Operational Policy Roadmap 2023-2030

December 2022

EIRGRID SONI

Background and Context

Introduction

Background

EirGrid and SONI are securely operating the All-Island system with world-leading variable renewables penetration, primarily from wind energy. In 2020, 43% of energy used on the island came from renewable resources. In 2022, the All-Island system can accommodate up to 75% of instantaneous generation from non-synchronous resources (mainly wind and HVDC interconnection).

However, while these achievements are leading the way worldwide, to meet evermore ambitious decarbonisation targets in the years ahead, the electricity system will need to accommodate greater amounts of renewable energy. This means that the operational constraints will need to be relaxed to facilitate another step change in accommodation of renewable energy resources.

Shaping our Electricity Future

The governments of Ireland and Northern Ireland, respectively, have recently introduced legislation relating to climate action. Energy and electricity usage will be core elements of the respective climate action legislation and implementation plans. In 2021 EirGrid and SONI delivered the Shaping Our Electricity Future roadmap – to allow EirGrid and SONI to enhance our capability in markets, networks, engagement and operations. One of the key commitments in the Shaping Our Electricity Future roadmap was to develop an Operational Policy Roadmap. This roadmap outlines the key actions in the operational policy space that will be required to deliver on the climate action targets while continuing to securely operate the electricity system.

The system will undergo radical transformation between now and 2030, including: the connection of at least two new HVDC interconnectors (to Great Britain and France), large offshore wind farms and solar generation, hydrogen energy production, demand response and energy storage innovations, coupling to European markets and anticipated market evolution, as well as significant growth in demand driven by electrification of society and large energy users. The roadmap will aim to plan a pathway for the evolution of operational policy to facilitate these radical transformations while maintaining and enhancing security of supply, reliability and resiliency for customers on the island of Ireland.

This operational policy roadmap sets out our plan to 2030 to accommodate continued growth in variable, non-synchronous renewable generation. It outlines the context, drivers, timelines, milestones, actions, and stakeholder impacts that are needed in each operational policy area to achieve the ambition of the governments' decarbonisation targets for the electricity sector.

Operational Policy Roadmap Drivers

Operational Policy Roadmap Drivers – Key Points

Demand Growth

Total All-Island energy use is expected to grow from 42.5 TWh in 2022 to 56.5 TWh in 2031

All-Island peak demand forecast to grow from 7.45 GW in 2022 to 8.89 GW in 2031

Network Evolution

At least 2 new HVDC interconnectors*

New offshore network development

Increase in smart network devices

Second North-South Interconnector

Generation Capacity Growth

Total All-Island on-shore wind, off-shore wind and solar generation capacity is expected to grow from c. 6 GW in 2022 to c. 18 GW in 2031

Government Targets

Targeted reduction in overall CO_2 emissions.

Achieving up to 80% of power from renewable sources by 2030, in both jurisdictions

Source: EirGrid and SONI Generation Capacity Statement 2022-2031 Link: https://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf

* Greenlink and Celtic HVDC are confirmed.

Innovative Solutions and New Technology – Key Points

Grid-Forming

Implement the concept in codes and standards by introducing definitions and requirements for Grid-Forming (GFM) inverter based resources. Improve confidence in the technology through simulations and live trials

Network Flexibility Technologies

Test and implement new network technology solutions to increase the utilisation of the existing network and accommodate new HVDC interconnectors and large offshore wind farms

Low Carbon Inertia Services

Part of the next phase of low carbon system services needed to reach our 2030 targets

Required to enable relaxation of operational constraints and to accommodate more wind and solar generation

Demand Flexibility

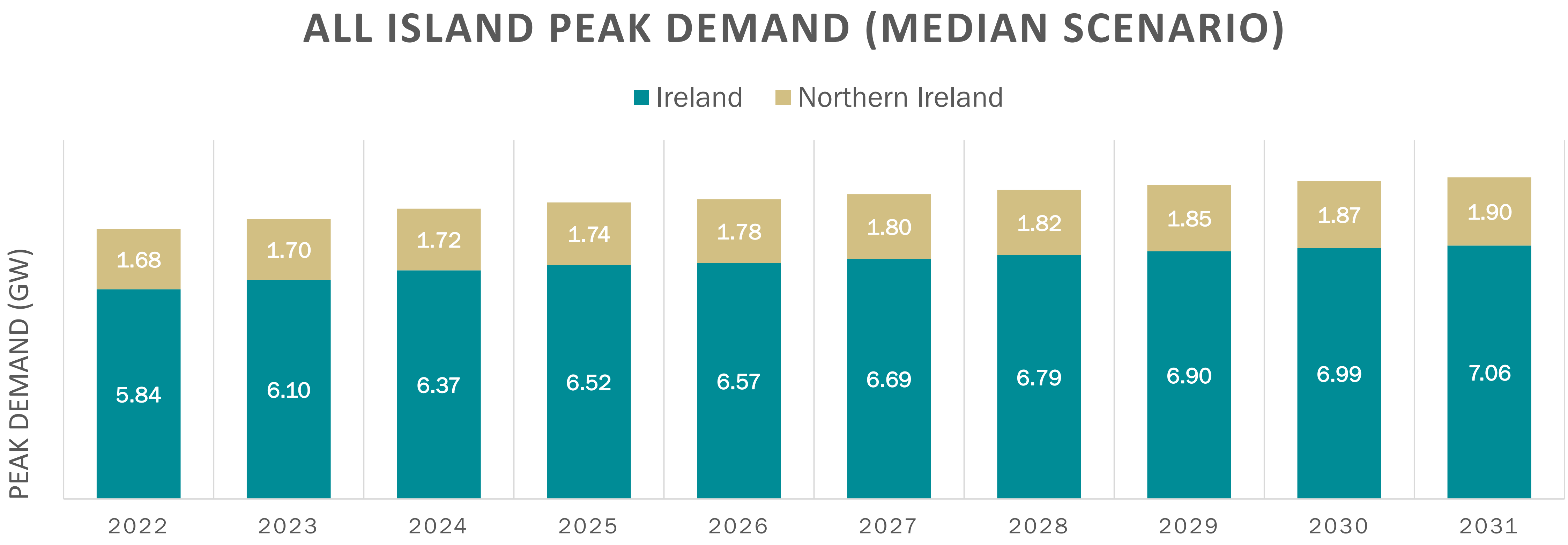
Incentivise demand customers to become more flexible and offer system services.

Demand response and demand aggregators expected to play an increased role

BESS

Expand the existing utilisation of battery energy storage systems (BESS) through enhanced TSO scheduling and dispatch capabilities and enhance the system services arrangements to allow for enhanced frequency management

Driver – Electricity Demand Growth



For the median demand forecast as set out in the Generation Capacity Statement 2022-2031, the All-Island peak power demand is projected to grow from 7.45 GW in 2022 to 8.89 GW in 2031.

There is expected to be an increase in large energy users, demand response, electrification in society, prosumer flexibility and demand aggregators.

Source: EirGrid and SONI Generation Capacity Statement 2022-2031 Link: https://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf

