17/07/2024

System Strength Requirements

Secure Operation of the All-Island Power System in the Presence of High Shares of Inverter Based Resources

EirGrid SONI

Agenda

- Introduction to the System Strength project
- Describing the need for system strength and the broader concept in international context
- Overview of current practices around system strength at EirGrid and SONI
- Overview of System Strength Metrics
- Potential System Strength Metrics for the All-Island power system
- Next Steps
- Q&A

Introduction to the System Strength project

Drivers of Change: Whole of Electricity System Challenge

Supply
(IE/NI)

Offshore Wind
(+ 5 / 0.5 GW)

Onshore Wind
(+ 4.5 / 1 GW)

Solar
(+ 5.5 / 0.3 GW)

Microgen
(+ 2.5 / 0.1 GW)

Conventional
(+2.2 / 1 GW)

Shaping Our Electricity Future

Demand (+50%)
(IE/NI)

Large Energy Users
(~1.6 GW)

Electric Vehicles
(~950 / 300 k)

Heat Pumps
(~600 / 120 k)

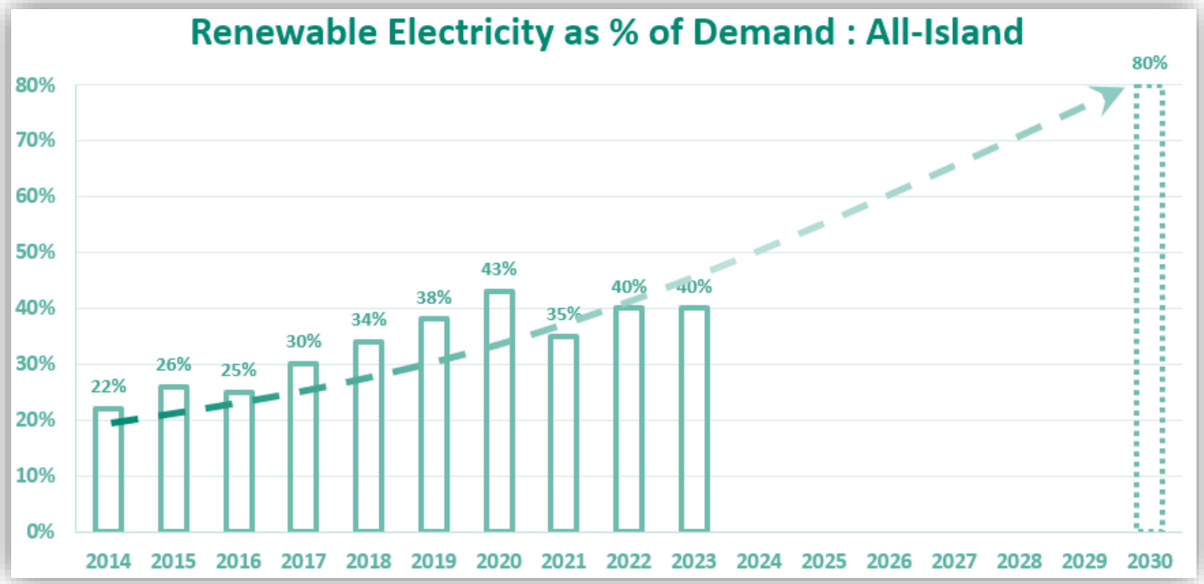
Social & Economic Growth

Energy Transition

- Targeted reduction in overall CO_2 emissions.
- Achieving 80% of power from renewable sources by 2030, in both jurisdictions.

https://assets.gov.ie/296414/7a06bae1-4c1c-4cdc-ac36-978e3119362e.pdf

https://www.daera-ni.gov.uk/articles/northern-ireland-climate-change-adaptation-programme



Fossil fuel generation

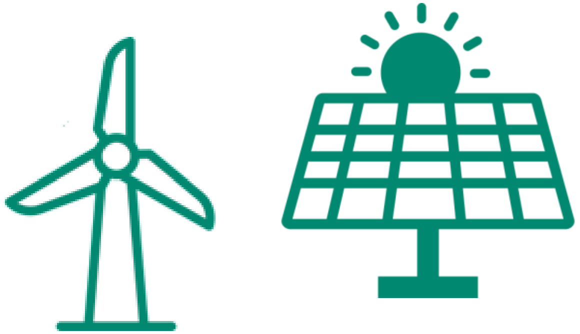
- Inherently provide system strength
- Generally, resilient against disturbances

Renewable Sources

- Generally, connected through converters
- Generally, don't provide system strength
- Require a stronger network

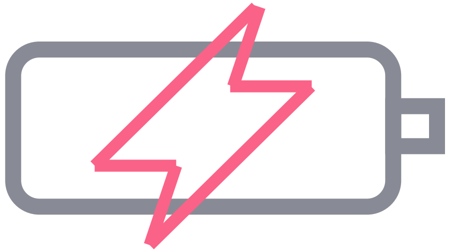
Power Electronic Interfaced Devices (PEID) will be dominating the All-Island Power System

Increase in renewable generation Capacity



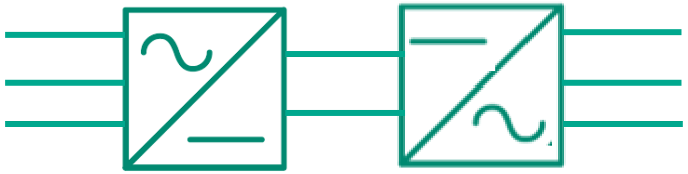
Total All-Island on-shore wind, off-shore wind and solar generation capacity is expected to grow significantly

Increase in BESS



Expand the existing utilisation of battery energy storage systems (BESS) to allow for enhanced frequency management

New HVDC connections



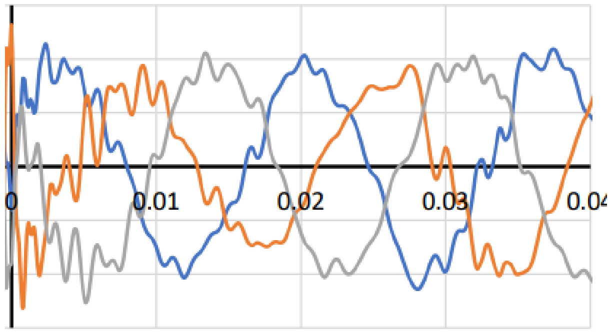
At least two new HVDC connections:
Celtic: 700 MW
Greenlink: 500 MW

EirGrid SONI

Instability and interactions of Inverter-Based Resources (IBRs): a new challenge around the world

Australian Energy Market Operator (AEMO) : weak grid associated stability challenges are viewed as the most significant challenges to higher IBR penetrations.

