Public

NESO Compliance Seminar

25 February 2025

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National Energy System Operator

Contents page

This document contains the slides from all sessions that took place at the Compliance Seminar on 25 February 2025. Session content is listed below

Breakout sessions

Welcome, Introduction and Agenda

09:45 to 10:00

Nick Harvey
Head of Network Operability

Welcome and Introduction

We are the National Energy System Operator for Great Britain, making sure that Great Britain has the **essential energy it needs by ensuring supply meets demand** every second of every day.

NESO is built on our previous experience as the Electricity System Operator (ESO).

We are a **public body, independent of the energy industry and Government**.

Ali Harper
Compliance Team Manager

Housekeeping and Agenda

Agenda

Join at Menti.com Use code 44443005

Registration	Oasis Suite Reception	09:00-0945
Welcome, Update, Housekeeping, Agenda	Oasis Suite	09:45-10:00
Breakout Session 1	Oasis Suite, Music room, RnB room	10:00-11:00
Coffee Break	Oasis Suite Reception	11:00-11:15
Breakout Session2	Oasis Suite, Music room, RnB room	11:15-12:15
Lunch	Oasis Suite Reception	12:15-13:15
Breakout Session 3	Oasis Suite, Music room, RnB room	13:15-14:15

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Agenda

Coffee Break	Oasis Suite Reception	14:15-14:30
Panel Q&A	Oasis Suite	14:30-15:30
Review and close	Oasis Suite	15:30-15:45
Networking	Oasis Suite Reception	15:45-16:30

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Breakout session:

Compliance Process and Technical Requirements

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Contents

Compliance Process

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NESO Roles and Responsibilities

During the compliance process, NESO will assign a Compliance Manager and a Compliance Engineer to each project

Contract Compliance Managers (CCM) manage the end-to-end compliance process and own the customer relationships

Engineers manage the technical aspects of the connection in accordance with the Grid Code and Contract.

Both will be available throughout the compliance process to help with any process/technical questions which may arise, and will work closely with one another through the process

Ensuring a unit can be integrated into the Control Room systems and therefore participate in the Balancing Mechanism (System Change Management team)

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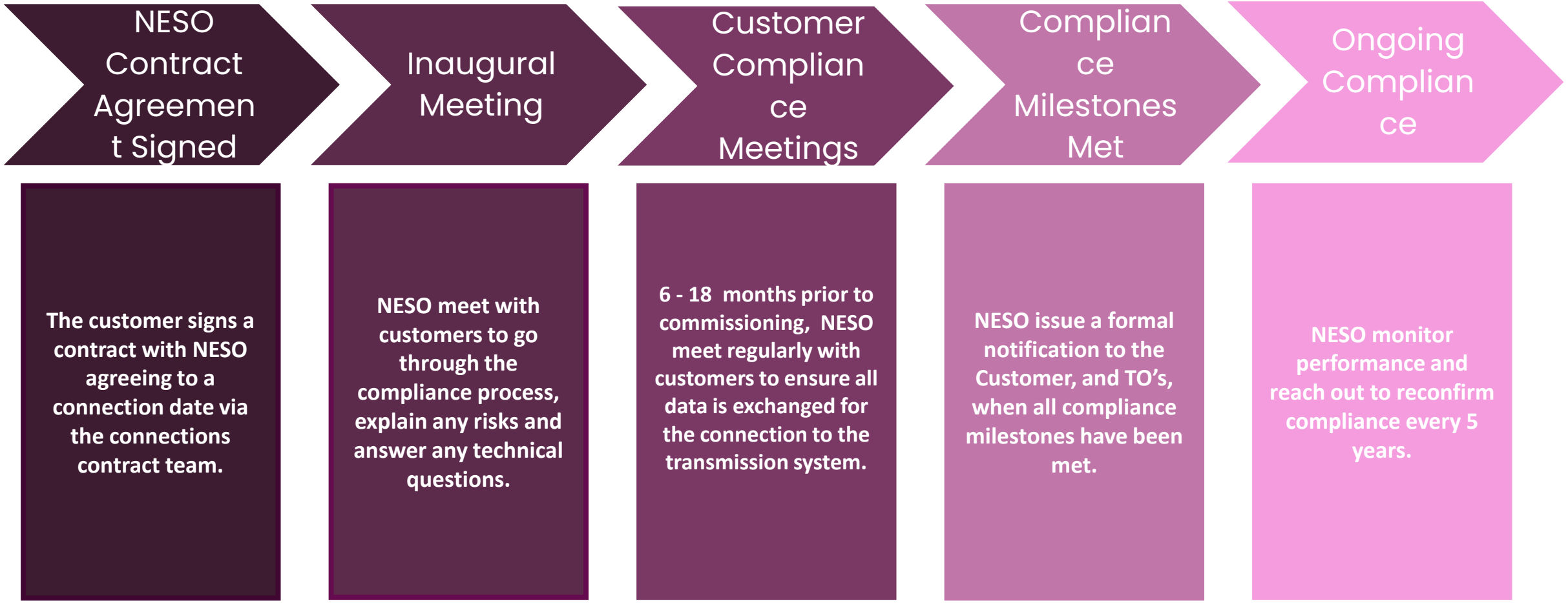
Compliance Process



Operational Notifications

There are three types of Operational Notification issued by “The Company” in respect of new connections, which are referred to within the Grid Code (GC), as follows:

Energisation Operational Notification (EON)

- This is required for first energisation (back feed) of a new connection when connecting directly to the National Electricity Transmission System

Interim Operational Notification (ION)

- This is required for the initial export of reactive or active power. The ION will list unresolved issues to be addressed before a Final Operational Notification is issued. The ION may also include Operational Restrictions for the new connection

Final Operational Notification (FON)

- This is issued when all issues identified within the ION have been satisfactorily addressed

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“Compliance Toolkit”

Several documents will be issued to the customer by “The Company” prior to the first Operational Notification and Compliance Panel Meeting, these are as summarised below:

Compliance Statement	This outlines the Grid Code and site-specific requirements from Appendix F (Site Specific Technical Requirements) to BCA, BEGA or BELLA. The customer confirms compliance and provides supporting comments
Operational Notification and Compliance Checklist (ONCC)	This checklist outlines key milestones and activities for the customer to complete through the ONCP, prior to issuing an EON, ION, and FON. The ONCC designates the lead party between the Relevant Transmission Owner and “The Company” for approving each compliance item
User Data File Structure (UDFS)	This folder structure is for the customer to demonstrate compliance in-line with the Compliance Statement and ONCC. Customers will submit the UDFS to "The Company" for review via the company's web-based facility. Access details will be provided once the ONCP commences

Technical Requirements

Compliance Testing

- Engineering Compliance test for the 3 below areas during the compliance process

Frequency Response

Reactive Capability

Voltage Control

- Engineering Compliance are embarking on automating the checking processes for these requirements. The goal is to reduce customer lead times and ensure consistency. To enable this automation, we kindly request that data be provided in specific formats

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Frequency Response

Sites are required to inject a series of frequency signals at varying loads (MLP's) to test the assess ability to respond to frequency changes

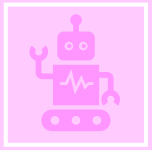
Frequency injections consists of -0.8hz, +/- 0.5Hz, +/- 0.2Hz and +/- 0.1hz (some tests will require multiple injection levels)

These tests are used to assess a sites Primary, Secondary and High Frequency Response

Voltage Control

Sites are required to inject a series of voltage signals to assess the voltage control/reactive power response of a site

Voltage injections consists of +/-1%, +/-2%, +/- 4% step changes



The key areas being assessed are droop level (%), delay time, and the speed of reactive power response

Reactive Power Capability

Sites are required to inject a voltage value to induce maximum leading and lagging reactive power, separately, for compliance testing. This process helps "The Company" evaluate the reactive power capabilities of the site

Tests are completed at 4 active power outputs (100% **(no less that 85%)**, 50% **(Leading only)**, 20% and 0%) at varying time scales

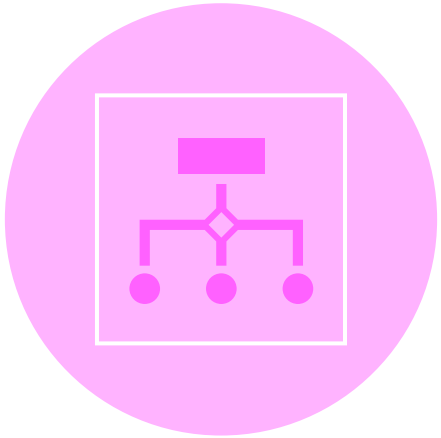
Steady active/reactive power output should be achieved for the duration of each test

Data Formats

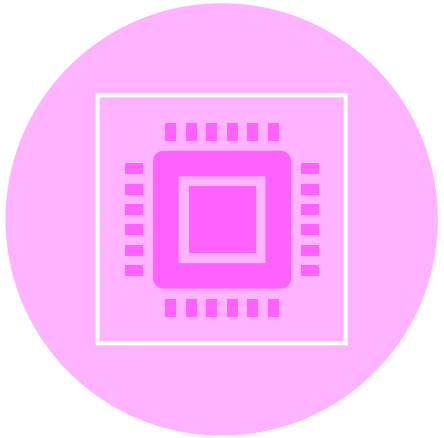
Time/Sample Rates	• Time to be provided in **HH:MM:SS.000** format • Sample rates to be provided in accordance with **CC.6.6.2.1/ECC6.6.3.2** unless agreed prior to submission with "The Company"
Active Power	• To be provided in **MW** values • In the case of frequency response, active power should reflect the corresponding MLP pre frequency injection (see clauses **OC5.A.2.8.6, OC5.A.3.6.6** or **OC5.A.4.5.6/ECP.A.5.8.6, ECP.A.6.6.6** and **ECP.A.7.5.6** dependent on technology type)
Reactive Power	• To be provided in **MVAR** values
Voltage	• Line to line voltage to be provide in **KV** values
Frequency (Frequency Response)	• To be provided on **Hz** • The injection profile to be given from **0** (Guidance for onsite test results) • Follow injection profiles given in **OC5.A.2.8.8, OC5.A.3.6.8** or **OC5.A.4.5.8/ECP.A.5.8.8, ECP.A.6.6.8** or **ECP.A.7.5.8** (technology dependent) • Please leave a gap between tests (Guidance for onsite test results)

Model Submissions

RMS and EMT models must comply with the performance requirements specified in **PC.A.9.8** and **PC.A.9.9** respectively



All models submitted to the "The Company" are required to represent the entire User system and should be submitted in the correct format and software version



All RMS models to be submitted **open source.** "The Company" can accept WEC/ICEE/IEEE format models. EMT models can be encrypted

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Sticking Points

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Sticking Points

BMU Registration

Data Submissions

Model Submissions

BMU Registration

- For a unit to participate in balancing actions, you must register as a Balancing Mechanism Unit (BMU) and be loaded into the NESO control room systems
- You will need to complete the BMU Registration process*
- Your TO must synchronise substation and NESO control room systems & establish communications links
- Once the communication links are established you will need to arrange for the first Operational Metering signals tests
- You are now ready to be dispatched by the control room and can be included in the next System Operation in Real Time (SORT) upload
- After successful SORT upload the NESO BMU team will be able to countersign your BMU registration form

***From 31 March 2025 all new BMU Registrations will take place through the Single Markets Platform**

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Sticking Points

BMU Registration

Data Submissions

Model Submissions

Data Submissions

- Data submissions to be sent in accordance with grid code requirements (DRC Schedule 19)
- Submit documents as and when they are ready rather than bulk submissions
- Every UDFS submission should contain all data relating to the connection
- Test data is required in the previously discussed formats
- New requirements around SSO Studies
- Working towards new guidelines for the process, please go to session D for further clarity.

