substation looped-in to the Maynooth – Shannonbridge 220 kV circuit in the eastern Midlands;
3. A new 220 kV renewable hub collector substation tailed into the Maynooth 220 kV substation; and
4. A new 220 kV renewable hub collector substation tailed into the Great Island 220 kV substation.

In addition to the renewable hub-based network developments, a number of network uprate and network flexibility candidates was identified.

In the Midlands, in addition to the large scale renewable hub arrangements assumed, uprating of the Corduff – Blundelstown – Mullingar 110 kV circuit and the Maynooth – Castlelost 220 kV was identified.

In the North West, additional network capacity is required to help meet the Renewable Ambition. Uprating the Letterkenny – Golagh T 110 kV, Cashla – Dalton 110 kV, and Castlebar – Dalton 110 kV circuits and the application of Dynamic Line Rating to the Srananagh – Cathaleen's Fall 110 kV was identified.

In the North East of the country, a number of uprates and Dynamic Line Rating projects were identified. The Gorman – Maynooth 220 kV circuit requires uprating, while the Baltrasna – Corduff 110 kV, Deenes – Drybridge 110 kV, Meath Hill – Louth 110 kV, Lisdrum – Louth 110 kV and Ratrussan – Shankill 110 kV circuits were identified for application of Dynamic Line Rating.

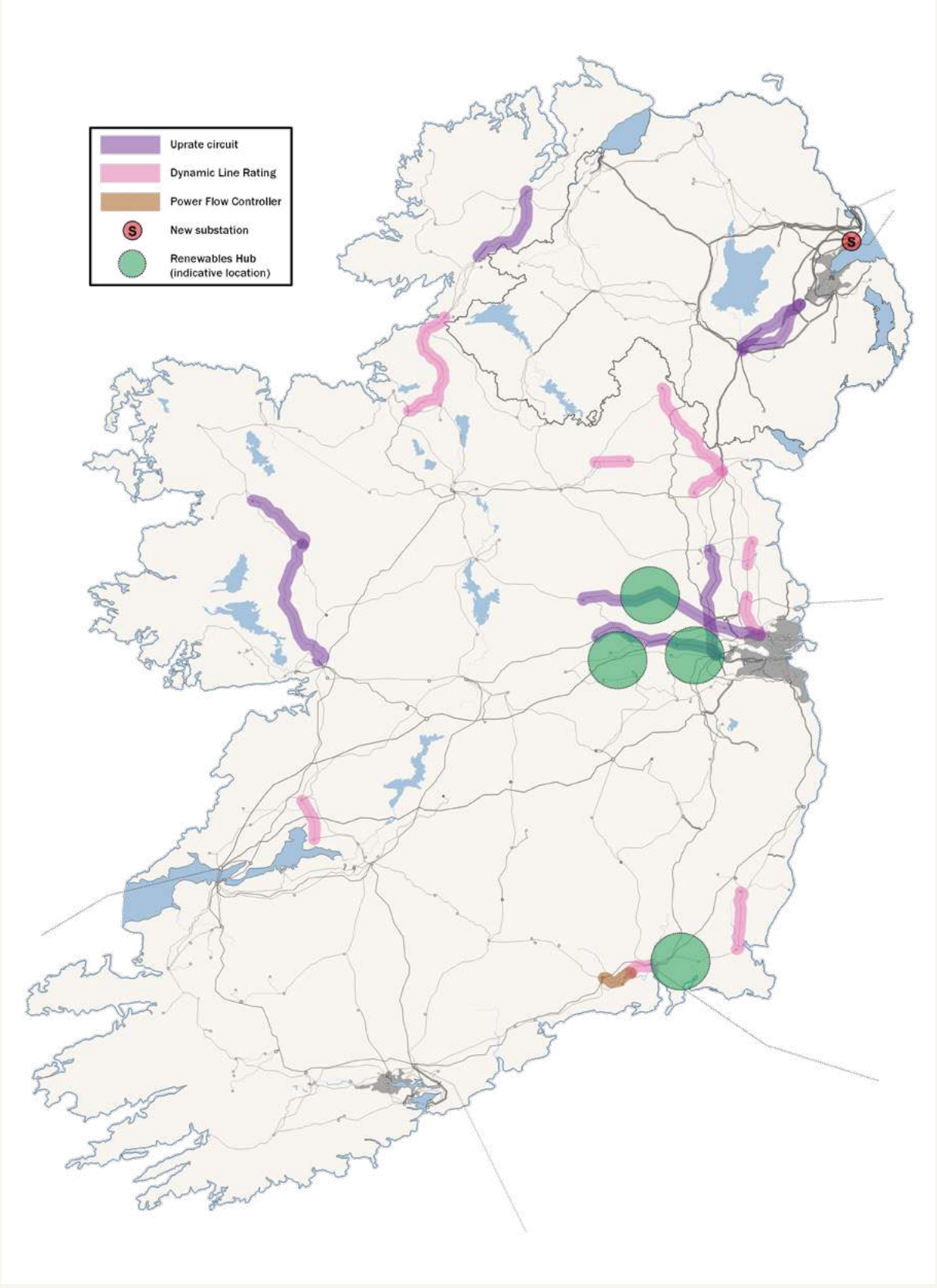
In the South East, the application of flexible network technologies, along with the large scale renewable hub at Great Island 220 kV substation, were identified. The analysis showed that the Crane – Wexford 110 kV and Great Island – Waterford 110 kV circuits require Dynamic Line rating while potential constraint on the Cullenagh – Waterford 110 kV circuit will be reduced by application of Dynamic Power Flow Controllers on the circuit.

The transmission network in the South West will be improved through application of Dynamic Line Rating on the Ennis – Drumline 110 kV circuit.

It is assumed that some Large Energy User (LEU) demand is incentivised to locate outside Dublin and Mid-East. Site selected in the analysis include Cashla and Great Island, 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.

12 These renewable hub substations are expected to be developed through existing development pathways or as new 'Renewable Hubs' (framework to be trialled for ECP2.4). EirGrid understands further renewable hubs will be, or are being, defined at transmission and distribution level in addition to the four hubs described here.

Figure 17: Identified candidate reinforcements



A summary of the quantity and types of candidate reinforcements is provided in Table 19. A full list of all candidate reinforcements can be found in the Appendix 3.

Table 19: Quantities of candidate reinforcements by type and jurisdiction

Reinforcement category	Ireland	Northern Ireland
New circuits	Dependent on scale of Renewable Hub arrangements	–
Uprate existing circuits	6	2
Power flow controllers	1	–
Dynamic line ratings	9	–
New substation	–	1
Total	**16**	**3**

6.4.3 Surplus renewable generation

Surplus renewable generation is a component of dispatch-down which happens when renewable generation supply exceeds market demand plus interconnector exports. Development of sufficient volumes of variable renewable generation to achieve RES-E and carbon dioxide emissions targets requires high installation resulting in surpluses at times.

Surplus renewable generation is a key feature of the analysis for 2030, and it has been shown to increase non-linearly at increasingly high levels of renewables.

Per this analysis, which assumes a perfect world, over 20% of available renewable generation is predicted to be dispatched down due to surplus availability of renewable generation in 2030. There is an opportunity for flexible services and/or innovative solutions to utilise this surplus energy for the benefit of society.

Further interconnection (new interconnectors between Northern Ireland – Scotland and Ireland – France), along with aggressive assumptions around long duration storage (over 2.8 GW) and demand side flexibility (over 20%) help maximise the utilisation of renewable surpluses and have been assumed to be in place in this revised Roadmap.

EirGrid and SONI recognise surplus renewable generation of this quantum represents an opportunity for innovative energy usage approaches and welcomes innovation in this area. Opportunities worth consideration (recognising the very significant challenges of having in place at any scale by 2030) could include:

- Connection of flexible industrial demand.
- Green focussed electricity tariffs to appropriately modify behaviours.
- Initiatives focussed on availing of excess generation to alleviate fuel poverty.

Significant infrastructural and technological solutions are required to support the implementation of the Renewable Ambition and, even with optimistic assumptions on the roll-out of these, the roadmap shows the scale of the challenge in electrifying and decarbonising our economy by 2030.

Because surplus renewable generation is a key feature of the future power system, additional renewables alone is not the solution to meeting targets.

Timely implementation of incentives and frameworks which support the development and implementation of the solutions to exploit this surplus renewable generation require careful consideration and focus by policy makers, regulators, and industry players. Other significant power systems in Europe, the US etc. are not expected to experience similar levels of surplus renewable generation until well into the next decade and thus Ireland and Northern Ireland will be at the forefront of this emerging space.

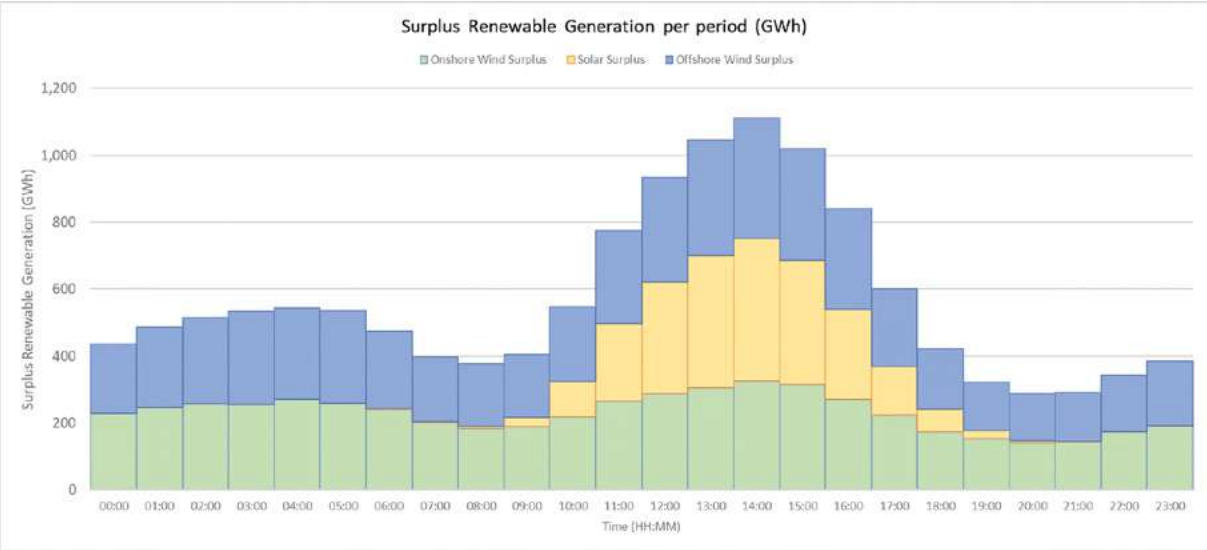


Figure 18: Summation of surplus renewable generation for each hour in 2030

6.4.4 Costs

The estimated capital expenditure (CAPEX) costs of candidate reinforcements are shown in Table 20 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.

These costs will be considered in more detail as the candidate reinforcements progress through EirGrid's Framework for Grid Development process or SONI's 3 Part Process for Developing the Grid.

The costs of the candidate reinforcements identified as part of Shaping Our Electricity Future v1.1 are considered in the context of the wider programme of capital investment in transmission infrastructure. Combining Shaping Our Electricity Future costs with EirGrid and SONI's current and future programme costs indicates the total transmission CAPEX required by 2030. This is detailed in Table 21.

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. In Northern Ireland, changes to the design or scope several projects has led to revised costs associated with Shaping Our Electricity Future v1.0.

Table 20: Estimated CAPEX by reinforcement type per jurisdiction		
Reinforcement category	**Ireland (€M)**	**Northern Ireland (£M)**
Uprate existing circuits	157	12
Power flow controllers & Dynamic line Ratings	19	–
New substation	–	48
Total	**176**	**60**

Table 21: Estimated total transmission CAPEX by 2030 by jurisdiction and pipeline category		
Category	**Ireland (€M)**	**Northern Ireland (£M)**
Current and future programme	2,117	178
Shaping Our Electricity Future v1.0	1,103	88
Shaping Our Electricity Future v1.1	176	60
Total	**3,396**	**326**

6.4.5 Economic benefits of candidate reinforcements

Evaluation of the Economic Performance is one of the five criteria used in our multi-criteria assessments of grid development projects. The other criteria are Technical Performance, Environmental Performance, Socio-economic Performance and Deliverability. Several metrics are used to assess the economic performance and these have been applied, at a high level, to the candidate reinforcements for Shaping Our Electricity Future v1.1. This is consistent with the methods used to compare the performance of the four draft approaches as part of the original consultation in 2021.

The economic performance metrics considered in the assessment are:

- 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).
- Reduction in grid losses, measured in gigawatt-hours (GWh).

The first four metrics are estimated as the difference between security-constrained unit commitment and economic dispatch simulations that have the Shaping Our Electricity Future v1.1 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 6.3 and assume that all reinforcements listed in appendices 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 to exceed the ambitions of both Ireland and Northern Ireland in the model.
- 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 0.6% and will correspond to approximately 352 GWh. At an average compensation rate of €88.62/MWh[13], this corresponds to a constraint cost of €31.2 million, this benefit is additional to the benefits mentioned in the Shaping Our Electricity Future v1.0 Roadmap report.
- 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 22.

Table 22: Estimated all-island benefits shown in Euros

Metric	Volume	Monetisation (€m)
RES-E achieved in 2030	c.89% (IE) c.80% (NI)	–
Renewable generation Constraint p.a.	352 GWh c. 0.6%	31.2
Grid losses change p.a.	-135 GWh	7

13 Cost of compensation determined based on assumed strike prices of €80/MWh for onshore wind; €80/MWh onshore solar PV; and €120/MWh for offshore wind. Assumed strike prices are based on LCOE estimates.

6.5 Transmission interface station capacity needs

EirGrid, as the Transmission System Operator (TSO) of Ireland, and ESB Networks, as the Distribution System Operator (DSO) 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, also called bulk supply points. A primary function of these stations is to facilitate power flows between the transmission and distribution systems to enable power to be distributed to where it is needed.

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 forecasted growth of electricity demand in the distribution network. This projected demand growth is driven by a number of factors including residential demand growth, electrification of heat and transport and growth in commercial sectors.

The electricity demand growth in the distribution system leads to a significant additional requirement from the transmission system. The existing bulk supply points and the associated transmission circuits are at risk of reaching their capacity limits. To address this need, new infrastructure is required.

Since publication of the original Shaping Our Electricity Future v1.0 roadmap the emerging needs have translated into connection requests made by the DSO to the TSO. Currently there are three projects underway to deliver new bulk supply points, one each in North County Dublin (CP1214), West County Dublin (CP1226), and Dublin Central (CP1273).

Further studies and investigations are underway to determine the best performing solution for the new bulk supply points, their required connections and associated new transmission circuits. Once more clarity about the best preforming solutions is available a process of wider engagement and consultation will begin. This is in line with the six step Framework for Grid Development. EirGrid continues to work with the DSO to progress plans for transmission interface stations and these projects can be seen in the Network Delivery Portfolio.

6.6 Duck Curve

The Duck Curve refers to a graphical representation of electricity demand from the grid on days when solar energy production is high and demand in the grid is low. When plotted on a graph the lines and curves form a distinctly duck-like shape.

Essentially, the Duck Curve creates power system challenges as the grid attempts to cope with extreme changes in demand across different parts of the day.

As more solar energy is exported to the grid, usually across the middle part of the day when the sun is shining, the curves deepen. Then, as the sun sets and solar energy is no longer being generated, the Duck Curve typically shows extreme changes in demand and the grid needs to 'kick in' suddenly – which can be difficult. These extreme changes in demand can result in the energy system becoming unstable.

The term was coined around 2012 by the California Independent System Operator in the United States. The graphical representation was a way to demonstrate the demand for electricity from a grid, with hourly solar generation and usage patterns. The Duck Curve is a worldwide phenomenon and now widely referenced in the energy industry.

Managing this issue will require close co-ordination between the TSO and DSO, in association with policy makers and regulators, as part of the joint system operator programmes.

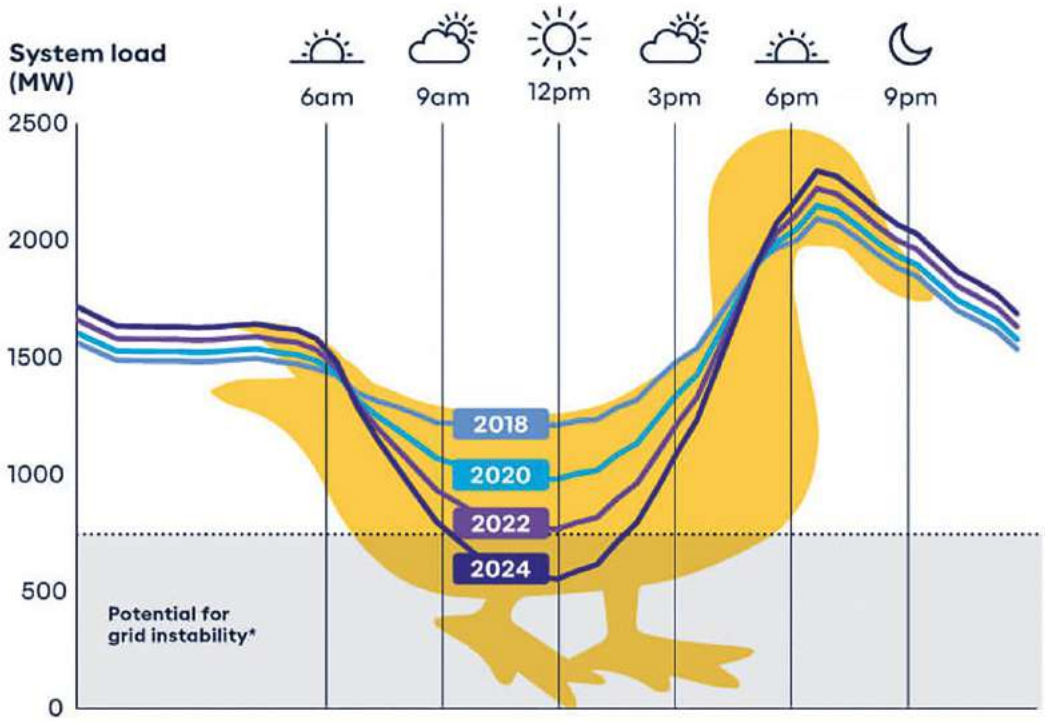


Figure 19: A graphical representation of the 'Duck Curve' for Western Australia

6.7 Carbon emissions and renewable penetration forecasts

6.7.1 Ireland emissions results

EirGrid has undertaken carbon emissions analysis to model a range of renewable generation trajectories to 2030, along with trajectories of demand changes, conventional generation changes and rate of storage roll-out. The modelled trajectories all describe a significant acceleration in the deployment of renewables, replacement of aging conventional generation with more efficient plant, and roll-out of enablers like storage. From these trajectories estimates of emissions to 2030 have been developed.

There are several dependencies which influence the outcome of emissions and three central scenarios explored variations of these, as summarised in Table 23 below.

For the purpose of this modelling, the Energy Transition Model[14], developed by Quintel, was used to model intervening years at hourly resolution from present to 2030 in Ireland.