The Odessa Disturbance



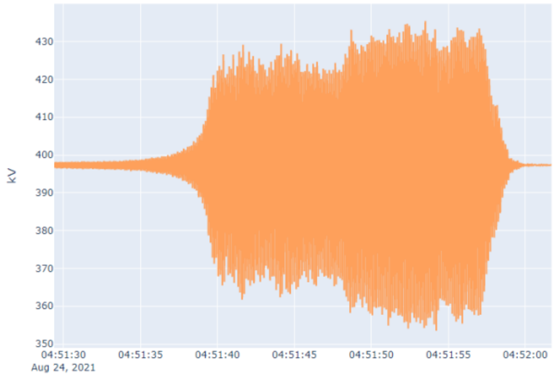
Loss of 1300 MW generation

2021

https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf

EirGrid SONI

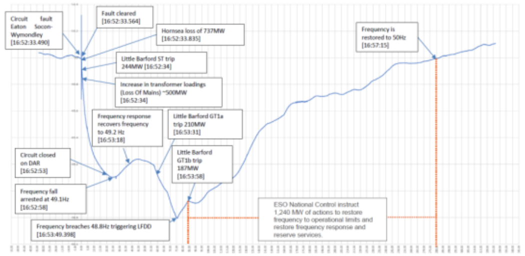
Sub-Synchronous Voltage Oscillations in GB



2021

https://www.nationalgrideso.com/document/318951/download

GB Power System Disruption 9 August

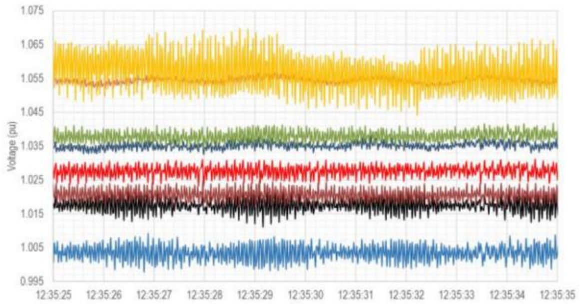


1 million customers affected

2019

https://assets.publishing.service.gov.uk/media/5e0e1fa9e5274a0fa7b4d96a/e3c-gb-power-disruption-9-august-2019-final-report.pdf

West Murray Zone Sub-Synchronous Oscillations



2021

https://aemo.com.au/-/media/files/electricity/nem/network_connections/west-murray/west-murray-zone-power-system-oscillations-2020--2021.pdf

Introduction of System strength as a new operational constraint

SNSP*

- A measure of the non-synchronous generation on the system at an instant in time

MUON**

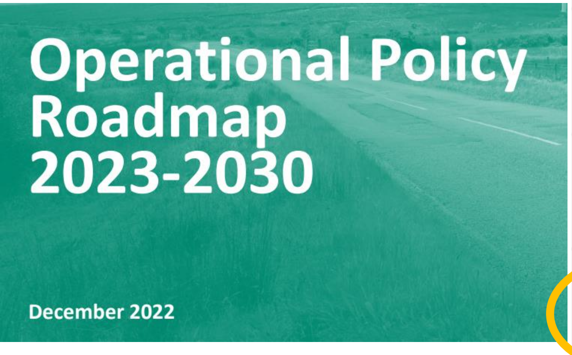
- Minimum number of conventional thermal units required to be synchronised in Ireland and Northern Ireland

- Global constraints
- To ensure enough synchronous generator traits are maintained to a level that guarantees secure and safe system operation
- Served a valuable purpose for system stability and renewable energy resources integration

→

- Operating the low carbon power system of the future will require us to transition from global constraints limiting non-synchronous resources to more targeted constraints.
- Relax and eventually replace them with **System Strength** related operational constraints

*SNSP : System Non-Synchronous Penetration
**MUON: Minimum Number of Conventional Units



See here

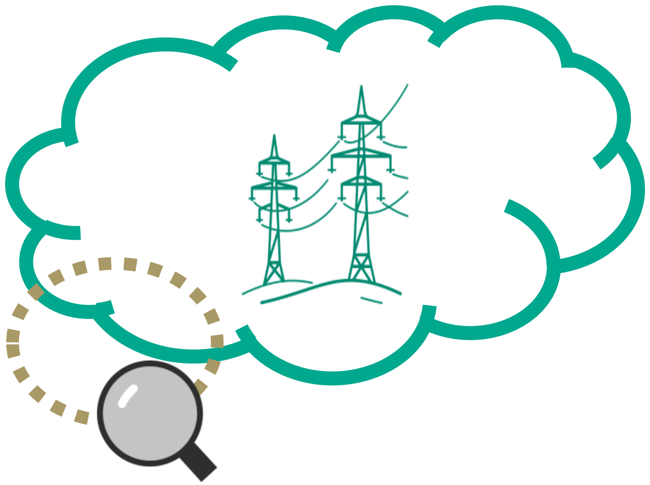
Key Changes: Greenlink HVDC (24H2/25H1); LCIS (25H2/26H1); North South Interconnector, Celtic HVDC (26H2/27H1); Offshore Wind (29H1); Potential Further Interconnection (2030)