Sticking Points

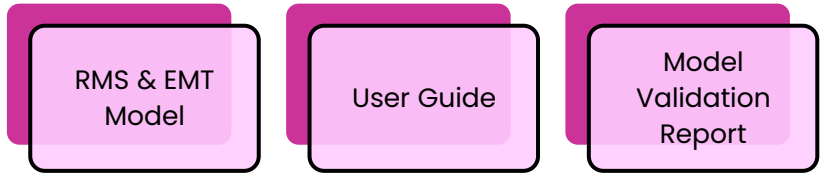
BMU Registration

Data Submissions

Model Submissions

Model Submissions

- Prior to receiving an ION, the below will need to submitted in line with section **PC.A.9** of the Grid Code:



- All models **must** be submitted **3 months before** the Interim Operational Notification (ION) and 1 month before the Limited Operational Notification (LON)
- A model validation/verification study against compliance test results must be provided **within 3 months** of completing compliance tests
- NESO must share models with Transmission Owners (TOs) as required by the System Operator Transmission Owner Code

Key Document Links

Compliance Process	•https://www.nationalgrideso.com/document/190686/download
Compliance Area (Guidance Documents)	•https://www.nationalgrideso.com/industry-information/connections/compliance-process#Compliance-documents
Grid Code	•https://dcm.nationalgrideso.com/ (web-based version)

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Breakout session:

Modelling Review Post GC0141

Arnaldo Rossier

Yuan Chen

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National Energy System Operator License Conditions

NESO License condition section E sets out the Industry Codes requirements.

- Balancing and Settlement Code (BSC).
- Connection and Use of System Code (CUSC).
- Grid Code.
- System Operator – Transmission Owner Code.
- NETS Security and Quality of Supply Standard (SQSS).

Grid Code Objectives

I. **Permit the development, maintenance and operation of an efficient, coordinated and economical transmission system.**

II. Facilitate Competition in the Generation and Supply of Electricity.

III. **Promote the security and efficiency of Electricity Generation, transmission and distribution system.**

IV. Efficiently discharge obligations imposed upon NESO by its License to comply with Electricity Regulation and any Relevant and Legally Binding requirements (i.e. RfG).

V. Promote efficiency in the implementation and administration of the Grid Code arrangements.

How does NESO achieve Grid Code objectives (I) and (III) ?

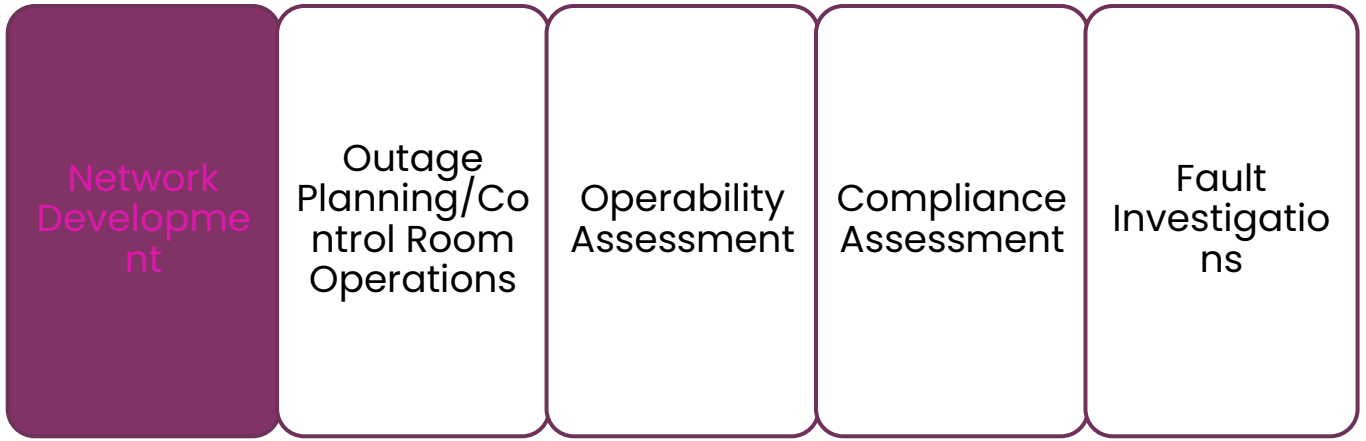
Largely via simulation studies.

Studies underpin key processes and activities across NESO departments:

Network Development	Outage Planning/Control Room Operations	Operability Assessment	Compliance Assessment	Fault Investigations

Network Development

What are the system requirements to accommodate the forecasted power transfers of the future and still comply with the SQSS standard?

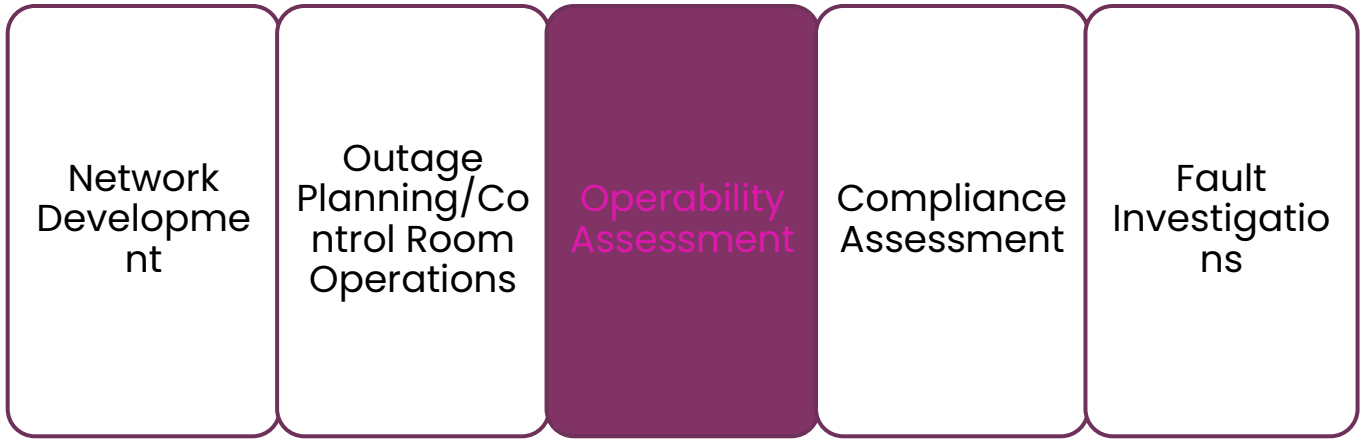


Outage planning / Control Room Ops

Will the system be secure when planned / unplanned outages are and testing is carried out to ensure Grid Code compliance and in accordance with SQSS?

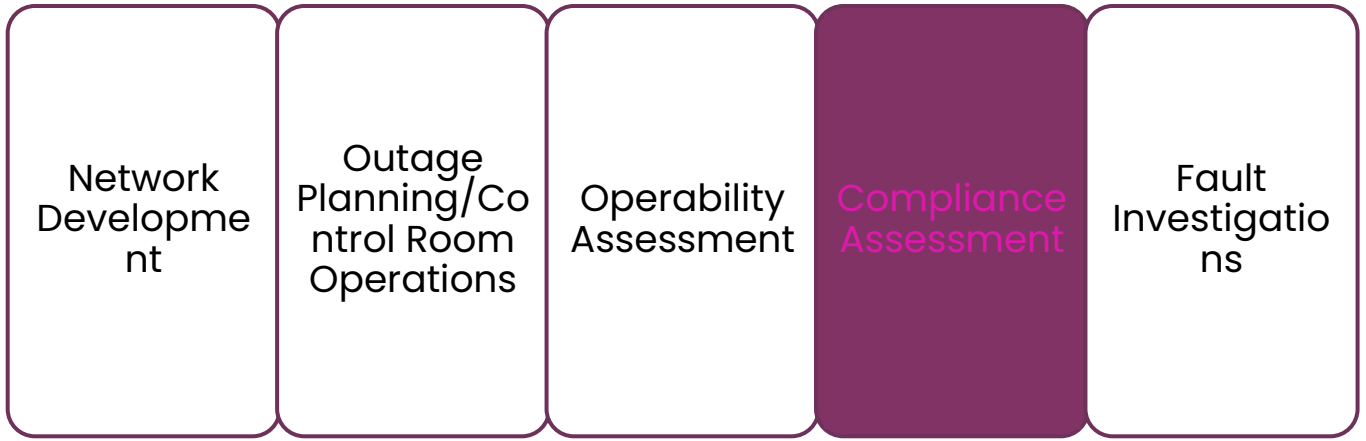
Operability Assessment

How do we increase the levels of IBR resources and facilitate the integration of new technologies while keeping adequate system performance metrics such as fault levels, dynamic voltage support, system inertia?



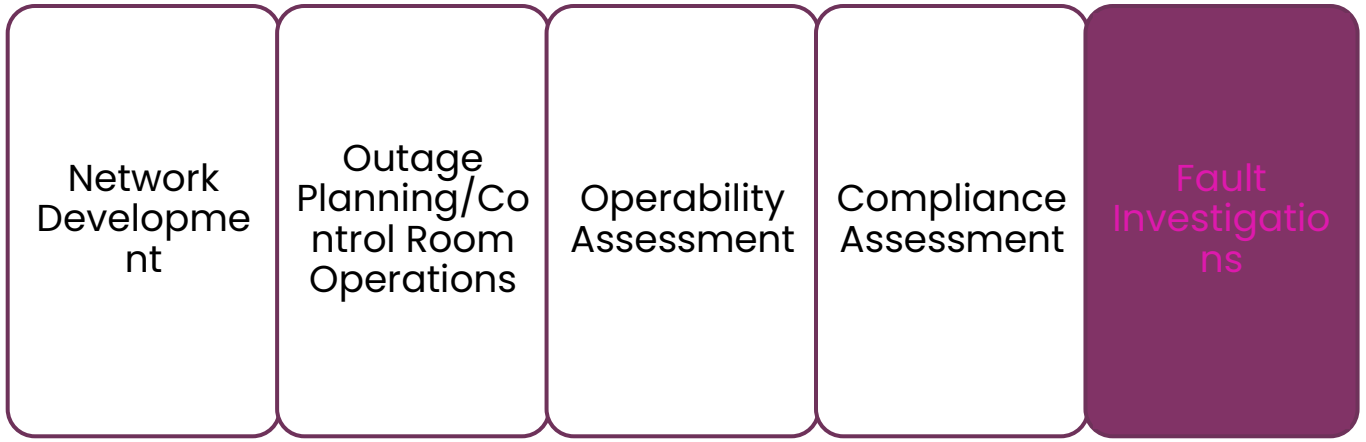
Compliance Assessment

How does NESO build confidence that new user systems meet the Grid Code technical requirements ahead of connection and will not have a detrimental effect on the system or another user?



Fault Investigation

How do find solutions to user systems displaying non-compliance behaviour (i.e. adjustment of controllers' parameters).



Models Quality

In essence, NESO relies on a model of the transmission network to carry out many of the activities mentioned

The credibility of the simulation results from system studies is heavily dependent on the quality and accuracy of the models in it.

Modelling Requirements

Where are these modelling requirements?

The Planning code under PC.A.9 of the Grid Code.

Modelling Requirements

Key clauses:

- In general, users are required to submit an RMS and an EMT model.
- EMT model can be encrypted but RMS model needs to be open source.
- A model of the entire user system as shown in the SLD is what NESO needs.