Table 23: Overview of the variables explored in the scenarios investigated in Ireland

Region	Scenario	Demand		RES MW		Thermal		Storage		Coal merit
		2025 TWh	2030 TWh	2025 GW	2030 GW	2025 GW	2030 GW	2025 GW	2030 GW	
IE	1. Low	38.5	45.0	11.0	22.0	4.7	6.5	1.5	3.0	High, then low merit
IE	2. Central	38.5	45.0	8.3	17.5	4.7	5.3	0.6	2.5	High, then mid-merit
IE	3. High	41.6	50.1	8.4	13.1	4.7	6.5	0.6	2.5	High, then mid-merit

14 Quintel, Energy Transition Model https://energytransitionmodel.com/

Expanding on the table above, the figure below visualises the annual renewable capacity roll out as part of the Low scenario. It is characterised by onshore wind growing from 4.3 GW in 2021 to 6 GW in 2025 accompanied by 5 GW of solar. The energisation of offshore from 2028 sees total variable renewables in 2030 amount to 22 GW.

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.

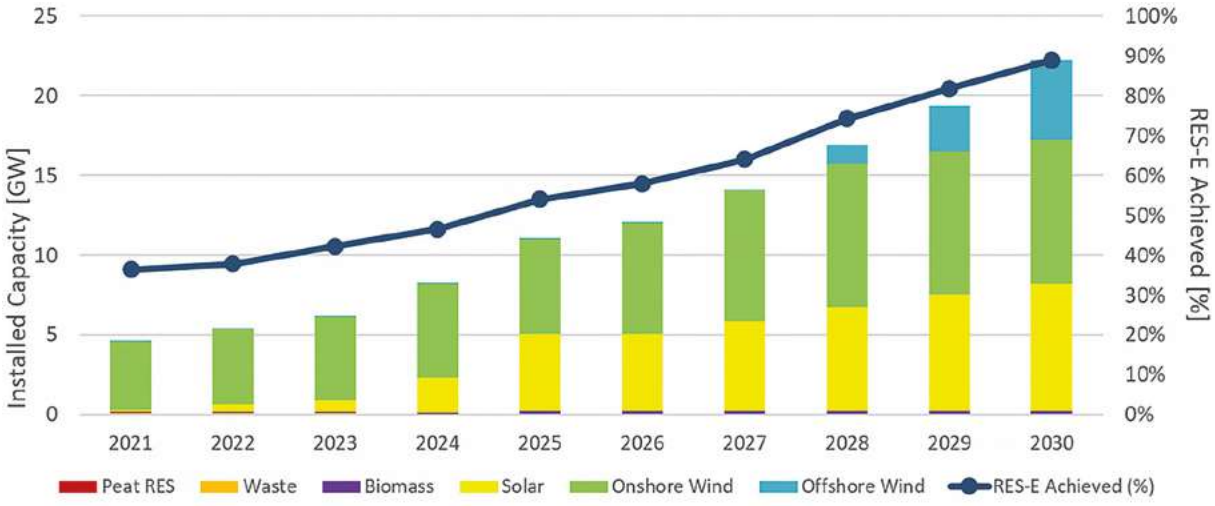


Figure 20: Projection for renewable generation growth and RES-E% levels in Ireland

The results are influenced by the key trends explored across the four scenarios:

1. Demand growth would drive up emissions in a counterfactual scenario where renewables remain static.
2. Carbon intensive fuels – the higher in the merit carbon intensive fuelled plant are, the higher the emissions.
3. Fuel switching – displacement of carbon intensive fuel generators and aging plant with more efficient conventional generation operating on lower carbon intensity gas, plays a beneficial role of maintaining security of supply while in doing so reducing emissions, compared to a scenario where aging plant are higher in merit.
4. Renewable MW with the pace of renewables deployment across the decade influencing pace of displacement of emissions. By extension, the amount of renewable power that can be used to meet demand also influences emissions. The Markets Recommendations and Operations Multi Year Plan outline the roadmaps for the evolution required to minimise operational constraints and accommodate higher shares of renewable power on the future grid. The ETM modelling methodology, for this emissions analysis, emulates the dispatch down observed historically, with the published ECP constraints and with the Plexos market model over the range of the study horizon.

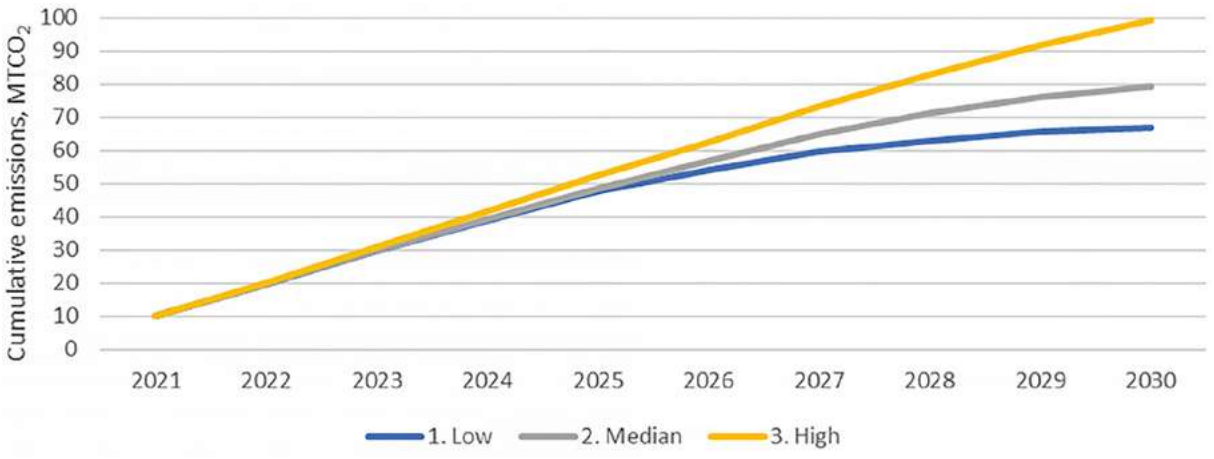


Figure 21: Cumulative carbon dioxide emissions for the low, median and high scenarios for Ireland

6.7.2 Northern Ireland emissions results

The Northern Ireland Climate Action Plan, due for publication in 2024, will set out a cumulative carbon budget for intervening years to at least 2030. An hourly residual load curve model, developed at SONI, was used in Northern Ireland.

Similar to above for Ireland, annual emission modelling was also undertaken by SONI for Northern Ireland in an hourly residual load curve model. The model was used to explore three scenario variations based on the key trends discussed previously. The key inputs in the milestone years of 2025 and 2030 are summarised in the table below.

Expanding on the inputs in the table below for Northern Ireland, Figure 22 visualises the annual rate of deployment for variables renewables assumed in the low scenario. It is characterised by onshore wind and solar dominating the decarbonisation effort until 2029 when offshore is assumed to energise, bringing total variable renewable capacity to over 4000 MW.

Table 24: Overview of the variables explored in the scenarios investigated in Northern Ireland

Region	Scenario	Demand		RES MW		Thermal		Storage		Coal merit
		2025 TWh	2030 TWh	2025 GW	2030 GW	2025 GW	2030 GW	2025 GW	2030 GW	
NI	1. Low	9.4	11.2	2.0	4.1	2.1	2.5	0.3	1.0	Close in 2023
NI	2. Central	9.4	11.2	1.9	3.6	2.1	2.5	0.3	0.6	Close in 2023
NI	3. High	9.5	11.7	1.8	3.1	2.1	2.5	0.3	1.0	Close in 2024

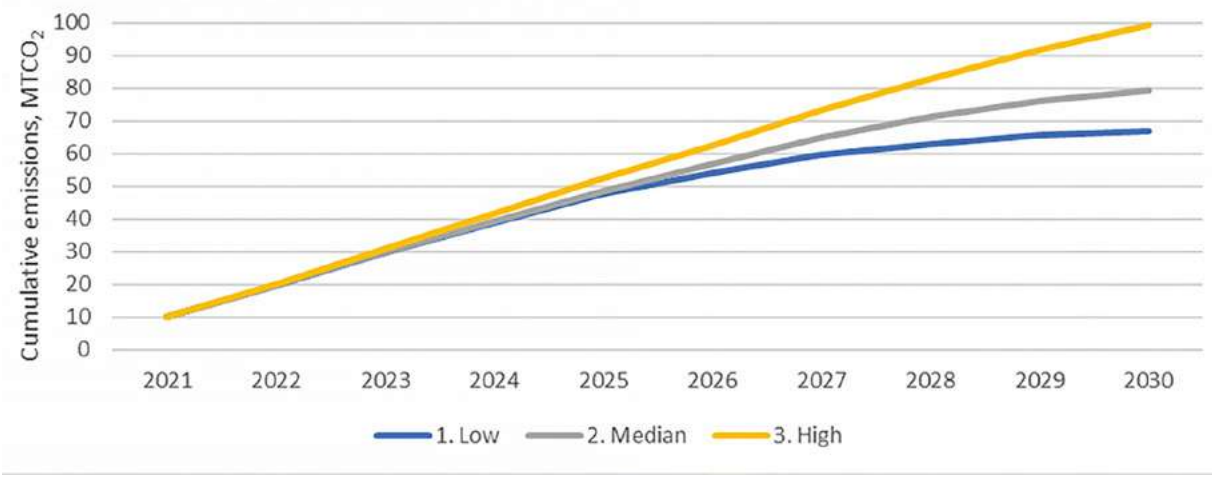


Figure 22: Projection for renewable generation growth and RES-E% levels in Northern Ireland

Following modelling of these inputs and again, like above, reflecting on the key dependencies which drive emissions, for Northern Ireland, the low scenario observes the lowest cumulative emissions trajectory owing to energisation of new CCGT displacing retiring carbon intensive fuels, growth of renewables including 1000 MW offshore, 2.6 TWh increase in electricity demand from the present value and additional flexibility.

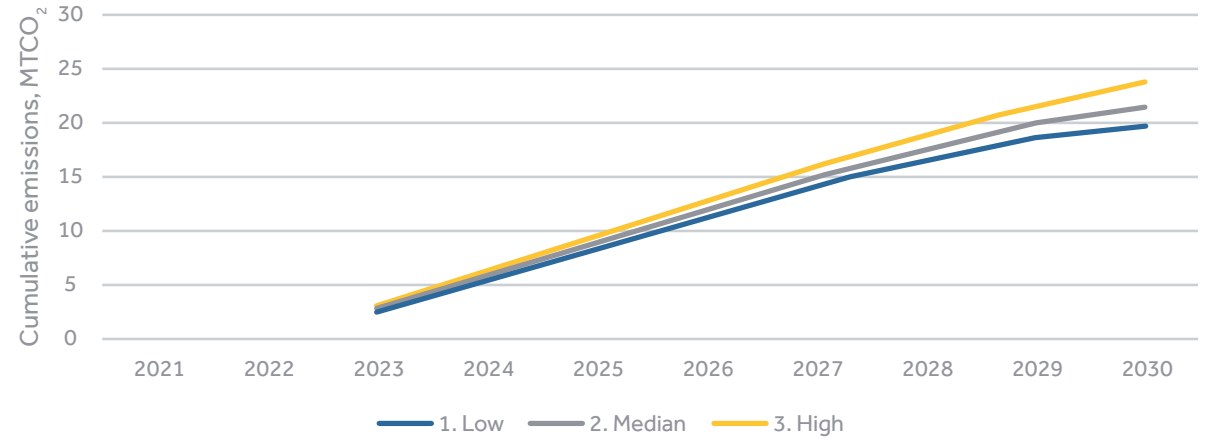


Figure 23: Cumulative carbon dioxide emissions for the low, median and high scenarios for Northern Ireland.

7. 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.

Shaping Our Electricity Future Roadmap version 1.1 builds on the foundations of the previous version, feedback since the launch and recognises evolving energy and climate policy in Ireland and Northern Ireland.

This section sets out multi-year plans or recommendations for the evolution of our transmission network, engagement approach, system operation and markets.

**Note: Throughout the multi-year plan tables of actions, where actions and dates have been updated/changed from the original version of Shaping our Electricity future, original dates or actions are shown in a subdued, italic text for reference only.

7.1 Network infrastructure

7.1.1 Network infrastructure key messages

The Network Delivery Portfolio (NDP) published in late 2022 lists the full programme of works planned for delivery on the transmission system in Ireland between 2022 and 2030[15]. The Transmission Development Plan Northern Ireland presents projects that are expected to meet the operational needs of the transmission network. In that period, in Ireland, we anticipate over 350 projects are required to reinforce the system and facilitate connections. This represents an investment of over €3bn in the Ireland and Northern Ireland grid and is a substantial ramp in delivery across the entire life cycle of project delivery.

The work is required to connect significant volumes of offshore and onshore wind, solar and conventional generation while also reinforcing the power system and implementing over 50 candidate solutions identified previously in Shaping Our Electricity Future version 1.

To support this ramp in delivery, there has been a considerable step change in approach to network delivery in Ireland. There has been substantial progress on our major programmes of work which has been described in the achievements section. In addition, we have worked to adapt our approach to streamline and ultimately accelerate delivery across the end-to-end life cycle of projects. Continued support across the sector from all stakeholders is needed to continue to make real progress on this.

15 This NDP will be published quarterly on the EirGrid website.

There are a number of strategic enablers which are fundamental for effective infrastructure delivery within the required timeframes out to 2030 in Ireland and Northern Ireland. These are based on a combination of project delivery experience across a range of infrastructure sectors, engagement with stakeholders and communities and our own recent experience of the delivery challenges. These include:

Public acceptance

Public Acceptance remains fundamentally 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. We will apply the learnings from projects and engagement approaches and continue to evolve our approach. Detailed engagement/communications plans are being developed for specific projects and programmes of work as required. Further details on our engagement approach is covered off in the engagement section of this report.

Planning and consenting

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 also implement our established exempted development process addressing those projects that do not require planning permission. We will continue to identify projects as part of national, regional and local planning policy, focussing on established development plan structures.

In Ireland, we are continuing to work with An Bord Pleanala to minimise the impacts of resource constraints on project programmes. We are also working with the Department of Housing, Local Government and Heritage (DHLGH) to progress marine licensing under the existing Foreshore Acts and the MAPA Act. The process and timelines for marine licenses have a key impact on our programme schedules.

In Northern Ireland, we believe consideration will need to be given to the planning system and whether it is working effectively. At present, planning decisions continue to take significant time (e.g. 5+ years) for strategic projects. Planning timescales of this length make it very challenging for Northern Ireland to meet new renewable energy targets by 2030. We will continue to engage proactively and constructively with the Department for Infrastructure, Department for Agriculture, Environment and Rural Affairs, as well as the local authorities the inform them of our infrastructural plans at the appropriate time in the consenting processes.

TSO/TAO/TO

Given the significant programme of grid development work identified, it remains essential that an overall optimal programme delivery of projects (TSO/TAO/TO Joint Delivery Approach) in Ireland and Northern Ireland continues to evolve to leverage efficiencies and to accelerate overall timelines for delivery.

Outages

Outages remain a key enabler for delivery of grid works out to 2030.

Focussing on Ireland, given current work practices and approaches it is not possible to facilitate all the outages required out to 2030. Significant transformation is needed in this area in order to accelerate grid delivery and deliver on the climate action plan targets. The key areas where transformation is needed are the following:

- Increased outage utilisation and optimisation.
- Increased outage availability.

The outage review in Ireland will include an end-to-end life cycle of outages review as well as consideration of outages during project initiation and decision making. It is also planned to carry out further analysis of the power system in the years out to 2030 to identify how any additional wires or non-wires solutions could be used to optimise the system to facilitate additional flexibility and additional system outages in the years out to 2030. The output is likely to be a transformation roadmap which will include a combination of technical, process and regulatory recommendations for consideration and implementation.

In Northern Ireland, to manage the 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 NIE Networks will continue to work closely to deliver the outage programme and in turn the grid delivery programme as effectively and efficiently as possible.

Plan led approach

The original version of Shaping Our Electricity Future noted how implementing a plan led approach in Ireland was crucial to deliver on the renewable electricity and carbon emission reduction targets. The networks plan developed minimised the amount of new grid build between now and the end of the decade. It is therefore crucial that new generation and demand are in areas which will be compatible with the overall network plans. This allows the system operator to optimise grid planning and associated delivery and will minimise the level of grid infrastructure required overall.

Public road network

Public roads remain a key enabler for delivery of network infrastructure where an underground cable has been selected as the preferred option following multi criteria analysis and decision making. The addition of the following: "Enable the use of the public road and potentially the rail networks for routing of new public and private electricity circuits." in the Climate Action Plan further embeds this policy. The use of public roads accelerates the programmes for delivery of underground cable infrastructure and minimises the risks associated with landowner agreements. We will continue to work closely with key stakeholders across the roads sector including Transport Infrastructure Ireland and the local authorities to derive pragmatic solutions in a timely fashion and optimise the use of our infrastructure in Ireland. In that regard, we have established a HV Interface forum with an independent chair (with representation across TII, local authorities, DECC, DoT, CRU, ESB and EirGrid) to ensure the effective implementation of this policy from an engineering perspective. To support this, our EirGrid Framework for Grid Delivery is under review in the context of this to ensure that this is reflected in this framework.

7.1.2 Networks – key risk and key dependencies

Dependencies

Our ability to deliver the network needed by the target dates is dependent on:

- Planning decisions being made in a timely manner.
- The granting of foreshore licenses in a timely manner.
- The availability of sufficient outages to facilitate the delivery of the required infrastructure.
- The efficient utilisation of outage windows by all parties to maximise delivery.
- Availability of the road network for routing of underground cable infrastructure (Maximising national infrastructure).
- The granting of licenses for site investigations in a timely manner.
- The availability of suitable land for strategic network investments.

Risks

- There is a risk that materials (e.g. HV cable) will not be available from suppliers/manufacturers in time to meet programme timelines. There is an added global supply chain shortage that will need to be monitored closely.
- There is a risk that Security of Supply constraints or other system conditions restrict our ability to obtain sufficient outages.
- There is a risk that Resourcing throughout project delivery (Main Contractors, Sub Contractors) may not be adequate to support multiple work fronts/pipeline projects required out to 2030.
- There is a risk of land acquisition and land access at various stages of project development which could impact on project schedules.

