INSIGHT

Innovative **N**etwork **S**tatus **I**ntelligence **G**athered by **H**olistic use of **T**elemetry

Alpha Phase: ‘Show and Tell’

22nd April 2024

ESO

University of Strathclyde Glasgow

The National HVDC Centre

“This project is funded by network users and consumers under the Strategic Innovation Fund, an Ofgem programme managed in partnership with UKRI.”

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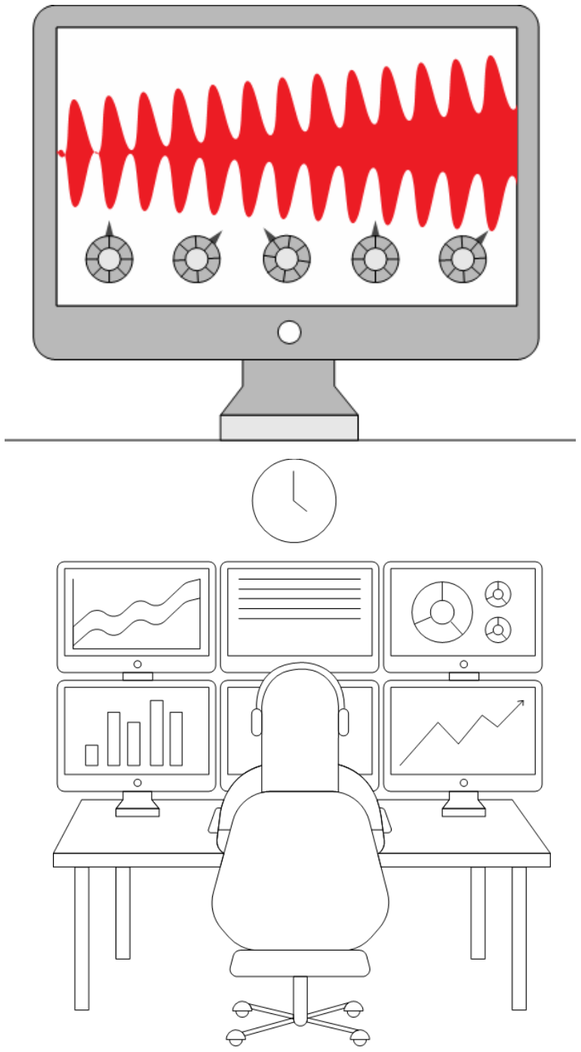
Problem Statement

The **Net Zero** energy system transition is causing new types of oscillations on the electricity transmission network

What is the problem?

- Renewable energy sources such as wind and solar are interfaced to the grid using **inverters** (power electronics) that have very different dynamic behaviour to fossil-fuel based generators
- **Inverter-based Resources** (IBRs) can interact with one another in ways that are difficult to predict and understand, causing oscillations on the grid
- **Inverter-based Oscillations**, have been experienced on power systems worldwide. They have the potential to reduce system reliability, cause equipment to maloperate, or in extreme cases, become damaged.



What is needed?

To manage IBR-based oscillations we need:

- **Visualisation and Analysis tools** to help network operators alert, identify, locate and understand oscillation modes.
- **Control and Mitigation tools** to help network operators take appropriate actions to mitigate oscillations when they occur.