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

The Need for Dynamic Stability Operational Policy Changes

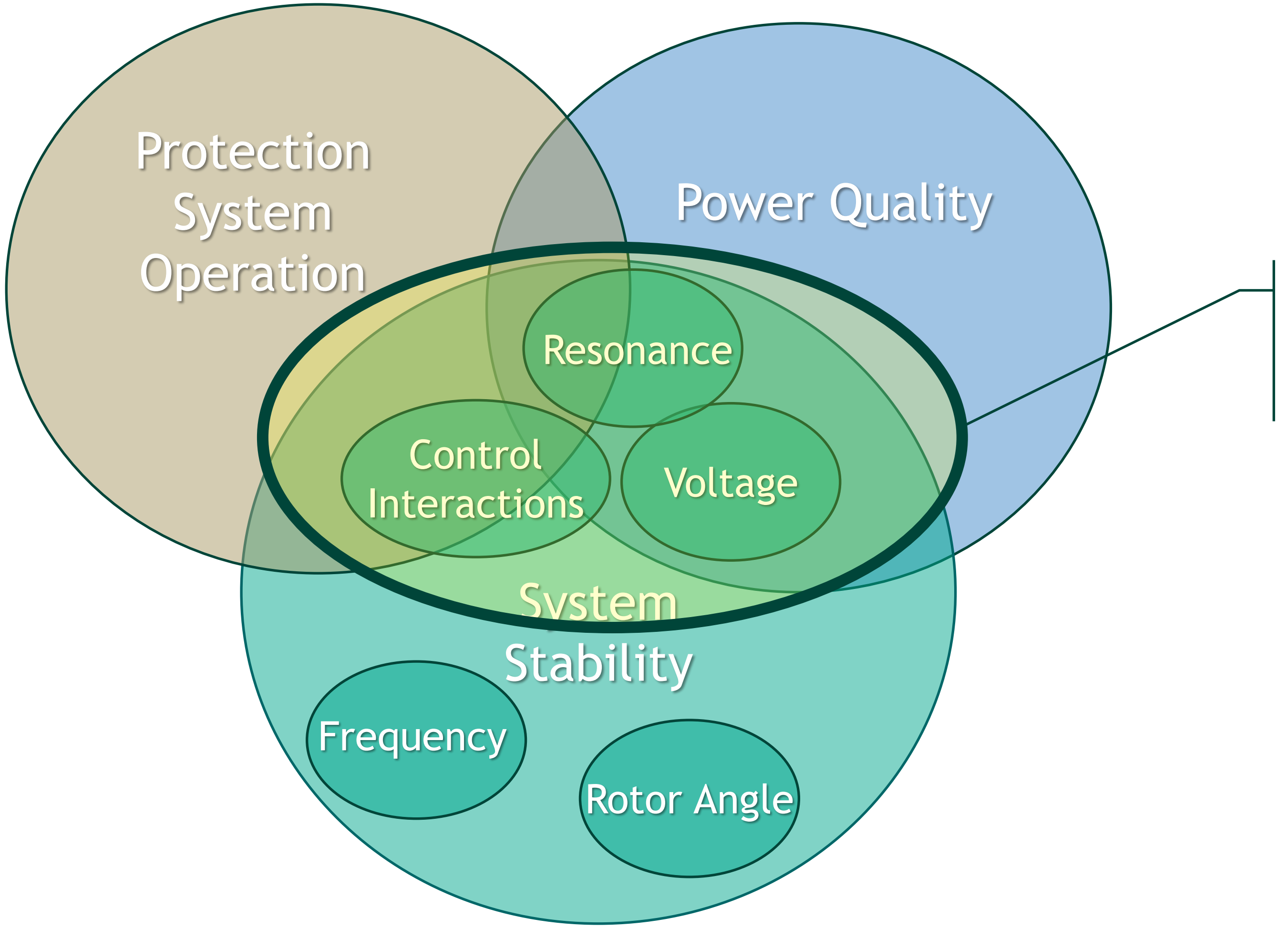
Need to link constraints more explicitly to physical system scarcities in specific areas



Incorporate Synchronous Condensers, Grid-Forming and other Emergent Technologies

Weak Grid Operation Enhanced System Monitoring

The concept of “System Strength”



Our “**System Strength**” focus

Motivation for a review of System Strength concept and Metrics (1)

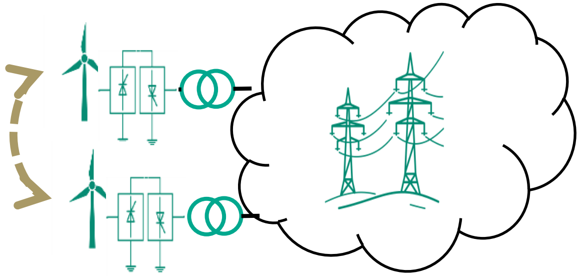
SCR*

*Short Circuit Ratio

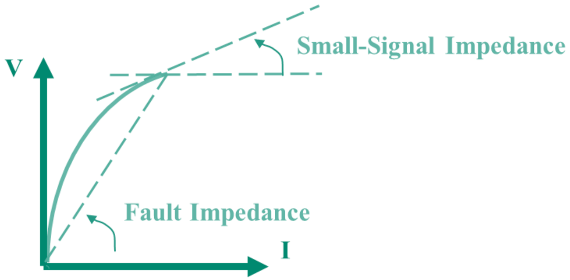
- The ratio of the short-circuit MVA capacity at a bus to the rated MW of the source
- A traditional metric to represent the voltage stiffness of a grid