7.1.3 Networks infrastructure multi-year plan

Ireland

Table 25: Networks – Ireland multi-year plan

Project name	Description	Parties	Start date	Finish date
Planning Implementation Plan & Strategic Environmental Assessment	Preparation of 5-year Implementation Plan with Strategic Environment Assessment Engagement including scoping, drafting and public consultation.	EirGrid, DECC, DHPLG, local and regional authorities, EPA	Q4 2022	Q4 2023
Optimal Joint Programme Delivery (TSO/TAO)	Implementation of an end–end TSO/ TAO joint approach to optimise programme delivery time of electricity infrastructure.	EirGrid, ESBN, CRU	Q4 2021 **Q4 2021	Q4 2023 **Q4 2022
Transmission outage review and transformation	Transmission outage review and development of a transformation programme. Review of international best practice and approaches. Publication of a transformation roadmap.	EirGrid, ESBN, CRU, DECC	Q4 2021 **Q4 2021	Q4 2023 **Q4 2023
Technology toolbox	Deliver enhanced electricity grid Technology Toolbox solutions which recognises international best practice.	EirGrid, ESBN	Q4 2021	Q4 2026
Flexible devices and methods	Deliver flexible devices (e.g. DLRs, DPFCs) and methods onto the power system. Consider: • Necessary changes to grid development framework. • Horizon scan of latest international developments.	EirGrid	Already commenced	Q4 2024 Q3 2023
Road networks	Leverage the public road Network for delivery of electricity infrastructure. Close out of HV Interface Forum.	EirGrid, ESBN, TII, Local authorities,	Already commenced	Project specific Q4 2023
Planning alignment	Engagement between TSO and DSO on alignment of transmission and distribution system planning (demand, generation etc.).	EirGrid, ESBN	Already commenced	Quarterly, ad-hoc as required

Northern Ireland

Table 26: Networks – Northern Ireland multi-year plan

Project name	Description	Parties	Start date	Finish date
Transmission Development Plan & Strategic Environmental Assessment	Preparation of 5-year Transmission Development Plan with associated Strategic Environment Assessment Engagement including scoping, drafting and public consultation.	UR, NI Planning and Environment Authority, Department of Agriculture, Environment and Rural Affairs (DAERA)	Already commenced	Q4 2023
End–end TSO/TO approach to delivery	Develop joint processes, and relevant amendments to subsidiary documents to support end–end TSO/TO approach to delivery. (i.e. Transmission Interface Arrangements).	UR, SONI, NIE Networks	Already commenced	2023 **Q1 2022
Technology toolbox	Deliver enhanced electricity grid Technology Toolbox solutions which recognises international best practice.	SONI, NIE Networks	Already commenced	Q4 2026 **Q4 2026
Flexible devices and methods	Deliver flexible devices (e.g. DLRs, DPFCs) and methods onto the power system. Consider: • Necessary changes to grid development framework • Horizon scan of latest international developments	SONI	Already commenced	Q4 2024 Q3 2023

7.2 Engagement

7.2.1 Engagement key messages

1. Only with the support of all stakeholders will the Ireland and Northern Ireland power industry 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.
2. Shaping Our Electricity Future (v1.0) strongly acknowledges this with the incorporation of a roadmap for engagement in addition to the networks, operations, and markets' roadmaps. The development of the Shaping Our Electricity Future roadmap was enriched through the breadth and depth of public engagement throughout its development and it is important to ensure that this public discourse continues through its implementation and future updates.

Dependencies

- Ongoing investment in stakeholder engagement processes across current and future grid development.

Risks

- Increasing stakeholder fatigue.
- Public engagement space is becoming saturated with actors from other public and private bodies.
- Lack of societal acceptance for grid infrastructure and generation technology/installations.
- General trust in public institutions.
- Lack of over-arching government led narrative on need to transition.

Ireland

Continually enhancing and improving our engagement approach has been evident in many of our activities since the publication of Shaping Our Electricity Future, not least through the introduction of our Energy Citizens Roadshows and the commencement of our engagement partnerships with MaREI, Young Social Innovators, Friends of the Earth and the Renewables Grid Initiative. These activities have helped enhance our understanding of community's attitudes towards hosting grid infrastructure and their ambitions to play their part in the climate transition – down to the energy they use every day. This helped us gain a deeper knowledge of their priorities and perspectives.

Northern Ireland

As one of the most extensive engagement strategies of any comparable organisations in Northern Ireland, SONI's three-part Engagement Process is at the heart of Shaping Our Electricity Future. Since its publication, we have continued to explore and evolve how we engage with local communities to increase knowledge and understanding of the importance of updating our grid infrastructure for a more sustainable future and build trust and confidence in our commitment to them. As a key example of the evolution of SONI's three-part process, we delivered our first ever Citizen Sounding Board for the Mid Antrim upgrade project in 2022.

Our strategic partnership with the Northern Ireland Chamber of Commerce to convene the 'Energy Forum' has been a critical enabler of strategic stakeholder engagement on the implementation of the Northern Ireland Energy Strategy.

7.2.2 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 delivery of Northern Ireland's Energy Strategy and Climate Change Act.

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 climate 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 deliver best in class public engagement in each jurisdiction that builds upon extensive work over the past decade. This approach must incorporate a process of continuous improvement and innovation.

In the context of Ireland, the engagement roadmap published in Shaping Our Electricity Future v1.0 contained many short-term enabling activities, most of which have been delivered. The updated engagement roadmap reflects the reframing of these initiatives as long-term deliverables with expanded actions through to 2030.

7.2.3 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. In addition to this, as we enter the realm of offshore engagement, we will approach our new stakeholders with the same openness and respect as we do with our existing stakeholders.

We acknowledge the challenges of what we ask from individuals and communities for the benefit of the entire population. We are committed to meaningfully engage with those most affected by grid development plans. This is reflected in our approach to individual project engagement and consultation but also through our commitment to community partners through our community fora and our community benefit during project lifecycle.

Additions to this roadmap include actions on Biodiversity, Offshore Engagement and Energy Ecosystem Upskilling. These reflect our ongoing learnings from stakeholders in delivering the required grid infrastructure.

EirGrid and SONI have made 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.

7.2.4 Engagement multi-year plan

Ireland

Table 27: Summary – Shaping Our Electricity Future engagement roadmap 1.1 (2023+)

Project name	Description	Parties	Start date	End date
Engage for better outcomes for all	Review and update Public Engagement Strategy every 3 years. **Embed Consultation and engagement toolkit within the Framework for Grid Development – 'Putting Communities at the Heart of Grid Development.'	EirGrid	Q1 2024 **Q4 2021	2030 **2025
International public engagement and participation leadership	Proactively identify and support opportunities to share learning and enhance our engagement approach through participation in relevant international fora (such as RGI, COP, TSO/TAO bilaterals, INGOs, etc.). This will support broader and holistic engagement advocacy in grid development processes.	EirGrid, RGI, other relevant parties	Q1 2023	2030
**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.		**Q4 2021	**Q4 2021
Continue development of participative forums across major grid development projects **Previously referred to as Community Forums	To ensure communities and other key stakeholders remain at the heart of our approach to grid development, we will continue to rollout independent participative forums across all major projects. These will be set up as early as possible in the framework for grid development.	EirGrid, Community stakeholders, Business stakeholders, relevant public bodies	Q1 2023	2030
EirGrid Energy Citizens Roadshows **Merges the following actions: 1) Regional Energy Citizen's Assemblies and 2) Community Energy Collaboration Roadshow/ Knowledge Hub	Collaborate with local and national stakeholders to engage the public on the topic of the energy transition at a strategic and practical level.	EirGrid, ESBN, SEAI, regional stakeholders	Q1 2023	2030
Engagement with local authorities and key state agencies and departments. **Previously referred to as Local Authority Roll-out	Engage with the relevant authorities on current and future grid needs in their area, including Local Authorities, Climate Action Regional Offices (CARO), the Department of Housing, the Department of Environment, Climate and Communications and Regional Assemblies.	EirGrid, local authorities, regional authorities, DHPLG, DECC	Q1 2023	2030

Table 27: Summary – Shaping Our Electricity Future engagement roadmap 1.1 (2023+)

Project name	Description	Parties	Start date	End date
Preparation and publication of Regional Strategic Framework for Planning and Environment documents **Previously referred to as Regional Master Planning	Regional grid development masterplans. Primary use for engagement with National, Regional and Local Planning and Environmental authorities and other stakeholders.	EirGrid	Ongoing	Ongoing
Implement environmental measures from Strategic Environmental Assessment **New	Implement environmental mitigation and monitoring recommendations arising from Strategic Environmental, Assessment of EirGrid Grid Implementation Plans, in consultation with Ireland's Environmental Authorities.	EirGrid	Q4 2023	2030
Transforming the power system for future generations/ Increase youth participation opportunities in the grid development process **Merges the following actions: 1) EirGrid Young Energy Citizen Initiative and 2) Youth Activation/ Sponsorship Partnership.	Continue to enhance Youth participation opportunities to deliver and leverage awareness among young people on Ireland's transition to a cleaner and greener electricity future through supporting innovation and recognition programmes.	EirGrid, relevant youth organisations	Q1 2023	2030
Our Energy Future project	Our Energy Future is a multi-year partnership with the Renewable Grid Initiative and Friends of the Earth. The partnership aims to initiate inclusive and diverse dialogue on the challenges and opportunities associated with Ireland's energy transition and more broadly inform EirGrid and other energy sector stakeholders on supporting communities with this transition.	EirGrid, RGI, Friends of the Earth	Ongoing. Review in Q4 2024.	2024
Regularly explore enhancements to our Community Benefit Policy **Previously referred to as Community Benefit Fund	Review and update Community Benefit Policy every 3 years. **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	Q3 2024	2030

Table 27: Summary – Shaping Our Electricity Future engagement roadmap 1.1 (2023+)				
Project name	**Description**	**Parties**	**Start date**	**End date**
Landowner engagement	Continue engagement with landowner representative groups and respond to landowner feedback. Enhance our approach on an ongoing basis in relation to earlier engagement, optioneering, route selection, site investigations and land acquisition.	EirGrid, landowners, relevant representative organisations	Ongoing	Ongoing
Energy tourism initiative	Explore the potential role of 'energy tourism' in supporting the energy transition.	EirGrid, relevant regional partner	Q4 2023	2026 **Q4 2022
Offshore infrastructure engagement	Undertake a process to co-design EirGrid's practical approach to engagement and consultation with offshore stakeholders. Work with partners to ensure a consistent approach. Utilise this process to agree an offshore engagement policy.	EirGrid, regional stakeholders	Q1 2023	Q4 2024
	Develop and embed an offshore engagement strategy for offshore Phase 2 grid development.	EirGrid, regional stakeholders	Q4 2023	2030
Biodiversity protection and nature restoration	Continue to protect species and habitats during project development and operation, while also delivering nature restoration (and Nature Inclusive Design), unless external factors pose impediment to restoration objectives. Develop a marine biodiversity policy statement.	Nature protection and restoration ongoing.	Q4 2023	2030
EirGrid explore opportunities to partner with education providers to deliver upskilling in the energy ecosystem for local communities.	Work with relevant local stakeholders to identify opportunities for upskilling in the Energy Ecosystem, in particular Offshore Grid and Asset Management, to provide growth opportunities for local and regional communities in these sectors as EirGrid and partners develop our offshore competency.	EirGrid, regional education partner	Q4 2024	2030

Northern Ireland

Table 28: Summary – Shaping Our Electricity Future engagement roadmap (SOEF) v1.1 (2023+)

Project name	Description	Parties	Start date	End date
Engage for better outcomes for all	Further evolve SONI's enhanced three-part process and Consultation and engagement toolkit within NI project delivery through the creation of new project engagement roadmaps. **Embed SONI's enhanced three-part process and Consultation and engagement toolkit within NI project delivery – 'Putting Communities at the Heart of Grid Development.'	SONI	Q1 2023 **Q4 2021	Ongoing and subject to annual review
Landowner engagement charter – refresh	Engage with key agricultural stakeholders on SOEF v1.1 to develop refreshed SONI landowner engagement charter to support SOEF delivery.	SONI, NI agricultural stakeholders	Q1 2023	Q4 2024 – implementation going
Innovate to engage	Continue the Citizen Sounding Board pilot programme and evaluate outcomes to inform future engagement options.	SONI, Local Communities	Q1 2023	Until project end
Council roll out	Engage elected representatives, CEOs and Planning official in a strategic roundtable series following the Northern Ireland Local Government Election in May 2023. Key topics to include SOEF v1.1, TDPNI 23 and individual projects. **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 2023 **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	Q1 2023 **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	Q2 2024 **Q4 2022	Ongoing
SONI Energy Forum	Convene the Northern Ireland Energy Forum to discuss challenges, opportunities to delivering SOEF and Northern Ireland's Energy Strategy	SONI, Northern Ireland Chamber of Commerce	Q1 2023	Ongoing

Table 28: Summary – Shaping Our Electricity Future engagement roadmap (SOEF) v1.1 (2023+)				
Project name	**Description**	**Parties**	**Start date**	**End date**
SONI 'Shaping Series'	As part of a refreshed SONI stakeholder engagement framework, deliver a strategic roundtable series with key stakeholders in Northern Ireland on SOEF v1.1.	SONI	Q1 2023	Q3 2024
Support SONI thought leadership and awareness	Support SOEF – via cost effective key influencer engagement, platform opps and earned media.	SONI	Q4 2021	Ongoing

Industry engagement plan

Table 29: Summary – Shaping Our Electricity Future Engagement Roadmap (SOEF) v1.1 (2023+)				
Project name	**Description**	**Parties**	**Start date**	**End date**
Engage for better outcomes for all	Regular Shaping Our Electricity Future Advisory Council.	EirGrid & SONI	Q2 2022 **Q1 2022	Ongoing; every 4 months or on ad hoc basis
	Industry briefing webinar.	EirGrid & SONI	–	Every 6 Months

7.3 System operations

7.3.1 System operations key messages

1. 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.

2. Continued secure operation of the power system is critical. We are currently operating the power system with System Non-Synchronous Penetration (SNSP) levels of up to 75% and trialling Rate of Change of Frequency (RoCoF) up to 1.0 Hz/s. Satisfactory completion of this RoCoF trial (expected in Q2 2023) will form the basis of further changes to our operational practices to achieve our 2030 targets.

3. 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 have the ability 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.

4. 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 builds 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%.

5. 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.

6. 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 up to 80% RES-E and facilitate electrification of the heat and transport sectors while maintaining power system security. A regulatory driven demand side 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.

7. The current maximum SNSP level facilitated by existing system operations capability is 75%. 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 Q2 2023) and to have a significantly reduced Minimum Number of Large Synchronous Units requirement (the current requirement is to keep eight 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 Ireland and Northern Ireland power system. In Q4 2022, we published an 'Operational Policy Roadmap to 2030'[16] which sets out our plan for evolving operational policy across a range of these key metrics as well as development of new metrics such as System Strength. This roadmap will be reviewed and updated if required every two years.

8. 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.

9. Network and market developments will also drive changes to how we operate the power system. New HVDC interconnectors, the second North-South Interconnector, 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.

16 Operational Policy Roadmap – EirGrid Website (link) Operational Policy Roadmap – SONI Website (link).

7.3.2 System operations – key risk and key dependencies

Dependencies

Our ability to deliver the operational policy changes needed to accommodate higher penetrations of renewable generation by the target dates is dependent on:

- Regulatory decisions being made in a timely manner.
- Securing regulatory approval for funding to deliver the TSOs' required operational capabilities and system services.
- Our ability to develop advanced models (working in partnership with industry stakeholders) and study capabilities.
- Timely delivery of system services, new flexible generation, the second North-South Interconnector and other transmission reinforcements required to assist with future challenges and meet the decarbonisation targets.

Risks

- There is a risk that Security of Supply constraints or other system conditions restrict our ability to run trials of new operational policies.
- There is a risk that power system performance or analysis indicates risks to power system security resulting in delays to, or unwinding of, operational policy changes.
- There is a risk of delays to the delivery of required system services and/or other necessary capabilities resulting in delays to our ability to make the operational policy changes needed to accommodate higher penetrations of renewable generation.

7.3.3 Overview of operational programme

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

1. Operational policy
   Undertake operational studies and analysis and develop operational policies to facilitate the transition up to 80% RES-E by 2030;

2. Standards and services
   Ensure we have the right operational standards and appropriate system services frameworks to support investment in required capability;

3. Operational tools
   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

4. Technology enablement
   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 workstream

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 below.

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 are 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.

7.3.4 Operations multi-year plan

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 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.

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 up to 80% RES-E by 2030 in Ireland and Northern Ireland.

We will achieve this by:

- Identifying technical scarcities and operational needs – both now and projected for the future;
- Developing operational protocols, policies and procedures;
- Completing system studies to facilitate the evolution of key operational metrics including, but not limited to, SNSP, inertia, minimum number of units and system strength; and
- 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.

Operational policy roadmap

The publication of the EirGrid and SONI Operational Policy Roadmap to 2030, published in Q4 2022, represents the completion of a key initiative in the MYP published in Shaping Our Electricity Future v1.0. The roadmap sets out the key actions in the operational policy space that will be required to deliver on climate action targets while continuing to securely operate the electricity system. It outlines the context, drivers, timelines, milestones, actions, and stakeholder impacts that are needed in each operational policy area. The operational policy roadmap will be reviewed and updated if required, every two years.

The Operational Policy Roadmap is divided into three policy areas:

1. Dynamic Stability.
2. Reserves and Ramping.
3. Operational Security.

The publication of the Operational Policy Roadmap to 2030 has identified new initiatives which now form part of the updated Operational policy workstream within MYP as set out in Tables 30, 31 and 32 below.

Note: New or reframed initiatives as a result of system studies and policy development since the publication of Shaping Our Electricity Future v1.0 are indicated by '**'. For example, the reduction in the minimum number of large synchronous units and the system inertia floor, which were previously combined in a single initiative, have been separated into two separate projects.