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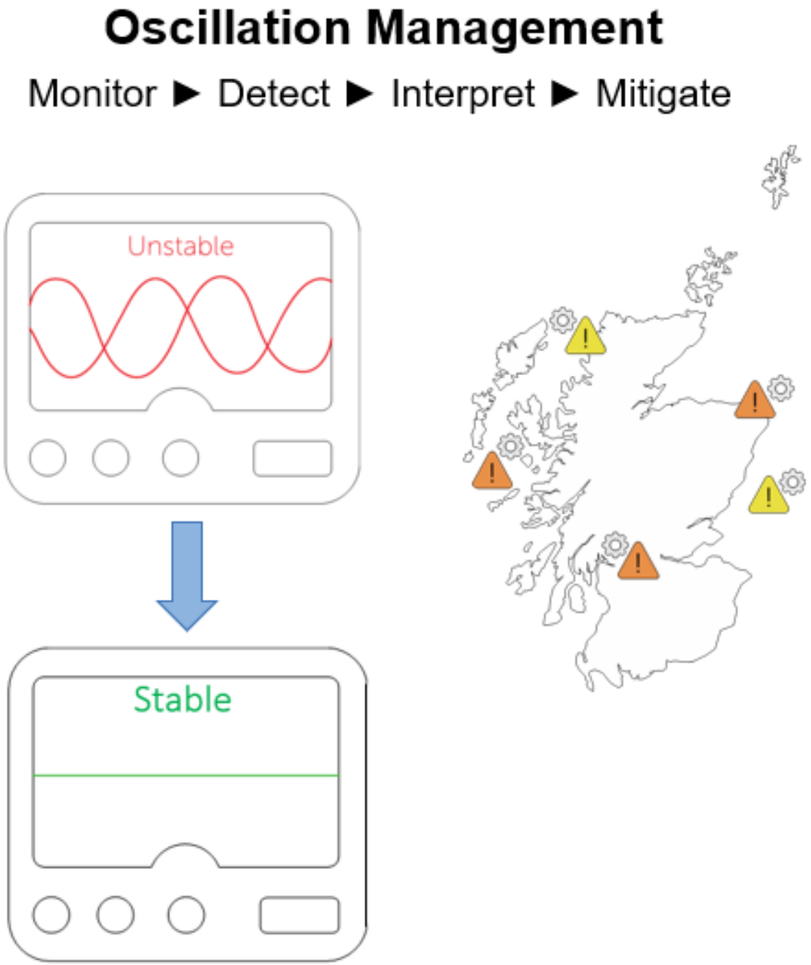
Project Overview

The **INSIGHT** project combines learnings from past oscillation events with new modelling and simulation techniques to better understand:

- The nature of these new oscillations.
- How to detect and address them in network design and operation for future events.

A key part of developing the solution is to build upon previous innovative work that focused on system stability dominated by power electronics covering:

- Modelling and simulation of IBR-rich networks and power system oscillations.
- Identifying technology solutions for monitoring and mitigating oscillations.



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User Needs

- **System Operator**: improve system operability and reduce balancing costs.

- **Network Owners**: improve network performance.

- **End User**: the eventual solution will be aimed at providing information to control room staff
  - **Need to consider**: alert only, alert and recommend actions, or alert and consider the best course of action.
  - UI will need development in subsequent project stages.

Potential solutions: proposed test-bed architecture to enable potential solution providers to demonstrate their solutions.

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Approaches to Address the Problem

The approach of the INSIGHT project has several elements:

1. Understanding the causes of IBR-based oscillations:
   - **Oscillation Events (Modelling & Simulation) - Led by Strathclyde University**

2. Understanding the oscillation monitoring capability on the Transmission Network:
   - **GB System Monitoring Roadmap - Led by SSEN Transmission**

3. Understanding the availability of potential solutions:
   - **Engagement with stakeholders & technology providers - Led by ESO**

4. Understanding the value provided by solutions:
   - **Cost Benefit Analysis (CBA) development - Led by SSEN Transmission**

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Work Package 2 - Engagement with Stakeholders

This work package:

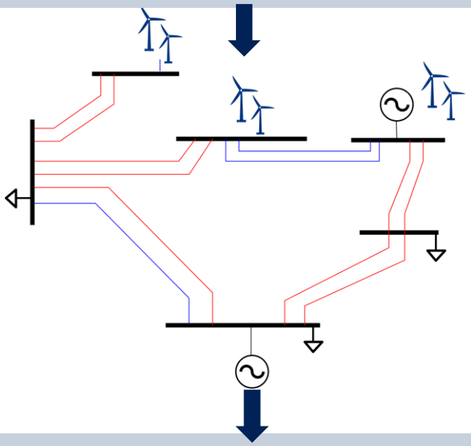
- Built on the output of the discovery phase (targeted questionnaire)
- Investigated current innovation best practice for oscillation detection and mitigation
- Held targeted webinars to disseminate progress on the project and seek engagement with potential suppliers and other interested organisations
- Held 1-2-1 sessions with interested parties to understand:
  - Their product(s)/solution(s) and readiness to meet the needs of the project
  - Their interest in participating in future project stages