Modelling Requirements

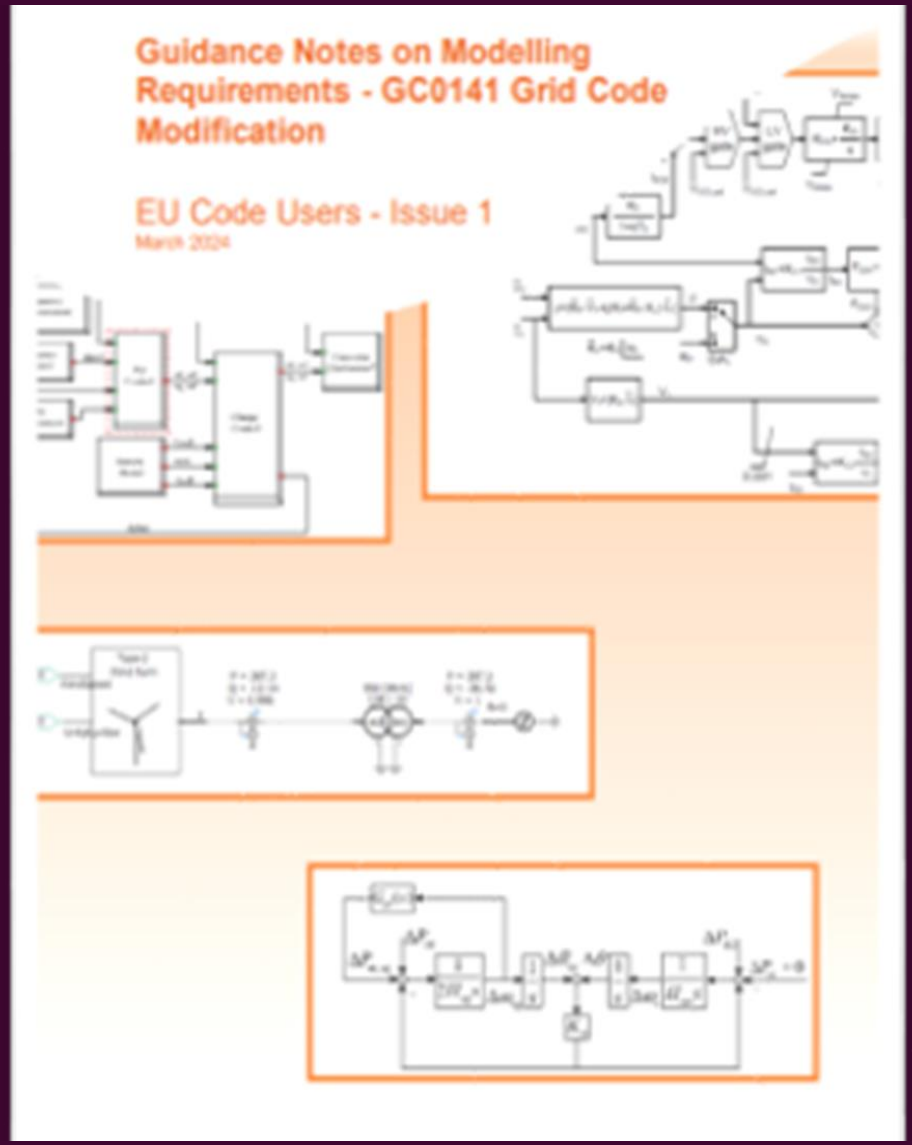
Key clauses:

- Models must be approved by the Company to release ION.
- Models must come with relevant documentation.
- Models need to be representative of the real system performance.

Guidance Notes

NESO has written a Guidance Note with the aim of providing clarity on the interpretation of these clauses.

https://www.nationalgrideso.com/document/316631/download



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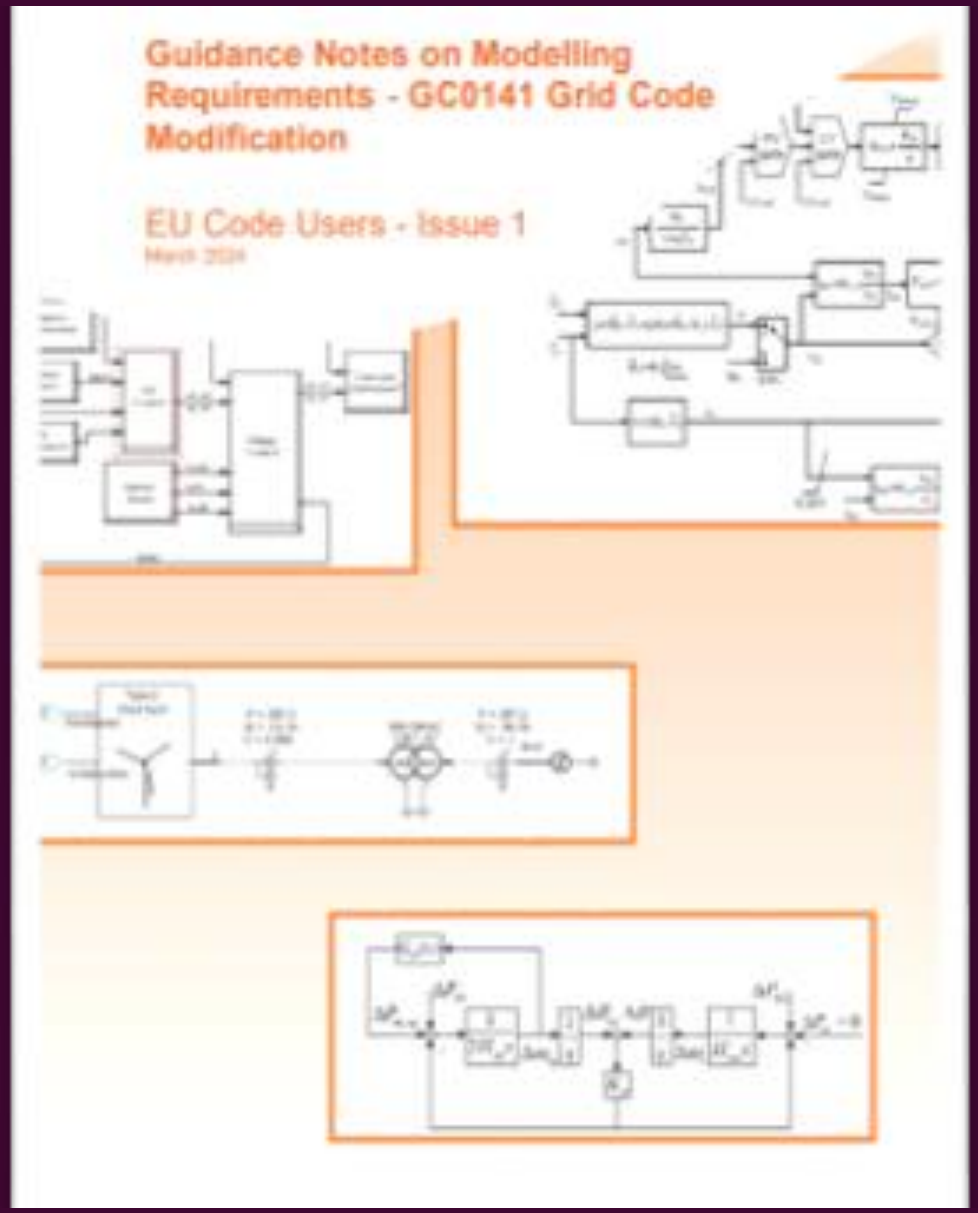
Guidance Note

It will be updated by NESO as feedback is received and considered aiming to get:

- The right overall message across to users on the what is required from these models
- Ensure it is consistent with the provisions in the Grid Code.
- The details on how to meet the more generic clauses in the Grid Code correct.



NESO experience since PC.A.9 approval

Some OEM's have opted for submitting generic RMS models to protect IP

There is a need to review the Guidance Notes for including appropriate industry feedbacks.

NESO experience since PC.A.9 approval

Submitted models with either missing or minimum information, no version control/audit trail in place.

Some time models lack important features included in the plant

NESO experience since PC.A.9 approval

A process is required for validating a single unit model for FRT to avoid duplicating efforts for all parties involved.

Many users were not aware that most model validation requirements were in the Grid Code before PC.A.9. was approved.

NESO experience since PC.A.9 approval

NESO is required to share the models with Industry participants.

Guidance Notes Accuracy requirements will be reviewed as NESO gain experience on what is adequate.

Public

Q&A

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Breakout session:

Data Registration Code (DRC) Generator Portal

Calum Erentz

Whole System Strategy Manager

NESO
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Agenda

1. Background
2. Development Timeline
3. Compliance Flowchart and DRC Portal Onboarding
4. DRC Portal Application Form
5. Demonstration
6. FAQs and Future Development
7. Q&A

Background

Background

WHY:

- Feedback from industry combined with NESO digitalisation strategy and efficiency improvements

BENEFITS:

- Clear data requirements for Users
- Single submission route for Connection, Week 24, CRP compliance submissions, and models for all assets
- Ease of use vs the current word format
- Provides a living record
- Accessible for Users and NESO at all times

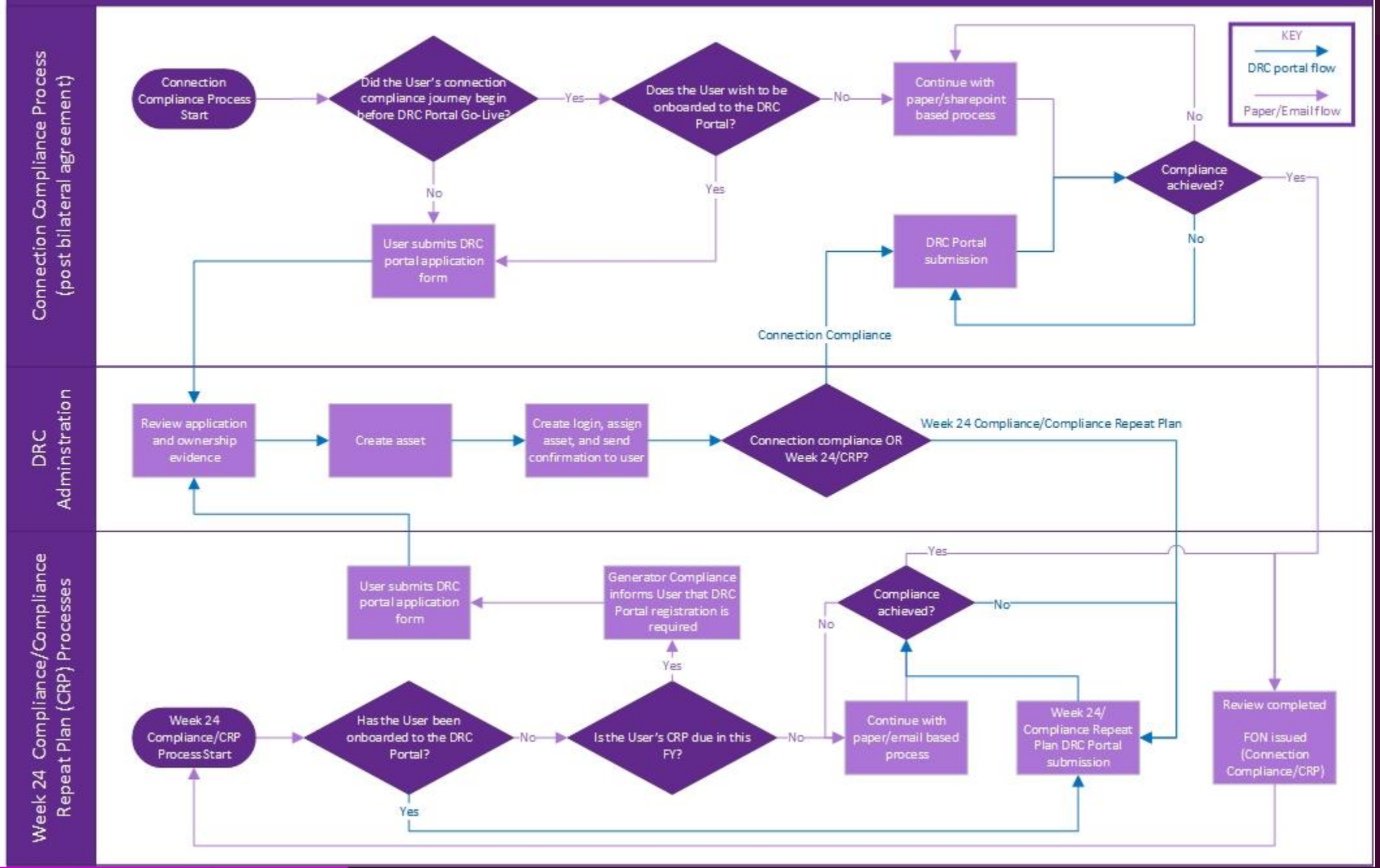
Development Timeline

Development Timeline

- Conceptualised in April 2024
- Comprehensive review of the DRC and underlying Grid Code clauses – Q2 2024
- Functional and non-functional requirements – Q2 2024
- Development – Q3-Q4 2024
- Internal UAT + improvements – Q4 2024
- External UAT + improvements – Q4 2024
- Webpage, guidance videos, and FAQs – Q4 2024
- Planned go live - end March 2025
- Grid Code change - PC and DRC housekeeping – Q4 2025
- Future development (TBC)