→ SCR alone is not sufficient for IBR-dominated systems

Capturing the Interactions of IBRs

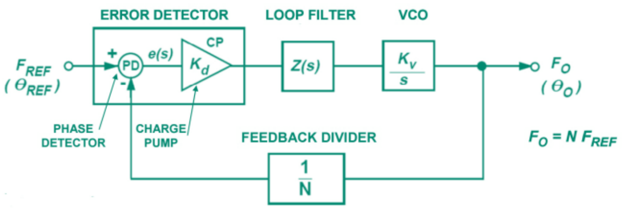


Capturing Small-Signal Instability Issues of IBRs

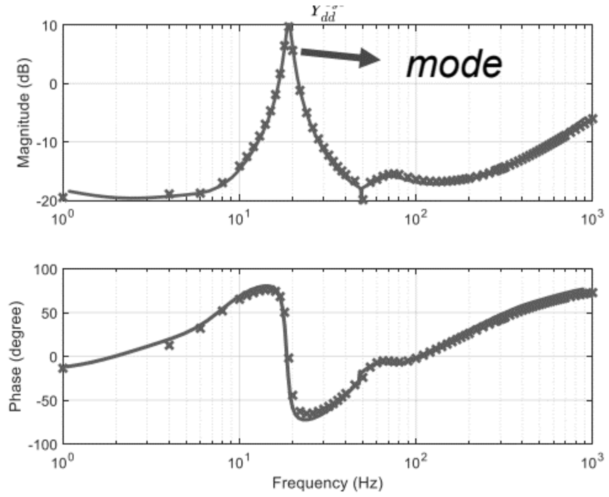


Capturing the Instability of IBRs due to PLL Issues**

**Phase-locked loop



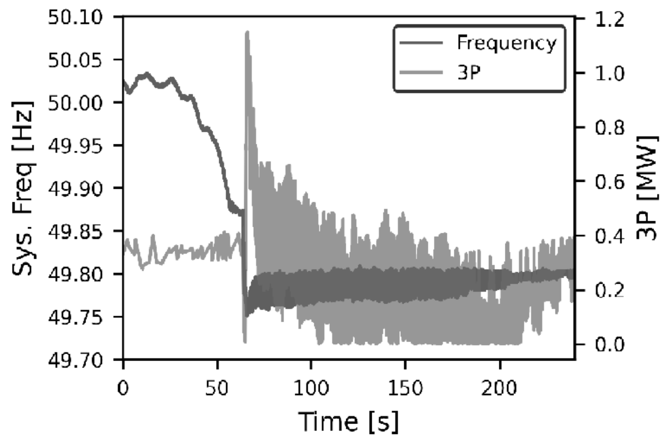
Considering the Impedance in a Wider Frequency Range



Motivation for a review of System Strength concept and Metrics (2)

Instability and interactions of IBRs happened where system had a high SCR value

The All-Island Power System
Sub-synchronous Oscillations in 2024



National Grid ESO
Events of Summer 2023 in GB*

We learned from these events that short circuit level alone could be a misleading indicator of system resilience against sub-synchronous oscillations and system stability.

The investigation found no evidence to suggest that the cause of these events is directly linked to system inertia, short circuit levels or any specific type of generation.

EirGrid SONI

*National Grid ESO, "Sub-synchronous oscillations in GB", May 2024

https://www.nationalgrideso.com/document/318951/download#:~:text=Since%20the%20events%20of%20Summer,damping%20than%20the%20Summer%20of

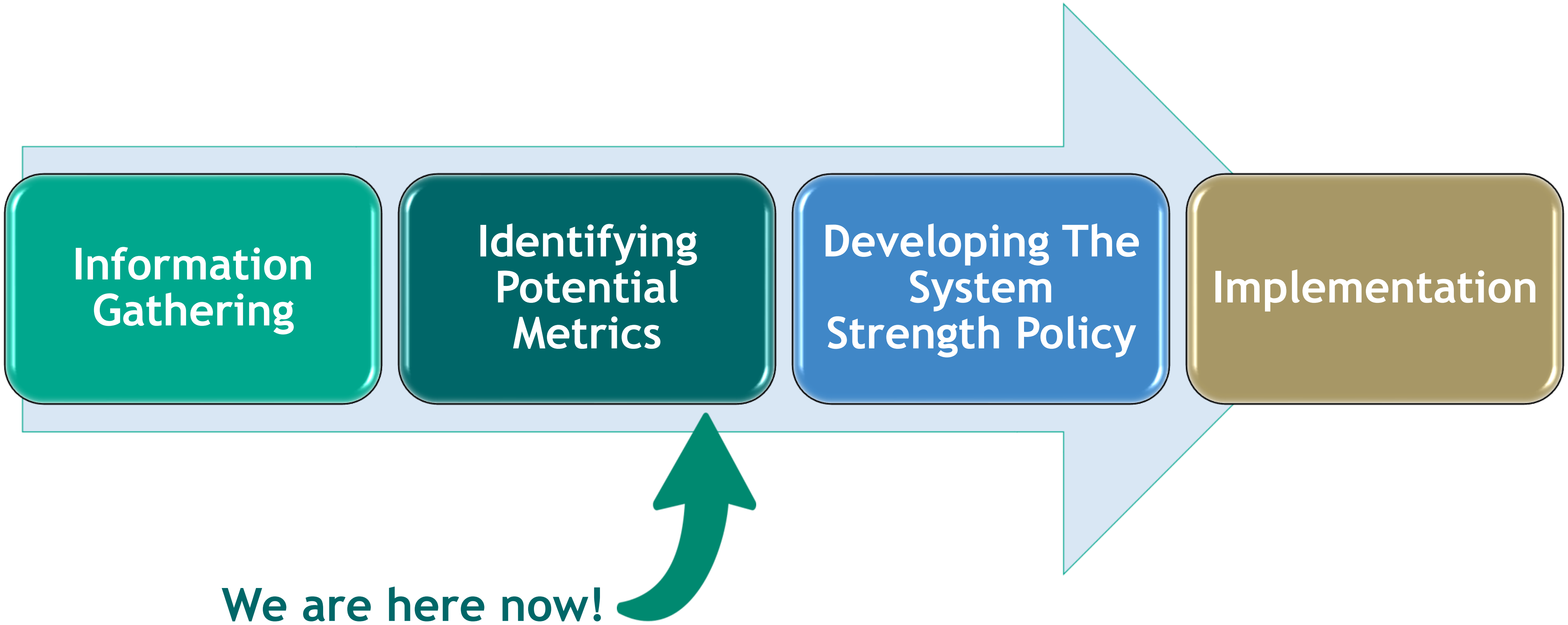
New project with the following objectives