WP3 Oscillation Events - Modelling and Simulation Studies

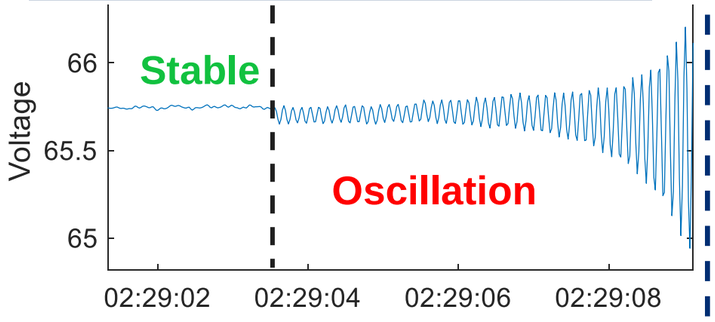
1. Modelling and Simulation

Analytical model of oscillation mechanism

Representative test network: North Scotland transmission system

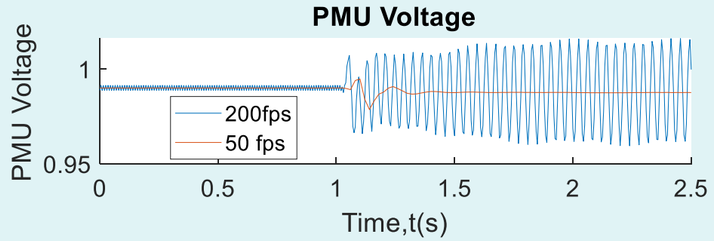


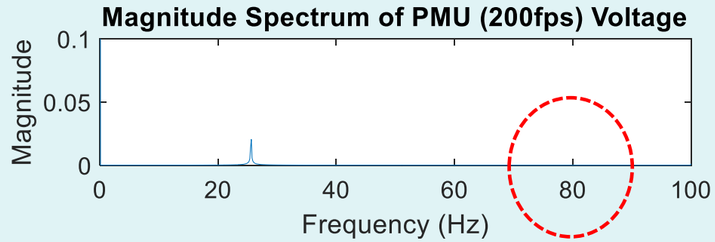
Simulation case studies



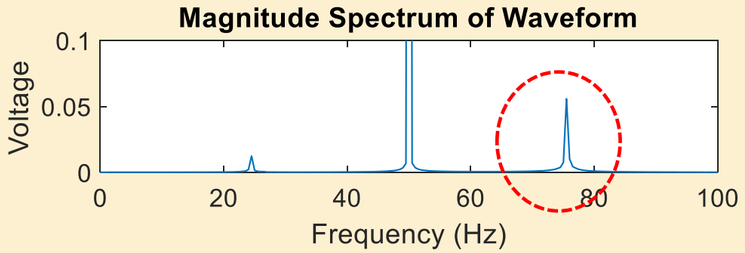
2. Analysis of IBR-based Oscillations

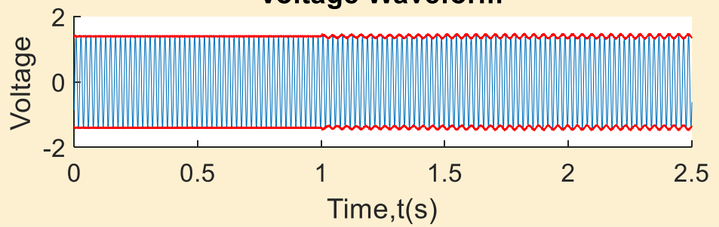
Phasor Measurements - streamed in real time