Compliance Flow Chart and DRC Portal Onboarding

DRC Generator Compliance and Registration Processes



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DRC Generator Portal Application Form

Demonstration

FAQs and Future Development

FAQs

- Will existing data be migrated? – no, existing users will be onboarded on to the portal when their CRP is due (full submission)
- Can contractors be granted access? – yes with permission from the asset owner (application form Approver)
- Are users/NESO automatically notified of submissions – no, this will be considered in future developments, email exchanges will be required when submitting/feeding back
- Is commentary and sign off available for NESO compliance engineers? – no, this will be a future development, email exchanges will be required when submitting/feeding back
- Will external users be able to download a copy of the data? – no, this will be considered in future developments, however NESO can provide a copy of the data in CSV format upon request
- Will Transmission Owners have access? – no, this will be considered in future developments
- Will a similar portal be created for DNOs in future? – unknown at this stage until GC0139 is completed

Future Development

- Automatic notifications of schedule submissions/commentary
- Automated week 24 reminders
- Data export for external users
- Commentary for NESO compliance
- NESO compliance sign off records
- Inclusion of CRP tab
- TO access to relevant assets and data

Public

Breakout session: Compliance learning – SSO

Hazem Karbouj

Xiaoyao Zhou

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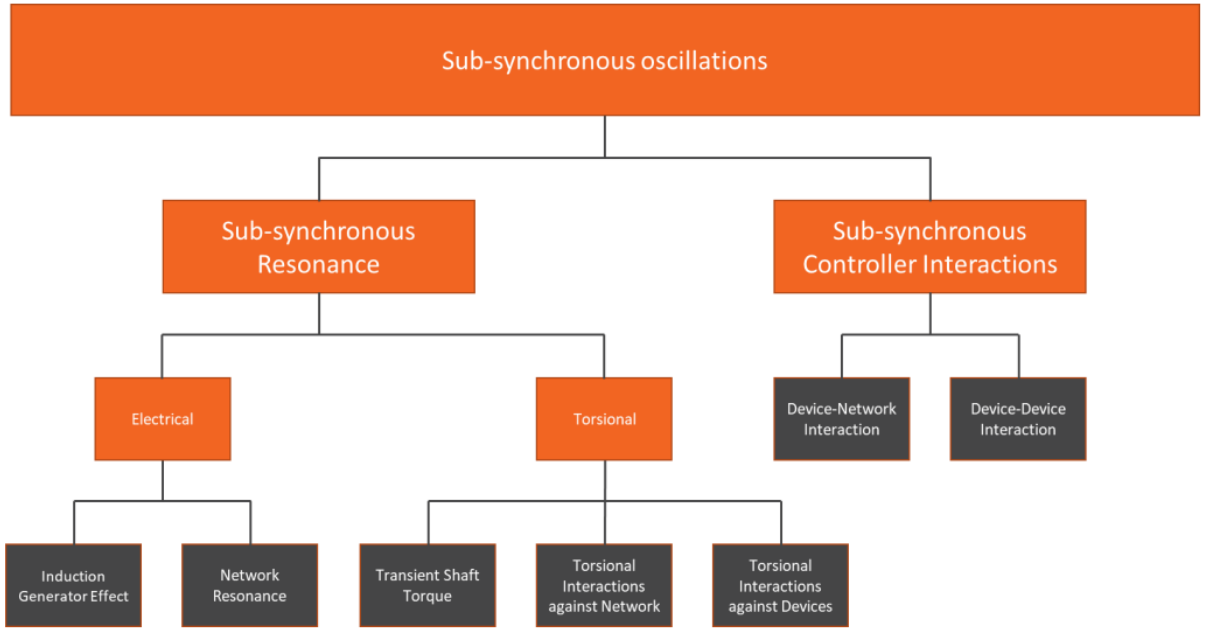
What are sub-synchronous oscillations?

- Not a new phenomenon.
- Not associated with a specific technology.
- Definition: Sub-synchronous oscillations are power system oscillations at frequencies that are less than the power frequency of 50Hz in Great Britain.
- If left undamped, sub-synchronous oscillations can cause equipment damage, disconnection of generation and in the worst-case scenario loss of supply.
- Classification of sub-synchronous oscillations is shown in the figure. More info in the reference in the footnotes.



Classification of sub-synchronous oscillations [1].

[1] CIGRE JWG C4/B4.52 Technical Brochure Reference 909, "Guidelines for Subsynchronous Oscillation Studies in Power Electronics Dominated Power Systems", June 2023.

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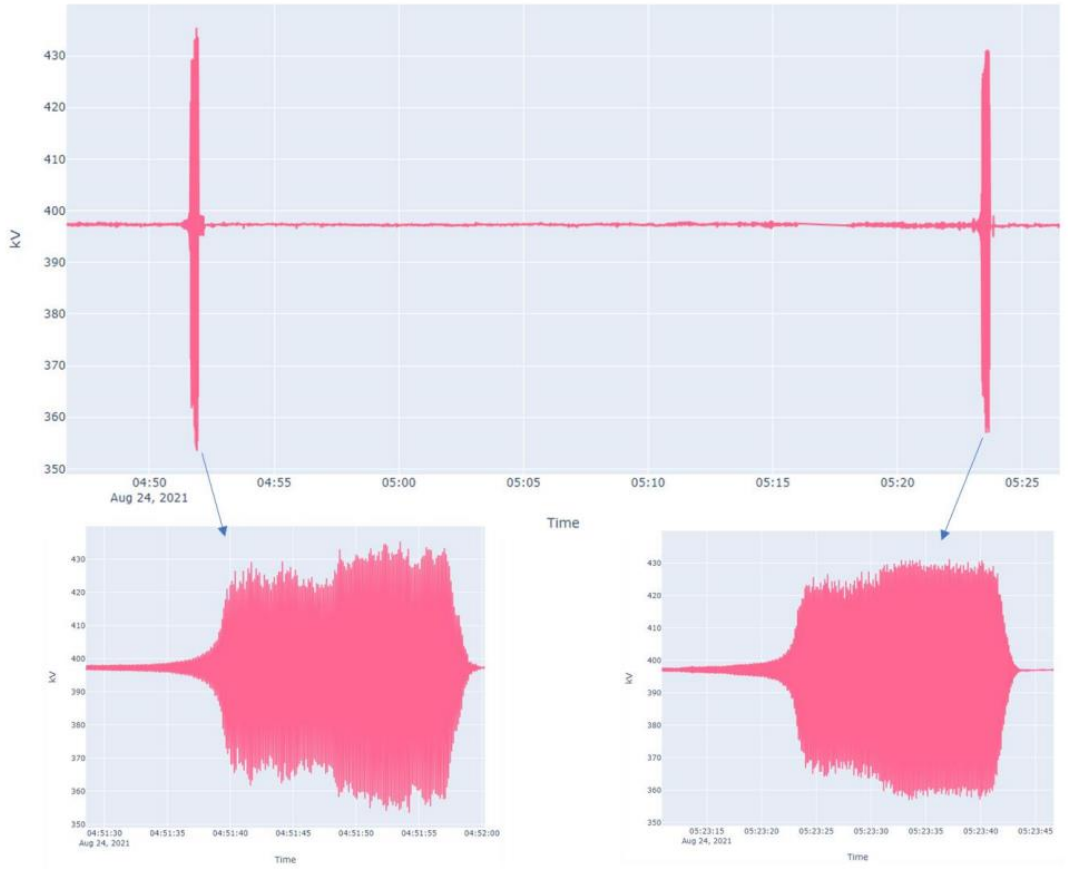
Past events

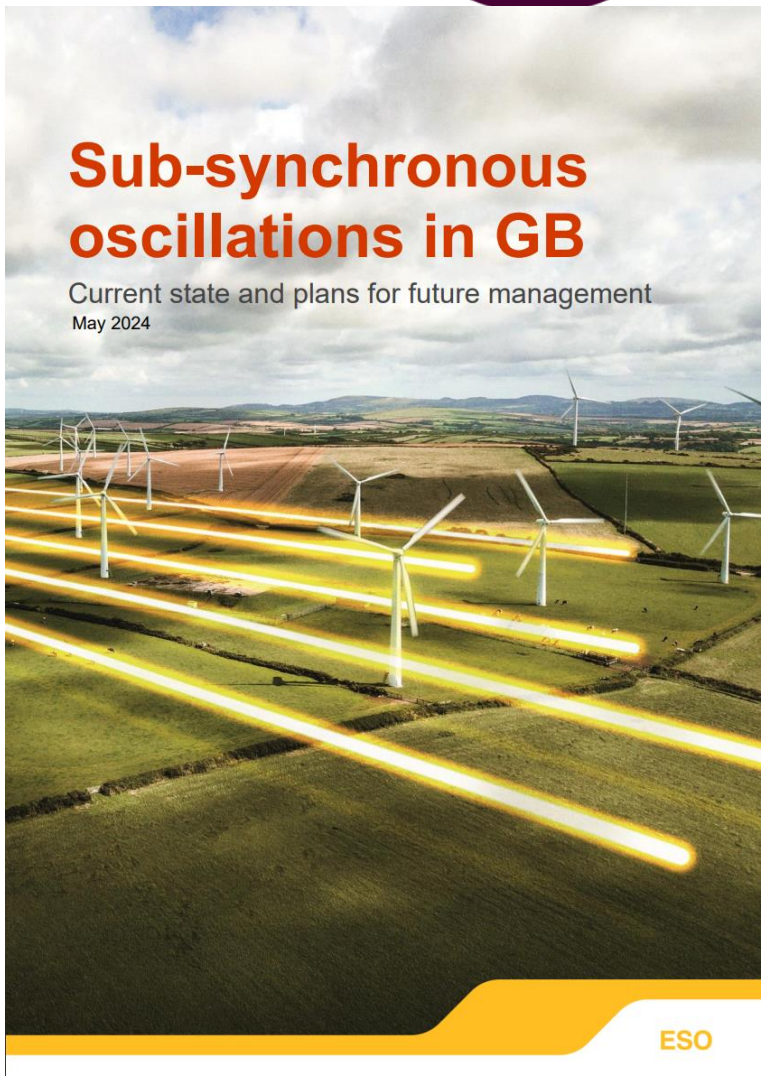
- A few sub-synchronous oscillations occurred since 2021. Range of frequency 3-20Hz. None of these events resulted in loss of supply.
- Not associated with a specific technology, short circuit level or the level of inertia.
- Example from 2021 oscillations is shown in the figure.
- Further details on Summer 2023 event is described in our paper.



Sub-synchronous voltage oscillations (8Hz) recorded in GB transmission system, North Scotland, in 2021.

Paper has been published!

- If left undamped, sub-synchronous oscillations can cause equipment damage, disconnection of generation and in the worst-case scenario loss of supply.
- Not a new phenomenon.
- Not associated with a specific technology.



Link to the paper

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2023 SSOs: What happened?

