ESO External Engagement Webinar
System Operability Framework (SOF) Development

27th April 2023
We will start at 10:02 (BST)

ESO

System Operability Framework (SOF)

The System Operability Framework (SOF) takes a holistic view of the changing energy landscape to assess the future operation of Britain's electricity networks.

The SOF combines insight from the Future Energy Scenarios with a programme of technical assessments to identify medium-term and long-term requirements for operability.

Evolving year-on-year

Through extensive industry interaction, the SOF evolves year-on-year to meet changing operational and stakeholder needs.

Growth of low carbon and renewable generation, closures of conventional thermal power stations and changing interactions across the whole of the power system are just a few of the areas considered in the context of a rapidly changing power system.

URL: https://www.nationalgrideso.com/research-and-publications/system-operability-framework-sof

Agenda

- **Welcome and Introduction** (Dechao Kong, ESO)

- **Session 1 (15 mins):** Presentation on the proposed generic SOF development process and topics for SOF 2023-2024 development (Dechao Kong)

- **Session 2.1 (15 mins):** Introduction of drafted SOF paper on "System Strength Management of Future GB System with Potential Dominance of Inverter-Based Resources (Dechao Kong)

- **Session 2.2 (45 mins)**: Introduction of relevant key findings from on-going Network Innovation Allowance (NIA) project – Strength to Connect in support to ESO's such proposed recommendations in the drafted SOF on System Strength (Yue Zhu, Imperial College London)

- **Session 3 (30 mins):** Q&A in line with questions/comments raised from online audience following those three presentations (Chaired by Kelly Larkin, ESO)

- **Session 4 (10 mins)**: Summary and Suggestion for Future Plan, AoB (Dechao Kong)

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How SOF Comms to link between Overall ESO Strategy and Its Operability Strategy

Overall ESO Strategy

- Mission & Ambitions

(URL: https://www.nationalgrideso.com/what-we-do/our-strategy)

- Current RIIO-2 Business Plan

(URL: https://www.nationalgrideso.com/what-we-do/our-strategy/our-riio-2-business-plan)

System Operability Framework

- Key aim: To take a ESO's **Holistic Review** of the changing energy landscape to assess the future operation of GB's Electricity Networks

- Format: Evolving year-on-year to demonstrate ESO's consistent commitments to its **Operability Strategy** and **Needs of its Stakeholders** through public comms channel.

Operability Strategy

Reliable Network:

a) Stability b) Voltage c) Thermal d) Restoration

Balancing the System:

a) Frequency b) Within-day Flexibility c) Adequacy

Proposed System Operability Framework (SOF) Document Development Process

Wider External Inputs e.g. SOF@nationalgrideso.com, Industrial Forums, etc.

ESO Inputs e.g., Operability-related Forums and Report

Initialisation and Prioritisation of SOF topics in line with inputs from Wider Ext. Stakeholders as well as ESO's strategy and other internal inputs.

Topics to be Proposed with Priorities

Stakeholder Engagement for Comms and Feedback e.g. Continuous Stakeholder Events

Delivery Plan for SOF Topics as selected

SOF Delivery in coming 12-18 months

Proposed Delivery Plan for SOF Topics in Coming 12-18 Months*

No.	Topic in 2022-23	Overview	When to deliver as expected
1	**System Strength Management of Future GB System with Potential Dominance of Inverter-Based Resources**	**How to effectively manage system strength of the GB system with a future high penetration of inverter-based resources (IBR) is important for stable operation of the system.** This report shares our thinking about how system strength should be defined and managed in an IBR dominated system.	Q2, 2023
2	**GB Grid Forming Development**	**Grid Forming is widely recognised as a promising technology for global net zero energy transitions.** This report introduces the GB Grid Forming strategic developments that will help address existing or potential operability challenges on the GB system. In particular it will look at the interaction with the decline of system inertia and the reduction in system fault levels.	Q4, 2023
3	**Management and Mitigation of Oscillations on the GB Transmission System**	**Since oscillations were observed on the GB transmission system in August 2021, detailed investigations have been taking place reviewing:** • Network analysis to understand the drivers of the oscillations. • Assessment of indicators to be used as a screening technique to determine areas at greater risk of oscillatory events; and • Application of system monitoring tools to give greater visibility of events This report will share findings and insights from our investigations.	Q3, 2023
4	**Power Quality in Electrical Transmission Network***	**Power quality is critical to the performance of equipment connected to the electricity network. There is direct correlation between power quality and system strength.** The stronger the system strength, the easier it is to manage the power quality to the relevant standards. As more asynchronous generation connects to the system, the system strength continues to decline. This report will provide an outlook of the changes in the power quality of the electricity network	Q1, 2023* Note*: Finalised with the collaboration of the Transmission Owners and published last month - we welcome any feedback through the SOF@nationalgrideso.com
5	**Alternative Metrics to SCR for future System Strength Management of GB system**	In line with key findings of the ESO's NIA project "Strength to Connect**" to suggest any possible metric(s) as alternative to existing all-purpose metric – Short Circuit Ratio when dealing with existing and potential challenges from future GB system with high penetration/dominance of IBRs**.	Q2, 2024