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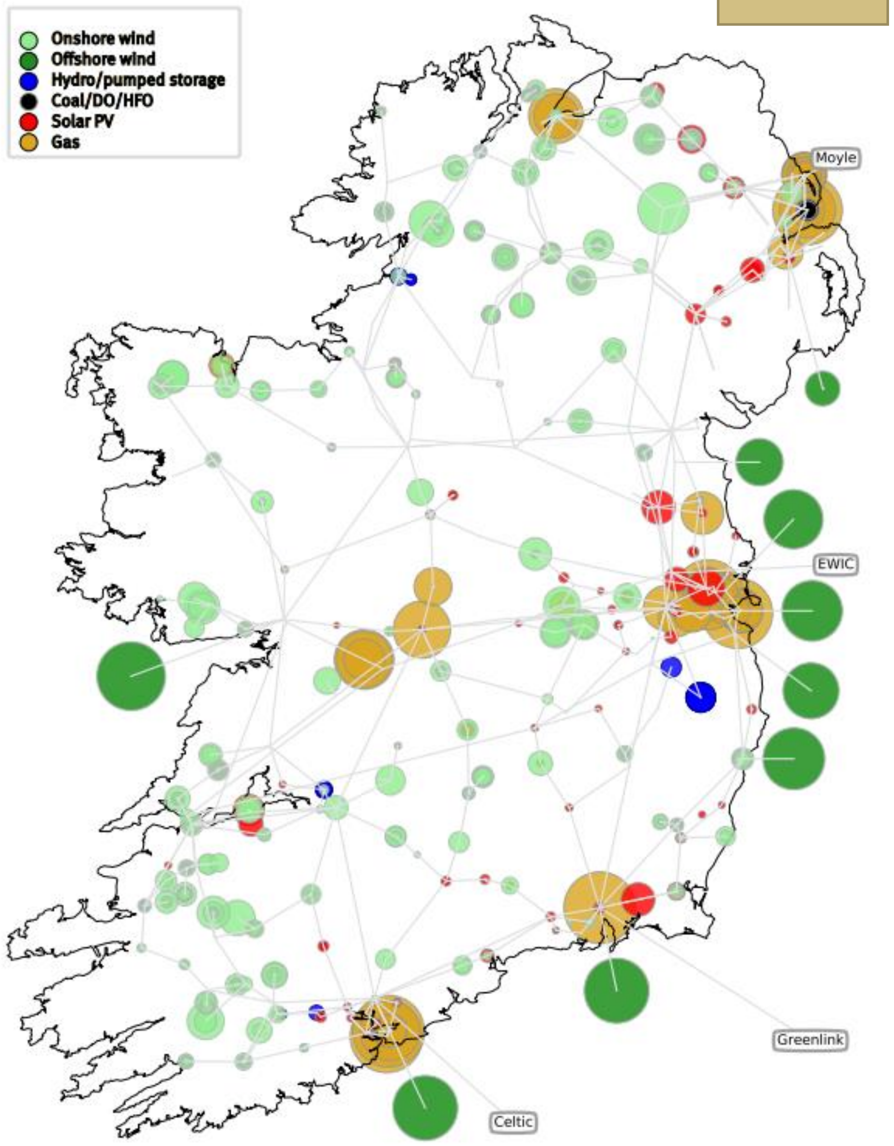
Driver – Electricity Network Expansion and Generation Growth

2030

By 2030 there is expected to be at least four HVDC links to the all-island system (Moyle, EWIC, Greenlink, Celtic). There is expected to be significant levels of offshore wind connected. New onshore wind, offshore wind and solar generation will drive the need for new transmission infrastructure and smart devices.

Shaping Our Electricity Future (November 2021)

The map shows the spatial distribution of generation by 2030. The assumed locations for future connections of renewables were informed by a range of information sources such as consultation feedback, grid connection applications, outcomes of auctions and projections of available grid capacity. These locations are subject to change; they will be updated as part of future revisions of Shaping Our Electricity Future to reflect the best available information.



Source: Shaping our Electricity Future Link: https://www.eirgridgroup.com/site-files/library/EirGrid/Shaping_Our_Electricity_Future_Roadmap.pdf

Operational Policy Framework

Operational Policy Framework

The EirGrid and SONI operational policies sit within an overarching framework, governed by relevant European and National Legislation and Network Codes, and guided by published codes and standards. Operational Policy is driven by the need to operate the transmission network securely and reliably, within asset and connected entities' limits. This must be achieved while managing the market in a transparent manner as per the Trading and Settlement Code. The synchronous area and load frequency control operational block operating agreements between EirGrid TSO and SONI TSO govern how both entities interact. All Operational Policies are linked to processes and procedures, detailing how the policies are implemented and maintained in practice in real-time operations and when planning the system.

European Union Legislation, Directives and Regulations (EU Network Codes)

National Legislation - Electricity Act (IE) and Electricity Order (NI)

National License Obligations

Synchronous Area Operational Agreement | Operating Security Standards | Grid Codes | Load Frequency Control Block Operational Agreement | Trading and Settlement Code

Dynamic Stability | Operational Security | Reserves and Ramping

Processes and Procedures

Operational Policy Framework – Definitions and Requirements

Policy Area	Operational Policy & Constraints	Definition	2022 Status
Dynamic Stability	**Inertia**	The minimum level of kinetic energy stored in rotating plant operating on the system. Inertia comes from synchronous generation, motor load and synchronous condensers.	23 GWs
	Rate of Change of Frequency	How fast the frequency moves when subjected to an event that results in a mismatch between generation and demand.	1 Hz/s (under operational trial)
	System Strength	Definition of the relative strength of the system in terms of short circuit strength, stability, retained voltage and others.	N/A
	Minimum Number of Conventional Units	Constraint on the system that specifies a minimum number of conventional thermal units required to be synchronised in Ireland and Northern Ireland.	8 (3 NI /5 IE)
	System Non-Synchronous Penetration	A measure of the non-synchronous generation on the system at an instant in time. It is the ratio of the real-time MW contribution from non-synchronous generation and net HVDC imports to demand and net HVDC exports.	75 %
Reserves and Ramping	**Fast Frequency Response**	Response by resources and service providers in the 2 to 10 second range.	TBD
	Regulating Reserve	Response by dynamic or spinning resources, usually conventional generation.	Minimum 75 IE / 50 NI MW
	Primary Operating Reserve	Response by resources and service providers in the 5 to 15 second range.	75% LSI
	Secondary Operating Reserve	Response by resources and service providers in the 15 to 90 second range.	75% LSI
	Tertiary Operating Reserve 1&2	Response by resources and service providers in the 90 second to 20-minute range in two tranches.	100% LSI
	Replacement Reserve	Response by resource and service providers in the 20 minute to 4-hour range.	100% LSI
	Ramping Margin	The level of dispatchable generation/demand available to mitigate very fast ramps and demand and RES forecast errors. There are 1, 3 & 8 hour ramping services.	Explicitly Scheduled
	Interconnector Ramping Rate	The rate of change of HVDC interconnector active power flow. This is an All-Island measure which includes the ramp rates for Moyle in NI and EWIC in IE.	10 MW/min across All-Island
Operational Security	**Voltage Management**	The ability to securely operate the system by controlling the voltage, within a specified range, pre and post contingency.	Operating Security Standards
	Thermal Security Management	The ability to securely operate the system by controlling the pre and post contingency thermal loading within the ratings of the transmission system plant.	Operating Security Standards
	Short Circuit Management	Assessment of equipment duty performed to ensure all plant is within its making, breaking and withstand ratings for the prospective short circuit current calculated.	Operating Security Standards

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Operational Policy Change Process

EirGrid and SONI's joint **Operational Policy Review Committee (OPRC)** governs the process of operational policy changes. The OPRC comprises members with extensive experience and expert knowledge of system operations. The members consider the proposed changes, review all related materials/reports, and approve or reject the proposed changes following an operational trial period and assessment of same.

Operational policy in EirGrid and SONI is monitored, reviewed, and updated according to a five stage continuous cycle process.

If the trial period of operation passes without adverse impacts, subject matter experts will study the results of the trial parameters and criteria.

An in-depth examination of the trial period is carried out and reported on to the OPRC. The conditions and events during the trial are examined to determine if any trial related issues arose. The OPRC reviews the outcome and report and decides whether to either:

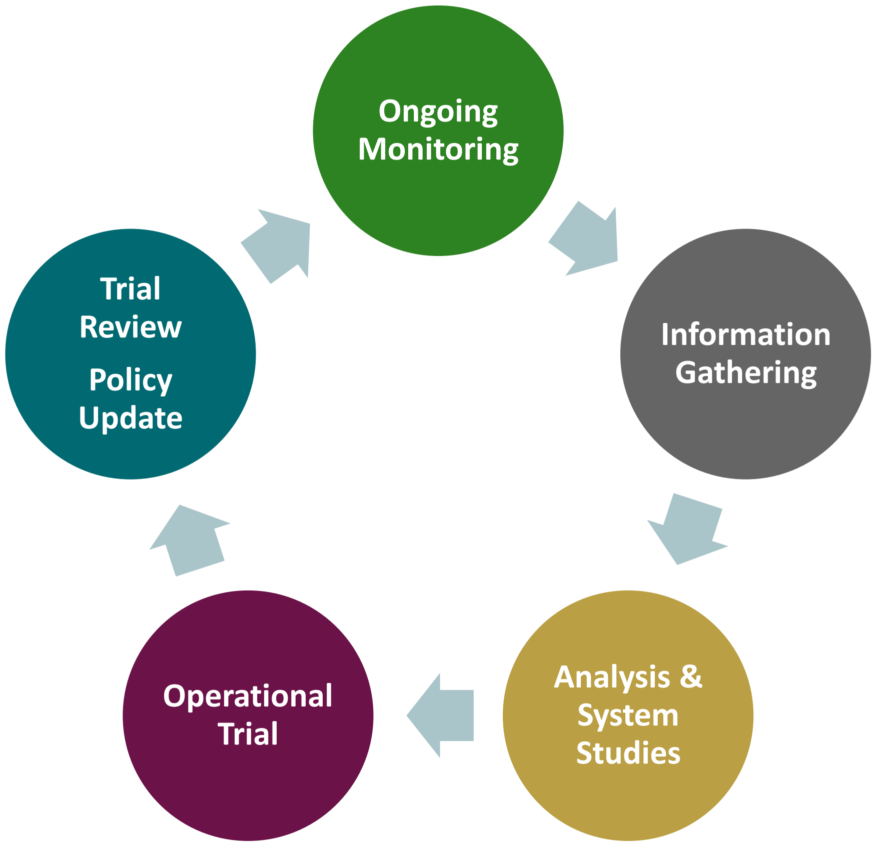
1. Cease the trial noting adverse impacts.