During June and July 2023, 8Hz Sub-synchronous Oscillation (SSO) occurred on five separate days, all centred in the Scottish network. The SSO was in the range 5 – 9Hz, mainly at about 8Hz (approximately 1/6th of 50Hz nominal frequency)

The SSO events caused disturbances on the power system which included the tripping of generation, tripping of an interconnector and HVDC link, and in one case a transmission circuit trip.

NESO initiated defensive measures and started an investigation after the first event. A dedicated project team was established after the second event.

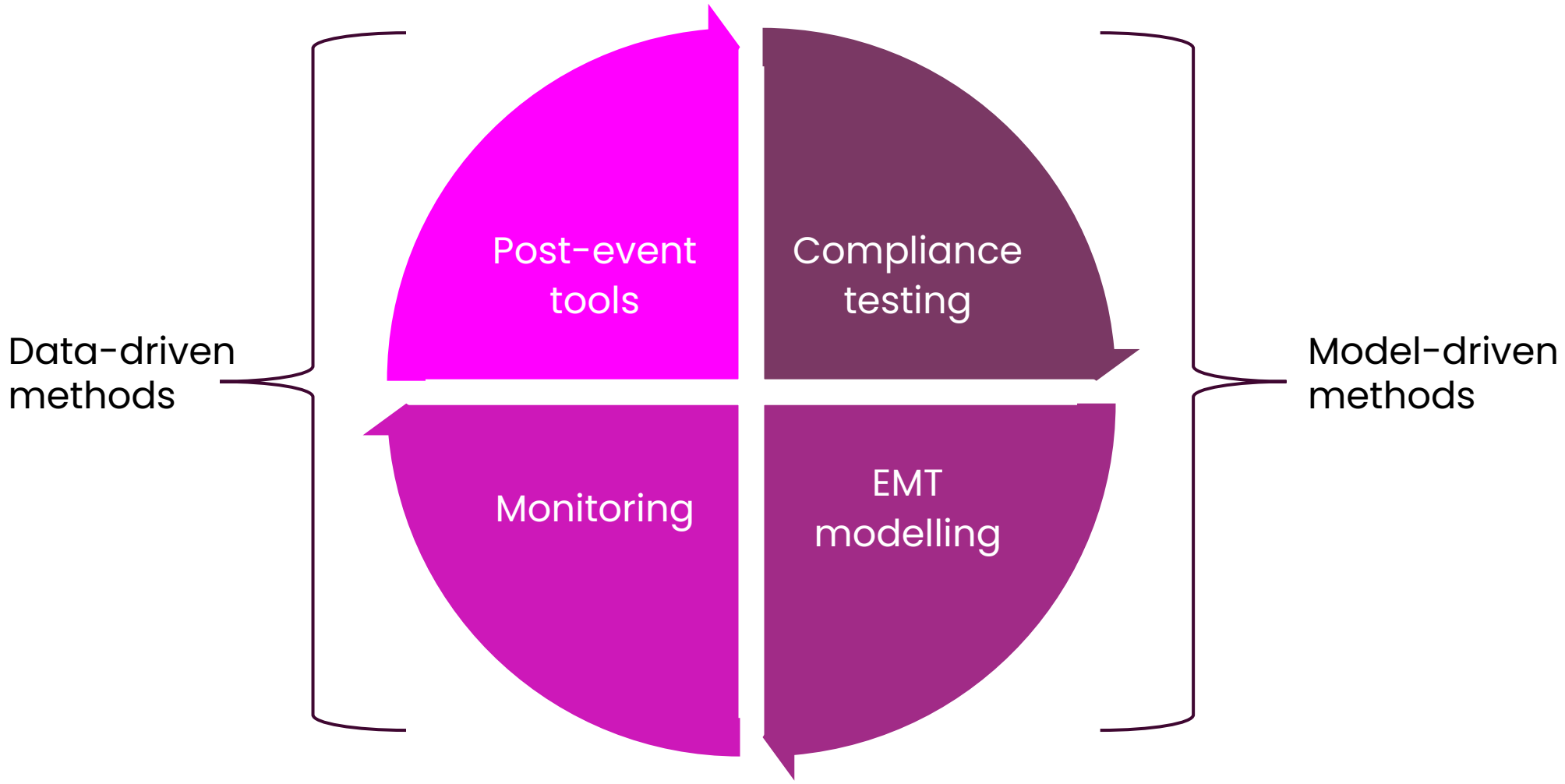
The project team led the investigation, co-ordinated the response across NESO and managed communication with relevant parties.

The most likely cause of the SSO was identified in mid-July.

The project team was stood down on 24th July 2023 and responsibility for concluding work transferred back to the relevant teams.

Changes have been made and there have been no further undamped SSO events in 2023.

Mitigations to the risk of oscillations



Real time monitoring

- We are building and integrating a Wide Area Monitoring System (WAMS) with oscillation monitoring functions.

- We are collaborating with SSEN-T on INSIGHT project, a Strategic Innovation Fund project that aims to create a virtual, real-time alert and control system that can highlight oscillatory instabilities on the network and then automatically inform control actions required to dampen/remove them.

- We tested a new monitoring system which relies on measurements on the distribution system, collecting data at a high frequency. The system proved effective and significantly improved the real time visibility of system damping and sub-synchronous oscillations.

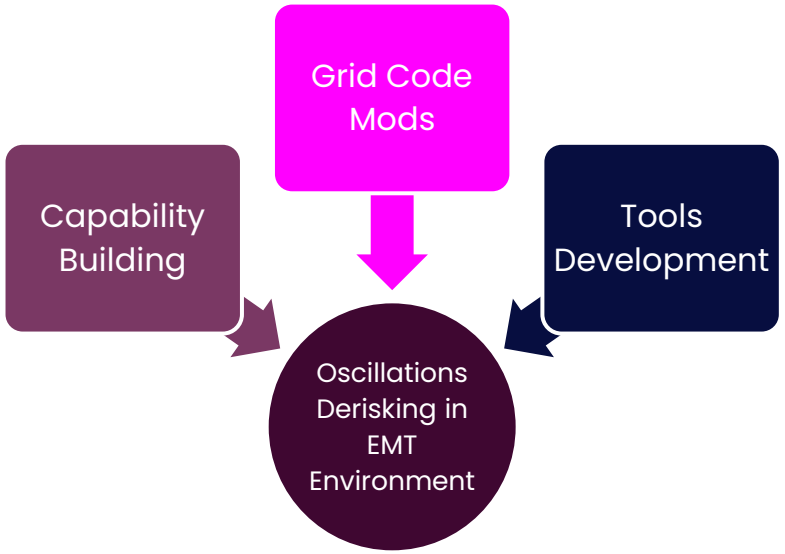
EMT modelling

- Accurate EMT modelling allows us to analyse and investigate various phenomena including oscillations.

- GC0141 (approved): Plants connected on or after September 2022 is required by Grid Code to share with NESO at the compliance stage an EMT model that accurately represents the connected plant.

- GC0168 (proposed): Require certain Users to provide NESO with EMT models.
- Capability building: New team and infrastructure to accommodate the computation need from EMT models.

- EMT Tools development to de-risk oscillations: example, Automated Identification of Sub-Synchronous Oscillations (SSO) Events.



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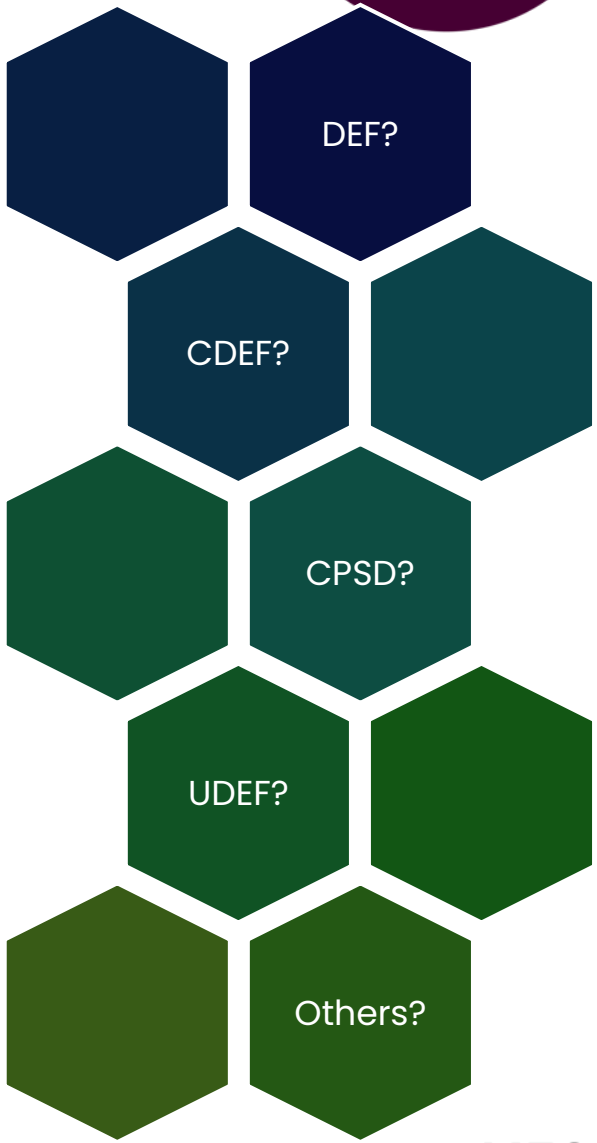
Post-event tracing tools

- Various data-driven have been proposed in literature to trace the source of oscillations.
- Some of these methods are well developed and tested in synchronous machine-based system.
- NESO tested a few existing methods on SSO events. Some of these methods were not effective, highlighting the need to do further evaluation and development of tools.
- We launched a few innovation projects to evaluate and develop tracing methods in IBR environment.



Compliance testing

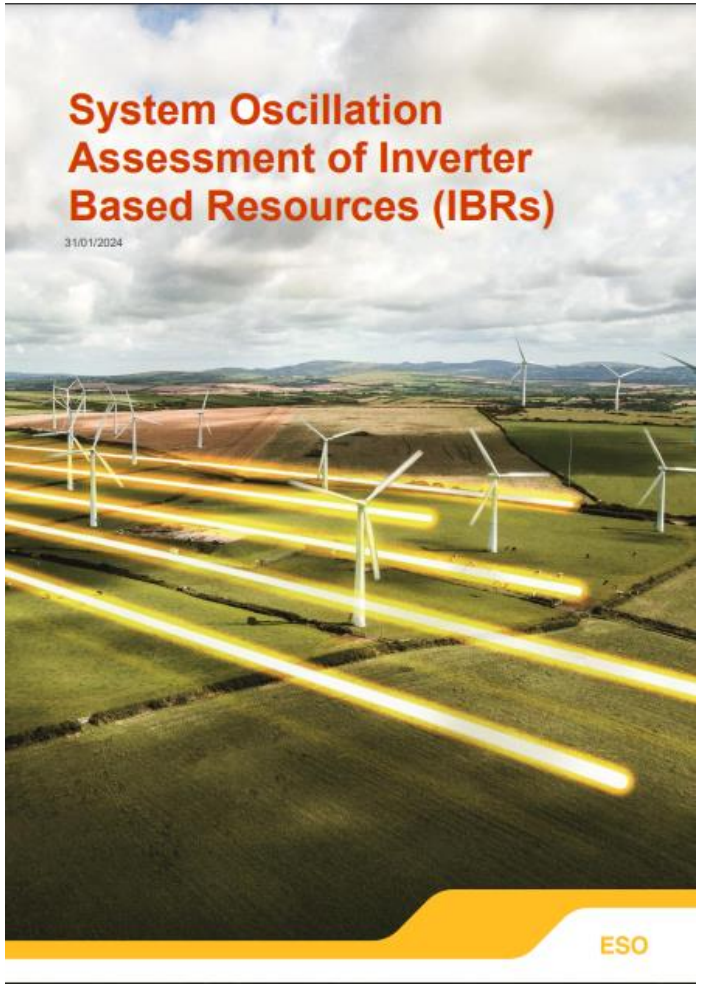
Compliance testing

- The oscillation assessment guidance has been published recently on the back of sub-synchronous oscillations investigation.