Note*

- Source for Topics 1-4, See Operability Strategy Report, December 2022: URL: https://www.nationalgrideso.com/document/273801/download
- Background for Topic 5: See Strength of Connect Project with URL: https://smarter.energynetworks.org/projects/nia2_ngeso020/

An Example: SOF Topic to capture ESO's Strategic Roadmap for GB Grid Forming Development

Business Case

- ESO Operability Strategy Report
- System Operability Framework (SOF) Article on GFM/VSM

Collaboration with External Stakeholders

- VSM Expert Group (Completed).
- GC0137 GB Grid Forming Working Group (Completed).
- GB Grid Forming Best Practice Group (Completed).

SOF "The Potential Operability Benefits of Virtual Synchronous Machines and Related Technologies", April, 2020

Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine/VSM Capability), implemented in Feb,

Innovation Projects:

- Virtual Synchronous Machine (VSM) Demonstrator (Completed)
- Hybrid Grid Forming Converter (Completed)
- Demonstration of Virtual Synchronous Machine Control of a Battery System (Completed)

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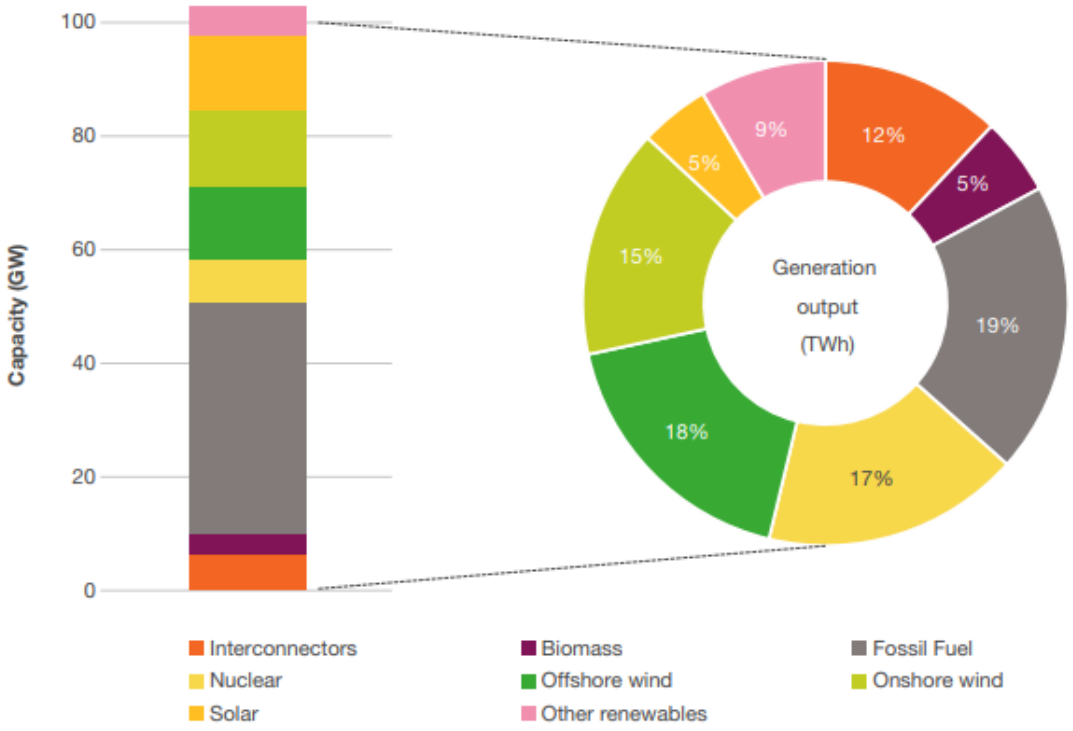
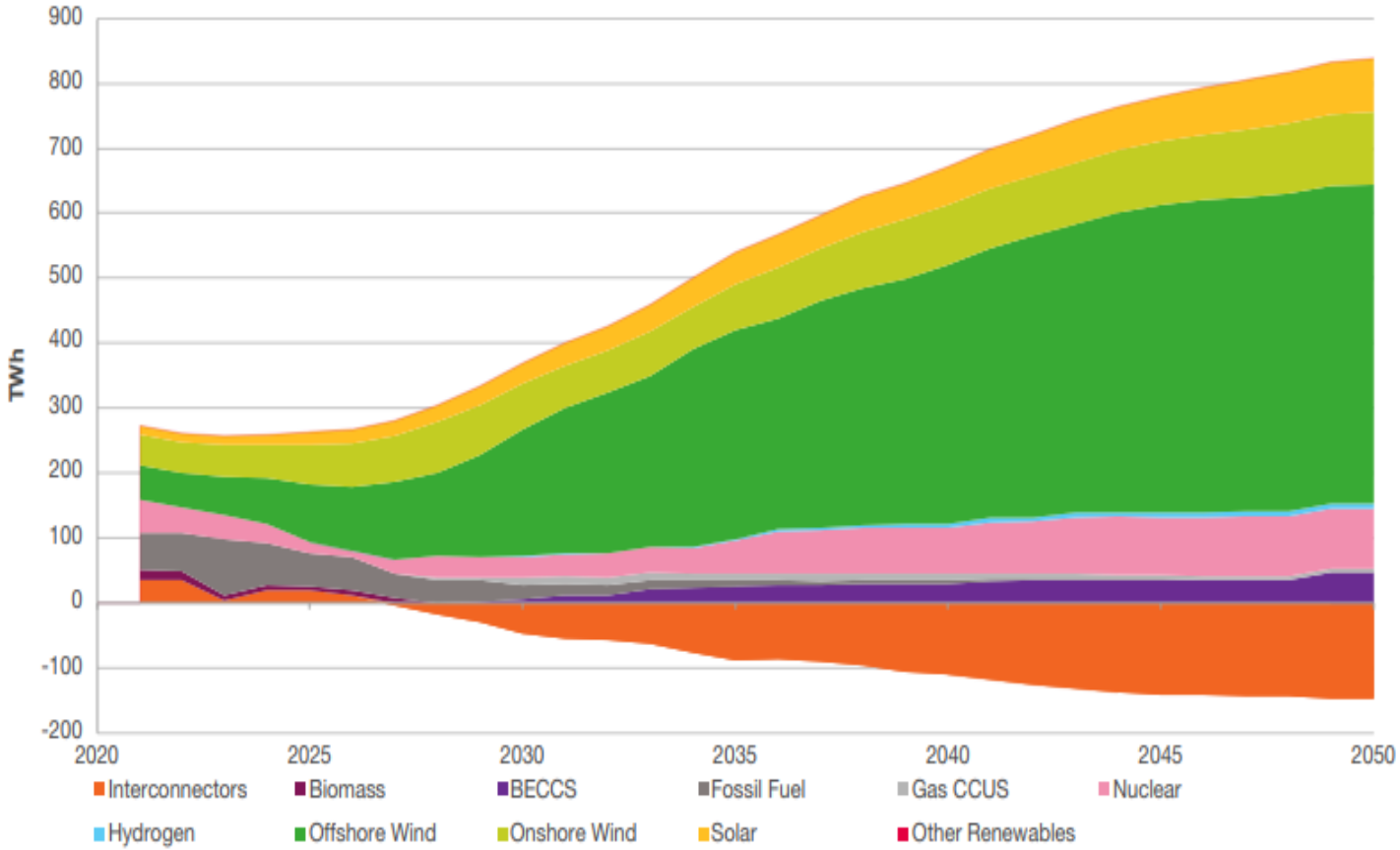
Background: Generation Mix – Roadmap from 2020 to 2050



Electricity Generation Capacity (GW) and Output (TWh) in 2021



Customer Transformation (CT), ESO's Future Energy Scenarios, 2022

Key Messages

Evolution of GB electricity system towards 2050

- Decarbonised
- Decentralised
- IBR-Dominated
- Significant decline in thermal power plants

Key Messages of SOF - Short Circuit Level (SCL) Vs System Strength

- **Conventional Short Circuit Level:** is the amount of current that flows on the system during a fault.
- **System Strength:** is power system's ability to maintain the stable voltage. It can be measured by the amount of current that flows on the system from the plants with voltage source behaviours during a fault.
- For a synchronous machine dominated system, SCL is very close to System Strength; **for a IBR dominated system, System Strength could be much lower than SCL**.