Dynamic stability policy area initiatives

Table 30: System operations – operational policy workstream – dynamic stability

Project name	Description	Parties	Start date	Finish date
Close-out of on-going DS3 programme operational trials	Complete the ongoing 1 Hz/s RoCoF trial and its transition to enduring operational policy.	EirGrid and SONI	Ongoing	Q2 2023 **Q1 2022
**Maintain the system-wide RoCoF limit at 1 Hz/s	Ongoing monitoring of power system performance as we operate to a RoCoF limit of 1Hz/s.	EirGrid and SONI	Q2 2023	2030
**Inertia Floor – reduction to 20,000 MWs	Develop enduring operational policy for operation with a 20,000 MWs inertia floor: • Undertake suite of studies to identify the capability and determine ability to proceed to trial. • Conduct operational trial. • Post-trial review and implementation of enduring operational policy.	EirGrid and SONI	2024	2025
**Transition to Regional Inertia Floors	Implement Regional Inertia Floors: • Perform analysis and information gathering. • Conduct operational trial. • Post-trial implementation of Regional Inertia Floors as enduring policy. • Continue ongoing monitoring.	EirGrid and SONI	2024	2030
**System Strength	Develop System Strength Policy including: • Perform analysis and system studies. • Conduct operational trial. • Post-trial review and implementation of new System Strength policy.	EirGrid and SONI	2024	2025
	Revision of System Strength Policy including: • Perform analysis and system studies. • Conduct operational trial. • Post-trial review and implementation of revised System Strength policy.	EirGrid and SONI	2028	2030

Table 30: System operations – operational policy workstream – dynamic stability				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
**Transition to 95% SNSP and relax/remove as a constraint	Increase SNSP limit from 75% to 80%. • Complete studies for operation at 80% SNSP. • Conduct operational trial with SNSP limit of 80%. • Post-trial review and implementation of 80% SNSP operational policy.	EirGrid and SONI	Q4 2023	2024
	Increase SNSP limit from 80% to 85%. • Complete studies for operation at 85% SNSP. • Conduct operational trial with SNSP limit of 85%. • Post-trial review and implementation of 85% SNSP operational policy.	EirGrid and SONI	2025	2026 **2025
	Monitor SNSP as an operational metric targeting system operation at SNSP up to 90%.	EirGrid and SONI	–	2028
	Monitor SNSP as an operational metric targeting system operation at SNSP up to 95%.	EirGrid and SONI	–	2030
**Reduction of the operational constraints related to the minimum number of large synchronous units	Reduce the minimum number of large synchronous units (MUON) requirement from 8 to 7: • Complete studies to identify the capability. • Conduct operational trial. • Post-trial review and implementation of enduring operational policy for operation with a minimum of 7 large synchronous units.	EirGrid and SONI	Ongoing	Q2 2024 **Q2 2023
	Reduce the minimum number of large synchronous units (MUON) requirement from 7 to 6: • Complete studies to identify the capability. • Conduct operational trial. • Post-trial review and implementation of enduring operational policy for operation with a minimum of 6 large synchronous units.	EirGrid and SONI	2025	2026
	Monitor minimum synchronous units (MUON) as an operational metric targeting capability to operate with 5 large synchronous units.	EirGrid and SONI	–	2027

Table 30: System operations – operational policy workstream – dynamic stability				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
**Reduction of the operational constraints related to the minimum number of large synchronous units (continued)	Monitor minimum synchronous units as an operational metric targeting capability to operate with 4 large synchronous units.	EirGrid and SONI	–	2028 **2030
	Monitor minimum synchronous units as an operational metric targeting capability to operate with 3 large synchronous units.	EirGrid and SONI	–	2030

Reserves and Ramping Policy Area Initiatives

Table 31: System operations – operational policy workstream – reserves and ramping				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
**Reserves	Consolidate Reserve Policy.	EirGrid and SONI	Ongoing	Q4 2023
	Reduce the requirement for downward reserve on conventional units in Northern Ireland. • Undertake analysis. • Conduct operational trial. • Post-trial review and implementation of enduring operational policy for operation.	EirGrid and SONI	Ongoing	Q2 2024
	Trial the enhanced provision of frequency reserves from alternative resources.	EirGrid and SONI	2024	2025
	Couple to European markets for reserve, post connection of the Celtic Interconnector. Note: Covered in Full EU Integration Design in Markets Roadmap.	EirGrid and SONI	2026	2027
	Ongoing monitoring of Reserve Policy, including the impact of the second North-South Interconnector.	EirGrid and SONI	2025	2030
**Ramping margin	Continue ongoing monitoring of the current ramping margin operational policy based on the performance of the ramping margin tool in real time operations.	EirGrid and SONI	Ongoing	2030

Table 31: System operations – operational policy workstream – reserves and ramping				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
**Interconnector ramping	Through studies and trials determine if a revision to the All-Island interconnector ramping rates is required in line with the connection of new HVDC interconnectors and offshore wind, including: • Greenlink (2024). • Celtic (2026). • Offshore Wind (circa. 2028).	EirGrid and SONI	Q4 2023	2030

Operational security policy area initiatives

Table 32: System operations – operational policy workstream – operational security				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
**TSO-DSO reactive power co-ordination	Plan for next steps on reactive power co-ordination in Northern Ireland.	DSO (NIE Networks)/ SONI	Ongoing	Q4 2023
	Plan for next steps on reactive power co-ordination in Ireland.	DSO (ESB Networks)/ EirGrid	Ongoing	Q4 2023
**Operational security – thermal/voltage/ short circuit	Review of relevant thermal and voltage transmission constraint groups (TCGs).	EirGrid and SONI	Ongoing	Q1 2024
	Develop new operational policies for the management of network flexibility technologies, where necessary.	EirGrid and SONI	Q4 2023	Q4 2024
	Develop a framework for weekly TCG study process and updates.	EirGrid and SONI	2024	2025
	Develop a framework for day ahead TCG study process and updates.	EirGrid and SONI	2025	2026
	Develop offshore network operating security standards.	EirGrid and SONI	2026	2027
	Update the onshore network operating security standards.	EirGrid and SONI	2026	2027
	Develop a framework for managing operational security using risk-based approaches (probability and impact).	EirGrid and SONI	2026	2027

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 80% 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;
- Publishing the standards that service providers will need to adhere to 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.

Note: New or reframed initiatives as a result of system studies and policy development since the publication of SOEF V1.0 are indicated by '**'. For example, the removal of Low Carbon Inertia Services (LCIS) sub-projects that were completed and the separation of LCIS phase 1 and phase 2.

Table 33: System operations – Standards and Services workstream

Project Name	Description	Parties	Start Date	Finish Date
**Low carbon inertia services – phase 1	Undertake a public consultation on the fixed term contracts, develop a proposed decision paper and submit it to the Regulatory Authorities for approval Undertake a procurement process leading to award of contract(s) Note: Commencing this process is dependent on a decision by the Regulatory Authorities.	EirGrid and SONI	Q2 2023 **Q4 2022	Q4 2023 **Q2 2023
**Low carbon inertia services – phase 2	Undertake a procurement process leading to award of contract(s) for LCIS Phase 2 Note: Commencing this process is dependent on a decision by the Regulatory Authorities.	EirGrid and SONI	Q4 2024	2025
**System services future arrangements – technical and volumes requirements	High-level review of system services products for inclusion in the first Future Arrangements auction. Develop methodology and process for: (i) Determining system services auction volumes as per SEMC HLD. (ii) Forecasting longer-term system services requirements. Ongoing review of efficacy of the system services arrangements and introduction of new services as required. Note: Further information on System Services in Markets Roadmap.	EirGrid and SONI	Q2 2023	2030
**Grid Code evolution to support the 2030 up to 80% RES-E	Ongoing identification and implementation of Grid Code changes as required. This will include working with the DSOs to consider any related Distribution Code changes.	EirGrid, SONI, ESB Networks and NIE Networks	Ongoing	2030

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.

Note: New or reframed initiatives as a result of system studies and policy development since the publication of Shaping Our Electricity Future V1.0 are indicated by '**'. For example, the inclusion of Enhance Modelling Capability to further improve future operating capabilities and removal of Future Arrangements for System Services implementation as it is covered in the Electricity Markets Roadmap.

Table 34: System operations – Operational Tools workstream

Project name	Description	Parties	Start date	Finish date
**Implementation/ Enhancement of already planned/ existing control centre tools	Operational Go-Live of Voltage Trajectory Tool (VTT)	EirGrid and SONI	Ongoing	Q3 2023 **Q4 2021
**Control Centre of the Future	Implementation of Control Centre of the Future Roadmap Note: Dependent on regulatory funding	EirGrid and SONI	Q3 2023	2030
**Enhance Modelling Capability	Enhance our Modelling Capability, for example: Review process for obtaining and developing models Enhance model validation activities Enhance modelling capability e.g. EMT	EirGrid and SONI	Q2 2023	2030
Operation of devices within the grid technology toolbox	Ongoing development of the capability to model and operate new grid technologies (such as Dynamic Line Rating and Power Flow Controllers) which will enhance capability to maximise the use of existing transmission grid infrastructure. These capabilities will evolve as the technology arrives.	EirGrid and SONI	Q2 2023 **Q4 2022	2029

Table 34: System operations – Operational Tools workstream				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
HVDC interconnector integration	Develop and deliver systems and interfaces for the integration of Greenlink Interconnector into our operational systems.	EirGrid, GIL, NGESO	Ongoing **2022	2024
	Develop and deliver systems and interfaces for the integration of Celtic Interconnector into our operational systems.	EirGrid/RTE	Ongoing	2026

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:

- 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 flexibility 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.

We are actively working on facilitating the integration of hybrid technologies on the power system in Ireland and Northern Ireland.

In Ireland, jointly with the DSO (ESB Networks), we have made recommendations to CRU on a range of items, including a framework to facilitate Multiple Legal Entities behind a single connection point, revisions to the over-install policy and a technical assessment for sharing of MEC behind a single connection point. We are engaging with CRU and, once clarity on next steps emerges, we intend to include relevant actions on future versions of this roadmap.

In Northern Ireland, SONI have jointly undertaken a review of the over-install policy with the DSO (NIE Networks) and have engaged with UR on recommendations. We will include relevant actions arising on future versions of this roadmap.

We expect that further engagement with stakeholders in both jurisdictions will be required as part of the next steps for the hybrids programme of work.

Note: New or reframed initiatives as a result of system studies and policy development since the publication of Shaping Our Electricity Future v1.0 are indicated by '**'; for example, the capturing of Operational Procedures for new HVDC interconnectors that were previously in the Operational Policy workstream, and inclusion of Grid Forming Technology as advancement in the technology is realised.

Table 35: 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.	EirGrid and SONI	Ongoing	Q3 2023 **Q2 2022
Residential demand response trial in Ireland	Plan for and conduct a trial for system services provision from residential demand response associated with Future Arrangements for System Services (planned pilot being led by the DSO).	EirGrid/ESB Networks	2025 **Q1 2023	2026 **Q4 2024
**Qualification trial process	Conduct annual QTP process to facilitate the integration of new technologies, for example: • Hydrogen-based technology; and • Grid forming technology. Note: Dependent on regulatory funding to run the QTP.	EirGrid and SONI	–	Annual
**Greenlink operational procedures	Develop Interconnector Operating Protocol for the Greenlink Interconnector.	EirGrid/GIL/ NGESO	Ongoing	2024
	Develop TSO processes and procedures related to operation of the Greenlink Interconnector, per the agreed operating model.	EirGrid and SONI	Ongoing	2024
**Celtic operational procedures	Develop TSO processes and procedures related to the operation of the Celtic Interconnector, per the agreed operating model.	EirGrid and SONI	2023	2026
**Grid forming technology	Develop a Grid-Forming Implementation Strategy which will cover: • Strategy for development of Grid-Forming technology models and analysis in the context of the Ireland and Northern Ireland power system. • Plan for trialling Grid-Forming technology on the power system. • Plan for the development of definitions and standards for Grid Forming technology.	EirGrid and SONI	Q4 2023	Q2 2024
**Energy Storage Power Station (ESPS) – evolution of arrangements	Reflect the relevant requirements set out in the Battery Energy Storage Power Stations (ESPS) Grid Code Implementation Note via Grid Code Modifications.	EirGrid and SONI	Ongoing	Q3 2023 **Q2 2023

Table 35: System operations – Technology Enablement workstream				
Project name	**Description**	**Parties**	**Start date**	**Finish date**
**Energy Storage Power Station (ESPS) – evolution of arrangements (continued)	Update codes and operating protocols based on the future arrangements for ESPS. Note: Systems and tools changes for ESPS technology are covered within Scheduling and Dispatch in the Markets roadmap.	EirGrid and SONI	Ongoing	2026
**Protection settings for our largest customers	Engagement with our largest customers to review the protection settings in place. Where required, work with our Largest Customers to update protection settings to ensure system security is maintained. 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.	EirGrid, SONI, ESB Networks, NIE Networks, Large Customers	Ongoing	Q4 2023
	Review the codes and standards applicable to our Largest Customers. Develop and implement new codes and standards as appropriate to ensure system security can be maintained.	EirGrid, SONI, ESB Networks, NIE Networks	Ongoing	2024
	Ongoing monitoring of the performance of our Largest Customers including their response to system faults.	EirGrid, SONI, ESB Networks, NIE Networks	Ongoing	2030
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 & Services workstream of this System Operations plan.	EirGrid and SONI	Ongoing	2025 **Q2 2023
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.	EirGrid, SONI, ESB Networks, NIE Networks	Ongoing	Q4 2023

7.4 Electricity markets

7.4.1 Electricity markets key messages

1. These recommendations are the TSOs' and MO view of the actions required to enable Ireland and Northern Ireland meet the 80% RES-E targets and also the carbon emission reduction targets in Ireland. The SEM Committee is ultimately responsible for the electricity market design and we will implement decisions from the SEMC.

2. Since the publication of the Shaping Our Electricity Future roadmap in late 2021, there has been a paradigm shift in market dynamics, due to the war in Ukraine. A number of short-term changes have been necessitated to minimise the impact of high energy costs to consumers. It is important that the longer-term plan outlined in this chapter is progressed and not impacted by the ongoing shorter-term actions.

3. The updated 2030 RES-E targets and the carbon emission reduction targets has required a re-evaluation of the required capacity needed to meet these ambitious targets. The analysis has shown an important need for a balanced power system portfolio of different technologies. There is an urgent requirement to ensure that there are no investment gaps in delivering on this. For example, long duration storage has been shown to be a crucial component of the balanced portfolio.

4. A market design reform is commencing at a European Union level in 2023. It is important that EirGrid/SONI/SEMO participates in these reviews. EirGrid and SONI are currently world leaders in integrating variable renewable resources into a power system, therefore can offer a unique perspective to our European neighbours.

Dependencies

- These recommendations are the view of the EirGrid, SONI and SEMO. The approval of this plan from the SEM Committee is required.

Risks

- Shorter term priorities such as Security of Supply in Ireland and Northern Ireland or priorities caused by the war in Ukraine will distract from the implementation of the longer-term market changes required.
- Timely decision making is needed by policy makers and regulators. Shaping Our Electricity Future is a complex integrated plan and a delay in decision making can have significant knock-on impacts on the overall plan.

7.4.2 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 the necessary energy and system services needed to operate the power system at 80% Electricity from Renewable Energy Sources (RES-E) and to enable us to achieve carbon reduction targets. 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 decarbonisation targets by 2030.

To achieve the higher levels of renewable supply 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 generation supply. This will require incentives that promote the right third-party investment in a balanced portfolio of new generation, demand side and system support assets to achieve a resilient power system at 80% 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 to meet the 70% renewable electricity targets. This figure will have increased in order to meet the new ambitious targets for 80% renewable electricity in both jurisdictions and the carbon emissions targets in Ireland. 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 decarbonisation targets.

The timelines outlined in the programme below are driven by the need for timely and appropriate investment decisions to meet the decarbonisation targets, a range of obligations arising out of European legislation, combined with specific directions from Regulatory Authorities. The obligations for non-priority dispatch of renewables (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 RESS[17] capacity auction participants when they commence connecting to the power system.

17 The Renewable Electricity Support Scheme (RESS) is a government backed support scheme for renewable generation in Ireland.

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 recommendations 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 decarbonisation targets.

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. 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 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:

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 balanced portfolio, energy and system services to meet dynamic demand requirements and physically operate the power system at 80% RES-E and be compliant with carbon emission reduction targets. This also includes wider aspects that influence third party investment such as RESS design, network tariff design and transmission loss adjustment factors.

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 of interconnection between SEM and the rest of the EU.

There are two main workstreams in this pillar:

1. Full trading arrangements between SEM and Great Britain market
   With the withdrawal of the UK from the EU on January 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.

2. 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 an implementation timeline to inform how to achieve the decarbonisation targets in an affordable, effective and timely manner. This multi-year recommendation is a starting point for discussion with our industry colleagues to debate the needs and challenges in achieving the decarbonisation target and to 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 (SEMC) 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 two pillars with related workstreams.

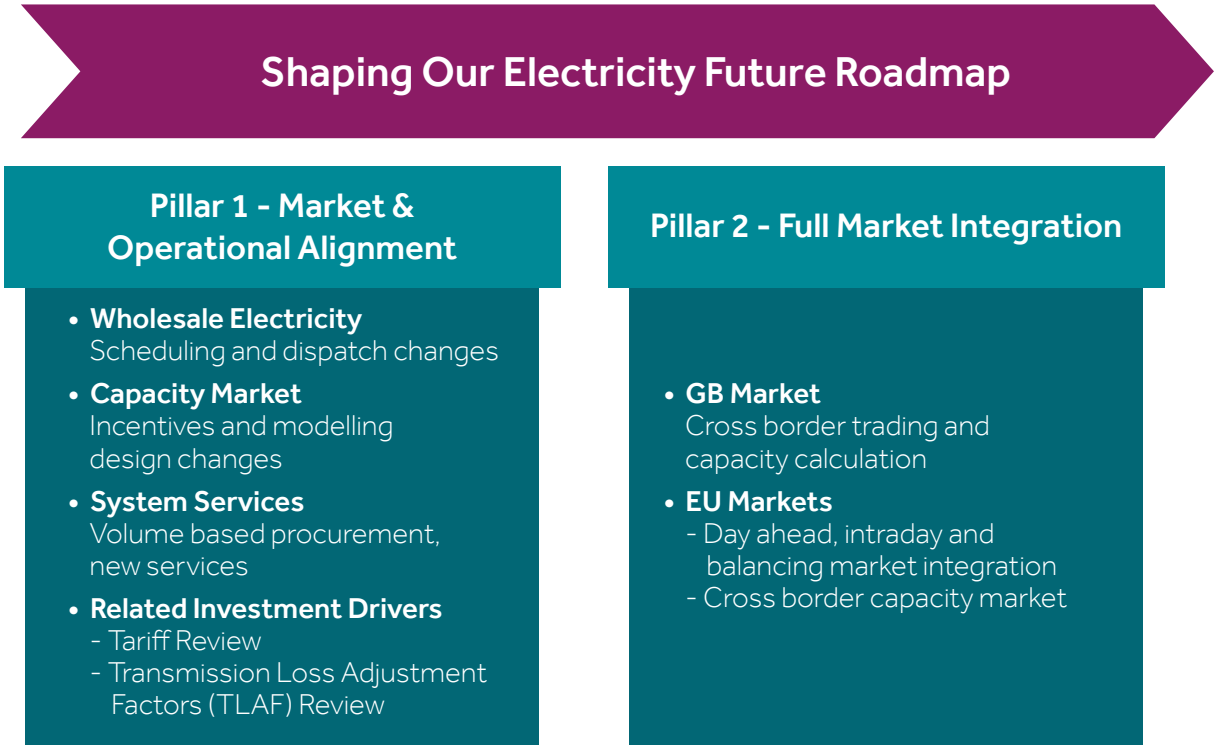


Figure 25: Markets approach

7.4.3 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 a balanced portfolio of other technologies such as, renewable energy resources, demand side resources, storage 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 sensitive to weather conditions. For example in the future our largest risk with adequacy will be that we may have a period of low wind/solar, coupled with high demand.

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.

Energy markets have traditionally been designed based on a portfolio of conventional synchronous generation plant. While the SEM has already integrated a large volume of renewable energy resources, to achieve the decarbonisation targets 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 surplus renewable generation should be treated.

Wholesale electricity markets

Currently, the day-ahead market delivers a market schedule that does not account for network or 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 1 January 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 Market Management System (MMS), the Energy Management System (EMS) and the existing wind dispatch tool.

Security constrained unit commitment – operating schedule

There may be changes 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 80% RES-E in real time shows that additional investment is required, and the operational challenges are more advanced than today.

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 decarbonisation targets. 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 be 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. 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 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. A SEMC decision paper outlining the High Level Design, SEM-22-012, was published in April 2022. At the time of writing, the detailed design of future arrangements is in the process of being scoped. 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 system services auction volumes as well as longer-term system services requirements over different planning timeframes.

- 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 low carbon inertia services

The objective of 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 for the future, the potential impact of on market outcomes could be considerable. The electricity capacity market must now enable the delivery of a balanced portfolio of technologies to enable us to meet our renewable and carbon emission reduction targets. It is no longer just around the least cost technology.