- The guidance describes a set of small signal studies which should be carried out by Users as part of the connection compliance process to demonstrate good damping performance.

    - Step change
    - Small signal injection study
    - Frequency scan
    - Eigenvalue analysis

- Quality Assurance Issues based on previous events: NESO suggested proposals to give further confidence that suitable quality assurance measures are in place for site commissioning activities. More can be found here.



Link to the guide

Test 1 – Step change

Test criteria:

Recommended Test Parameters:

1. ±5% step change in AC grid voltage from nominal voltage.
2. ±30-degree Phase Jump in AC grid voltage angle.
3. ±3% step change in AC grid Voltage combined with ±10-degree phase jump in AC grid voltage angle.

Acceptable Response:

11. Response time should be within the timings specified in the Grid code.[5]
12. Overshoot should not be more than 5% peak to peak and settling time should be less than 2s.

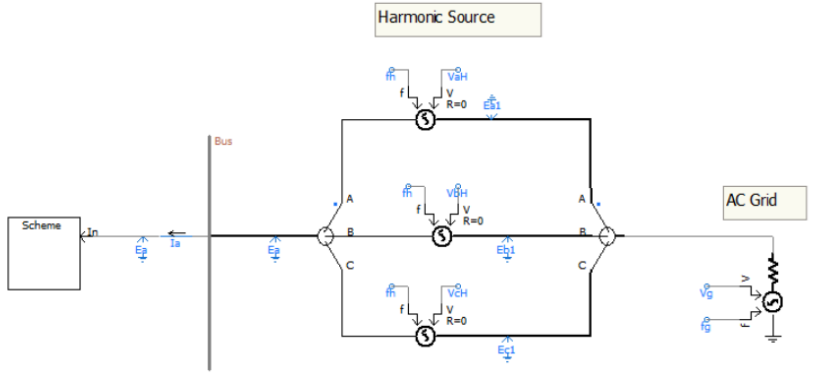
Test 2 – Small Signal Injection Study

2.1 – Voltage magnitude oscillations

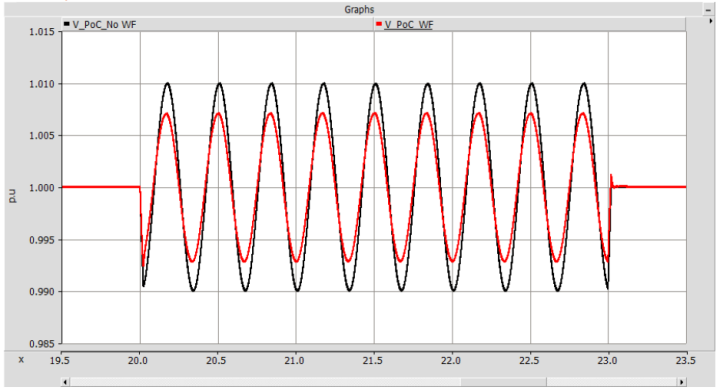
Test criteria:

Recommended Test Parameters:

1. Frequencies ranging from 1Hz to 100Hz (or desired frequency range of interest) to be injected in series with the grid with no more than 1Hz gap in each simulation.
2. An injection signal magnitude of 1% of nominal voltage is recommended. The User is allowed to choose a different injection amplitude as long as the overall system remains in the linear region.
3. Injection should remain until steady-state conditions have been reached.



Case 1 plots:



Acceptable Response:

Acceptable Response:

11. No increase in magnitude of injected oscillations, ideally the system should damp any oscillations. The response shall be demonstrated by plotting the transmission interface point (TIP) or PCC voltage with and without the scheme being studied. Refer to appendix for expected response from this study.
12. Once the injection is removed the system should recover immediately to pre-disturbance conditions.

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Test 2 – Small Signal Injection Study

2.2 – Voltage phase oscillations

Test and acceptance criteria:

In this test, the Thevenin voltage source angle is modulated to observe the behaviour of the scheme. The test parameters and scenarios referred in section 1.2.1 should be performed for this set of simulations. The frequency control function should be disabled for this test and a phase angle modulation of ±2 degrees should be applied.

Acceptable Response:

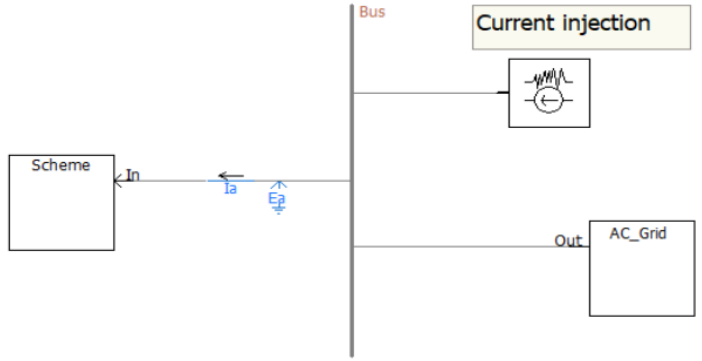
1. It is expected that grid following converters show very limited response for angle oscillations.
2. Grid forming plant would have a P/f droop response below the 5Hz range. The inertia element of the grid forming plant is expected to be in phase with the modulated angle.
3. Once the injection is removed the system should recover immediately to pre-disturbance conditions.

Test 3 – Impedance scan

Test criteria:

Recommended Test Parameters:

1. The injected current or voltage amplitude should not be so small that it is lost in the noise and should not be large enough to cause any non- linear effects.
2. The frequency increment should be chosen so that no impedance vs frequency information is lost.



Acceptable Response:

Acceptable Response:

12. The resistance (R) of the scheme under scrutiny should be positive throughout the frequency range. In case the negative resistance is observed further investigation shall be required.

Test 4 – Eigenvalue Method

Test criteria:

In the past it has been considered a complicated method to estimate the Eigenvalues but nowadays this functionality has been included in power system tools which solves the state space solution and provides oscillation modes, frequency of oscillation and damping co-efficient.

In order to validate the study, it is recommended that results obtained from the Eigenvalue method should be consistent with the results obtained from studies of Section 1.1,1.2 and 1.3.

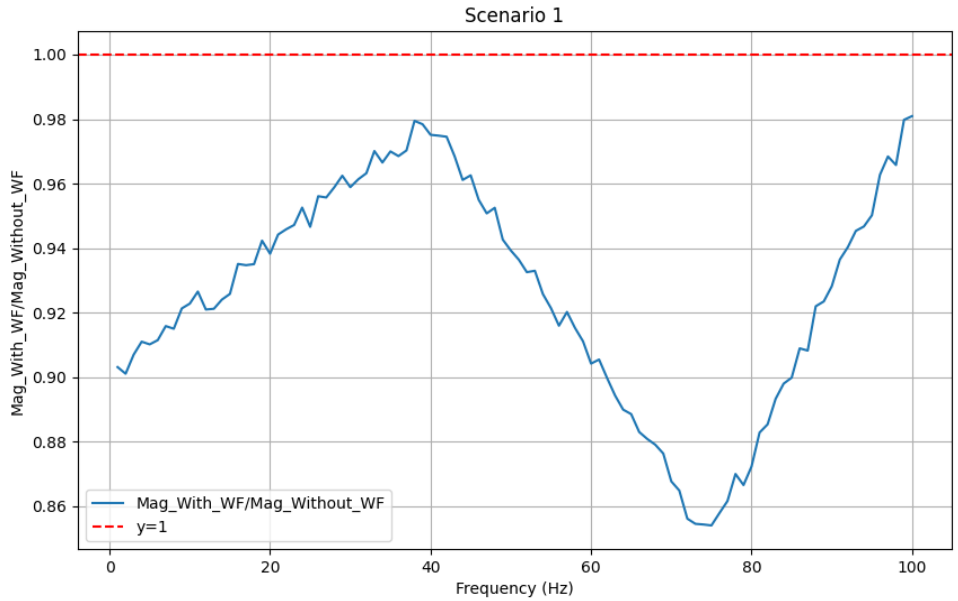
Acceptable Response:

Acceptable Response:

1. Minimum 10% damping ratio is expected for all oscillation modes.

What's next?

- We are preparing to issue the second version of the guidance which takes on board comments from customers and wider industry.
- The second version of the guidance will include:
  - Guidance on data visualisation.
  - Reduced number of scenarios where possible.
  - A more specific guidance for each technology.
  - Harmonisation with the Grid Code requirements, where possible.



Public

Breakout session:

Grid Connection Simulation Tool

Gopi Yericherla

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Contents

Model Sharing – Current Practices (for HVDC Projects- RMS Model)

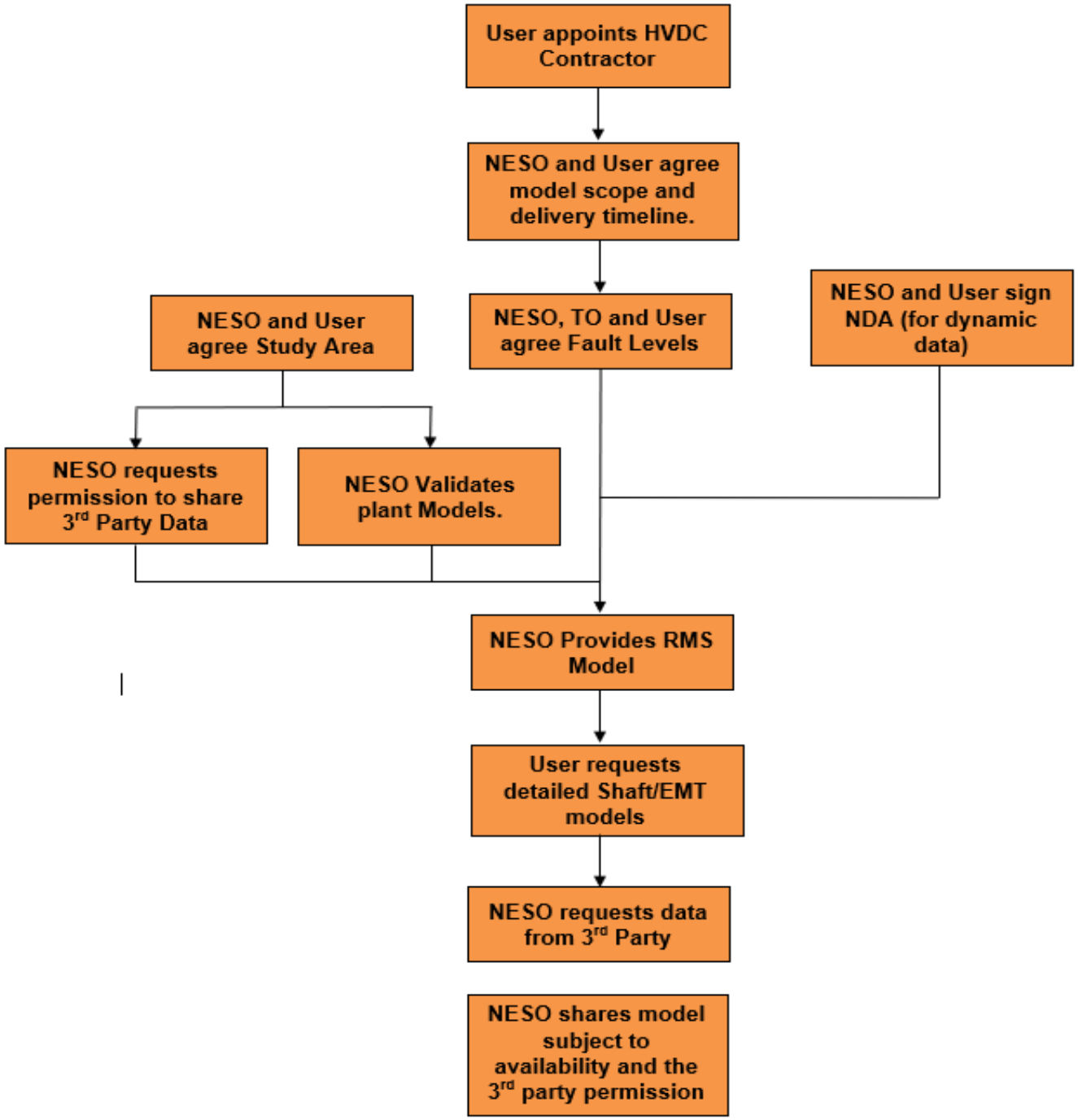
- Grid Code ECC.6.3.17 - User to ensure its HVDC converters (including controllers) within the HVDC system do not cause negatively or lightly damped resonances or interactions on the NETS .