2. Continue the trial if there is insufficient evidence. Gather more relevant data points and information to support decisions.

3. Approve the proposed operational policy change as the enduring operational policy.

If the OPRC grant approval, an operational policy trial is commenced with strict operational criteria and parameters to be monitored, including hours of operation.

The trial may be suspended at any time by operations staff if adverse impacts arise during the trial.



In the Ongoing Monitoring phase, EirGrid and SONI monitor the system parameters and analyse events and disturbances to assess system performance and generator compliance relative to operational policy parameters and metrics.

During the Information Gathering stage the current status of the policy and parameters are assessed and consultation is held with operations specialists on the drivers, requirements and need for changes.

At the Analysis/System Studies stage subject matter experts and operations policy specialists study the system under an extensive and detailed range of conditions. They study the impact of the proposed policy change and make recommendations on the conditions of the operational trial.

The OPRC approve or reject the proposed trial, based on the studies and in-depth discussions.

System Level Overarching Dependencies and Risks

The Operational Policy Roadmap is an ambitious vision for how policy should evolve through the decade to support the decarbonisation targets. The system is currently challenged by resource adequacy issues causing security of supply concerns on the island. The medium- and long-term milestones and targets are tentative and will be dependent on an extensive series of studies, a review and monitoring process, and funding, development and timely deployment of alternative innovative solutions which will determine the future operational policy and constraints.

Security of Supply

Operational trials will be dependent on system and operational conditions.

Operational Capability

Operational capability must be uplifted to align with the new challenges and requirements introduced by the increased complexity of system operations. For example, enhanced operational forecasting, observability, monitoring and control capabilities will be required.

Operational Studies

Analysis will be the key factor to determining the precise constraint values and policy direction. The capability to perform advanced analysis (e.g. EMT simulations for IBR dominated networks) must be further developed and increased automation will be necessary to carry out relevant analyses more frequently to inform the system constraints.
To ensure high accuracy of the simulation studies, an important aspect is the capability to adequately model the performance of new and emergent technologies. Codes and standards must be updated to reflect the requirement for provision of representative models.

Network and System Services Development

Timely delivery and commissioning of system services providers, new flexible generation, the 2nd North-South Interconnector and other transmission reinforcements are required to assist with future challenges and meet the decarbonisation targets.

Operational Policy Roadmap

Dynamic Stability

Dynamic Stability
Key Objectives for 2030

Between 2023 and 2030, EirGrid and SONI will continue to operate the system securely while also aiming to:

1. Maintain the system-wide RoCoF limit at 1 Hz/s.
2. Transition to a model of regional inertia for Ireland and Northern Ireland to replace the All-Island inertia floor. This will be revaluated after connection of the second North South Interconnector.
3. Introduce a new *System Strength* policy for planning and operations in EirGrid and SONI.
4. Relax and eventually remove SNSP as a constraint but maintain it as a key operational reporting metric. Our aim is to achieve the ability to operate up to 95% SNSP by 2030.
5. Relax and eventually remove the minimum conventional unit constraint while ensuring any local constraints are satisfied and linked to specific system scarcities. The aim is to achieve secure system operation with three or less conventional units by 2030.

Dynamic Stability – Definitions

Dynamic Stability can be broadly categorised and defined in the following way

Dynamic Stability

Stability type	Definition
Frequency Stability	Maintain and restore equilibrium between the demand and supply after being subjected to a mismatch
Transient and Small-Signal Stability	Maintain synchronism when subjected to large severe and small disturbances
Voltage Stability	Maintain steady voltage levels at all busbars in the system after being subjected to a disturbance
Converter-driven Stability	Avoid undamped oscillations due to interactions between IBR units and between IBR and other power system components
Resonance Stability	Avoid unwanted interaction between IBR controls and resonances present in the network

Dynamic Stability – Metrics

The inertia of a power system refers to the ability of the system to oppose changes in system frequency due to the resistance imposed by the large rotating masses of the synchronous machines. The inertial energy has an important role in the frequency control process. The natural resistance of the synchronous machines to a change in speed assists with keeping the power system frequency close to its nominal frequency of 50 Hz.

$$H = \frac{1}{2}\frac{J\omega_o{}^2}{S_n}$$

The System Non-Synchronous Penetration (SNSP) and the Minimum Number of Conventional Units On (MUON) are system constraints introduced to ensure enough synchronous machine traits are maintained to a level that guarantees secure and safe system operation.
The SNSP metric was introduced following analysis performed as part of Facilitation of Renewables (FoR) studies in 2010.

$$SNSP\ [\%] = \frac{non\!-\!synchronous\ generation + net\ imports}{demand + net\ exports}\, x\ 100$$

The Rate of Change of Frequency (RoCoF) is a measure of how fast the frequency moves when the system is subjected to an event that results in a mismatch between generation and demand. RoCoF is inversely proportional to the system inertia; the lower the inertia, the higher the RoCoF.

$$RoCoF\,(Hz\ per\ second) = \frac{f * Power\ Loss}{2(H_{total} - H_{power\ loss})}$$

Note: this calculation method does not consider the effect of fast frequency response from IBR or the inherent response from frequency and voltage dependent load.

The Minimum Conventional Units Online (MUON) constraint was introduced to ensure enough large synchronous units are operating to preserve the voltage control capability and maintain a minimum level of system inertia.

Currently, the constraint is set to 8 large conventional generation units (from a selected list of generators considered large). A minimum of 5 units in Ireland and 3 in Northern Ireland are required to satisfy this constraint.

The Need for Dynamic Stability Operational Policy Changes

Need to Disaggregate Global Constraints

- Global constraints (SNSP, MUON) have served a valuable purpose for system stability and RES integration, but a new approach is needed for the transition to 2030.
- Need to target policies at system issues and link market constraints more explicitly to physical system scarcities in specific areas.

Incorporate Synchronous Condensers, Grid-Forming and other Emergent Technologies

- Synchronous condensers are an alternative solution to assist with inertia, reactive power range, fast voltage control, fault current infeed and power quality support. Performance requirements must be incorporated into codes and standards and policy updated with operational guidelines.
- Introduce definitions and requirements to specify IBR Grid-Forming performance.
- Create the framework for other innovative solutions and emergent technologies to be deployed.

Weak Grid Operation
Enhanced System Monitoring

- Requirement for enhanced dynamic stability monitoring, particularly in weakly interconnected areas of the network.
- New policies are required to assess network stability that account for very high IBR integration and lack of conventional generation.
- New metrics for system strength are required.

The Need for Operational Policy Changes

SNSP emerged as a metric from the 2010 Facilitation of Renewables report. Intended to act as a temporary operational limit until further analysis was performed to better understand the risks and implement mitigation solutions.