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. The future capacity market design needs to ensure it delivers with the longer term ambition to deliver on net carbon zero.

Suggested existing capacity market changes

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 overhaul the current capacity market design to better deliver against the decarbonisation targets and operate the power system with up to 80% RES-E by 2030 and also importantly to deliver on the carbon emissions reduction targets. 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. The analysis outlined in Shaping Our Electricity Future notes that a balanced portfolio of different technologies is essential to meet the government targets. Finally, 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. This includes both the volume and type of capacity to deliver on the balanced portfolio. The analysis carried out in Shaping our Electricity Future notes the importance of new technologies such as long duration storage. We need to ensure that the are adequate electricity market incentives to deliver on these new types of capacity as without these we will not achieve our renewable and carbon emission reduction targets.
  - 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 80% 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 [o] 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).

The Department for the Economy (DfE) in Northern Ireland published a consultation paper on 2 February 2023 seeking views on the design of a new Electricity Support Scheme for Northern Ireland. The introduction of a renewable support scheme in Northern Ireland is a key step to achieve the 80% renewable electricity target by 2030, set out in the Climate Change Act (Northern Ireland) 2022.

It is suggested, based on trends in industry and regulatory practices, that modifications could be made to the Ireland renewable support scheme to achieve the Renewable Ambition in a more cost-effective manner. Any such enhancements would be subject to the respective departmental approval. Renewable support schemes in other jurisdictions have traditionality 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. It is crucial that any renewable support schemes include the appropriate incentives for locating in the correct parts of the power system. Finally, schemes must take into account any structural changes being proposed to the EU market design as part of the initiatives by the EC Commission in 2023.

Treatment of surplus renewable generation

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 which in turn has the potential risk of increasing electricity costs.

At times when there is a surplus renewable generation – more generation than the market needs to meet consumer demand, including exports, this surplus cannot be not utilised, without the progression of innovative solutions where the demand can follow the renewable generation output. The European Clean Energy Package recognises that the generation owners need to make sufficient revenues to remain economically viable and therefore curtailed and constrained renewable generation should be remunerated. The question of how, and who pays for surplus renewable generation and how we maximise its utilisation should be considered in terms of ensuring appropriate investment signals to renewable generators, innovators and on 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 engaged with the relevant Regulatory Authorities in 2021 in relation to their specific review of DTUoS tariffs and have committed to providing qualitative analysis and modelling to support this important initiative. The work ceased in late 2022 but it anticipated that it will recommence in late 2023.

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, the time of the year 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 and 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.

EU market reform

EirGrid and SONI (The TSOs) in their roles as TSOs and MOs have been at the forefront of the integration of non-synchronous renewables onto the transmission systems in Ireland and Northern Ireland. The TSOs need to balance long term investment signals with short term flexibility and end consumer cost. The key factors is having a robust capacity remuneration mechanism, strong system services (which drives appropriate technologies on the system) and appropriate short term energy prices which drives the end consumer behaviour and demand side flexibility.

The world-leading levels of System Non-Synchronous Penetration (SNSP) has enabled the TSOs to identify scarcities (rarely seen elsewhere in the EU) and anomalies in contemporary system operation and market design. The island of Ireland is solving challenges today in relation to planning and managing a power system with high levels of renewables, that other EU countries will not experience for several years to come. These challenges are due to our current policy drivers and limited interconnection with neighbouring systems.

This latest version of Shaping Our Electricity Future highlights the need to consider the multiple market nature of the power system with forwards, capacity, system services and supports playing an increasingly important role in addition to the spot markets for energy.

While it has to be acknowledged that the EU needs to develop both a comprehensive and common approach to the issue, the experience on the island of Ireland, is that a flexible jurisdictional (local) approach is most effective i.e. a one size fits all approach may not be the most efficient outcome.

Pillar 1: Multi-year recommendations

Electricity markets and power system operational alignment

Table 36: Markets – pillar 1 multi-year recommendations

Project name	Recommendation	Parties	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 engagement, detailed design, implementation planning – including resourcing and timeline.	SEMC	2021–2026
	Regulatory Authority High Level Design Decisions in respect to the treatment of non-priority dispatch renewable generators.	SEMC	
	Workshop concepts and issues for scheduling and dispatch tool changes with industry and other consulted and agreed changes.	EirGrid, SONI, SEMO	
	Develop proposed 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.	EirGrid, SONI	
	Developed Detailed Design for scheduling and dispatch changes including proposed amendments to formal arrangements, solution architecture and detailed systems design to inform required vendors selection.	EirGrid, SONI	
	Regulatory Authority approval for Detailed Design implementation including resourcing and timeline following consultation.	SEMC	
	Implementation and go live of detailed design system changes.	EirGrid, SONI	
	High level design decision on Compensation for non-market based redispatch down of renewables (Article 13, para 7) and other settlement impacts.	SEMC	
	Develop a detailed design for on Compensation for non-market based redispatch down of renewables (Article 3, para 7) in dispatch and settlement systems following consultation and workshops with industry.	EirGrid, SONI, SEMO	
	Regulatory Authority approval for Detailed Design and implementation plan including resourcing and timeline following consultation.	SEMC	
	Solution Architecting the detailed design to inform required vendors selection – Compensation for non-market based redispatch down of renewables (Article 13, para 7).	EirGrid, SONI, SEMO	
	Implementation and go live of detailed design system changes.	EirGrid, SONI, SEMO	

Table 36: Markets – pillar 1 multi-year recommendations

Project name	Recommendation	Parties	Date
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.	SEMC	2021–2026 **2021–2026
	High Level Design of Capacity Market Modelling changes and associated changes to the capacity market including strengthening incentives for physical performance.	SEMC	
	Implement changes with benchmarked performance on new modelling approaches against previous and future scenarios – following consultation with industry.	EirGrid, SONI	
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.	SEMC	2021–2026 **2021–2026
	A new national resource adequacy assessment (NRAA) methodology is to be developed to align with the need identified by Shaping Our Electricity Future market roadmap. Key aspects of the new methodology are: • Ensure consistency with Article 24 of REGULATION (EU) 2019/943. • Ensure consistency between European and national resource adequacy assessments. • Enable efficient transfer between national data and EU data. • Provides support to government and regulatory bodies for preparation of risk preparedness plans.	EirGrid, SONI, SEMO	
	The new national resource adequacy assessment, will inform our 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.	EirGrid/SONI/ SEMC/DECC/ DfE	

Table 36: Markets – pillar 1 multi-year recommendations

Project name	Recommendation	Parties	Date
Future arrangements Phase 1 new daily auction	High Level Design Decision for Future Arrangements following consultation and workshops with industry.	SEMC	2022–2027 **2022–2024
	Detailed Design development: • Auction design and design of procurement mechanisms for non-auctioned services.	EirGrid, SONI, SEMO	
	Regulatory Authority approval for implementation and enduring operation including resourcing and timeline following consultation.	SEMC	
	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.	EirGrid, SONI	
	Market Trial of Future Arrangements daily auction.	EirGrid, SONI	
	Go-live of Future Arrangements.	EirGrid, SONI	
Future arrangements Phase 1: Transition from DS3 system services to future arrangements	Review of existing services' suitability for mitigating scarcities in extended period.		2022–2027 **2022–2024
	Consultation with Regulatory Authorities and Industry Stakeholders on detail of future procurement arrangements.	EirGrid, SONI	
	Introduction of Fixed Term layered procurement approach for products not immediately suitable for the Daily Auction.	EirGrid, SONI	
	Develop a migration approach from DS3 SS to FA for all products including valuation of this and proposed mechanism to access this value.	EirGrid, SONI	
	Termination of existing agreements and establishment of System Services Review Panel.	EirGrid, SONI	
Future arrangements Phase 2: Fixed term contracts for zero carbon	Plan provided as part of the Operations Multi-year plan.	EirGrid, SONI	2022–2025

Table 36: Markets – pillar 1 multi-year recommendations

Project name	Recommendation	Parties	Date
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.	EirGrid, SONI	2024–2027 **2024–2027
CRU Demand Transmission Use of System review	Develop and publish scope of review and timelines for deliverables.	CRU	2022–2025 **2022–2025
	Develop detailed implementation plan.	EirGrid, ESBN	
	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 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.	EirGrid, ESBN	
	Implement settlement system changes to accommodate the new DTUoS tariff design policy.	EirGrid, ESBN	
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.	EirGrid, SONI	2026 **2026

* Dates have pushed out due to complexity of SEMC High Level Design Decision and delay in detailed design decision from SEMC
**Original dates included in Shaping Our Electricity Future v1.0

7.4.4 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).

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 models, and ex-ante versus ex-post imbalance 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 37: Markets – pillar 2 multi-year plan

Project name	Milestone	Owner	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.	SEMC	2025
	GB/EU Transmission System Operator Capacity allocation technical procedure development – to follow the outcome of the Cost benefit assessment and SCE guidance.	EirGrid, SONI	
	Opinion by GB Regulatory Authorities and ACER.	Ofgem, ACER	
	Possible amendments required by GB/EU specialized Committee on Energy.	DECC, DfE, BEIS	
	Final recommendation to adopt the and EU/GB day-ahead capacity allocation technical procedure.	Ofgem, SEMC	
	Possible new systems design, test and go-live	EirGrid, SONI	
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.	SEMC	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.	EirGrid, SONI	
	Opinion by GB Regulatory Authorities and ACER.	Ofgem, ACER	
	Possible amendments required by GB/EU specialized committee on Energy.	DECC, DfE, BEIS	
	Final recommendation to adopt an EU/GB day-ahead capacity calculation technical procedure.	Ofgem, SEMC	
	New SEM/GB capacity calculation process detailed system design, test and go-live.	SEMC	
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.	EirGrid, SONI	

Table 37: Markets – pillar 2 multi-year plan

Project name	Milestone	Owner	Date
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.	EirGrid, SONI	2022–2026
	Agree with All EU Transmission System Operators to amend the Capacity Calculation Region (CCR) determination.	EirGrid, SONI	
	Develop and submit for regulatory approval for a new EU CCR proposal.	EirGrid, SONI	
	Receive regulatory approval of CCR.	SEMC	
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.	EirGrid, SONI	2022–2026
	Develop issues and options for scoping including: • Ex-ante and ex-post imbalance pricing options; • Considerations of self-dispatch or central dispatch arrangements in the SEM; • Regional Coordination Centres (RCC) operations; and • Cross border services	EirGrid, SONI	
	Develop new methodologies with relevant EU TSOS for integration into EU Forwards, Intraday, Day ahead and Balancing markets.	EirGrid, SONI	
	Propose a High Level Design of Re-integration for consultation and decision by the SEM Committee.	SEMC	
	Develop Detailed Design and Programme Plan.	EirGrid, SONI	
	Industry readiness preparation for re-integration and new market design.	EirGrid, SONI	
	Over-arching governance of new market design including Rules Working Group, Technical Liaison Group and Business Liaison Group.	EirGrid, SONI	
	Procurement of Vendor new system/Change request current systems.	EirGrid, SONI	
	Build and deploy enhanced SEM (SEM 4.0) to address scope and issues identified in detailed design.	EirGrid, SONI	

8. What's next?

EirGrid and SONI are now implementing the roadmap as outlined in Shaping Our Electricity Future V1 and we need to transition to implementation and delivery as outlined in this updated roadmap.

EirGrid and SONI recognise 2030 is a milestone on the ultimate journey to a net zero energy system. To that end, we have commenced development of the next iteration of Tomorrows Energy Scenarios – this will consider credible pathways for the evolution of the power system in 2035, 2040 and 2050.

A consultation on Tomorrows Energy Scenarios, which will be benchmarked against energy scenario developments in other jurisdictions, will take place in summer 2023.

EirGrid and SONI are also working with colleagues around Europe on the evolution of offshore energy systems to 2050.
EU countries have agreed on new, ambitious long-term goals for the deployment of offshore renewable energy up to 2050 in each of the EU's five sea basins, with intermediate objectives to be achieved by 2030 and 2040.

These agreements build on strong regional cooperation instruments and tools established by the revised Regulation on trans-European energy networks (TEN-E Regulation). By going beyond national approaches, EU countries are laying the framework for a trans-European method which allows for a cost-effective expansion of grids needed to incorporate the expected offshore renewable generation with least environmental impacts and tackle internal bottlenecks. EirGrid and SONI, along with colleagues in ENTSO-E are combining this with information on maritime spatial planning and will propose strategic integrated offshore network development plans. This will give visibility to grid promoters, investors, and the supply chain on what offshore grids to expect for each sea basin by 2050.

The Shaping Our Electricity Future roadmap will be updated approximately every two years, in response to the latest technology, economic, policy and system developments. We will continue to work together with governments and regulators and in consultation with industry stakeholders and the public, in making our energy system safe, affordable, secure, reliable and sustainable. It should be noted the anchor year for the analysis may change from 2030.

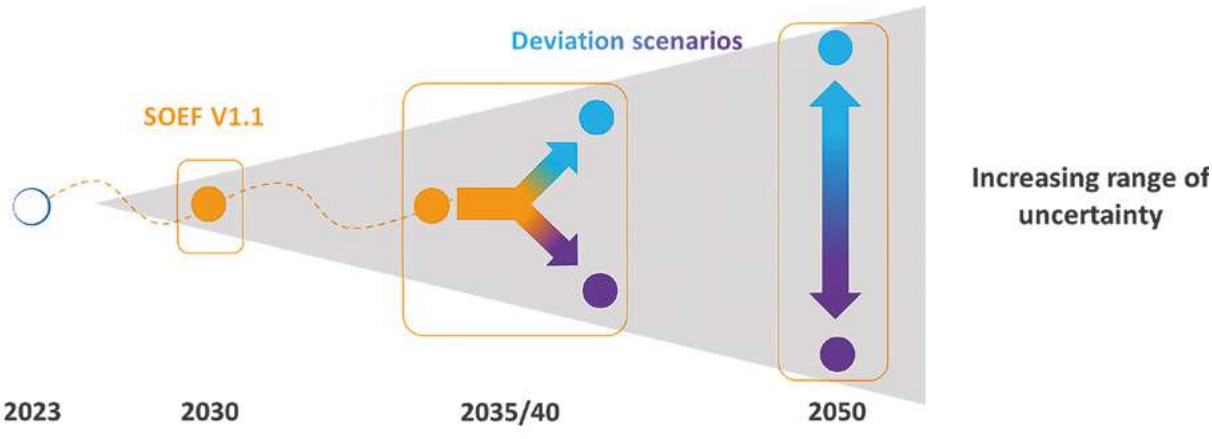


Figure 26: Deviation of scenarios across the decades

Appendices

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.
CO_2 emissions	CO_2	Carbon dioxide emissions or CO_2 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	A 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	Supports the sustainable and efficient delivery of well-planned homes and effective local government.
Direct Current	DC	Direct current is an electric current which flows only in one direction, in contrast to alternating current 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	Operational tool aimed at maximising electric power transmission when environmental conditions allow it.
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.
Electricity 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.
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.

Term	Abbreviation	Description
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	A 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.
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.

Term	Abbreviation	Description
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.
Photovoltaics	PV	Conversion of light into electricity.
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		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		80% of electricity from renewables by 2030 in both Ireland and Northern Ireland, 51% reduction in greenhouse gas emissions by 2030 relative to 2018 and carbon neutral electricity system by 2050 in Ireland.
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 80% by 2030 in Ireland. 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.
Surplus Renewable Generation		This is a component of dispatch down which occurs at times when there is more generation than the market needs to meet consumer demand, including exports, sometimes called oversupply.
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.
Technological Levers		Suitable technologies providing flexibility which would help minimise the over installation of renewable generation and help maximizing the utilization of surplus renewable generation.
Technology Readiness Level	TRL	Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology.

Term	Abbreviation	Description
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.
Tomorrow's Energy Scenarios	TES	Scenario plans for Ireland.
Tomorrow's Energy Scenarios Northern Ireland	TESNI	Scenario plans for Northern Ireland.
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 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 and industry engagement

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.

EirGrid and SONI conducted a range of engagement and participation activities over the course of a 14-week consultation – 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.

The consultation feedback highlighted that there was 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. The public and industry consultation feedback formed the basis of the original version of Shaping Our Electricity Future (version 1) published in November 2021.

Since November 2021, through the implementation of the engagement pillar in Ireland and Northern Ireland, there has been continuous engagement with the public on delivering on the Renewable Ambition. In Ireland this engagement has included Energy Citizen roadshows across the country, partnership with Young Social Innovators and partnership with Friends of the Earth and the Renewables Grid Initiative. In Northern Ireland this included convening the Northern Ireland Energy Forum with Northern Ireland Chamber of Commerce and establishment of a Citizen Sounding Board for the mid-Antrim project.

Similar to public engagement, there has also been continuous engagement with the industry over the last 2 years. This included a Call for Inputs over summer 2022 and regular engagement with the Shaping Advisory Council (over 30 subject matter experts representing various sectors of electricity industry in Ireland and Northern Ireland).

The public and industry engagement feedback in aggregate over the last 2 years formed the basis of this updated version of Shaping Our Electricity Future (version 1.1).

Summer 2022 call for inputs – feedback themes and response

The Call for Inputs generated feedback from 29 different electricity industry stakeholders and the diversity of responses ranged from regional development groups, renewable developers, energy and business associations and energy storage providers. Our review of the feedback identified several key themes that we correlated and applied to the underlying assumptions and modelling inputs. The key themes are grouped under the following headings:

Broad feedback

Commentary relates to networks, markets, and operations.

Transmission networks

Feedback that relates specifically to networks.

Power system operations

Feedback that relates specifically to enhancement of power system operations processes and tools.

Electricity markets

Feedback that relates specifically to market enhancements.

Stakeholder engagement

Feedback that relates specifically to the stakeholder engagement process.

Feedback common to networks, system operations and markets

Greater ambition and post-2030 vision

Feedback

Many industry respondents stated that the vision should extend beyond 2030 and consider the electricity demand out to 2050. Currently, the vision appears to end in 2030, yet there is significant work to be done beyond then. Given the timelines required to deliver major infrastructure projects, we would urge EirGrid and SONI to account for a higher renewable energy ambition beyond 2030.

Response

EirGrid and SONI recognise 2030 is a milestone on the ultimate journey to a net zero energy system. To that end, EirGrid and SONI have commenced development of the next iteration of Tomorrows Energy Scenarios for Ireland and Northern Ireland – this will consider credible pathways for the evolution of the power system in 2035, 2040 and 2050. A consultation on Tomorrows Energy Scenarios, which will be benchmarked against energy scenario developments in other jurisdictions, will take place in summer 2023. Tomorrows Energy Scenarios will act as the platform for development of the electricity system out into the future.

EirGrid and SONI are also working with colleagues around Europe on the evolution of offshore energy systems to 2050. EU countries have agreed on new, ambitious long-term goals for the deployment of offshore renewable energy up to 2050 in each of the EU's five sea basins, with intermediate objectives to be achieved by 2030 and 2040. EirGrid and SONI, along with colleagues in ENTSO-E are combining this with information on maritime spatial planning and will propose strategic integrated offshore network development plans. This will give visibility to grid promoters, investors, and the supply chain on what offshore grids to expect for each sea basin by 2050.