- Exploring the concept of system strength in the context of operation and planning of the All-Island power system
- Identify an initial set of potential system strength metrics
- Identify offline and online evaluation and monitoring methods for the system strength metrics

EirGrid | SONI | Guidehouse | EPRI

Long-term Planning → New Connections → Operational Planning → Real-time Operation → Online from Measurements

Outlook for System Strength Policy development and enforcement



Defining System Strength

System Strength at EirGrid and SONI

The Operational Policy Roadmap 2023-2030* has set out for the development of a new, comprehensive system strength policy at EirGrid and SONI for planning and operations.

- **EirGrid and SONI have been at the forefront of energy transition** by their continuous desire to increase the level of renewable generation utilised on a day-to-day basis in delivering energy to Ireland and Northern Ireland without impacting on the secure operation of the electricity supply network.
- Currently there are two† system constraints utilised within EirGrid and SONI to ensure enough synchronous machines are operational to maintain safe and secure system operations at all times: the system non-synchronous penetration (**SNSP**) and the minimum number of conventional units on (**MUON**).
- Additionally, the traditional short circuit ratio (**SCR**) is provided to customers during the connection process for compliance purposes.

[†] Additionally, the key dynamic stability performance indicators within the above two constraints are the inertia and the rate of change of frequency (RoCoF).

SNSP

System Non-Synchronous Penetration

- Real-time measure of the **percentage of generation that comes from non-synchronous sources**, such as wind, solar and HVDC interconnector imports, **relative to the All-Island demand**.
- While the threshold is currently **75%**, over the next six years till 2030 this will gradually be raised to a target of **~95%** to accommodate increasing IBR penetration.

MUON

Minimum number of conventional Units On

- Specifies a **minimum number of conventional thermal units required to be synchronised** in Ireland and Northern Ireland in order to maintain a secure system from a dynamic stability point of view (key driver being the inertia floor – 23 GWs).
- The current requirements have been **relaxed from 8 units to 7** (3 in Northern Ireland and 4 in Ireland).

SCR

Short Circuit Ratio

- Traditional measure of **available fault current at the point of connection (POC) of a generator relative to the rating of that generator**.
- While not at the forefront with specific constraints, this metric in the form of minimum fault level is **provided to customers** to check for compliance with grid code requirements.

[*] Operational Policy Roadmap 2023-2030 [1]

Project Overview

The aim of this project is to propose an initial set of potential metrics to measure system strength based on research and practical experiences.

We are here

Benchmarking Practices → **Recommending Metrics** → **Stakeholder Engagement** → **Developing Policy and Metrics** → **Implementation and Go-Live**

Definition of System Strength

A definition of system strength needs to cover a broad range of system strength issues and is to be supported by a holistic set of metrics.

Defining System Strength

- Past definitions of system strength reflect the evolving nature of the subject over time.
- Several utilities do not use specific system strength definitions, defining it rather merely as (a set of) metrics (e.g., Fingrid).
- Key to any system strength definition is that it should **cover a wide range of issues and be supported by a set of metrics that span the gamut of system strength issues.**

Examples of Evolution of System Strength Definition

AEMO (Australian Energy Market Operator)

2020 *"a characteristic of an electrical power system that relates to the size of the change in voltage following a fault or disturbance on the power system"* [3]

2022 *"the ability of the power system to maintain and control the voltage waveform at any given location in the power system, both during steady state operation and following a disturbance"* [4]

nationalgridESO

2014 *"system strength is a measure of the ability of the system to remain stable during and following disturbances and variations in system parameters. System strength can be divided into two main factors: system inertia and short circuit level"* [5]

2016 *"system strength is an indication of the system's inherent robustness to voltage disturbances"* [6]

Potential Metrics for System Strength

A set of potential metrics for accompanying a definition of system strength was developed through literature research and a benchmark of peer-TSOs.

1 Literature Research

- Desktop research identifying the available metrics to measure system strength from **literature review and publications**.
- These metrics have researched thoroughly and compared based on e.g.:
  - Area of application;
  - Metric coverage; and
  - Calculation difficulty/speed and data complexity.

2 Peer-TSO Benchmark

- Identifying international definitions of system strength metrics used by peer system operators.
- Conduct **in-depth benchmarking interviews** with a set of relevant peer system operators around their choice of system strength metrics and use of such concept in their system planning and operations.
- Findings from this assessment are **anonymised** as these relate to confidential, internal TSO processes and procedures in several countries.

Potential Metrics

- **A set of potential metrics to measure system strength across the planning and operations context for EirGrid and SONI** based on the benchmark and desktop review that are recommended for further assessment.
- These metrics will **need to be tested and thresholds will need to be developed for them during the follow-up phase**.

System Strength Metrics

Overview of System Strength Metrics

There is an abundance of system strength metrics available from literature, each with different strengths and weaknesses focusing on various aspects of system strength.

Broad Categorisation of Available Metrics

- There are **two distinct groups of metrics**; one based on calculation of fault current and the second on establishing some form of an interaction factor. These two groups are **complemented by other metrics** that follow some other, specific form of analysis.
- **All metrics were qualitatively assessed** based on their **area of applicability** (stability, protection, etc.), **time frame relevance** (connections, operations, real-time, etc.) and **implementability** (calculation difficulty, data requirements, etc.). Additionally, the interaction-based metrics were assessed based on the specific interaction types (control interaction, resonance, etc.) they pertain to.