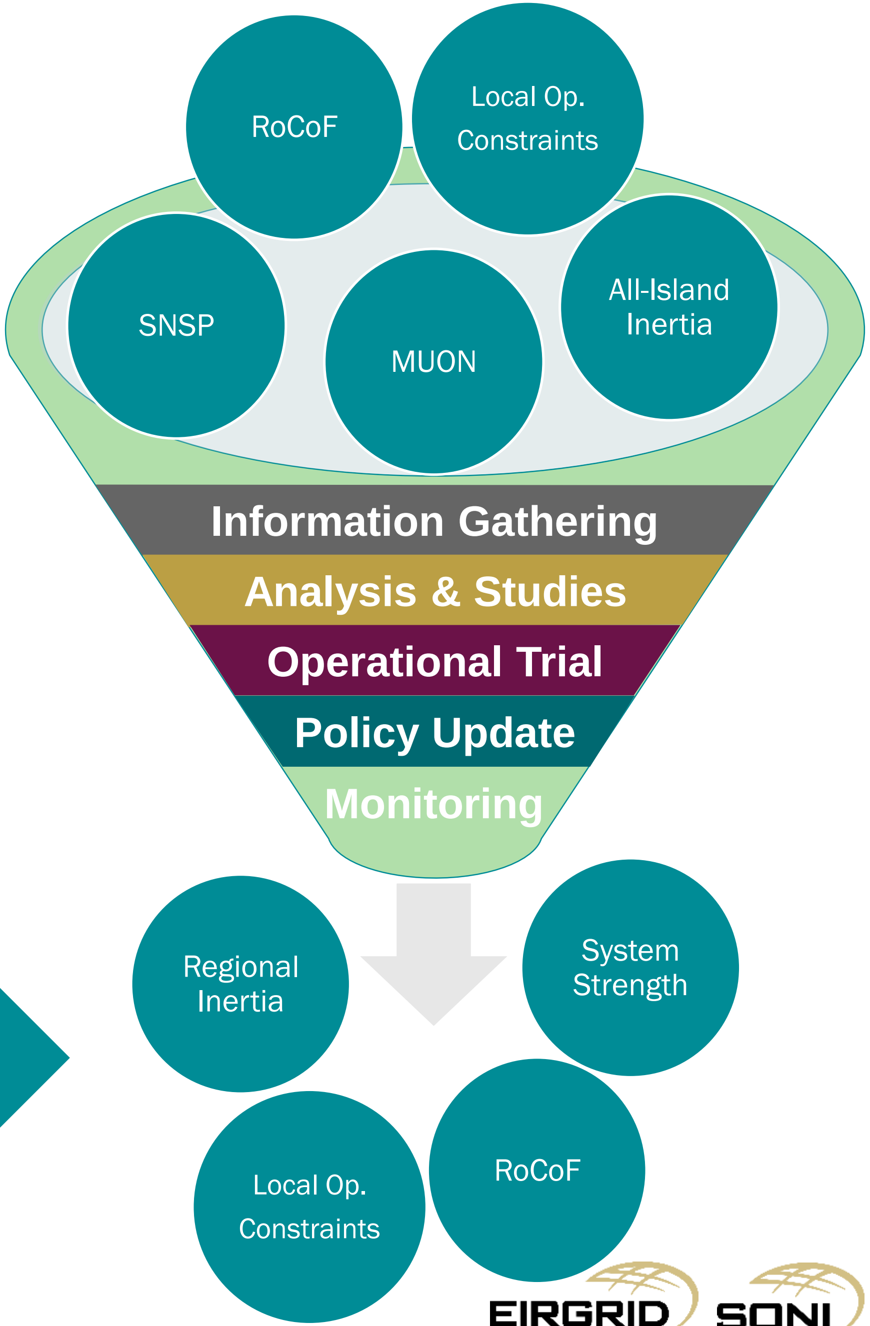
2022 – SNSP, All-Island Inertia and **MUON** are global constraints and metrics. Introduced to ensure enough **synchronous generator traits are maintained** to a level that guarantees secure and safe system operation.

Operating the low carbon power system of the future will require us to transition from global constraints that limit non-synchronous resource output to more targeted constraints.

EirGrid and SONI will study the system with a view to refining and developing new operational policies to operate the system securely for the new operational paradigms.

2025 – EirGrid and SONI aim to develop operational constraints to target local, regional and system constraints and scarcities.

This will involve development of a new system strength policy, a new regional inertia framework and the relaxation, and eventual removal of the SNSP and MUON constraints, while maintaining them as reportable operational metrics.



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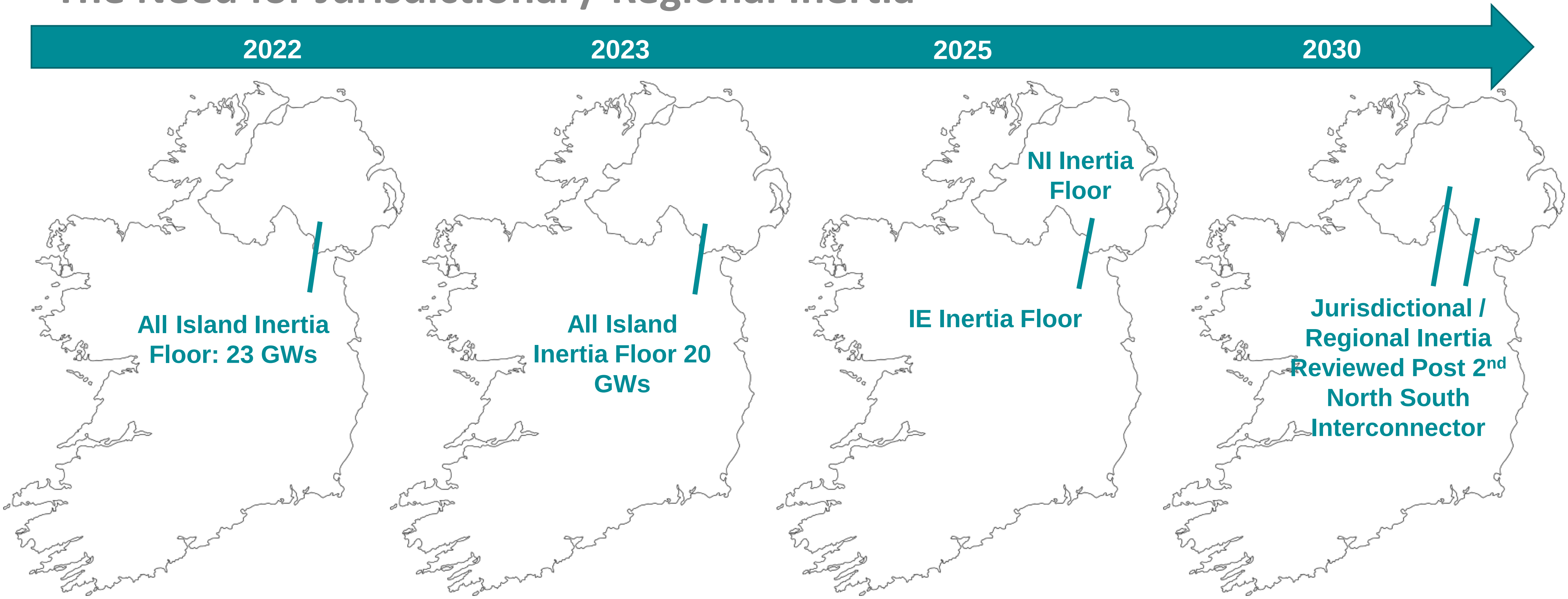
The Need for Jurisdictional / Regional Inertia



In 2022 there is an inertia floor of 23 GWs that must always be maintained on the island for dynamic stability. There is also a requirement for a minimum number of large conventional units in both jurisdictions, to mitigate the risk of the loss of the North-South Tie-line. Moving to a model of jurisdictional inertia floors by 2025 should replace the requirement for jurisdictional minimum conventional units constraints while ensuring dynamic stability and operational security for the loss of the tie-line. This approach will be re-assessed post connection of the second North-South Tie-line; review to be informed by experience of operating the system with low inertia floor levels.

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The Need for a New Approach and Policy
System Strength – New Dynamic Stability Metric

System Strength Today

The relative strength of the network is being tested in many areas.

System strength is monitored, and risk assessed in different ways using different tools in system operations

- The dynamic stability assessment tool monitors transient voltage and frequency stability in real time with look ahead capability.
- Short circuit level is monitored in the EMS.
- Small signal stability and frequency oscillations are also monitored in the EirGrid and SONI Wide Area Monitoring System (WAMS) using Phasor Measurement Units (PMUs).

Drivers for a New Approach to System Strength

- Decommissioning of synchronous generators
- Maintain stable operation of IBR during high SNSP scenarios
- Manage unwanted interactions between HVDC interconnectors and large offshore wind farms connecting in close proximity
- Regional voltage management and dynamic stability concerns during high SNSP scenarios
- Small-signal stability challenges
- Power quality considerations
- Network protection adequacy

A need for a streamlined, holistic approach to assessing system strength on the network in the planning and operations timeframes has been identified. The system strength policy should define key parameters and methodologies.

The policy should enhance the capability to assess system strength at the planning stage and in real-time operations in EirGrid and SONI.

Operational constraints can be targeted at system strength scarcities providing signals for investment in infrastructure, new generation resources and system services.