Adequate resourcing

Feedback

Many industry respondents stressed the importance adequate resourcing within the EirGrid and SONI to be able to deliver the multiple workstreams in terms of grid development, renewable connections, system operations and electricity markets.

Response

Achieving the Renewable Ambition requires significant changes in how EirGrid and SONI 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 critical 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 that increased capacity and additional capabilities are required to augment our existing resources – both in terms of skillset and levels of relevant experience to new areas. This capacity and capability build is already underway as we add depth and experience to our delivery teams.

EirGrid and SONI, as regulated TSOs, will continue to evolve and develop our 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, inclusive of the resourcing requirements, will be informed by the recommended activities contained within this report. Through the defined regulatory frameworks in Ireland and Northern Ireland, we will work with the Regulatory Authorities to ensure that adequate allowances are provided in regard to operational and capital expenditure.

Emissions trajectory

Feedback

Several industry respondents stated that a trajectory for year-on-year electricity sector emissions reductions to 2030 must be set out and ensure the roadmap supports these.

Response

As part of this updated Shaping Our Electricity Future roadmap version 1.1, EirGrid and SONI carried out modelling of electricity sector carbon emissions for each year out to 2030.

Maritime area consent

Feedback

Some industry respondents said that one of the most significant early milestones in the development of an Offshore Wind Farms will be achieving Maritime Area Consent (MAC). A key criterion in achieving this is showing consistency with the Transmission System Operator Development Plans, including the Shaping Our Electricity Future Roadmap.

Response

EirGrid acknowledges the importance of Maritime Area Consent milestone for Offshore Wind Farms in obtaining development consents and occupying the relevant maritime area.

The Government document, 'Accelerating Ireland's Offshore Energy Programme Policy Statement on the Framework for Phase Two Offshore Wind, March 2023 ('Phase 2 Policy')' is the most recent offshore wind policy decision. Section 5 of the Phase 2 Policy notes that alignment of offshore wind farm designated areas with available onshore grid capacity identified by EirGrid is a key consideration of the new plan led approach.

The Phase 2 Policy goes on to identify offshore development area on the South coast which are geographically aligned with existing onshore grid capacity as identified in Shaping Our Energy Future v1.0. The Phase 2 Policy notes that these areas are to be formally designated in Q4 2023. Maritime Area Consents will subsequently be issued by the competent authority within these designated areas. The Phase 2 Policy notes that the plan led approach will continue through future phases.

Grid development costs

Feedback

Several industry respondents stated developing the network should be seen as an investment which reduces the overall cost of deploying renewables and meeting Net Zero targets. The cost of grid is relatively minor compared to the costs of onshore and offshore wind over the life of a renewable energy project. Reductions in the levelised cost of onshore and offshore projects through investment in the grid and therefore allowing greater competition in RESS auctions will deliver much higher net savings to consumers.

Response

EirGrid and SONI recognise that grid development is one of the key enablers to meeting decarbonisation targets out into the future in Ireland and Northern Ireland. Indeed, the need to develop a robust, comprehensive set of candidate reinforcements is one of the key drivers for Shaping Our Electricity Future.

The candidate reinforcements outlined in this document, combined with the existing pipeline of network reinforcement projects, represents an absolute transformation of the transmission network in Ireland and Northern Ireland across the decade and will be a very significant step change in delivery from previous. EirGrid and SONI know also that 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. Grid development costs is part of this overall cost and needs to be appropriately managed.

Hybrid connections

Feedback

Several industry respondents in Ireland stated that hybrid connections should be permitted as the facilitation of such connections, as provided for in the Climate Action Plan, would enable complementary technologies such as offshore wind, battery storage, interconnectors, etc. to make efficient use of available grid capacity whilst enhancing security of supply. Such connections could also deliver beyond the current offshore ambition and therefore, should be recognised in the updated Roadmap and the Climate Action Plan initiatives to address existing regulatory barriers to such connections delivered upon as soon as possible.

Response

The introduction of 'Hybrids' presents an opportunity for both market participants and system operators to optimise the use of grid infrastructure by increasing the overall capacity factors of connected entities, with the potential for improving security of supply. EirGrid and SONI are working closely with ESB Networks and NIE Networks respectively to unlock the potential for these developments.

In Ireland, jointly with the DSO (ESB Networks), EirGrid has submitted three separate papers to CRU covering the following:

- A suggested contractual framework approach to facilitate Multiple Legal Entities behind a single connection point (June 2022);
- Recommendations on revisions to the over-install policy (October 2022); and
- A technical assessment for sharing of Maximum Export Capacity (MEC) behind a single connection point (January 2023).

We are engaging with CRU and, once clarity on next steps emerges, we intend to include relevant actions on future versions of this roadmap.

In Northern Ireland, SONI has jointly undertaken a review of the over-install policy with the DSO (NIE Networks) and have engaged with the Utility Regulator on recommendations.

Energy storage

Feedback

Some industry respondents stressed that a coordinated strategy for energy storage is needed to ensure investment is supported through the various pillars of the market and that new energy storage technologies are fully integrated into the electricity system and market to unlock their full potential. This should bring together the relevant stakeholders such as the System Operators, Regulatory Authorities, Government departments and industry to ensure a coordinated approach to energy storage going forward.

Response

As part of the Shaping Our Electricity Future v1.1 analysis, it is clear that there is a need for a balanced portfolio of technologies to deliver on the RES targets and carbon emission reduction targets. Long duration energy storage is a key aspect of this. As part of the updated markets recommendations, we have outlined how we have put in place a team to investigate market options to incentivise long duration energy storage. Engagement with industry representative bodies has already commenced.

Repowering of existing renewable generation assets

Feedback

Some industry respondents stated that repowering of existing renewable generation assets must be factored into grid planning. When looking to the renewable generation targets, there can be a tendency to look to future greenfield opportunities, however it must be noted that many operational assets in Ireland are approaching a point where repowering with newer more efficient technologies has significant potential to increase output. This must be planned for and barriers to implementing these upgrades must be removed.

Response

Repowering existing renewable generation sites at the end of the asset life is a good use of existing grid connection assets and capacity. Where advances in renewable generation technology mean that the footprint of an existing site could accommodate more installed generation the advantage is obvious. Existing rules related to the level of installed capacity relative to contracted capacity are being changed. Grid capacity may not be available to accommodate the additional generation, and where possible and appropriate, the grid will be upgraded to accommodate the additional generation.

Grid upgrades take time and planning. Renewable generation developers with plans for repowering and increasing the installed capacity must engage with EirGrid and SONI as early as possible in their planning to help with network planning. Consideration should also be given by developers to co-location of storage or demand which can help manage increased renewable generation within the existing limits of the grid.

Network infrastructure feedback and responses

Building 220kV rated 110kV cable circuits

Feedback

Several industry respondents stated that new underground cable circuits being developed and progressed by EirGrid and SONI should be built to the minimum standard for 220kV even if they are only operated at 110kV. This will allow circuits to be more easily voltage uprated in future to add capacity while minimising the social impact and maximising the use of grid routes.

Response

Where possible, and appropriate, future proofing of new circuits for operation at a higher voltage at a future date is done. There are examples of this that can be seen around the grid, most recently in North Dublin where the Belcamp substation will get a second connection by cable that had been operated at a lower voltage. When making these decisions Multi Criteria Assessment is used to determine the possible benefits to compare against demerits.

Maximise use of existing grid

Feedback

Many industry respondents stated that maximising the use of the existing power grid is key to delivering the 80% RES-E target, but there needs to be evidence of a programme of work to deliver a smarter network that makes better use of the renewable assets that we possess.

Response

EirGrid and SONI's is committed to maximising the use of the existing grid and, by extension, minimising the need for 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.

We have included an action in the Networks Multi-Year plan to address implementation of flexible devices and methods onto the power system. This will consider:

- Necessary changes to grid development frameworks.
- Horizon scan of latest international developments.

We will report on progress in this as part of the delivery of Shaping Our Electricity Future.

Technical solutions and non-wire technologies

Feedback

Several industry respondents suggested that dynamic line rating, series compensation and longer duration storage should be progressed to ensure that they are deployed as quickly as possible. These technologies can be deployed in the short to medium term and can help bridge the gap until new grid transmission infrastructure is built out. This will play a vital role in reducing constraints during network build out and will support early build of renewable projects.

Response

We recognise and agree with the potential benefits of non-wire solutions. EirGrid and SONI 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, dynamic power flow controllers and long duration storage are all technology areas which we see potential in for supporting the transition to high RES-E.

Further, these technologies contribute to increased utilisation of existing infrastructure which is a key focus of the Shaping Our Electricity Future Programme. EirGrid and SONI have also commenced a horizon scan of latest international developments to make sure we remain abreast of latest developments and can incorporate these as appropriate into how we develop the transmission network in Ireland and Northern Ireland.

New grid infrastructure

Feedback

Some industry respondents stated that in order to reach 2030 targets and beyond significant new grid infrastructure will be required. New transmission overhead lines, significant upgrades to existing lines, underground cables and substations are required to achieve significant increases in capacity in areas of the country where there are large amounts of onshore and offshore generation available, but limited grid capacity.

Only seven of total 52 network upgrades across Ireland and Northern Ireland outlined in Shaping 1.0 were new circuits. This number falls far short of the expectations of industry for new grid development for 2030 and beyond. The proposed roadmap limits opportunities for new onshore generation to connect across the country. It would have been expected that there would have been new transmission circuits identified in Mayo, Tipperary, West-Cork, etc. where the grid is highly constrained and there is significant generation capacity available.

Response

The analysis carried out to determine the candidate reinforcements required to accommodate the Renewable Ambitions has considered input and feedback from consultation with a wide range of stakeholders – both public and industry. The feedback supported minimising new network build in favour of upgrading existing grid, making best use of the grid, and looking to renewable generation connections that can access unconstrained grid.

In Ireland, this roadmap highlights four new renewable hub arrangements which will have significant new network build requirements to connect renewable generation into areas of the existing grid that have realisable capacity. In Northern Ireland, it highlights the potential need for a new 275 kV substation in the Belfast area. It also highlights a number of potential non-wire solutions in Ireland and Northern Ireland to help maximise the use of the existing transmission network.

Progression of existing and new grid projects

Feedback

Several industry respondents highlighted that extensive upgrades must be made to the network to support the new renewable energy assets that will be connecting in the coming years. An updated capital investment and network development plan must be brought forward, sufficiently addressing the above, and setting a course for net zero, with delivery timelines for each asset required. Existing renewable assets awaiting energisation must be connected to the grid at the earliest possible opportunity.

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 quantum of reinforcement projects highlighted in this Roadmap, the original Shaping Our Electricity Future publication and the existing pipeline of projects.

In Ireland the updated network development plan out to 2030 is published in the Network Delivery Portfolio on the EirGrid website. In Northern Ireland, the latest status of the network development is captured in the Transmission Development Plan Northern Ireland.

Regional development

Feedback

Some industry respondents stated that development of the grid in Ireland should be spread across more regions to aid regional development rather than focused on the eastern part of the country. Without ambitious additional measures by EirGrid and SONI to strengthen our grid capacity, we are concerned that these socio-economic challenges could become further embedded.

Response

In Ireland, we have changed our assumptions in relation to the growth of large energy users with 300 MVA connecting outside of Dublin and the Mid-East – we have assumed 75 MVA of LEU demand in the Galway, Limerick, Cork, and Waterford areas. Similarly, in Northern Ireland, we have assumed that 20 MVA of LEU demand will connect in the Coolkeragh area.

Developments like these 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.

Distribution network development considerations

Feedback

Some industry respondents stated that in order to facilitate the necessary volumes of renewable generation and low carbon technologies, the development of the transmission network must be cognisant of the development of the distribution network. One cannot efficiently happen without considering the other. Such collaboration will be key in meeting the challenges to 2030 and beyond. It is important that network technologies and resources are deployed where they will deliver the optimal and efficient solution for the electricity customer, in terms of impact and cost.

Response

Close partnerships between the TSOs and the Distribution System Operators (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 (decarbonised system, reliability maintained and economically delivered) 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.

Strategic energy zones

Feedback

Some industry respondents stated there is a need to maximise the marginal utility of grid investment within a clearly focussed grid development plan – where the utility delivered is two-fold – decarbonisation and security of supply. This would be facilitated by the identification of Strategic Energy Zones to send clear investor signals to where generation of various types and grid supporting technologies should locate, allowing suitable projects to be realised. What the past few years has taught us is that there is an urgent need to overbuild/ overprocure vis a vis the past in terms of new dispatchable, storage and renewable capacity. New dispatchable capacity will need to be built to help secure baseload and in light of current circumstances should be prioritised. With new government targets on Green Hydrogen, this can be a vehicle to greening the baseload power needed to run the system.

Response

The new candidate network development projects in Ireland focus on large scale clustering of renewable generator projects at renewable hubs. Renewable hub substations are strategically located to allow significant quantities of new renewable generation in the vicinity connect to it. The renewable hub substation is then, in turn, connected to a part of the network that has the required realisable capacity to cope with the additional generation. This approach avoids multiple smaller-scale connections to the 110 kV grid with associated planned outage implications and addition to congestion on the 10 kV network.

The concept of renewable hubs used in this analysis assumes they are likely built contestably by developers, or consortia of developers, of renewable generation projects.

At each of these renewable hubs it is assumed that new-build of substations and circuits can be minimised through co-location of onshore wind and solar PV generation in hybrid connection arrangements, in conjunction with long duration battery storage to capture variable renewable generation peaks and release that energy when network conditions allow.

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. 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.

Evolving transmission development and multi-year plans

Feedback

Some industry respondents said that it is important that the Transmission Development Plan and Multi-Year Plan evolves and iterates to address constraints and challenges and ensure the right projects are being developed to meet the targets set out in the Climate Action Plan.

Response

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.

The Shaping Our Electricity Future roadmap will be updated approximately every two years, in response to the latest technology, economic, policy and system developments. We will continue to work together with governments and regulators and in consultation with industry stakeholders and the public, in making our energy system safe, affordable, secure, reliable and sustainable. It should be noted the anchor year for the analysis may change from 2030.

Outage schedule considerations

Feedback

Several industry respondents suggested that the updated roadmap, including new projects identified, should aim to set out a plan in terms of timelines and outage schedules for delivery of the projects.

Response

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 security of supply and 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 which will require change across the entire life cycle of delivery.

EirGrid will work closely with ESBN as both the DSO and TAO to implement this programme ensuring that the operational security of the transmission and distribution systems are maintained. We will also include the regulator, industry and the department in this where required to ensure that all the relevant actors in this space are informed and that the agenda for transformation is progressed. Work in this space is specifically called out in the Networks multi-year plan.

Grid action committee

Feedback

Several industry respondents stated that it may be appropriate for a 'Grid Action Committee' to be formed at governmental level that would work together with both TSOs and industry in order to deliver grid at the pace that is needed.

Response

A Shaping Advisory Council was established in 2022 – this consisted of approximately 30 subject matter experts representing various sectors of the electricity industry in Ireland, Northern Ireland and further afield. This considers the evolution of transmission network, external engagement, system operation and electricity markets across the decade.

The council has met approximately every three months since initiation and builds on the successful DS3 Advisory Council established in the previous decade. The Shaping Advisory Council consists of industry members and also colleagues from energy ministries and regulators in Ireland and Northern Ireland. EirGrid and SONI also contribute actively to a number of other government sponsored fora and believe engagement initiatives like this have an important role to play during this time of significant change in the electricity sector.

System operations feedback and responses

Operating at 100% SNSP

Feedback

Several industry respondents stated that the current Shaping Our Electricity Future roadmap only targets 95% SNPS by 2030 with 2 conventional generators in ROI and NI. With the increased target of 80% renewables by 2030, EirGrid now need to stretch their ambition to operating the system at 100% SNSP and 0 conventional generators. By removing conventional generators operating at min gen and replacing them with alternative technology has the potential to facilitate necessary additional capacity on the network to meet the renewable ambition.

Response

It is EirGrid and SONI's ambition to achieve operation at 100% SNSP with no conventional thermal generation online in the next decade (2030+). Prior to this we have set out an ambitious roadmap to evolve these operational metrics from an SNSP limit of 75% and a minimum of 8 conventional thermal generators online at the beginning of 2023, to be capable of operating at 95% SNSP and 3 or less conventional thermal generators online by 2030. The target of 95% SNSP by 2030 set out in our Operational Policy Roadmap 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 the required level of RES-E by 2030 as per current government targets.

This journey to 2030 and beyond will require a number of significant technical and operational challenges to be overcome. 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 to ensure system security is maintained throughout the transition.

We agree that the replacement of conventional thermal generation by low carbon sources of System Services is a key aspect of this journey, and we are actively progressing the procurement of Low Carbon Inertia Services to enable us to reduce the minimum number of conventional thermal generators online.

Low/No carbon fuel technologies

Feedback

Some industry respondents said that the requirement for very low carbon emissions in 2030 highlights the need to focus on the minimum number of units as well as the SNSP level. A very high SNSP level still combined with a high number of minimum thermal units is unlikely to meet carbon targets. The operations roadmap should consider what alternative zero carbon options including low/no carbon fuel alternatives such as hydrogen are available if the minimum unit requirement cannot be removed.

Response

During 2023, EirGrid and SONI will (subject to Regulatory Authority Approval) be undertaking a procurement process for Low Carbon Inertia Services. This procurement will deliver new capability that can replace many of the System Services provided by conventional thermal generation and significantly contribute to our ambition to reduce the number of conventional thermal generators that we 'must run' at times for these Services.

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 in early stage of development and further experience with the technology is needed. 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.

Flexibility programmes

Feedback

Some industry respondents stated that flexibility programmes should be prioritized and appropriately resourced by the TSO to enable the development of flexibility across existing grids.

Response

Flexibility is at the heart of Shaping Our Electricity Future and is well recognised as a key enabler for decarbonisation in Ireland, Northern Ireland and internationally. Focussing on Shaping Our Electricity Future, it is implicit across the pillars of the initiative and is a priority for EirGrid and SONI.

- The evolution of flexibility in transmission networks (e.g. use of non-wire devices, outage management etc.).
- Flexibility in how we operate the power system through transformation of system operation (e.g. system services, new technologies etc.).
- Incentivising flexibility through electricity markets (e.g. alignment of electricity markets with a high renewable world etc.).

Electricity markets feedback and responses

Surplus renewable generation

Feedback

Several industry respondents said that they agree with the TSO that the treatment of surplus renewable generation needs to be addressed. This issue needs to be discussed, consulted upon and decided in advance of future RESS (onshore and offshore) auctions. This is a risk that is well understood which needs to be answered. The work on this element of the Renewable Support Schemes in the market pillar needs to be progressed at a faster pace.

Response

Surplus renewable generation is a key feature of the analysis for 2030, and it has been shown to increase non-linearly at very high levels of renewables. These surpluses occur when renewable generation supply exceeds market demand plus interconnector exports. The surplus renewable generation represents a significant opportunity for innovative energy usage in Ireland and Northern Ireland. Per this analysis, over 20% of available renewable generation is predicted to be surplus to demand requirements in 2030.