	SCL	System Strength
Synchronous Machine	Yes	Yes
Grid Following Converter	Yes	No
Grid Forming Converter	Yes	Yes

	SCL	System Strength
Protection	Yes	No
Equipment Rating	Yes	No
System Stability	No	Yes

Key Messages of SOF - Short Circuit Ratio (SCR) and Minimal SCR

- **Short Circuit Ratio** was first introduced in 1990s as

  SCR= SCL/Rating of the Machine

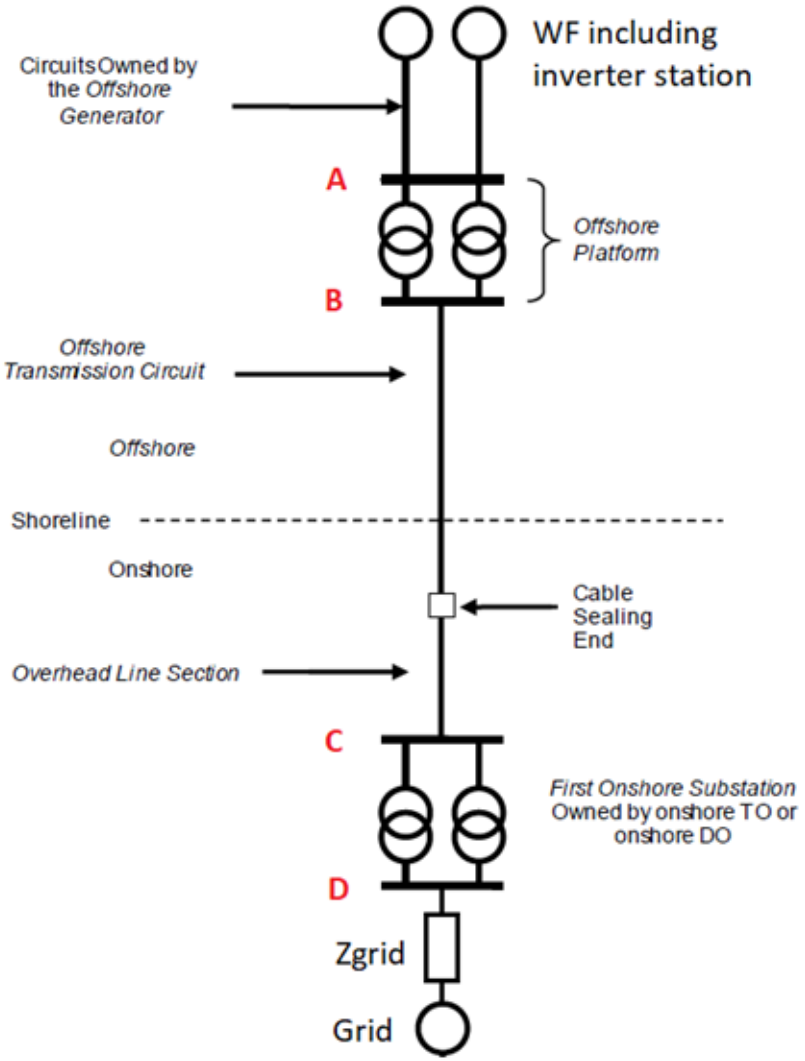
  SCR is more relevant to a particular user connection.

- **For an IBR-dominated system,** following those differences between SCL and System Strength, It is more appropriate to use system strength rather than SCL when calculating SCR.

  SCR= System Strength/Rating of the Machine (To be proposed)

- **SCR for a specific connection can be estimated at different points.** For example, the SCR for an offshore windfarm would be higher if estimated at the TIP than if estimated at the inverter terminal (Point A) due to high impedance between Points A-D.