Milestones to 2030 – Dynamic Stability

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)

Key: Information gathering | Analysis System Studies | Operational trial | Trial Review Policy Update | Ongoing monitoring

Notes

1. The ~ symbolises that the exact figure will be determined as part of extensive studies. The numbers quoted are our targets as viewed at the end of 2022.
2. For inertia, post the connection of the second North-South Interconnector, a determination will be made to maintain a regional inertia model, or revert to the all-island model.
3. RoCoF requirements may change for new generators connecting before 2030, which must comply with the EU network codes: Requirements for Generators (RfG)
4. Proposed new System Strength policy to define requirements and limits to ensure safe and secure system operation with high penetration of IBR.
5. The intention with SNSP and MUON is to relax the application of the constraints before removing them but to maintain monitoring of both through 2030.

Operational Policy – Near-Term Actions 2022-2023

Dynamic Stability

- **Inertia**
  - 2023: Complete studies and begin operational trial in early 2023. Based on the outcome of the operational trial, review and decide if an update to the operational policy is required by end of 2023, to potentially move to 20 GWs All-Island inertia.
- **Rate of Change of Frequency**
  - 2023: Complete operational trial of RoCoF at 1 Hz/s. Review the operational policy and update. Monitor operations events as they occur, including generator unit compliance with RoCoF limits.
- **System Non-Synchronous Penetration**
  - 2022-2023: No anticipated increase to SNSP to end of 2023. Ongoing monitoring of system parameters and detailed analysis of events and disturbances and market outcomes.
- **Minimum Number of Conventional Units**
  - 2023: Complete studies and begin operational trial in early 2023. Based on the outcome of the operational trial, review and decide if an update to the operational policy is required by end of 2023, to potentially move to a minimum of 7 conventional units All-Island.
- **System Strength**
  - 2023: Begin information gathering on system strength policy formulation

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Operational Policy – Long-Term Actions 2024-2030

Dynamic Stability

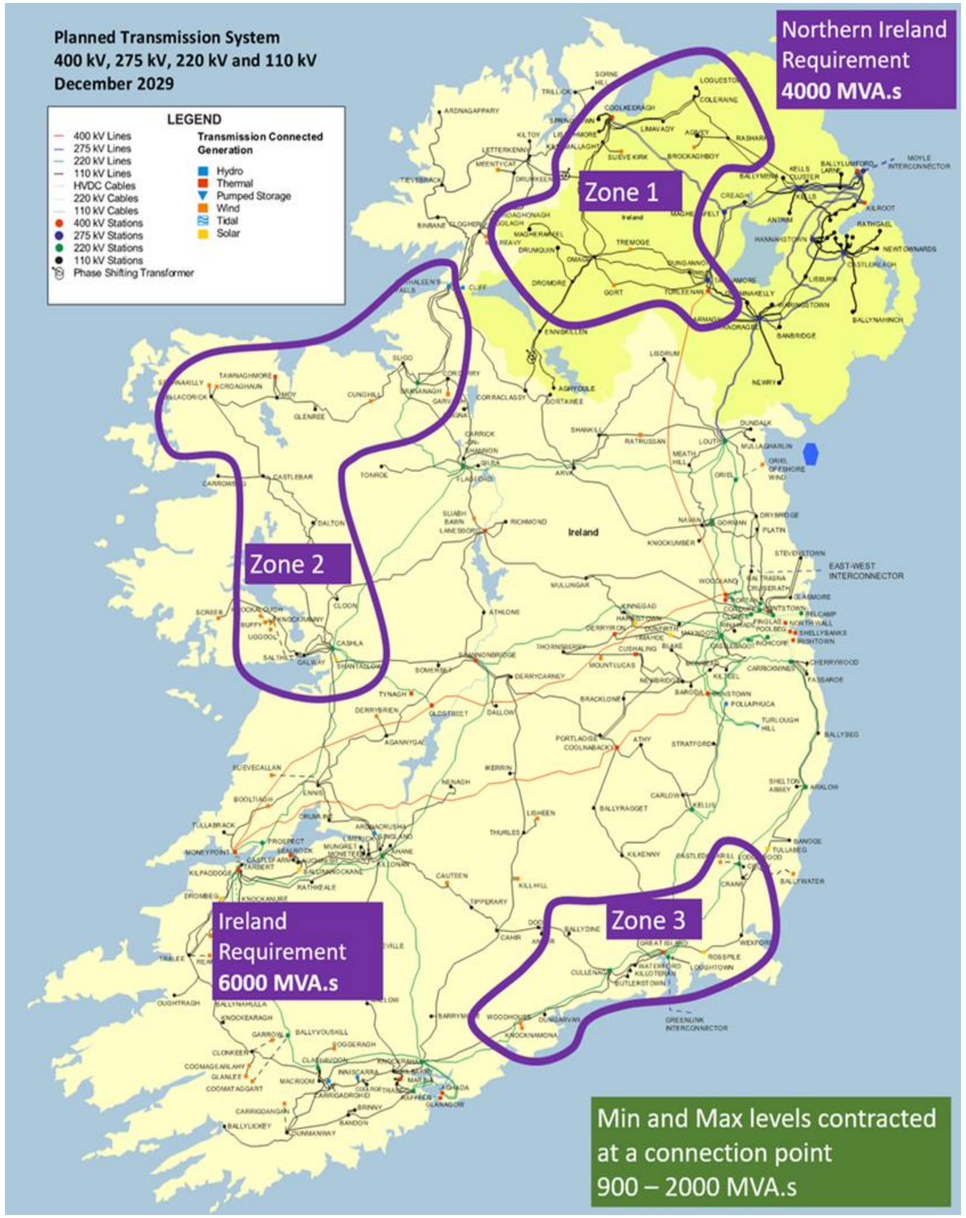
- **Inertia**
  - 2025: Implement regional inertia
  - 2026: Review the regional approach after the commissioning of the 2nd North South Interconnector
- **Rate of Change of Frequency**
  - 2024 – 2030: Continue active monitoring of network, generation and large energy users' performance during system events
- **System Strength**
  - 2025: Introduce new policy on System Strength
  - 2025 – 2030: Monitor the system strength policy and assess network parameters to inform the requirement for implementing potential modifications later in the decade.
- **System Non-Synchronous Penetration**
  - 2024: Begin 80% SNSP trial
  - 2025: Perform analysis to investigate impact of removing SNSP constraint
  - 2026: Phase out SNSP as an active market/system constraint and continue to use as progress monitoring metric
- **Minimum Number of Conventional Units**
  - 2024 – 2030: Monitor system operation with multiple Low Carbon Inertia Providers and other new/enhanced system services providers, and perform analysis to determine further relaxation and removal of this system constraint

Low Carbon Inertia Services (LCIS) – 2022-2030

The outcome of extensive simulation studies outlined the requirement for a system service comprising the provision of synchronous inertia, reactive power support and short-circuit contribution to alleviate future system operation challenges.

LCIS will contribute to a reduction in the minimum number of conventional units required to be running, increased renewables integration, reduction in production costs, reduction in carbon emissions and enhanced security of supply.

- Part of the next phase of low carbon system services needed to reach our 2030 targets
- For Phase 1, we recommend a procurement process to deliver 10,000 MVA.s of inertia (6,000MVA.s in IE and 4,000 MVA.s in NI, total of 5 to 11 large devices) to meet our 2026 requirements (outcome of comprehensive suite of studies)
- EU-SysFlex study set out clear and significant benefits from innovative provision of system services
- The delivery of Low Carbon Inertia Services is dependent on regulatory approval of contractual, procurement and funding arrangements.