Metrics are developed once a shortcoming is established with existing ones. All metrics are aimed to identify some form of stability risk. As such, no single metric can identify all possible risks and **a collection of metrics will need to be used to capture and cover all aspects of system strength** across planning and operational timeframes.

	Area of Applicability	Time Frame	Implementability
Short Circuit-based Metrics	**System strength,** with some capturing LCC.	• **Connections** • **Long-term planning** • **Operations** • **Real-time** (for the simpler metrics)	• **Low** data complexity • **Simple to medium** calculation difficulty
Interaction-based Metrics	**Interaction,** with each metric targeting specific type(s) of interactions (control interaction, resonance, etc.).	• **Connections** • **Long-term planning**	• **Low to medium** data complexity • **Medium to hard** calculation difficulty
Other Metrics	**Varying depending on the metric** (e.g., system strength, PLL stability, voltage stability, etc.).	• **Connections** • **Long-term planning** • **Operations** (for some)	• Data complexity and calculation difficulty **varying depending on the metric.**

Peer-TSO Benchmark Findings

While peer-TSOs have different implementations of system strength, commonly used, straight-forward metrics consistently form the basis.

	TSO #1	TSO #2	TSO #3
Description	An electricity system operator.	An electricity system operator and asset owner.	An electricity system operator.
Key Metrics In-use	**SCR**	**SCR, X/R** and **EqSCR**	**EMT studies, SCR, AFL** in planning, **EMT studies** in operations
System Strength Implementation	• **SCR is used across real-time, operational and planning time frames,** but has identified deficiencies in SCR and is looking into a more advanced concept of system strength. • For connections, minimum and maximum SCL numbers are supplied to prospective parties, who are to design robustly within the expected range. They use **interaction metrics for connection studies** to determine interactions with the new connection. • This TSO calculates **system inertia**, both in planning and operational time frames (including real-time). This is calculated from the inertia of the connected generators, with a modification based on the connected IBR.	• **This TSO uses the EqSCR method for IBRs that use a grid-following control, whilst using traditional SCR for synchronous machines and HVDC**. This TSO has not decided on the metric to use for grid-forming controls (including BESS and STATCOMS), but currently believes it will likely use SCR. The X/R ratio is an additional metric which is used for IBRs. • Prospective connected parties must ensure operation to provided SCR/EqSCR-level. • **EqSCR calculations are performed to see if EMT studies are required for planning outages**. In case of known issues in specific areas, EMT studies are always conducted.	• This TSO relies heavily on their implemented EMT model to study system strength. • For planning, system strength is assessed to see if the fault level is adequate for protection and voltage control. **Adequacy is determined using EMT**, then an RMS/short circuit model is used to calculate the fault level (SCR, AFL). • For operations, traditional system strength is not used, and the TSO rely fully on EMT modelling. In operations, **the minimum number of generators needed to keep all IBRs in a region connected for a N-1 fault ride through and meet other requirements such as protection dispatched in each region, based on an EMT assessment**.

Potential Metrics

Potential Metrics for System Strength

Based on the conducted research and assessment, propose an initial set system strength metrics for planning and operational purposes to take forward and further refine.

- A qualitative selection process was applied to **identify and propose screening methods** that can be used to identify various system issues for **across three (3) key areas:**
    - **Planning** (for connections and long-term system planning);
    - **Operations** (for operational planning and real-time operations); and
    - **Measurement**-based**.**
- The high-level selection process and outcomes for each of the areas are **detailed on the following two slides**. Metrics for measurement purposes are left for further study, as only one practical metric was assessed.
- Throughout this project, several **barriers and challenges with the implementation of these metrics** have been uncovered and are documented in the following slides.

1 Planning

- Potential metrics for use **connections** (associated with connection of new plants) and **long-term planning** (associated with long-term system development).
- For planning purposes, metrics together should cover the full spectrum of possible system strength issues.

2 Operations

- Potential metrics for use **operational planning** (day-ahead, outages, etc.) and **real-time operations** (in the control room).
- For real-time operations, a metric should be both simple to calculate and easy to comprehend. An easy to comprehend metric is one that allows the operator to take action to mitigate an adverse scenario easily and consistently.

3 Measurement

- All metrics explored, explained and proposed for planning and operational purposes are **based on calculations using available system models**.
- There are limited examples in literature and practice around measurement-based methods, other than the proprietary **inertia measurement** technology implemented by NGESO and measurement methods based on the **PMU network**.
- As such, **this area is left for further study** and no specific recommendations are made at this point in time.

Overview of all Identified Metrics

In total **24** metrics were identified as possible metrics for measuring system strength from the literature desktop review and TSO benchmark, all of which were individually assessed.

	Metric	Description
Short Circuit-based	SCR	Most widely known and method, based on ratio of the available fault current at the point of connection (POC) over generator active power. [7]
Short Circuit-based	SCR + X/R	Extends the SCR metric by including X/R-ratio at the POC. [7]
Short Circuit-based	WSCR	Weighed SCR builds upon the SCR metric by considering groups of IBRs (such as wind parks) and considers them connected at the same POC. [8]
Short Circuit-based	EqSCR	Equivalent SCR introduces the concept of interaction factors of IBRs when determining the system strength at the IBR's POC. [7]
Short Circuit-based	CSCR	Composite SCR, like EqSCR and WSCR, attempts to consider a wider power park in its calculation rather than individual turbines. [7]
Short Circuit-based	ESCR	Effective SCR metric is used in analysing the system strength at the connection points of LCC HVDC links. [9]
Short Circuit-based	MIESCR	Multi-Infeed Effective SCR is a generalised version of for considering multiple LCC HVDC infeeds within close proximity of each other. [9]
Short Circuit-based	IILSCR	Inverter Interaction Level SCR to monitor the impact of nearby IBRs interacting with each other and reducing the local system strength. [10]
Short Circuit-based	SDSCR	Site-Dependent SCR is another extension of the SCR metric to account for interactions between IBRs. [11]
Short Circuit-based	ESDSCR	Effective SDSCR extends the definition of SDSCR with the additional consideration of the interactions of shunt capacitors. [12]
Short Circuit-based	ISCR	Interactive SCR considers the impact of IBRs and static var compensators connected at the same busbar. [13]
	UIF	Unit Interaction Factor (IF) quantifies risk of sub-synchronous torsional interactions between LCC HVDC's controls and generator controls. [18]