- NESO Published guidance notes for model exchange for converter-based plant interaction studies (January 2023) - https://www.neso.energy/document/261766/download.

- The current practice is that NESO to provide Root Mean Square (RMS) model for the User, in association with the relevant Transmission Owner (TO).

- User then convert the RMS model provided by NESO to Electromagnetic Transient (EMT) model to carry out interaction studies.

Model Sharing – Current Practices



Challenges – Model Sharing

- Grid Code requires Generators and HVDC Interconnector Owners (Users) connected since September 2022, to provide detailed and validated Electromagnetic Transient (EMT) models and that could be shared with other Users.
- Challenges:
  - EMT models for Users connected before September 2022 are not available.
    - NESO is working through Grid Code Modification (GC0168) to get the retrospective EMT Models
    - NESO is also working on STC code modification (CM097) to get the required EMT models for TO Assets.
  - Sharing models, particularly third-party models, can be challenging and often involves lengthy discussions regarding NDAs and IP protection. It is not practical to enter into specific NDA with every manufacturer.
    - ESO's view is that the obligation to provide the models is on the user and they need to sign NDA with manufacturer if required to apiece their concerns.
    - NESO has been exploring a project focused on the feasibility of running a large EMT network area on a cloud-based platform.
    - This platform would allow vendor plant owners to connect their plant models to a designated point in the NETS and perform EMT studies without exposing sensitive network data or that of other Original Equipment Manufacturers (OEMs).

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Sample Network Model

- To meet the Grid Code **PC.A.9.7.7** and **PC.A.9.9.3 (x)** requirements-
  - The user shall demonstrate that the model(s) remain representative of the user system performance regardless of whether the user system model(s) is connected to a Thevenin equivalent network or to a multi node power system network.

- GC0141 - The company proposes the use of the **IEEE 9 bus system** model (available in PF & PSCAD)

- The PSCAD technical note mentions that future upgrades to the IEEE 9 bus system include replacing voltage sources for detailed machine models and the flexibility to modify fault levels to replicate the system strength condition at the specific point the user will connect to the network.

- The requirement to test the model(s) against the IEEE 9 bus system is **not applicable** to **HVDC links** connections.

- HVDC links projects are required by the Grid Code to carry out **SSCI** and **SSTI** as per “guidance notes for model exchange for converter-based plant interaction studies “.

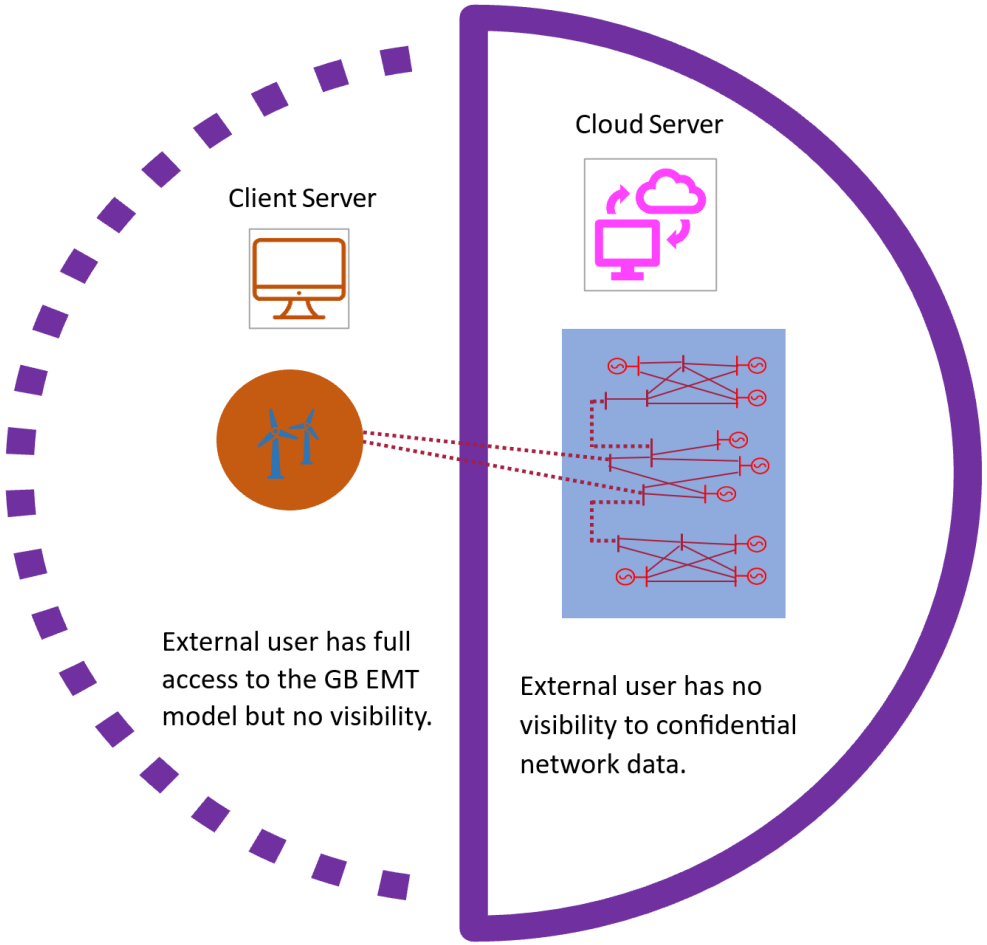
Trial Project – EMT Network Model Provision

- Recently, NESO has undertaken a trial project to provide an EMT network model to a User for conducting SSCI and TOV studies.

- The primary reasons for this initiative include:
    - Presents an opportunity for NESO to prepare for **future scenarios** where similar efforts will be necessary when a web-based connection portal is established for User interaction studies
    - It has provided valuable insights regarding **resource requirements**, **approximate timelines for completion**, and **the identification of technical limitations** and **assumptions**.
    - In cases where nearby vendor models are unavailable, **generic models** can serve as an alternative. This trial has allowed NESO to enhance its experience in **developing Generic EMT** models.
    - The experience gained from EMT network model development will be particularly beneficial in a scenario where **two new Users are connecting** one after the other in proximity.

- This trial project provided key learnings and capabilities to NESO on the development of EMT models for User to carry out interaction studies.

Grid Connection Simulation Tool



Features:

- Confidential electrical connection across servers
- User only sees the connection point and potentially beyond (upon consent).
- Plant owner confidentiality is protected
- Automated PSCAD start/stop scripting tied to client-side run.
- Client influence on the study undertaken and ability to apply range of network disturbances.
- Measurement transfer between servers
- Full UK wide-area PSCAD model
- Re-dispatch of new operating conditions
- Selection of smaller region to speed up studies
- Automatic results request generation
- And more!

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Grid Connection Simulation Tool

Accelerated plant design finalization

- Improved visibility of plant interaction with the wide-area UK network
- Enhanced model quality
- Early problem identification and mitigation
- Speed up connection
- Overcoming **NDA**

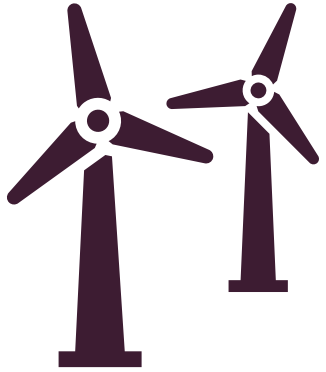
Time savings

- Faster approval process enables quicker plant operation
- Reduced process iterations lead to time savings.

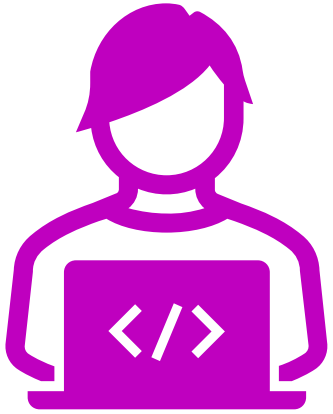
Cost savings

Cost saving as a result of expedited design completion

Users of Grid Connection Simulation Tool



Plant developers and OEMs



Engineering Consultants

Academic Professionals

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GCST Innovation Project – Current Status

- The Project was kicked off in Jan 2025.
- Currently MHI & NESO IT team in working on WP1, WP2 and WP3.
- 18 months to complete the project and get productionize in NESO.
- Take the support of some manufactures (model developments) to test the tool.

Work Pakage	Activity
WP1	PSCAD Cloud Infrastructure Assessment
WP2	Determination of Hardware and Software Needs
WP3	Security & Collaboration Framework
WP4	Proof of Concept Development
WP5	User Accessibility
WP6	Automation Tool Development
WP7	Scaling the Proof of Concept to Full System Application
WP8	Comprehensive Testing and Validation
WP9	Knowledge Transfer and System Handover

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Q&A

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Breakout session:

Compliance Requirements for Co-located Sites

Tanmay Kadam

NESO
National Energy System Operator

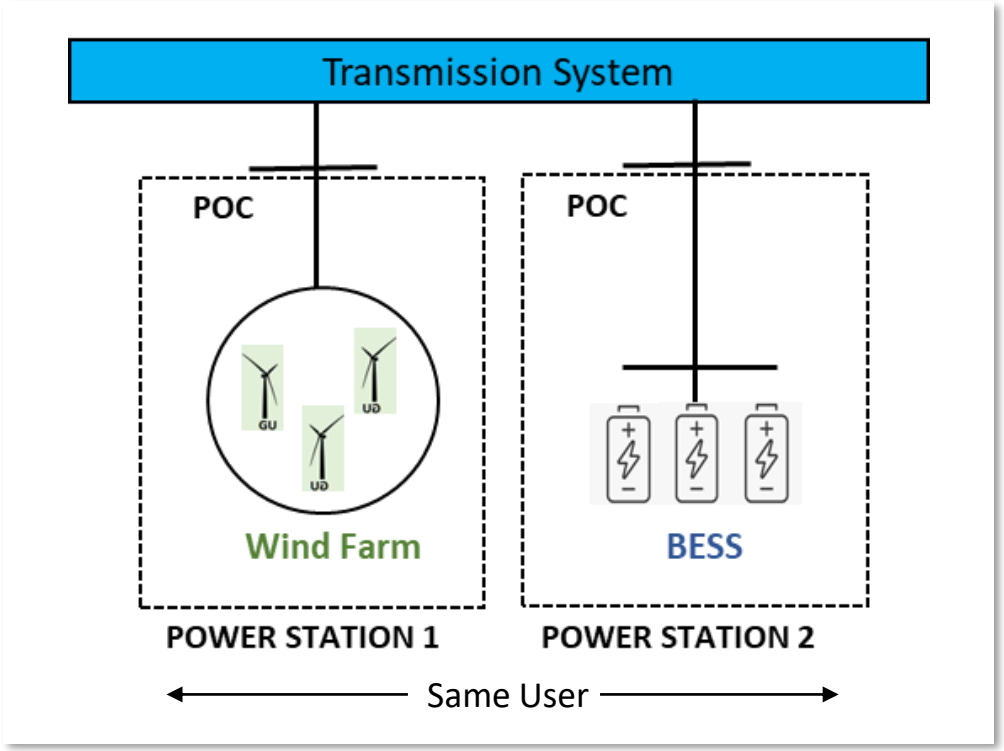
Agenda

- Types of Grid Connections
  - I. Parallel Connection
  - II. Consolidated Connection
- Independent Control Configuration
  - I. Grid Code Compliance
- Supplementary Control Configuration
  - I. Grid Code Compliance