Further Reading: https://www.eirgridgroup.com/site-files/library/EirGrid/LCIS-Information-Session-Requirements-and-Procurement-approach.pdf

EU-SysFlex: https://eu-sysflex.com/wp-content/uploads/2020/05/Task_2.5-Deliverable-Report_for_Submission.pdf

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Grid-Forming Implementation Strategy – 2024-2030

Grid-Forming

No well-established industry definition for the Grid-Forming (GFM) concept. Defined through the traits required from IBR operating in GFM mode:

- To act as a voltage source behind a series impedance, regulate the power by controlling directly the voltage at its terminals and provide a reference voltage for other nearby IBR operating in grid following mode
- To have the capability to self-synchronise to the grid e.g., by emulating the power synchronisation principle of a synchronous machine
- Variations in voltage, frequency or angle at the IBR terminals cause immediate and autonomous change in the power flowing from the IBR

We will develop a Grid-Forming Implementation Strategy which we expect will cover the following:

- Test the capability with:
  - Offline studies (phasor and EMT) with vendor models
  - Online analysis in real time digital simulator environment with protection and control replicas
  - Live demonstration trials with GFM algorithms on existing IBR
- Introduce framework to incentivise developers/plant owners to deploy GFM capability on their plant
- Update Grid Codes with GFM definitions and performance requirements
  - Consult with representatives from plant owners and OEMs to determine what the current technology can provide
  - Define compliance testing regime to prove capability
- Where appropriate, update performance requirements for system services (inertia, system strength, restoration etc.) to encourage participation of innovative solutions like IBR using GFM algorithms
  - Enhanced level of testing to gain confidence

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Stakeholder Impacts for Dynamic Stability

- **Renewable Generators**
  - During the operational trials, renewable (e.g., wind/solar) generation is likely to be less curtailed during periods of high wind/solar and/or low demand.
- **Conventional Generators**
  - Some conventional generator units may be run less frequently during periods of high renewable generation and/or low demand during the operational trials, and if operational policies are changed
- **System Services Providers**
  - Low carbon inertia providers will be included as part of the regional inertia model.
  - The system strength policy will be informed by system service provider capability.
- **Large Energy Users**
  - Increased dynamic performance monitoring
  - As required, define new standards and requirements to ensure that system security is maintained (fault ride through performance)
- **Distribution System Operators (DSOs)**
  - Impact will be considered under the respective TSO-DSO (SONI-NIEN and EirGrid-ESBN) joint programmes of work.

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Operational Policy Roadmap

Reserves and Ramping

Reserves and Ramping
Key Policy Objectives for 2030

Between 2023 and 2030, EirGrid and SONI will continue to operate the system securely while also aiming to:

1. Consolidate on all reserve definitions and volumes, including upward and downward reserve, fast frequency response and regulating reserves.
2. Align with European network code requirements for reserves with 100% containment coverage for reference incidents.
3. Schedule and dispatch non-conventional resources such as IBR and BESS for reserve provision across all tranches.
4. Deploy new reserve auction framework and couple to European markets for reserve, post connection of the Celtic Interconnector.
5. Develop a ramping margin policy and publish ramping requirements.
6. Increase the All-Island interconnector ramping rates in stages in line with new HVDC interconnections and offshore wind.

Reserves and Ramping Definitions

Reserves

Frequency control is the real-time continuous act of balancing the generation and demand. It is the most important process performed by the control room operators. To ensure the operational and statutory frequency limits are met, in a cost-efficient manner, frequency response and reserves are essential to cope with the inherent variability of demand, generation and changes in HVDC interconnector power transfers, and especially for the loss of large infeeds or outfeeds. Depending on the nature of an imbalance, the frequency actions could be automatic or 'manually' initiated by the operators.

Frequency reserves are critical for the frequency control process across all system states (normal, alert, emergency and restoration) and every effort must be made to maintain adequate levels of reserves and ensure these are replenished as soon as possible. The existing definitions of the frequency reserve categories are aligned with the ENSTO-E SOGL terminology: Frequency Containment Reserves (FCR) include Primary Operating Reserve (POR) and Secondary Operating Reserve (SOR) as defined in the EirGrid and SONI Grid Codes. Frequency Restoration Reserves (FRR) include Tertiary Operating Reserve 1 (TOR1) and Tertiary Operating Reserve 2 (TOR2) as defined in the EirGrid and SONI Grid Codes. Replacement Reserves (RR) are as defined in the EirGrid and SONI Grid Codes.

Ramping

Ramping is the term used for the rate of change of active power per unit time.

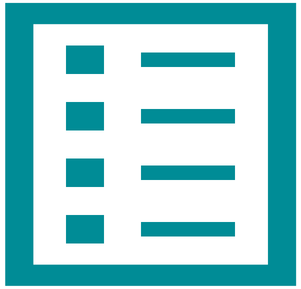
The Ramping Margin is the minimum level of ramping capability available from online or offline generation and demand units. Ramping Margin was introduced as part of the DS3 Programme to enable safe and secure system operation with higher penetration of renewable generation, aiming to assist with the challenges introduced by the inherent wind and solar forecast errors by providing a certain level of dispatchable generation across different timescales.

Apart from dealing with forecasting errors, the Ramping Margin products can help during times when the output of wind farms is deliberately reduced in anticipation of wind turbine cut-outs or high-speed shutdowns to defensively limit the impact on the system.

Interconnector ramping refers to the change in transfers on the HVDC interconnectors. The fast change of active power output across the interconnectors imposes system operation difficulties, if not enough fast acting plant is available to support these exchanges of power with neighbouring systems. Interconnector ramping can be split into normal operation, when moving from the current operating reference point to the next as part of a planned schedule, and emergency operation, when the output is changing in response to a system event in order to assist with balancing needs..

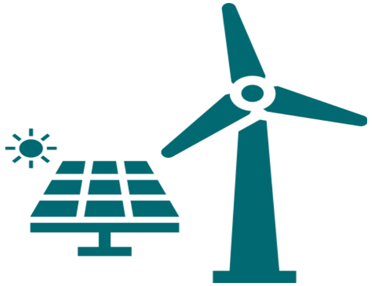
Need for Reserves and Ramping Operational Policy Changes

Definition Consistency and European Alignment



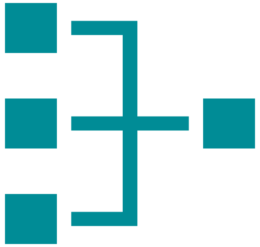
- Ensure alignment with European network code for system operation by having upward and downward reserve volumes and reference incident covered (% of LSI/LSO)
- New reserve products may be required and a new day-ahead auction framework for reserves is expected to be introduced from 2025, with European reserve market coupling post Celtic HVDC.

RES Proliferation



- Reduction in conventional units on the system reinforces the need to use non-conventional resources for frequency reserves, given their demonstrated capability to provide frequency response.
- Utilise BESS, HVDC interconnectors, DSU, renewables etc. for FFR and other reserve services as required.

New HVDC and Offshore Wind



- Two confirmed HVDC interconnectors to Britain and France by 2030 and two potential further connections. Six new offshore windfarm clusters on the east coast.
- Require rapid ramp rates across all interconnectors to meet market schedules.
- Need to increase ramping rates on all interconnectors on the island

Provision of Frequency Reserves

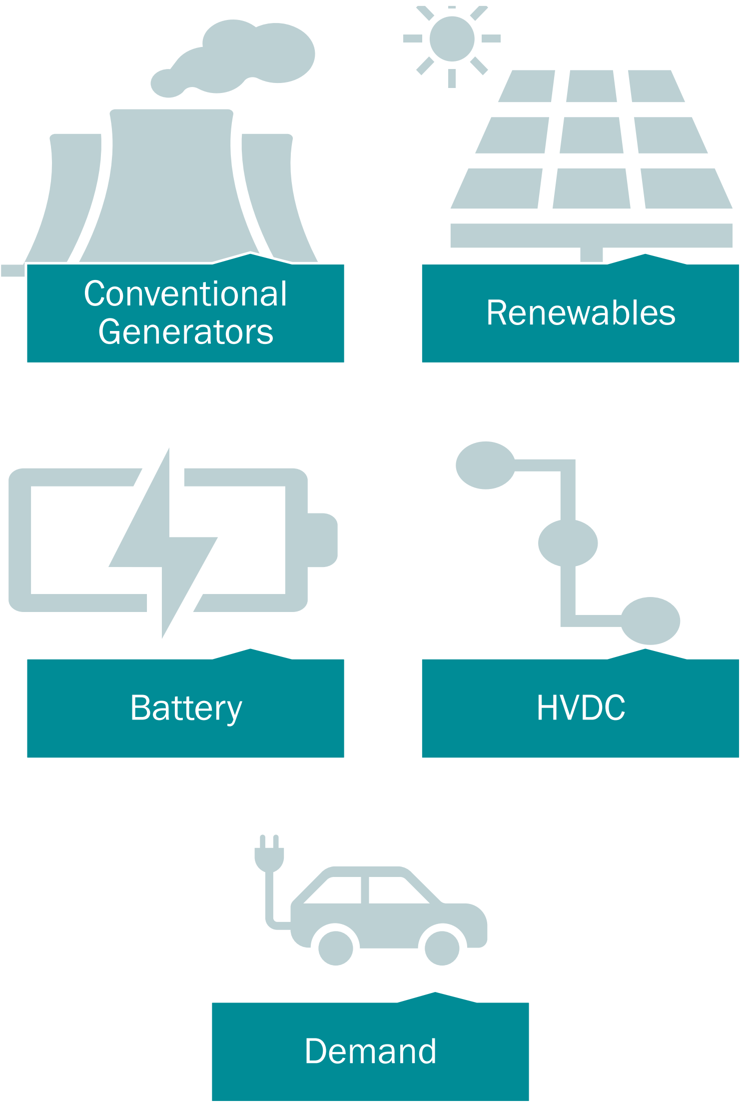
Traditionally, reserve in all tranches was provided primarily by conventional generation sources such as gas, coal and pumped-hydro. In the coming decade, as conventional generation is replaced by IBR, BESS and HVDC interconnectors, the sources of reserve will have to diversify.