	Metric	Description
Interaction-based	EDS	Electrical Damping Screening EDS is a more intensive method of screening for sub-synchronous torsional interactions (SSTI). [23]
Interaction-based	AIM	Apparent Impedance Methods are impedance-based methods for analysing oscillatory stability issues in high IBR power systems. [18]
Interaction-based	RF	Radiality Factor is a screening method based on network impedance indicating potential for two dynamic devices to interact with each other. [21]
Interaction-based	MIIF	Multi Infeed IF reflects the interaction between an LCC HVDC under study with the power system. [9]
Interaction-based	MVIF	Multi-infeed Voltage IF quantifies the level of IBR interactions and is applicable regardless of the IBR type and control mode. [19]
Interaction-based	HMIIF	Harmonic MIIF is a useful metric for identifying interactions between two sources at different harmonic frequencies. [20]
Interaction-based	EMIIF	Extended MIIF to target voltage source control links. [20]
Other	GSIM	Grid Strength Impedance Metric utilises small-signal impedance models to quantify the system strength independently of short circuit level. [14]
Other	AFL	Available Fault Level is a screening metric for assessing highest quantify of IBR MW generation that can be installed in a specific location. [15]
Other	IMR	Impedance Margin Ratio is a metric for quantifying small signal system strength. [22]
Other	Voltage Sensitivity	Voltage Sensitivity quantifies the relationship between the maximum power infeed into the network by an IBR and the voltage and angular stability. [16]
Other	ACCT	Advanced Critical Clearing Time of an IBR is the maximum fault duration that an IBR can be subject to before its PLL loses stability. [17]

Initial Set of Potential Metrics for Planning

An initial set of potential system strength metrics for use with connection and long-term system covering the full spectrum of possible system strength issues.

Selection Process

For planning purposes, **two separate scenarios were considered:**

- A **Connections** (planning associated with connection of new plants); and
- B **Long-term Planning** (planning for long-term system development).

The following **criteria** were used in selecting a **shortlist of metrics,** including (but not limited to):

1. Metrics should cover **all areas of interest** (specifically stability) and be a **mixture of system strength calculations and interactions;**
2. **Simple to calculate** (the acceptable level of complexity is driven by the analytical timeframe) and be **possible to calculate with existing system model**.
3. Metrics should **cater for all potential connection types** (i.e., IBR, IBL, FACTS, HVDC and synchronous machines).

Selected Metric	A Connection	B Long-term Planning	Rationale & Purpose
SCR (with X/R)	●	●	Commonly used, simple metric for calculating system strength, and improvement of just SCR.
EqSCR	●	●	Commonly used, simple metric for calculating system strength, that also includes effects of high IBR penetration areas.
ESCR		●	Specifically for use with HVDC LCC systems (e.g., Moyle Interconnector).
AFL	●		For describing the potential for a part of the system to allow the connection of additional IBR.
Voltage Sensitivity	●	●	To serve as an indicator for voltage collapse issues.
ACCT	●	●	To serve as an indicator for PLL stability issues.
UIF	●		Initial screening metric to study new HVDC connections.
AIM	●	●	Second tier for screening, used if other metrices show issues.
RF	●		Second tier for screening, used if other metrices show issues.
EMIIF	●	●	To study interactions between nearby plants on the grid.

Initial Set of Potential Metrics for Operations

An initial set of potential system strength metrics for use with operational planning and real-time operations that are simple to calculate and relatively easy to comprehend.

Selection Process

For operational purposes, **two separate scenarios were considered:**

- A **Operational Planning** (day-ahead, week-ahead, etc.); and
- B **Real-time Operation**.

The following **criteria** were used in selecting a **shortlist of metrics,** including (but not limited to):

1. Metrics should cover **as many areas of system strength as possible** depending on the calculation complexity and the analytical timeframe**;**
2. Metrics should be possible to **calculate with existing system model**.
3. Metrics should be a subset of planning metrics and **cater for all potential connection types** (i.e., IBR, IBL, FACTS, HVDC and synchronous machines).

Selected Metric	A Operational Planning	B Real-time Operation	Rationale & Purpose
SCR (with X/R)	●	●	Commonly used, simple metric and improvement of just SCR.
EqSCR	●	●	Commonly used, simple metric and improvement of just SCR.
ESCR	●		Specifically for use with HVDC LCC systems (e.g., Moyle).
Voltage Sensitivity	●		For understanding key issues around IBRs (voltage, PLL stability).
ACCT	●		For understanding key issues around IBRs (voltage, PLL stability).

System Strength

- What’s next?

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System Strength: Potential Opportunities and Challenges

Opportunities

1. **Increased Power System Stability & Reliability**
   More secure system operation possible due to better understanding and awareness of complex system phenomena.

2. **Alleviating Constraints**
   Deeper and more accurate insight into local power system operating conditions potentially allows for reduced level of constraints.