Technology levers such as further interconnection (beyond existing interconnection and new projects such as the Celtic interconnector and Greenlink), and aggressive assumptions around long duration storage and demand side flexibility help mitigate the surpluses and have been assumed to be in place in this revised Roadmap. However, EirGrid and SONI acknowledge implementation of these technology levers by 2030 is extremely ambitious.

EirGrid and SONI agree that surplus renewable generation needs to be carefully considered out across the decade. Focussing specifically on renewable auctions, the terms and conditions in the Ireland Renewable Electricity Support Scheme is a responsibility of the Department of the Environment, Energy and Communications. In relation to Northern Ireland the Department of the Economy is concluding a consultation in April 2023 in respect of this scheme.

Timely implementation of incentives and frameworks which appropriately and effective utilisation of this surplus renewable generation require careful consideration and focus by policy makers, regulators, and industry players.

More granularity

Feedback

Some industry respondents said that the timelines for some of the projects are extremely wide ranging with little or no information on the minor milestones. It is believed that more granularity is required to fully understand if the projects are aligned with the needs of industry.

Response

We agree that further granularity of the plans is required. Many of the programmes are in the initial high-level scoping and planning phase. Once we move into the detailed design phase more granularity can be provided to industry. Industry engagement will take place for each of the respective programmes.

Firm access methodology consultation

Feedback

Several industry respondents suggested that good regulatory practise would require that Firm Access Methodology paper to go through a full consultation process rather than what appears to be activated through an information note.

Response

EirGrid published the 'Firm Access Methodology Review'[18] in December 2021. SEM-C initiated a consultation (SEM-22-068) on the new methodology which was published on the 27th of September 2022[19]. SEM-C decision paper (SEM-23-004) followed from this consultation, and it was published on the 25th of January 2023[20]. There have been several engagements between EirGrid and SEM-C on the new Firm Access Methodology for Ireland. Based on the feedback, the methodology is being further tested and improved. As a next step, CRU plans to take the lead on releasing a detailed paper on the new Firm Access Methodology.

Capacity market

Feedback

Some industry respondents stated that a review of the capacity market is needed to support new investment in low carbon technologies and avoid locking in inflexible generation for years to come. To date the capacity market has been geared towards conventional thermal plant but this focus needs to shift and a review of the market carried out to ensure investment is delivered in the technologies that can support renewables and our capacity needs over the longer-term. Strict emissions limits could be considered here for new build contracts in future capacity auctions to support new zero carbon technologies.

Response

The TSOs made a number of interim recommendations to the SEMC in relation to areas of improvement in relation to the capacity market over the last number of years. These recommendations related to strengthening security of supply, but also in ensuring we remain on a trajectory to a low carbon power system.

In this version of Shaping Our Electricity Future v1.1. EirGrid and SONI have outlined how we need a balanced portfolio of technologies to delivery on the Renewable Ambition and carbon emission reduction targets. The current capacity market is constrained in relation to delivering on this as it delivers on the least cost technically acceptable solution.

18 https://www.eirgridgroup.com/site-files/library/EirGrid/Firm-Access-Review-2021.pdf
19 https://www.semcommittee.com/sites/semc/files/media-files/SEM-22-068%20SEMC%20Firm%20Access%20in%20Ireland%20consultation.pdf
20 https://www.semcommittee.com/sites/semc/files/media-files/SEM-23-004%20SEMC%20Firm%20Access%20in%20Ireland%20decision.pdf

To deliver on the decarbonisation ambitions requires the correct mix of renewables, demand side, interconnection, long duration storage, open and combined cycle gas turbines which are renewable gas ready. It is also crucial that this portfolio locates in the correct part of the grid.

The current EU State Aid approval of the capacity market expires in 2027. The TSOs have commenced the process of establishing a National Resource Adequacy Assessment (NRAA) to comply with the relevant EU legislation.

The future evolution of the capacity market design is ultimately the responsibility of the SEM Committee.

Holistic approach

Feedback

Some industry respondents support a holistic approach to the various pillars of the market which allows revenue stacking across different revenue streams and does not penalise or restrict providers from access to different markets.

Response

The existing arrangements which allow revenue stacking against a number of different markets such as capacity, energy and system services has served us well in the Single Electricity Market. It has delivered on the previous government targets and the TSOs and MO believe this will continue to be crucial as we move into a world where the majority of our electricity comes from renewable sources. We welcome this feedback and we will continue to ensure that all market design changes are considered and applied in a holistic manner, whilst also protecting consumers from high costs.

Grid services

Feedback

Some industry respondents suggested that clarity on the mechanisms for grid services projects should be provided, including locational elements to these support schemes. This will assist in constraint management by incentivising developers to locate assets in areas that currently suffer from high levels of constraint by providing certainty on system services revenues.

Response

EirGrid and SONI agree that locational signals will be an important aspect of ensuring new capacity locates in the correct areas of the grid. For example, EirGrid recommended that a locational signal be incorporated as part of RESS3 in Ireland and we await the final decision on this.

In Ireland, EirGrid believe meeting the challenge of the Climate Action Plan targets requires a change in our approach to how we collectively decarbonise the electricity sector. The power sector must transition from a developer led to a plan led approach. The developer led approach has served Ireland well in meeting and exceeding our 2020 renewable electricity targets. However, as we transition to higher levels of renewables, the changing realities of the electricity system, balancing the needs of society as a whole, the wishes of communities and the energy citizen all require a different approach to ensure delivery. As well as continuing to focus on cost competitiveness and innovation, we must factor in macro level constraints – in particular, grid capacity as we plan towards 2030.

Stakeholder engagement feedback and responses

Offshore wind connection policy – Northern Ireland

Feedback

Some industry respondents suggested that as a key priority, it is essential to devote resources to quickly develop with key industry players (NIE and UREG) and DfE, a clear offshore windfarm connection policy.

Response

SONI has been supporting the Department of the Economy (DfE) on the NI Energy Strategy Action Plan for 2022. Specifically, SONI has been actively involved in the various working groups established by DfE to progress its plans for Offshore in NI. DfE has recently published its Draft Offshore Renewable Energy Action Plan (OREAP). SONI will continue to support DfE in this important strategic area.

National debate

Feedback

Some industry respondents said that one of the big constraints on building out the network is local opposition. Effective local engagement is essential but there also needs to be a national debate about how we, as a society, balance the rights of individuals with the need as a society to build infrastructure for the common good.

Response

Public acceptance is central to the delivery of electricity infrastructure. 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, 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.

Stakeholders believe the transformation of EirGrid's and SONI's approach to engagement needs to be sustained, iteratively evolved, and be supported by consistent and targeted communications at local, regional and national level. At every opportunity, stakeholders have reiterated to us 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.

Only with the support of stakeholders will Ireland and Northern Ireland 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. When 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.

The delivery of this Roadmap and wider government electricity ambitions is crucially dependent on activities by 3rd parties. This includes overarching, government led support on the need for the energy transition and visible support for the delivery of challenging infrastructure.

Project delivery board

Feedback

Several industry respondents said that in relation to specific projects or regions of the grid, that project delivery management boards shall be set up for each of the six regions identified in the TES 2019 System Needs Assessment report. These would be similar to the board established several years ago between EirGrid and ESB Networks for the delivery of the South West 220 kV projects, which worked very well.

Response

Several programme boards are in place within EirGrid Group to support delivery of our grid infrastructure programmes. There is a Network Projects Programme Board and a Dublin Programme Board which take place monthly along with monthly reporting into an Infrastructure Executive Committee. In addition, there are explicit reporting requirements monthly in terms of risk, cost and schedule. In addition, we are open to providing network infrastructure updates at a regional level in a forum type format to industry to outline programme progress bi-annually.

Shaping Our Electricity Future advisory council

Feedback

Some industry respondents welcomed the establishment of the Shaping Our Electricity Future Advisory Council but believe the Shaping Our Electricity Future programme is very broad and would benefit from specific focus on key areas such as grid development.

Response

A Shaping Advisory Council was established in 2022 – this consisted of approximately 30 subject matter experts representing various sectors of the electricity industry in Ireland, Northern Ireland and further afield. This considers the evolution of transmission network, external engagement, system operation and electricity markets across the decade.

The council has met approximately every three months since initiation and builds on the successful DS3 Advisory Council established in the previous decade. The Shaping Advisory Council consists of industry members and also colleagues from energy ministries and regulators in Ireland and Northern Ireland.

EirGrid and SONI recognise the Shaping Advisory Council is broad in nature – to that end, at the most recent council meeting, it was agreed that members would meet as a sub-group on a pilot basis to deep dive a particular issue. Initiatives like this would need to be balanced against time constraints of council members.

Appendix 3: Technologies to maximise the utilisation of surplus renewable generation – preliminary assessment

Purpose

This appendix describes the process followed and the results obtained from preliminary analysis performed in support of Shaping Our Electricity Future (SOEF) v1.1. This analysis was carried out up to May 2022.

The analysis sought to identify suitable technologies to provide flexibility which would help minimise the over installation of renewable generation. We refer to these as technological levers. The recommendations from the analysis informed subsequent modelling phases for SOEF v1.1.

Whilst policy has evolved since May 2022, the findings of this preliminary analysis remained valid for determining appropriate technological levers to maximise the utilisation while minimise surpluses of renewable generation capacity. It should be noted that this was preliminary analysis to inform, subsequent more detailed analysis which reflected latest evolving policy – the results below should be borne in that context.

Preliminary assessment

Renewable generation to meet the 80% targets

Building upon the final generation portfolio from SOEF v1.0, an iterative assessment was performed in PLEXOS to determine the additional renewable generation capacities needed to deliver the 80% RES-E targets in Ireland and Northern Ireland. Three scenarios were considered:

- Increasing the installed onshore wind capacity only;
- Increasing the installed offshore wind capacity only; and
- Increasing the installed PV capacity only.

For each scenario, the capacity of additional renewable generation was increased in an unconstrained PLEXOS schedule until 85% RES-E was achieved – this allowed for an estimated 5% of renewable generation constraint to be considered, a figure based on analysis from SOEF v1.0.

By assessing only one renewable generation type in each scenario, the relative performance of each was able to be compared. Figure 27 shows the quantities of each renewable generation type required to deliver 85% RES-E in an unconstrained analysis.

The quantities of additional renewable generation required to move from 70% RES-E to 80% RES-E were significant. Further analysis of the PLEXOS schedules demonstrated that surplus renewable generation was a major reason for this.

Figure 27 shows the corresponding surplus associated with the three scenarios.

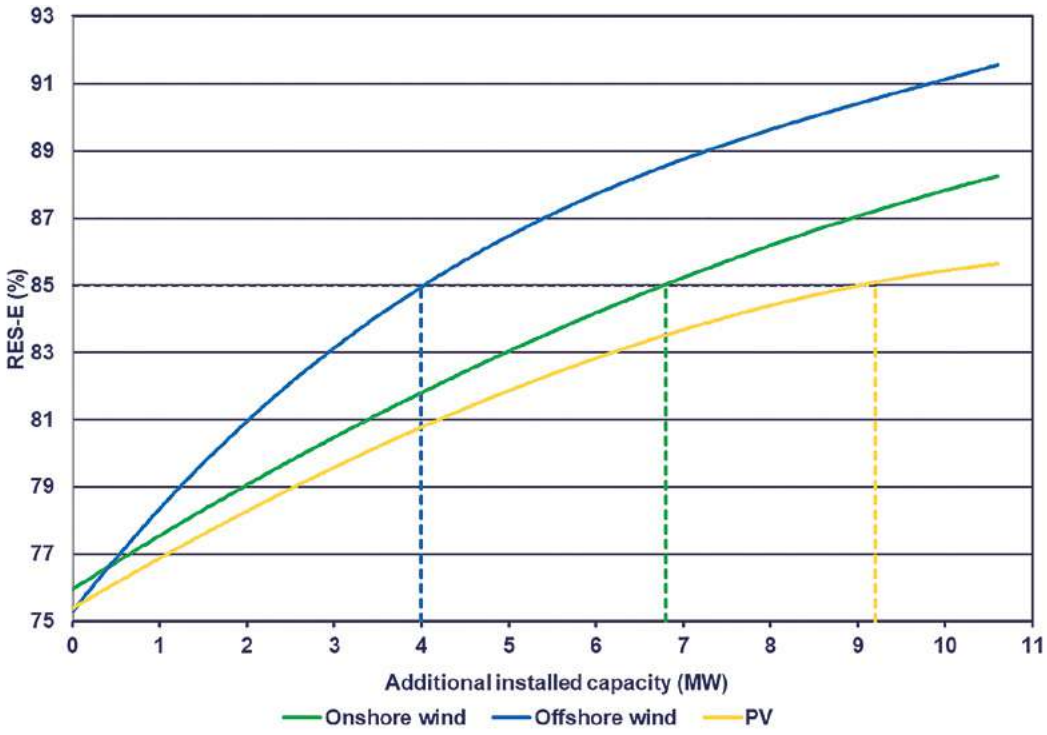


Figure 27: Additional capacity per scenario and corresponding RES-E

The volume of surplus renewable generation for each scenario was significant and led to a further investigation of technological levers to help reduce the surpluses and, correspondingly, the additional quantity of generation capacity in each scenario required to deliver 80% RES-E.

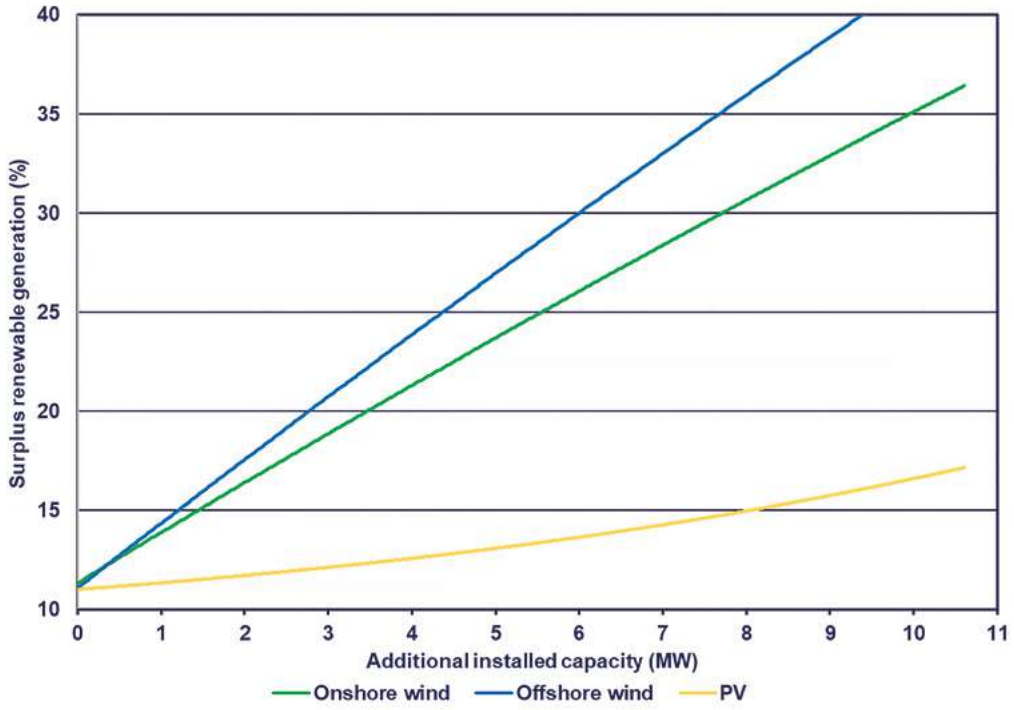


Figure 28: Additional installed capacity per scenario and corresponding surplus generation

Assessment of technological levers

A number of technological levers were included in the unconstrained PLEXOS schedules for each scenario, and the impact of each in turn assessed against the improvement noted in RES-E. The levers considered in the analysis were:

- 2 GW of Battery Energy Storage of 2-hour duration;
- 2 GW of Battery Energy Storage of 10-hour duration;
- 2 GW of Battery Energy Storage of 20-hour duration;
- 1 GW of intra-day Demand Side Flexibility;
- 25% of total Electric Vehicles with charging responsive to market pricing;
- An additional 700 MW of interconnection capacity into the SEM; and
- 360 MW of additional Pumped Hydro Energy Storage capacity.

The assessment performed to determine the renewable generation capacities necessary to deliver 80% RES-E was repeated with each technological lever in turn. Figure 25 shows the improvement in RES-E associated with all of the technological levers for the three capacities of renewable generation required to deliver 80% RES-E.

As clearly demonstrated in Figure 29, additional HVDC interconnection was the most effective technological lever at improving RES-E. When considering the other levers, demand side flexibility had a superior impact in comparison to the rest.

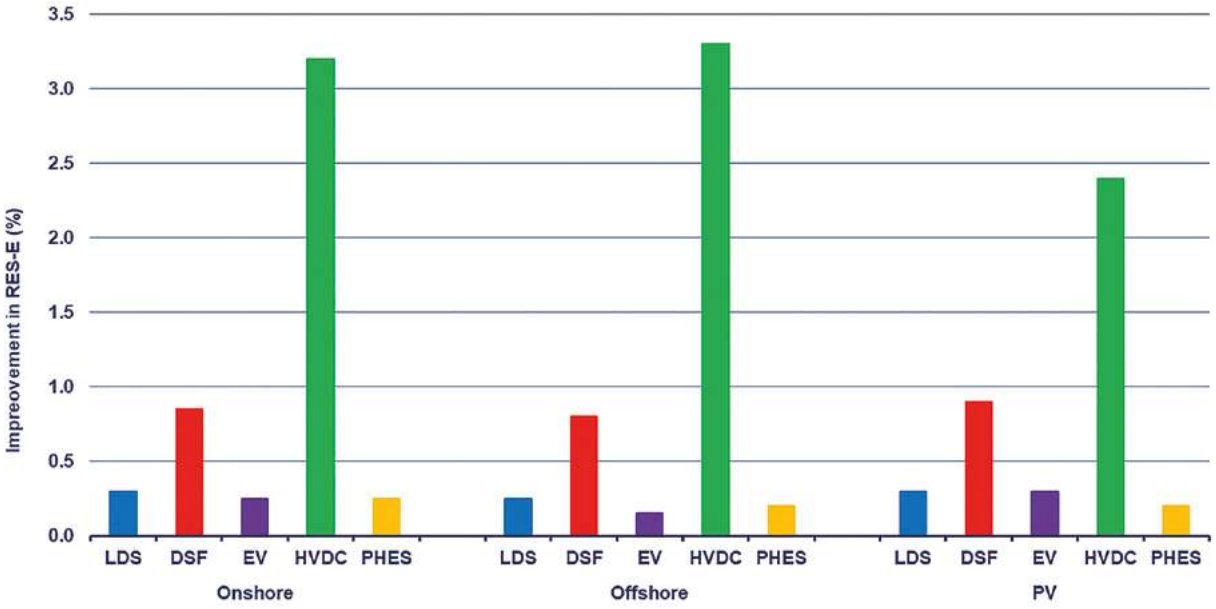


Figure 29: Improvement in RES-E for long duration battery storage (LDS), demand side flexibility (DSF), price responsive EV charging (EV), new interconnection (HVDC) and pumped hydro (PHES)

Conclusion

Following the completion of the analysis, a portfolio comprising quantities of each renewable generation type and a number of the technological levers was determined and used to commence the detailed market and network modelling work informing this roadmap.