HVDC interconnectors, batteries and DSUs today provide fast frequency response, arresting the frequency deviation in the seconds after a disturbance.

Although non-synchronous resources are not yet providing inertia, non-synchronous resources provide downward and, when curtailed, upward frequency regulation.

Demand response reduction services have always been a part of reserve strategies, but today with the proliferation of DSUs, it can provide reserves in all tranches. EirGrid are developing a platform for reserve auctions as part of the future arrangements for system services, open to all generation and system service providers. This is expected to go live from c. 2025 (exact timeline is dependent on the outcome of the Future Arrangements for System Services detailed design and implementation process).

In advance of this, it is expected that studies and operational trials will be carried out on the full range of technologies that can provide reserve, in line with a new reserve policy document for EirGrid and SONI.



Milestones to 2030 – Reserves and Ramping

Key Changes

- Scheduling dispatch process outcome
- Greenlink HVDC
- Reserve Auction Platform
- North South Interconnector
- Celtic HVDC
- ACER Probabilistic Ops Methodology
- Offshore Wind
- Potential Further Interconnection

Policy	EU NC	IE/NI		22H2	23H1	23H2	24H1	24H2	25H1	25H2	26H1	26H2	27H1	27H2	28H1	28H2	29H1	29H2	2030
Reserves	FCR	FFR		TBD	Update Reserve Policy including Upward & Downward Reserve Undertake System Services Product Review and Develop System Services Volume Forecast Methodology		Study enhanced use of non-conventional generation and demand resources for reserve provision	Trial enhanced use of non-conventional generation and demand resources for reserve provision	TBD	TBD			Post Celtic European Market Coupling	New All-Island Reserve Policy					TBD
		POR SOR	Reg.	Min NI: 50 MW, IE:75 MW					Reserve Policy Update										TBD
			Op.	75% LSI					~100%	~100%									~100%
				75% LSI					~100%	~100%									~100%
	FRR	TOR1		100% LSI															~100%
		TOR2		100% LSI															~100%
	RR	RR		100% LSI															~100%
Ramping Margin				Monitoring at 80% Forecast Confidence		Ramping Margin Policy & Requirements Update							Updated Policy with Celtic Ramping Requirements						Based on Operational Scenarios
Interconnector Ramping Rate				10 MW / Min All-Island				Greenlink Revision ~ 15 MW / min				Celtic Revision				Large OSWFs & new HVDC			~ 40 MW per min All Island

Key: Information gathering | Analysis System Studies | Operational trial | Trial Review Policy Update | Ongoing monitoring

Notes

1. The ~ symbolizes that the exact figure will be determined as part of extensive studies. The numbers quoted are based on best available information in 2022.
2. POR and SOR are split between operating and regulating reserves. In 2022 POR and SOR reserves are managed as single tranches, with a minimum regulating reserve from dynamic resources.
3. The volume of FFR to be carried into the future is under consideration and being studied in 2022/2023. Future volumes will be determined through studies.
4. The intention is to align upward and downward reserve policy by end of 2023 and through the decade the percentage of LSI/LSO can be updated according to studies and experience.
5. The ramping margin is determined by 80% confidence in the wind forecast. This will be reviewed as part of ongoing studies and may be updated post-connection of the Celtic Interconnector.
6. The intention is to increase the interconnector ramping rates on the island as new interconnectors are commissioned, but this will be dependent on the generation fleet and exact requirements will be determined through studies and trials.
7. The scheduling and dispatch process outcome and reserve auction platform dates are indicative, as of 2022.

Operational Policy Actions Timeline – 2022-2023

Reserves and Ramping

- **Reserves**
  - 2022: Commence information gathering to consolidate reserve policies and information.
  - 2022: Commence information gathering and studies/analysis on impact of reducing downward reserve limits on conventional units in NI.
  - 2023: Information gathering process for FFR policy development.
  - 2023: Trial on battery frequency response modes of operation with possible reserve policy review.
  - 2023: Trial with reduced requirement for downward reserve on conventional units in Northern Ireland

- **Ramping Margin**
  - 2023: Continue ongoing monitoring of the current ramping margin operational policy based on performance of ramping margin tool in real time operations.

- **Interconnector Ramping**
  - 2022: Commence early-stage information gathering and assessment of the interconnector ramping operational policy and the need to increase the ramping rate for the interconnection of Greenlink in 2024.

Operational Policy Actions Timeline – 2024-2030

Reserves and Ramping

- **Reserves**
  - 2024: Trial the enhanced provision of frequency reserves from alternative resources
  - 2025: Implement policy changes to enable enhanced provision of frequency reserves from alternative resources
- **Ramping Margin**
  - 2024 – 2030: Monitor the adequacy of the existing ramping margin policy against improved accuracy of forecasting and the commissioning of large offshore wind projects. Adapt ramping margin tool and services accordingly.
- **Interconnector Ramping**
  - 2024 – 2030: Trial increased ramping rates to adapt to the increased penetration of HVDC interconnectors and large offshore wind farms.

Stakeholder Impacts for Reserves and Ramping

- **Renewable Generators**
  - Frequency reserves testing and monitoring
  - Reserve auction management framework and European market coupling will require more commercial actions and bidding
- **Conventional Generators**
  - Continued compliance monitoring requirements for reserve provision
  - Reserve auction management framework and European market coupling will require more commercial actions and bidding
- **System Services Providers**
  - Compliance monitoring for reserve provision
  - Reserve auction management framework and European market coupling will require more commercial actions and bidding
- **Large Energy Users**
  - Future potential opportunity to assist with provision of system services
- **Distribution System Operators**
  - Impact will be considered under the respective TSO-DSO (SONI-NIEN and EirGrid-ESBN) joint programmes of work.

EIRGRID SONI

Operational Policy Roadmap

Operational Security

Operational Security
Key Policy Objectives for 2030

Between 2023 and 2030, EirGrid and SONI will continue to operate the system securely while also aiming to:

1. Assess the thermal and voltage transmission constraint groups (TCGs) that are active in 2022.
2. Develop a framework for more regular assessment and updating of thermal and voltage transmission constraints on the network.
3. Develop new policies for the management of network flexibility technologies such as power flow controllers, dynamic line rating and other FACTS devices in operations.
4. Develop offshore network operating security standards and update the onshore network operating security standards for EirGrid and SONI.
5. Develop a framework for managing operational security using risk-based approaches (probability and impact).

Operational Security Definitions

Voltage and Reactive Power Management
Voltage ranges are defined in Section 6 of the Operating Security Standards (OSS), the Transmission System Security and Planning Standards (TSSPS) and the Grid Code according to the EU Guideline for system operation (SOGL).
Higher network voltage levels can increase stability margins and decrease transmission losses, but the system must be operated within its technical operating envelope to reduce the risk of voltage instability or long-term asset damage due to overstressing. Low voltage levels can occur for high demand, high power transfers, weakly interconnected areas or inadequate generation pattern scenarios. Grid Controllers in EirGrid and SONI manage the voltage profile at key network nodes throughout the day in line with demand patterns.

Short Circuit Management
The short-circuit levels are controlled to ensure safety and security. The short-circuit level must be within the switchgear, equipment and infrastructure rating, whilst ensuring high enough levels to maintain network protection adequacy. Historically, the short-circuit level was used as a proxy to determine system strength when screening for weak areas of the network that may impose operational challenges. In a system with high penetration of IBR this method becomes less adequate.

Thermal Management

The power flows across the network are driven by the requirement for the supply to meet demand. Due to inherent thermal limits associated with the elements of the network, the power flows must be managed to ensure these limits aren't violated to avoid damage and safety hazards. The power transfers must be controlled during steady state normal operation, but also in response to contingencies.

To ensure all equipment on the transmission system is operated within rated capacity, including short-term admissible overload limits, as specified by the Transmission Asset Owner (TAO), actions must be taken at planning and in the real-time operational stages.