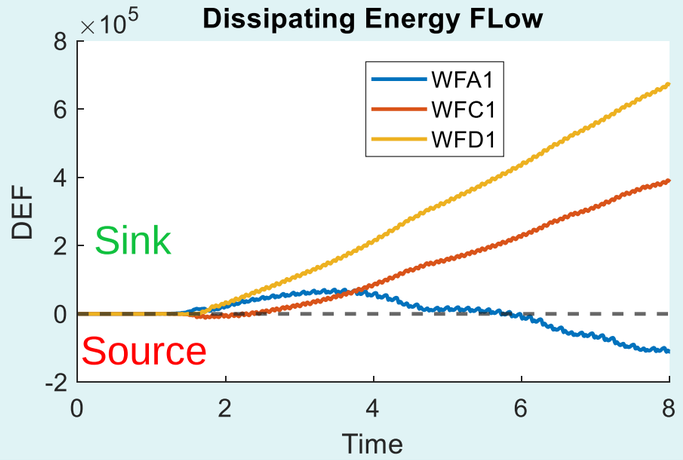
Waveform: not typically used in real-time



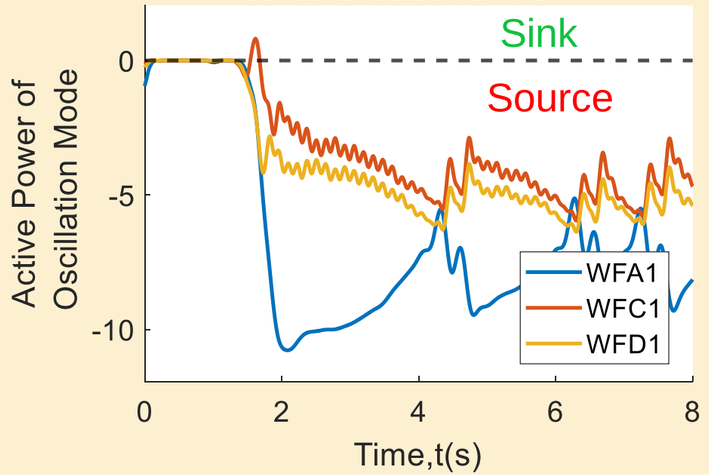


3. Evaluation of Oscillation Location Methods

Example: Dissipating Energy Flow – Phasor based



Example: Oscillation Power – Waveform based



WP3 Oscillation Events - Modelling and Simulation Studies

Key Findings:

1. Modelling of IBR-based Oscillations:

- More detailed analytical modelling required to improve understanding and support informed modelling tuning
- Network model needs to be expanded and further developed for realistic testing.

2. Analysis of IBR-based Oscillations

- Traditional measurements (phasors) have limitations in monitoring emerging oscillations
- Increasing phasor reporting rate can improve oscillation analysis
- Waveform measurements (not typically utilised in real time) appear to better characterise oscillation mechanisms

3. Evaluation of Oscillation Location Methods

- Existing oscillation analysis and location methods can be unreliable
- Inconsistent outcomes observed with different methods for emerging oscillations

Work Package 4 - System Monitoring Roadmap

WP4 reviewed the current state of system monitoring:

- A Look-ahead to what is currently planned for the next 5 years with a focus on the north of Scotland transmission network.
- To show what visibility and monitoring data would be available from the system without any specific device installation for the INSIGHT project
- Transmission & Industry Codes and Standards that apply to all Onshore TOs
- Proposed some next steps