Types of Grid Connections | Co-located Sites

Parallel Connection

- New technology being co-located is connected directly to the transmission system at an existing or contracted connection site but with a **new independent connection point**
- User may opt for a new Connection Application for an independent connection point to the transmission network which would be treated as a **separate power station** with a **separate Bilateral Connection Agreement** (BCA)

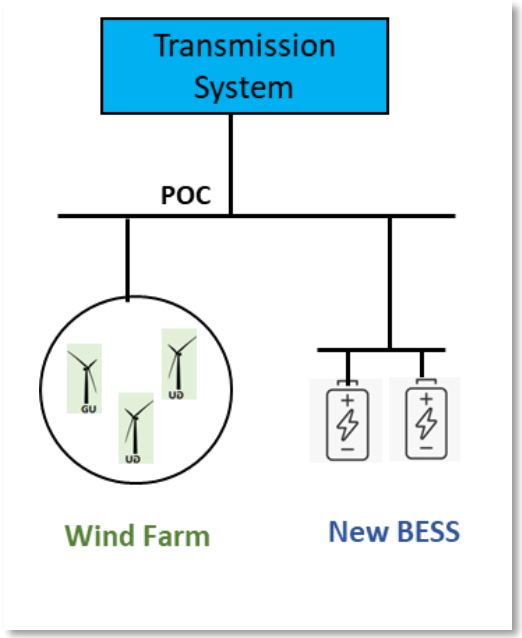


Types of Grid Connections | Co-located Sites

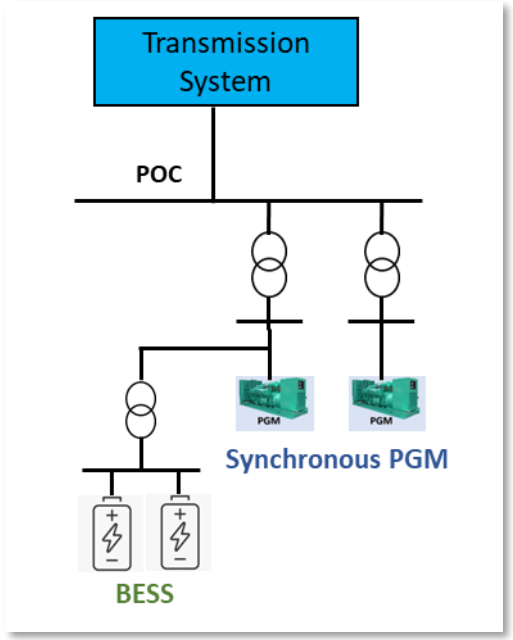
Consolidated Connection

- New technology being co-located is connected to the transmission system **behind an existing connection point** at the existing (or contracted) connection site
- A **Modification Application** will be required to review and potentially amend the existing Bilateral Connection Agreement (BCA) prior to connection to include the relevant technical requirements of modified site in respective Appendix F of each technology

Independent Control



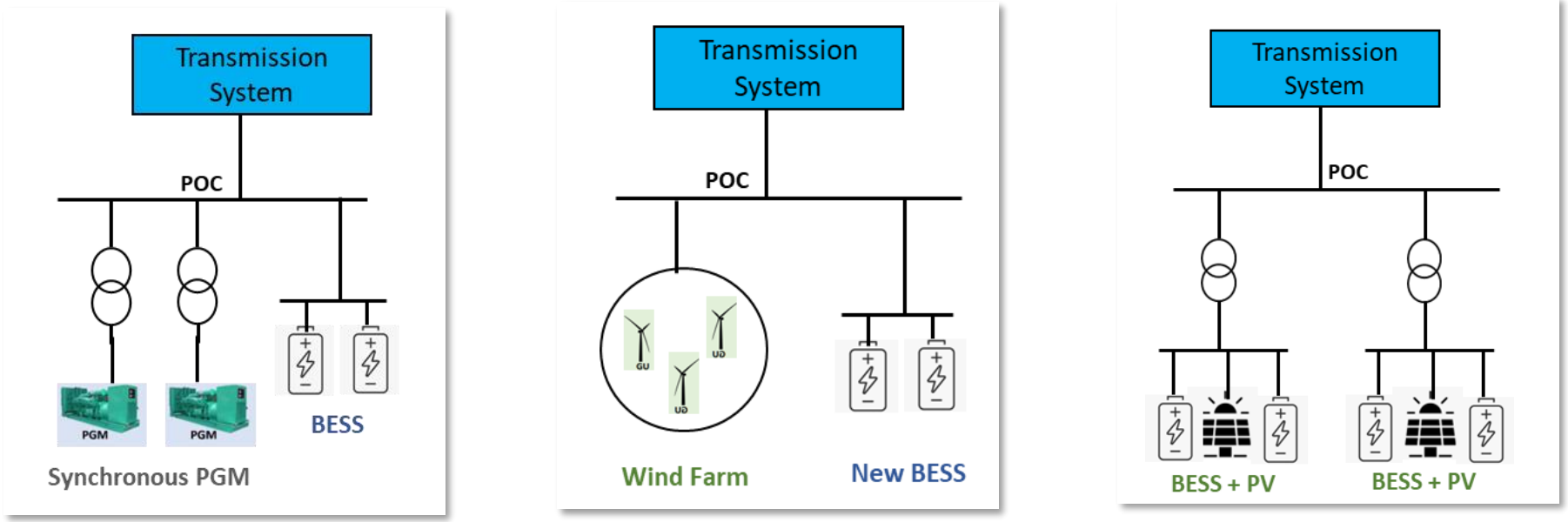
Supplementary Control



Consolidated Connection | Independent Control

Grid Code Compliance

- Consider a co-located site with Wind Farm and BESS technology. The Grid Code compliance shall be demonstrated in the following stages:
  - Stage 1: Full Compliance when Wind Farm is operational, and BESS is out of service
  - Stage 2: Full Compliance when BESS is operational, and Wind Farm is out of service
  - Stage 3: Reduced Compliance may be agreed when Wind Farm and BESS, both are operating together

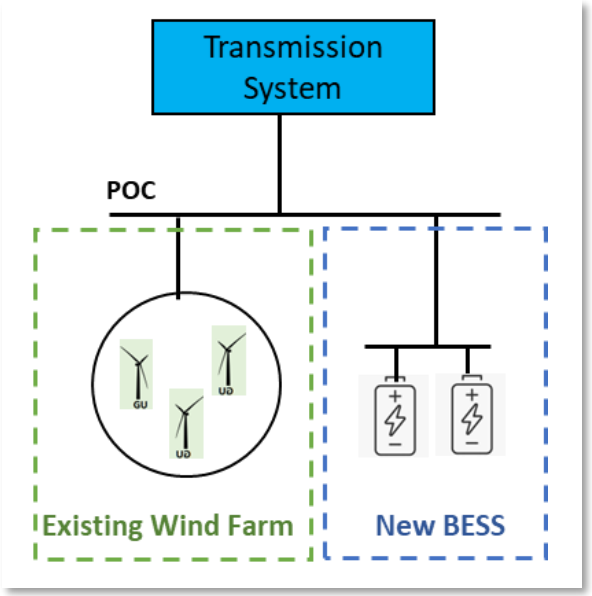


Examples of Co-located Power Stations

Consolidated Connection | Independent Control

Grid Code Compliance

- What if the existing Power Generating Modules have already achieved FON?
  - Full Compliance of new Power Generating Modules in standalone operation with respect to latest Grid Code
  - Reduced Compliance may be agreed when both the existing and new Power Generating Modules operating together
  - Existing Power Generating Modules (GB Code Users) may continue to demonstrate compliance with respect to the GB Code unless the User undertakes Substantial Modification to the existing Main Plant and Apparatus
- The Power Generating Modules of different technology and/or fuel type shall be classified into separate BM Units so they would need to be separately instructible and controllable



Independent Control | Compliance in Stage 3

Before Synchronisation to the Network

Simulation Studies (detailed scope to be agreed on case-by-case basis)

- Voltage Control and Reactive Capability
- Fault Ride Through
- Frequency Response
- Model Submission and Verification

After Synchronisation to the Network

Onsite Test Results (reduced scope may be agreed)

- Voltage Control
- Reactive Capability (not all tests mandatory)
- Frequency Response (not all tests mandatory)

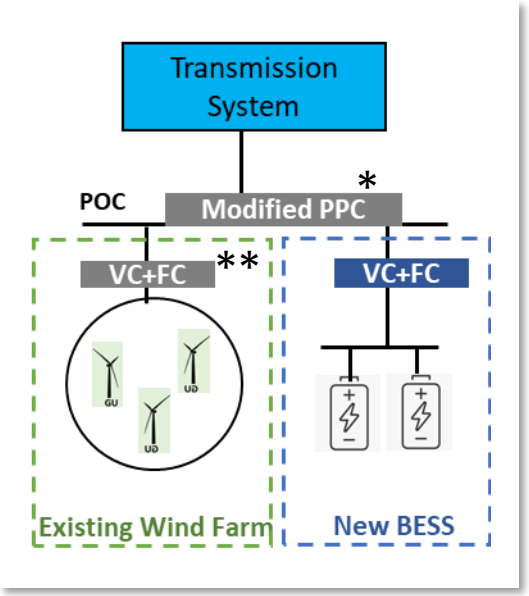
Model Submission

For existing Users intending to Co-locate

- Where an existing User intends to undertake modification or control system change to an existing Power Park Module, this shall invoke PC.A.9 model requirements
- Users are advised to contact NESO at the earliest stage in the Compliance to identify any potential risks and ensure they meet the Grid Code requirements in timely manner

For New Co-located Connections

- RMS and EMT models of entire Power Park Module as per PC.A.9 to be submitted for compliance



*: Power Park Controller

** VC: Voltage Controller, FC: Frequency Controller

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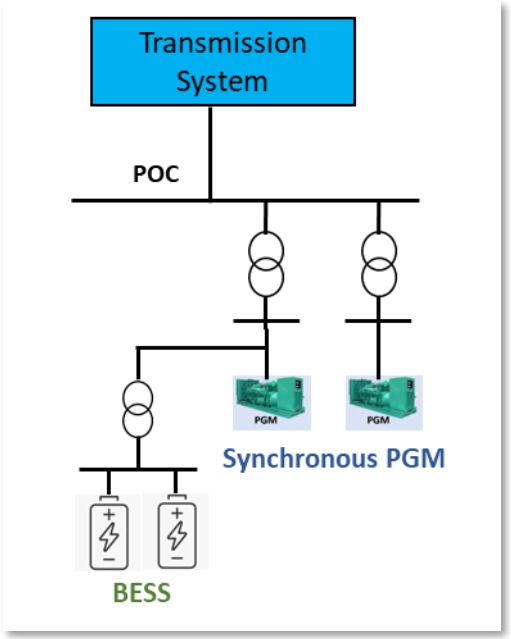
Consolidated Connection | Supplementary Control

What is Supplementary Co-location?

- A facility comprising newly added Generating Units of different technology that are linked to the operation of the existing Generating Unit **AND both modules cannot be independently controlled and operated**
    - For example: BESS is installed to enhance frequency response of Main Plant, such that it cannot operate on its own independently and will always be operating in combination with the existing Generator.

Grid Code Compliance

- If the modification to an existing Generator is planned after the EU Code implementation cut off times (27th April 2019), then the whole plant will be accessed against EU Code requirements
- The compliance will be assessed with respect to the enhanced capability of the Main Plant, i.e. Main Plant's frequency response capability will be assessed while the assistance is provided by the storage device



Thank You!