The main actions available to manage the active power flows are the dispatch of generation and HVDC interconnectors, changes in network topology through switching actions, adjusting parameters of power flow control devices like phase-shifting transformers and last resort actions like demand disconnection. Future alternative solutions can involve the utilisation of batteries and flexible demand.

Need for Operational Security Operational Policy Changes

Constrained System

- Infrastructure development timelines, increases in demand and generation connecting away from the main demand centres results in a constrained network
- Congestion-imposed difficulties with planned maintenance outages
- Need for improved network flexibility and control and enhanced system analysis capability

New Network and Technologies

- New HVDC links and new offshore networks expected by 2030 will require new or updated codes and standards
- New network flexibility technologies such as dynamic equipment rating, special protection schemes, power flow controllers, series compensation.
- Policies and capability to manage a smarter grid

TSO / DSO Coordination

- Increasing quantity of IBR located on distribution networks
- Distribution network constraints driven by IBR export or demand increase due to electrification of heating and transport
- Need for closer coordination to define approach for managing congestions

Operational Security Transmission Constraint Management

The physical network limits on the system impose constraints on the least cost market schedules. These constraints are reflected in the generation schedule by means of TCGs entered in the market.

The thermal, voltage and dynamic stability constraints are studied by EirGrid and SONI under a range of scenarios, before being entered as TCGs. They are reviewed and updated as required or if major system changes warrant updates. In recent years, EirGrid and SONI have uplifted their operational study capability by utilising forecasted IBR and demand in thermal, voltage and dynamic stability studies.

As demand increases, and resources evolve in the coming decade, the pace of change will require a more dynamic approach to transmission constraint management in operations. Network constraints will need to be studied and updated on a more structured and regular timeline. SOGL requires members to perform at least yearly review and update of active constraints on their networks.

The Operational Policy Roadmap aim is to transition from multi-year constraints studies to more regular studides (yearly, monthly, weekly). The aim is to develop the capability to automatically run contingency analysis and determine constraints based on the day-ahead forecasts and schedules and to optimise the market schedule based on near-time analysis results.

Restructuring the process of constraints management will result in more accurate constraints, and target signals for network development, resource investment or new system services to alleviate system scarcities. It will require more active system management and study capability.

Transmission and Distribution Constraint Management

Increasing penetration of IBR on the distribution network poses challenges for bulk transmission system operation and generation demand balancing. The increase in distribution connected generation changed the traditionally passive characteristic of the distribution network, and now active and reactive power flows from the distribution to the transmission network are experienced more often.

New operating models for operations between EirGrid and ESB Networks in Ireland, and SONI and NIE Networks in Northern Ireland, will be required to manage thermal congestions and voltage constraints. These operating models are currently under discussion and expected to be agreed and implemented in the coming years.

Milestones to 2030 – Operational Security

Key Changes

- Network Flexibility Technologies
- Greenlink HVDC
- LCIS
- North South Interconnector
- Celtic HVDC
- ACER Risk. Ops Methodology
- Large Offshore Wind

Policy	22H2	23H1	23H2	24H1	24H2	25H1	25H2	26H1	26H2	27H1	27H2	28H1	28H2	29H1	29H2	2030
Thermal		Assess and Study TCGs	TSO / DSO Op Model Agreed	New Network Flexibility Technology Policy Annual Review Process & Update of TCGs		Weekly TCG Study Process & Updates	New TSO/DSO Operating Model in Operation	Day Ahead TCG Study Process and Update of Constraints	Risk Based Ops Policy	Risk Ops Policy GFM in GC New Offshore OSS Updated Onshore OSS						Stream-lined Constraints Process Enduring TSO/DSO Operating Model Enduring OSS
Voltage																
Short Circuit					New System Strength Trial	New System Strength Policy										

Key: Information gathering → Analysis System Studies → Operational trial → Trial Review Policy Update → Ongoing monitoring

Notes

1. TCG: Transmission Constraint group: There are thermal, voltage and transient stability (system strength) TCGs which should be reviewed every year for applicability as part of a formal process.
2. OSS: Operating Security Standards. There is one OSS for EirGrid and one for SONI. By 2027 an offshore network OSS will be required to complement the onshore network OSS.
3. A new system strength policy will replace the existing short circuit screening methods by 2025. While a new system strength policy is developed the upper security limits on short circuit levels will still be captured as part of the OSS.
4. ACER is the association of Agency for the Cooperation of Energy Regulators in Europe who regulate the implementation of the EU network codes.
5. Modifications to the Grid Code for inverter-based resources with grid forming capability will likely be required during the second half of the decade.

Operational Policy Actions Timeline – 2022-2023

Operational Security

- **Voltage Management**
  - ❑ 2023: Implementation of Voltage Trajectory Tool (VTT).
  - ❑ 2023: Review of voltage based TCGs that are actively constraining the power system.

- **Thermal Management**
  - ❑ 2023: Review of thermal based TCGs that are actively constraining the power system.

- **Short Circuit Management**
  - ❑ 2023: Consider interaction with system strength operational policy development as outlined in the Dynamic Stability policy area.

Operational Policy Actions Timeline – 2024-2030

Operational Security

- **Voltage Management**
  - 2024 – 2030: Utilisation of IBR, Low Carbon Inertia Service providers, STATCOMs and SVCs to remove long standing TCGs related to voltage constraints
  - 2024 – 2030: Active monitoring of voltage quality to inform requirement for policy changes

- **Thermal Management**
  - 2024: Develop policy on network flexibility technologies for system operations.
  - 2024 – 2030: Trial utilisation of BESS to manage post-fault thermal constraints
  - 2024 – 2030: Development of capability to operate to more dynamic pre- and post-fault equipment and plant rating limitations

- **Short Circuit Management**
  - 2024 – 2030: Monitor and test protection adequacy with reduction in fault current contribution. Enhanced IBR modelling and short-circuit analysis methods employed
  - 2024 – 2030: Update codes and standards to set requirements for fault current contribution from IBR to unbalanced faults

Stakeholder Impacts for Operational Security

- **Renewable Generators**
  - Offshore wind farms will have to comply with grid codes and new offshore OSS.
- **Conventional Generators**
  - Conventional generation that was scheduled as a constraint might not be as frequently scheduled with a move to more dynamic transmission constraint group studies.
- **System Services Providers**
  - Voltage and reactive power system services to be developed further, where appropriate.
- **Large Energy Users**
  - Future potential opportunity to assist with congestion and operational security management through provision of flexible demand response services
  - As required, define new standards and requirements to ensure that system security is maintained (fault ride through performance)
- **Distribution System Operators**
  - Impact will be considered under the respective TSO-DSO (SONI-NIEN and EirGrid-ESBN) joint programmes of work.

EIRGRID SONI

Glossary and Abbreviations

BESS	Battery Energy Storage Systems
DER	Distributed Energy Resource
DLR	Dynamic Line Rating
DSO	Distribution System Operator
DSU	Demand Side Unit
EMS	Energy Management System
EMT	Electromagnetic Transient
EWIC	East West Interconnector
FACTS	Flexible AC Transmission System
FCR	Frequency Containment Reserve
FoR	Facilitation of Renewables
FRR	Frequency Restoration Reserve
GFM	Grid-Forming
HVDC	High Voltage Direct Current
IBR	Inverter Based Resource
IE	Ireland
LCIS	Low Carbon Inertia Service
LSI	Largest Single Infeed
LSO	Largest Single Outfeed
MUON	Minimum Conventional Units Online
NI	Northern Ireland
NIEN	Northern Ireland Electricity Networks
OEM	Original Equipment Manufacturer
OPR	Operational Policy Roadmap
OPRC	Operational Policy Review Committee
OSS	Operating Security Standards
PFC	Power Flow Controller
PMU	Phasor Measurement Unit
POR	Primary Operating Reserve
RoCoF	Rate of Change of Frequency
RR	Replacement Reserve
SNSP	System Non-Synchronous Penetration
SOGL	System Operation Guidelines
SONI	System Operator of Northern Ireland
SOR	Secondary Operating Reserve
STATCOM	Static Synchronous Compensator
SVC	Static Var Compensator
TAO	Transmission Asset Owner
TCG	Transmission Constraint Group
TOR1	Tertiary Operating Reserve 1
TOR2	Tertiary Operating Reserve 2
TSO	Transmission System Operator
TSSPS	Transmission System Security and Planning Standards
VTT	Voltage Trajectory Tool
WAMS	Wide Area Measurement System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