With the introduction of ambitious carbon emissions budgets and target quantities for renewable generation in Ireland, the results of the technological lever assessment were used to inform additional quantities of flexibility services included the final scenario.

Appendix 4: Candidate reinforcements

These candidate reinforcements are in addition to projects already committed and those identified in Shaping Our Electricity Future v1.0.

#	Component	Voltage (kV)	Path	Domain	Class	Region
1	Deenes – Drybridge 110 kV	110	New	Static device (DLR)	HVAC	North-East
2	Gorman – Maynooth 220 kV	220	Uprate	Circuit	HVAC	North-East
3	Meath Hill – Louth 110 kV	110	New	Static device (DLR)	HVAC	North-East
4	Lisdrum – Louth 110 kV	110	New	Static device (DLR)	HVAC	North-East
5	Ratrussan – Shankill 110 kV	110	New	Static device (DLR)	HVAC	North-East
6	Baltrasna – Corduff 110 kV	110	New	Static device (DLR)	HVAC	Mid-East
7	Corduff – Blundelstown – Mullingar 110 kV	110	Uprate	Circuit	HVAC	Mid-East
8	Maynooth – Castlelost 220 kV	220	Uprate	Circuit	HVAC	Mid-East
9	Crane – Wexford 110 kV	110	New	Static device (DLR)	HVAC	South-East
10	Cullenagh – Waterford 110 kV	110	New	Static device (PFC)	HVAC	South-East
11	Great Island – Waterford 1 110 kV	110	New	Static device (DLR)	HVAC	South-East
12	Drumline – Ennis 110 kV	110	New	Static device (DLR)	HVAC	South-West
13	Letterkenny – Golagh T 110 kV	110	Uprate	Circuit	HVAC	North-West
14	Cashla – Dalton 110 kV	110	Uprate	Circuit	HVAC	North-West
15	Castlebar – Dalton 110 kV	110	Uprate	Circuit	HVAC	North-West
16	Srananagh – Cathaleen's Fall 2 110 kV	110	New	Static device (DLR)	HVAC	North-West
17	Lisburn – Tandragee 1 110 kV	110	Uprate	Circuit	HVAC	NI
18	Lisburn – Tandragee 2 110 kV	110	Uprate	Circuit	HVAC	NI
19	New 275 kV substation in South East Antrim	275	New	Substation	HVAC	NI

Appendix 5: Base case reinforcements

The base case reinforcements assumed for Shaping Our Electricity Future v1.1 are given here.

In Ireland, approved projects in the Network Delivery Portfolio makes up the bulk of the base case reinforcement assumptions. These are combined with the Shaping Our Electricity Future v1.0 candidate projects listed in the table below.

In Northern Ireland, projects listed in the Transmission Development Plan Northern Ireland that are past Part 1 of the SONI Grid Development Framework make up the bulk of the base case reinforcement assumptions. These are combined with the Shaping Our Electricity Future v1.0 candidate projects listed in the table below.

#	Component	NDP(IE)/TDP(NI)
1	Mid Antrim Upgrade	TDPNI
2	Coolkeeragh – Strabane 110 kV circuit	TDPNI
3	Coolkeeragh – Killymallaght 110 kV circuit	TDPNI
4	Coolkeeragh – Limavady 110 kV circuit	TDPNI
5	Omagh – Strabane 110 kV circuit 2	TDPNI
6	Drumnakelly – Tamnamore 110 kV circuits 1 & 2	TDPNI
7	Coleraine – Coolkeeragh 110 kV circuit	TDPNI
8	Mid-Tyrone Project	TDPNI
9	Bandon – Dunmanway 110 kV circuit	NDP
10	Athy – Carlow 110 kV circuit	NDP
11	Rinawade – Dunfirth 110 kV circuit	NDP
12	Drybridge – Louth 110 kV circuit	NDP
13	Maynooth – Timahoe 110 kV circuit	NDP
14	Maynooth – Rinawade 110 kV circuit	NDP
15	Galway – Salthill 110 kV circuit	NDP
16	Inchicore – Carrickmines 220 kV circuit	NDP
17	Poolbeg – Carrickmines 220 kV circuit	NDP
18	Finglas – North Wall 220 kV circuit	NDP
19	Poolbeg South – Inchicore 220 kV circuit 1	NDP
20	Poolbeg South – Inchicore 220 kV circuit 2	NDP

CP #	Voltage (kV)	Path	Domain	Class	Type	Region
–	110	New	Circuit	HVAC	OHL	Northern Ireland
–	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
–	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
–	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
–	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
–	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
–	110	Uprate	Circuit	HVAC	OHL	Northern Ireland
–	275	New	Circuit	HVAC	OHL	Northern Ireland
CP1211	110	Uprate	Circuit	HVAC	OHL	South-West
CP1312	110	Uprate	Circuit	HVAC	OHL	South-East
CP1403	110	Uprate	Circuit	HVAC	OHL	Mid-East
CP0808	110	Uprate	Circuit	HVAC	OHL	Mid-East
CP1391	110	Uprate	Circuit	HVAC	OHL	Mid-East
CP1390	110	Uprate	Circuit	HVAC	OHL	Mid-East
CP1191	110	Uprate	Circuit	HVAC	OHL	West
CP1226	220	New	Circuit	HVAC	Cable	Dublin
CP1146	220	Uprate	Circuit	HVAC	Cable	Dublin
CP1100	220	Uprate	Circuit	HVAC	Cable	Dublin
CP1157	220	Uprate	Circuit	HVAC	Cable	Dublin
CP1150	220	Uprate	Circuit	HVAC	Cable	Dublin

#	Component	NDP(IE)/TDP(NI)
21	North Wall – Poolbeg 220 kV circuit	NDP
22	Louth – Oriel 220 kV circuit	NDP
23	Woodland – Oriel 220 kV circuit	NDP
24	Great Island – Kellis 220 kV circuit	NDP
25	Arklow – Ballybeg – Carrickmines 220 kV circuit	NDP
26	Killoteran – Waterford 110 kV circuit – Uprate not required following detailed need assessment	
27	Athlone – Lanesboro 110 kV circuit	NDP
28	Woodland – Finglas 400 kV cable cct	NDP
29	Kilteel – Maynooth 110 kV circuit	NDP
30	Baroda – Monread 110 kV circuit	NDP
31	Drumkeen – Clogher 110 kV circuit	NDP
32	Flagford – Sliabh Bawn – Lanesboro 110 kV lines	NDP
33	Sligo – Srananagh – Corderry 110 kV lines	NDP
34	Letterkenny – Tievebrack – Binbane 110kV lines	NDP
35	Letterkenny – Cathaleen's Fall or Letterkenny – Clogher 110 kV lines	
36	Killonan – Knockraha 220kV line	NDP
37	Clashavoon – Knockraha or Cullenagh – Knockraha 220 kV lines	NDP
38	Baroda – Newbridge 110 kV circuit 1	NDP
39	Bellacorrick – Castlebar 110 kV circuit 1	NDP
40	Cashla – Dalton 110 kV circuit 1	NDP
41	Cathaleen's Fall – Coraclassy 110 kV circuit 1	NDP
42	Cushaling – Newbridge 110 kV circuit 1 – Scope change to Uprate	NDP
43	Binbane – Clogher – Cathaleen's Fall 110 kV Clogher tie-in	NDP
44	Clogher – Srananagh 220 kV circuit	NDP
45	Magherakeel – Omagh circuit 1	
46	Great Island 220/110 transformer No.3	NDP
47	Knockraha – Cahir 110 kV circuit	
48	Flagford – Srananagh 110 kV circuit	NDP
49	Sligo – Srananagh 110 kV circuit 3	NDP

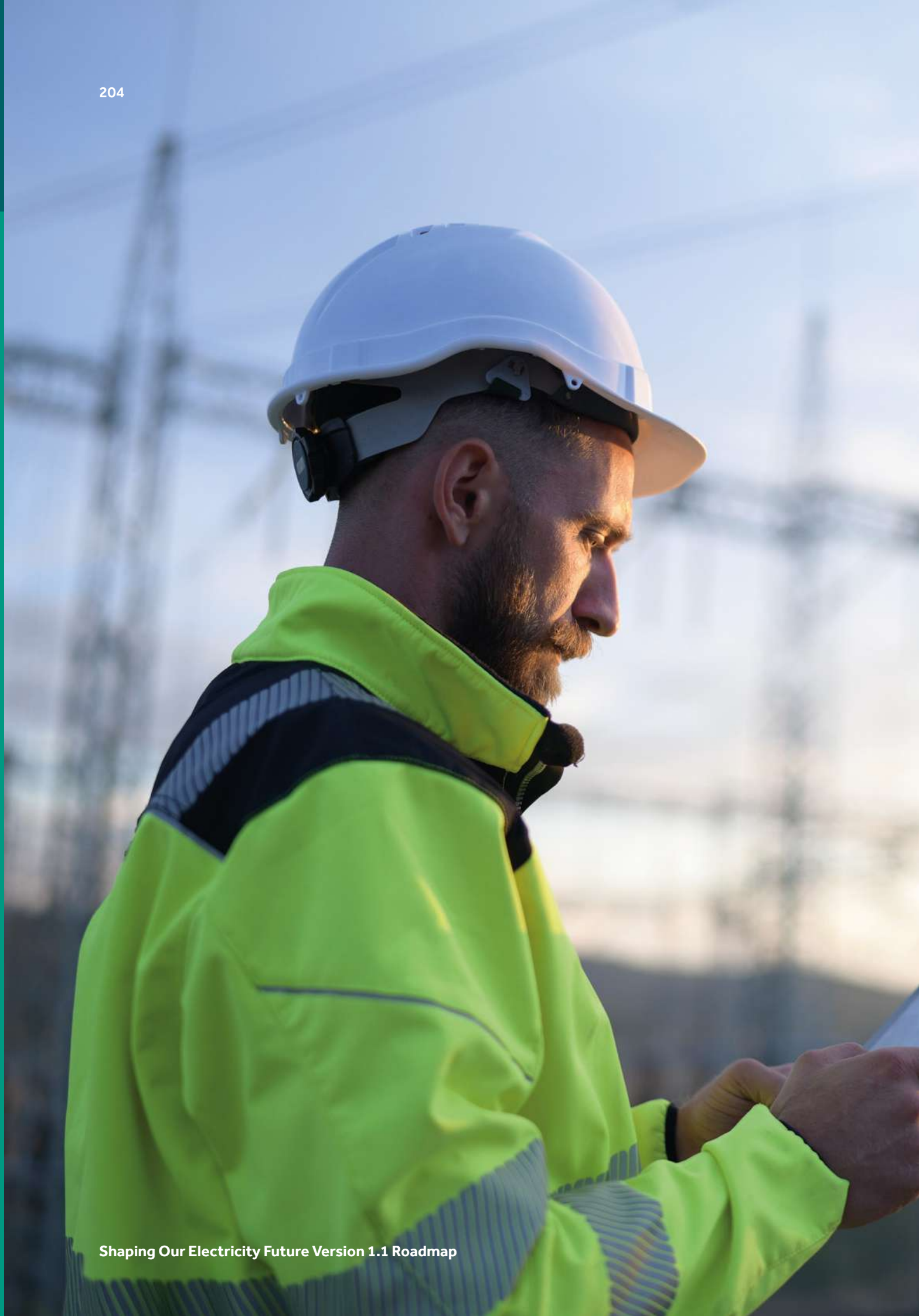
CP #	Voltage (kV)	Path	Domain	Class	Type	Region
CP1216	220	Uprate	Circuit	HVAC	Cable	Dublin
CP1235	220	Uprate	Circuit	HVAC	OHL	Mid-East
CP1235	220	Uprate	Circuit	HVAC	OHL	Mid-East
CP1405	220	Uprate	Circuit	HVAC	OHL	South-East
CP1196	220	Upvoltage	Circuit	HVAC	OHL	South-East
	110	Uprate	Circuit	HVAC	OHL	South-East
CP1311	110	Uprate	Circuit	HVAC	OHL	Midlands
CP1021	400	New	Circuit	HVAC	Cable	Dublin
CP1384	110	Uprate	Circuit	HVAC	OHL	Mid-East
CP1315	110	Uprate	Circuit	HVAC	OHL	Mid-East
CP1327	110	Uprate	Circuit	HVAC	OHL	North-West
CP1381	110	New	Static Device (PFC)	HVAC	OHL	Midlands
CP1404	110	New	Static Device (PFC)	HVAC	OHL	North-West
CP1388	110	New	Static Device (PFC)	HVAC	OHL	North-West
	110	New	Static Device (PFC)	HVAC	OHL	North-West
CP1383	220	New	Static Device (PFC)	HVAC	OHL	South-West
CP1324	220	New	Static Device (PFC)	HVAC	OHL	South-West
CP1315	110	New	Static Device (DLR)	HVAC	OHL	Mid-East
CP1317	110	New	Static Device (DLR)	HVAC	OHL	West
CP1321	110	New	Static Device (DLR)	HVAC	OHL	West
CP1322	110	New	Static Device (DLR)	HVAC	OHL	North-West
CP1326	110	New	Uprate	HVAC	OHL	Mid-East
CP1233	110	New	Circuit	HVAC	OHL	North-West
CP1233	220	New	Circuit	HVAC	OHL	North-West
	110	New	Static Device (DLR)	HVAC	OHL	Northern Ireland
CP1242	220/110	New	Transformer	HVAC	Transformer	South-East
	110	Uprate	Circuit	HVAC	OHL	South-West
CP0982	110	Upvoltage	Circuit	HVAC	OHL	North-West
CP0982	110	Uprate	Circuit	HVAC	OHL	North-West

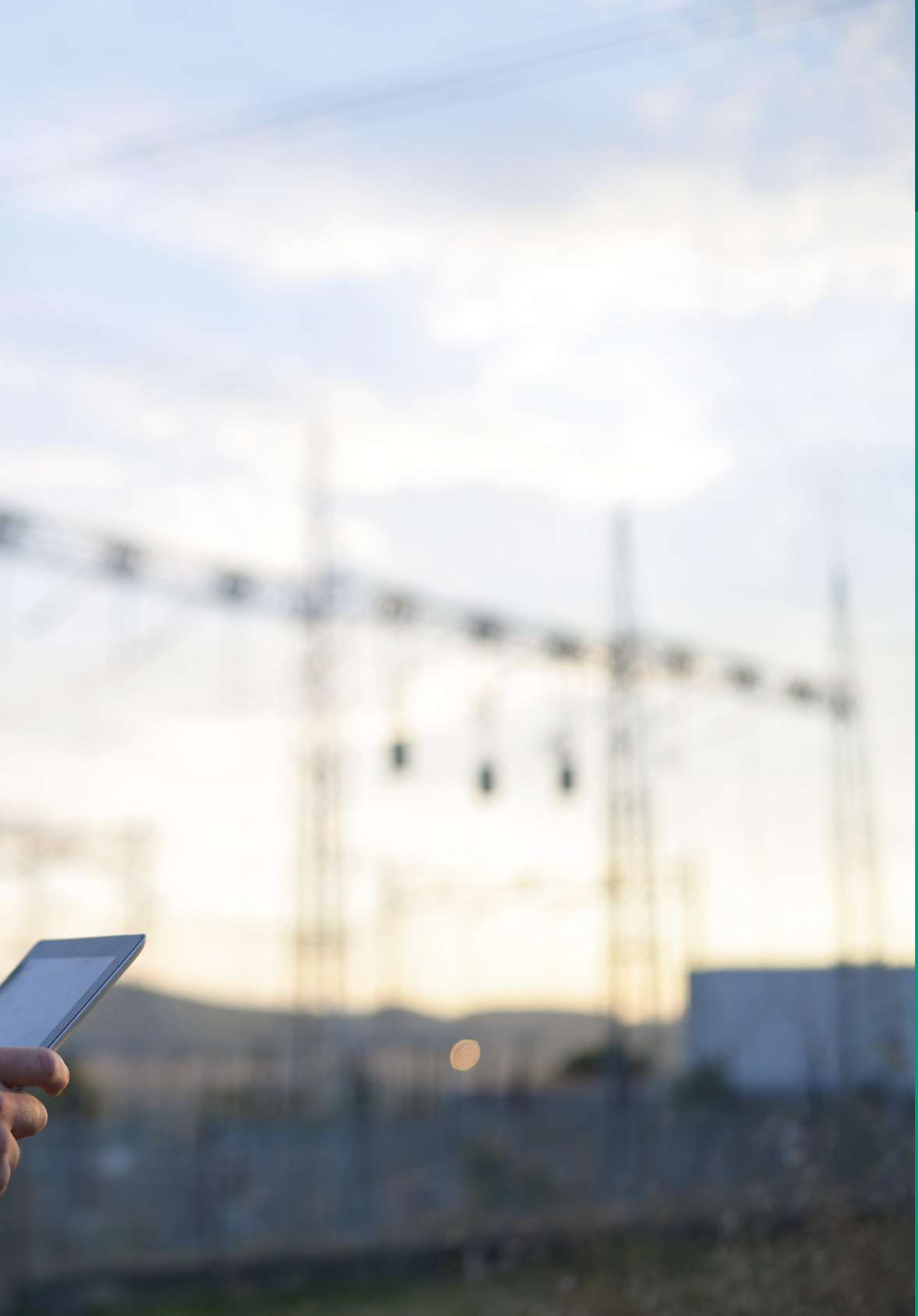
Appendix 6: Regional data

Area	Onshore wind (MW)	Offshore wind (MW)	Solar PV[21] (MW)
IE AREA A	1,150	0	150
IE AREA B	1,330	0	470
IE AREA C	630	0	520
IE AREA D	380	0	260
IE AREA E	1,830	390	560
IE AREA F	320	0	90
IE AREA G	370	370	490
IE AREA H1	630	0	450
IE AREA H2	860	1170	1,260
IE AREA I	10	350	460
IE AREA J	1,380	2,720	2940
IE AREA K	110	0	350
NI SE	450	500	450
NI NW	2,000	0	150

21 Includes micro-generation solar PV.

Area	Gas (MW)	Distillate (MW)	Battery (MW)	Pumped storage (MW)	Hydro (MW)	Interconnector (MW)	Bio, CHP, waste, other non-RES (MW)
IE AREA A	0	0	200	0	70	0	0
IE AREA B	0	100	200	0	0	0	0
IE AREA C	550	0	450	0	0	0	5
IE AREA D	750	0	0	0	90	0	0
IE AREA E	160	0	200	0	30	700	10
IE AREA F	0	0	0	0	0	0	5
IE AREA G	0	0	125	0	0	0	30
IE AREA H1	0	0	350	300	0	0	0
IE AREA H2	440	0	250	0	0	500	10
IE AREA I	1,100	0	400	0	0	700	2
IE AREA J	2,750	100	950	300	40	500	95
IE AREA K	0	0	100	0	0	0	2
IE TOTAL	**5,750**	**200**	**3,225**	**600**	**230**	**2,400**	**160**
NI AREA SE	1,600	250	625	0	3	1,200	75
NI AREA NW	450	0	0	0	4	0	55
NI TOTAL	**2,050**	**250**	**625**	**0**	**7**	**1,200**	**130**





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