Challenges

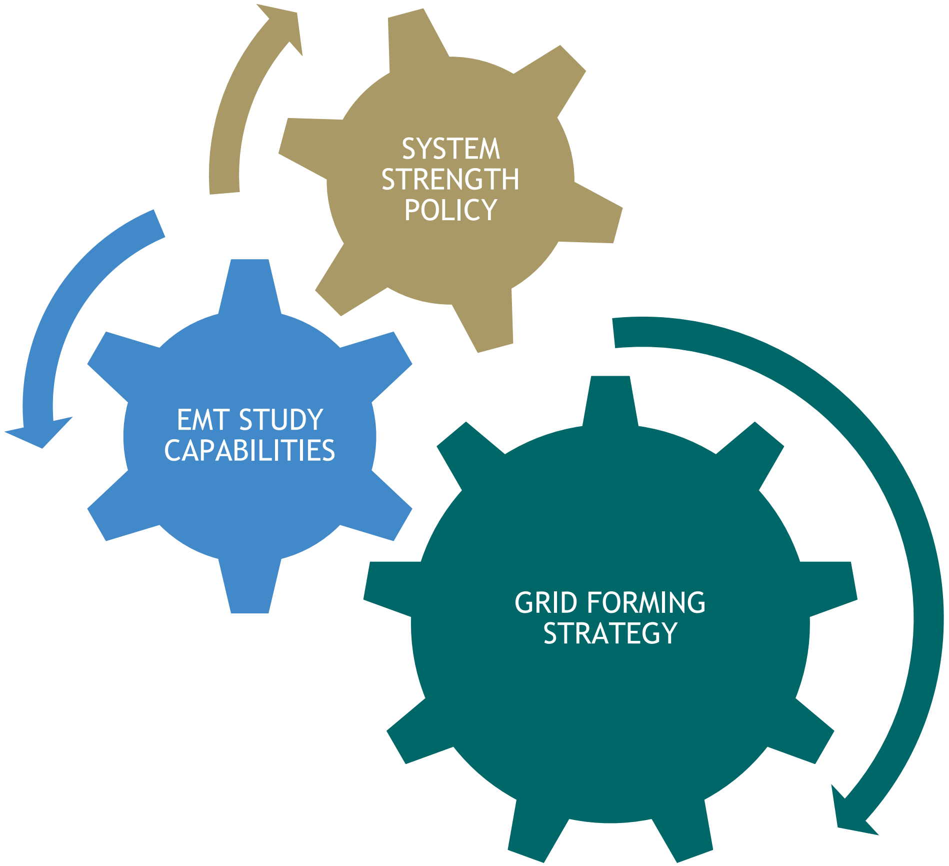
1. **Modelling, Data and Tools Availability**
   The availability of models, data and tools is key to performing accurate analyses. It is of great importance to have access to an all-island system model with validated data in both phasor and EMT domain.

2. **Customer Plants and Compliance**
   The introduction of system strength concept may accompany revised customer compliance requirements (e.g. modelling and studies).

Ongoing Related Projects

We are adopting a **holistic approach** to address emerging system strength challenges and opportunities for new technologies to support the system

- **System strength Policy**
  - IBRs need system strength to operate in a stable manner.
  - System strength is also needed to ensure correct operation of protection relays and adequate Power Quality.
  - Metrics and methodologies needed to quantify system strength requirements and monitor performance.
- **Enhanced Study Capabilities**
  - New dynamic behavior driven by low system strength and fast IBR controls requires advanced modelling capabilities.
- **Potential mitigation options**
  - Identify technologies such as Synchronous Condensers and Grid Forming (using advanced IBR control) that can provide system strength.



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Next steps

Next Steps

1. We will **further assess selected system strength metrics** for implementation and adoption into various planning and operational time frames and, ultimately, business-as-usual.
2. We will develop **an All-Island system strength policy**, with the various metrics that are used and the timeframes they apply. This policy will be reviewed periodically.
3. We will **review modelling and study requirements** for new customer connections.
4. We will develop an approach for **determining appropriate threshold levels** for metrics to be used. We will continue to **advance our modelling and simulation capabilities** (e.g. EMT).
5. We will **engage with stakeholders and industry around associated benefits unlocked by introducing this concept of system strength,** as well as their **changing role and requirements** within this system strength concept.
6. We will develop an implementation plan **for assessing, forecasting, monitoring and improving system strength** in the All-Island system.

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Q & A

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List of Abbreviations

AC, HVAC	(High Voltage) Alternating Current
ACCT	Advanced Critical Clearing Time
AFL	Available Fault Level
AIM	Apparent Impedance Methods
CSCR	Composite SCR
DC, HVDC	(High Voltage) Direct Current
DER	Distributed Energy Resource
DNO	Distribution Network Operator
DSO	Distribution System Operator
EC, EU	European Commission, European Union
ESCR	Effective
EqSCR	Equivalent SCR
EV	Electric Vehicle
FACTS	Flexible AC Transmission Systems
GSIM	Grid Strength Impedance Metric
GW(h)	Gigawatt(hour)
IBR	Inverter-Based Resource
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
IMR	Impedance Margin Ratio
ISO, SO	(Independent) System Operator
kW(h)	Kilowatt(hour)
LCC	Line Commutated Converter
LFDD	Low Frequency Demand Disconnection
MIIF, EMIIF	(Extended) Multi Infeed Interaction Factor
MW(h)	Megawatt(hour)
MUON	Minimum number of conventional Units On the system
POC, PCC	Point of Connection, Point of Common Coupling
PLL	Phase Locked Loop
PMU	Phasor Measurement Unit
RES	Renewable Energy Sources
RfG	Requirements for Generators
ROCOF	Rate of Change of Frequency
SCR, SCL	Short Circuit Ratio / Level
SNSP	System Non-Synchronous Penetration
SME	Subject Matter Expert
SSTI	Sub Synchronous Torsional Interaction
TAO, TO	Transmission (Asset) Owner
TSO	Transmission System Operator / Owner
TW(h)	Terawatt(hour)
UFLS	Under Frequency Load Shedding
UIF	Unit Interaction Factor

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