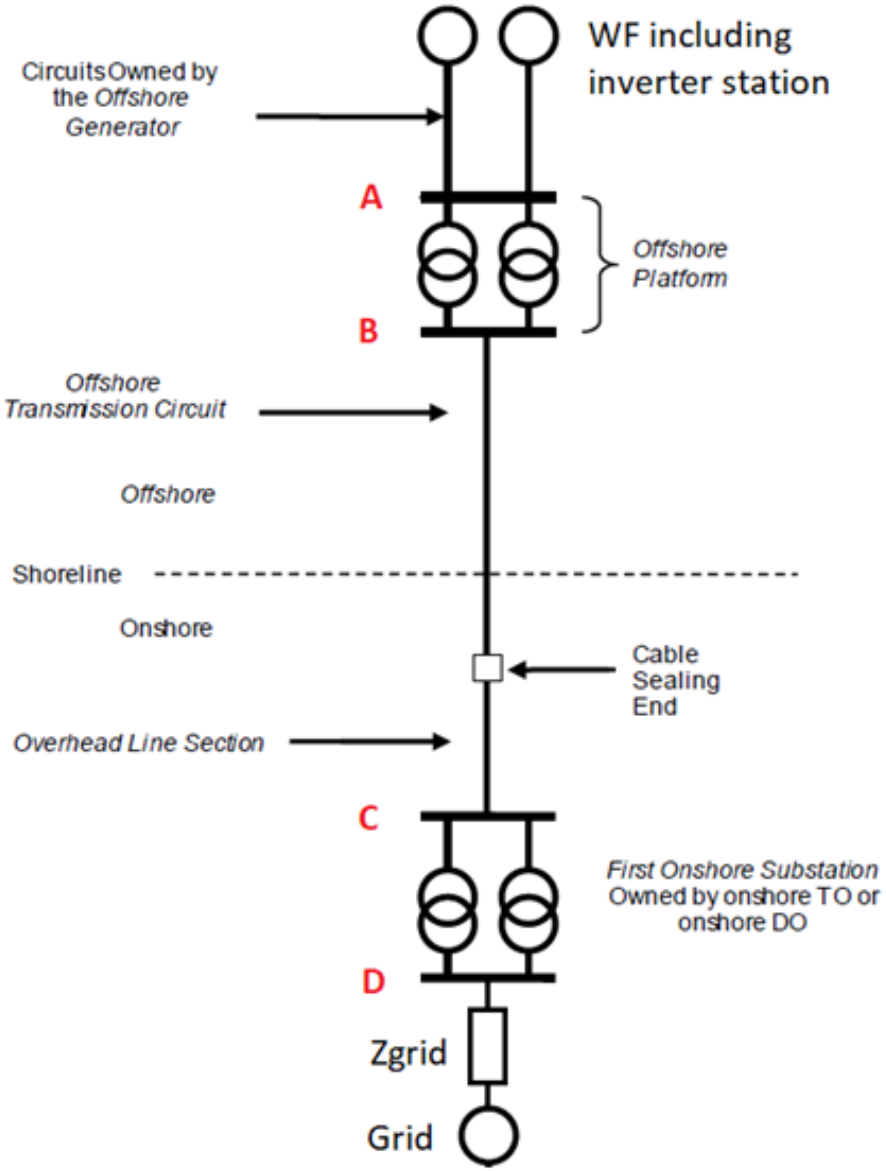
Point	Voltage Level	SCR
A	66kV	1.26
B	132kV	1.64
C	132kV	1.96
D	400kV/275kV	3



Minimal SCR for Single IBR Stable Operation

- **Minimal SCR (MSCR)** is the minimum SCR required for IBR to maintain stable operation.
- To avoid confusion, the MSCR value provided to the User is normally estimated at **Transmission Interface Point** (TIP - Point D as shown in Figure 1).
- **Many TSOs have attempted to apply a consistent assumption** for MSCR across their network. Examples are shown in the table.

	MSCR at TIP	Connection Type
Australia	3	AC
Ireland	2	HVDC
Germany	2	HVDC



Key Messages of SOF – SCR Modifications for Multiple IBR Power Plants

- **Initial SCR-related definition, assumption and calculation method** are applicable for connection of single power plant.

- **When increasing IBR-based power plants are connected to this system,** two or more IBR-based power plants can be located in close proximity to each other, particularly within a region with high density of IBR applications.

- **Three modified SCR definitions are introduced as follows,** considering SCR evaluation of multiple IBR-based power plants within the specific study area of a power system.

- **ESCR method is considered as a preferred method** (To be proposed; more details, see Yue Zhu's slides based on Literature Review and Case Studies.

SCR Variations	More Suitable for Multiple IBR Power Plants	Consider weak electrical coupling between IBR plants	Able to Consider effects of Individual IBR Plants
• Short Circuit Ratio (SCR)	No	No	No
• Composite Short Current Ratio (CSCR)	Yes	No	No
• Weighted Short Current Ratio (WSCR)	Yes	Yes	No
• Equivalent Circuit-based SCR (ESCR)	Yes	Yes	Yes

Future Works after Publication of this SOF Paper on System Strength

- **The ESO are implementing a Network Innovation Allowance (NIA) project "Strength to Connect"** to investigate any possible metric(s) as alternative to existing all-purpose metric - SCR when dealing with existing and potential challenges from future GB system with high penetration/dominance of IBRs.

- **This NIA project will help ESO deal with longer-term challenges** as relevant to system strength in a consistent and strategic manner.

- **For more details of this NIA project** including SoW, Project background and on-going WP1 on Grid Strength Assessment, please see presentation slides in coming session.

- **This NIA project's key findings,** when it is delivered, will be captured in the other SOF paper "**Alternative Metrics to SCR for future System Strength Management of GB system**" which is expected to be released in Q2, 2024.

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Q&A

Thanks for your attention!

Any Question?

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