SSEN Transmission Network

PMU – Phasor Measurement Unit

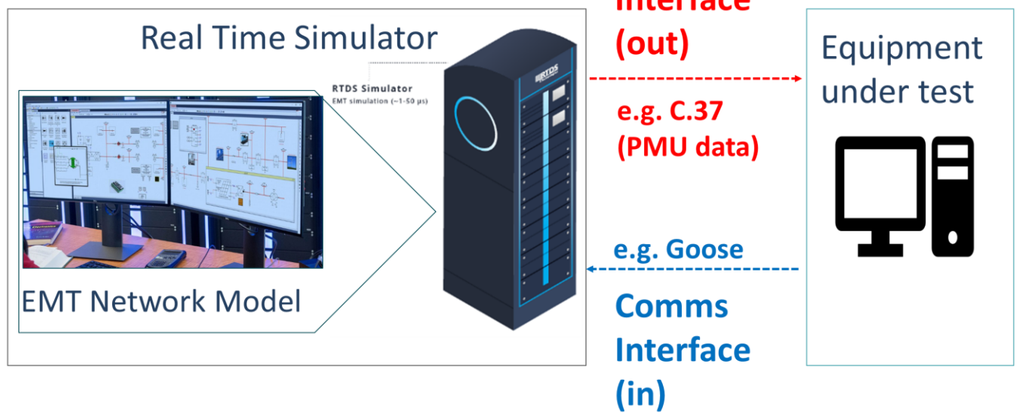
DFR – Digital Fault Recorder

Voltage	PMU	DFR
132Kv	40%	60%
275kV	70%	85%
400kV	100%	100%

NOW

Voltage	PMU	DFR
132Kv	60%	75%
275kV	95%	98%
400kV	100%	100%

2030



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Potential Benefits

Financial and Environmental

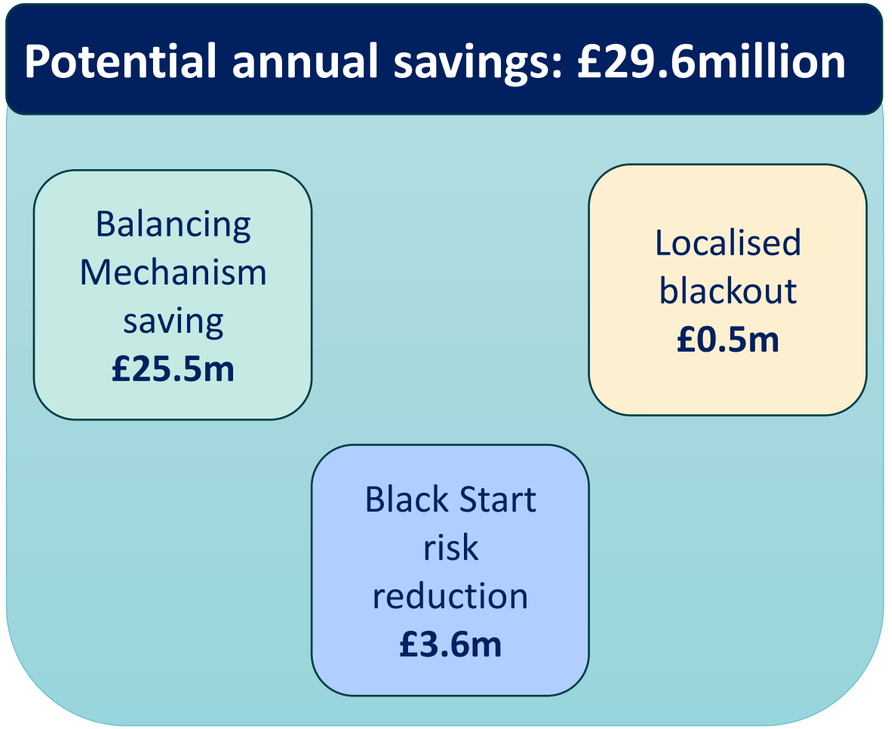
Improved system operability

- Currently restricting output generation is used to manage oscillations or operate high-carbon sources.
- INSIGHT will enhance system operability and help reduce the balancing mechanisms costs across the network.

Risk reduction

- Unstable network leading to a partial or total system shutdown (leading to the disconnection of customers).

Plus, it lowers the risk of damage to plants and equipment including users' equipment AND reputational risk.



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How Findings are informing the Future Direction

- Decision taken by partners **not** to submit a Beta Round 2 application, because
    - Existing measurement and analysis methods for low-frequency oscillations are insufficient
    - Currently Technology Providers do not have mature solutions
- Further work is required before pursuing a Beta application to:
    - Work with simulation and analysis tools to understand the problem in more depth
    - Work with Technology providers to develop new solutions
- Plan to submit to plan and execute an NIA project
- Potentially make a Beta application after an NIA project in 2026

Alpha has unlocked the priorities for moving forward

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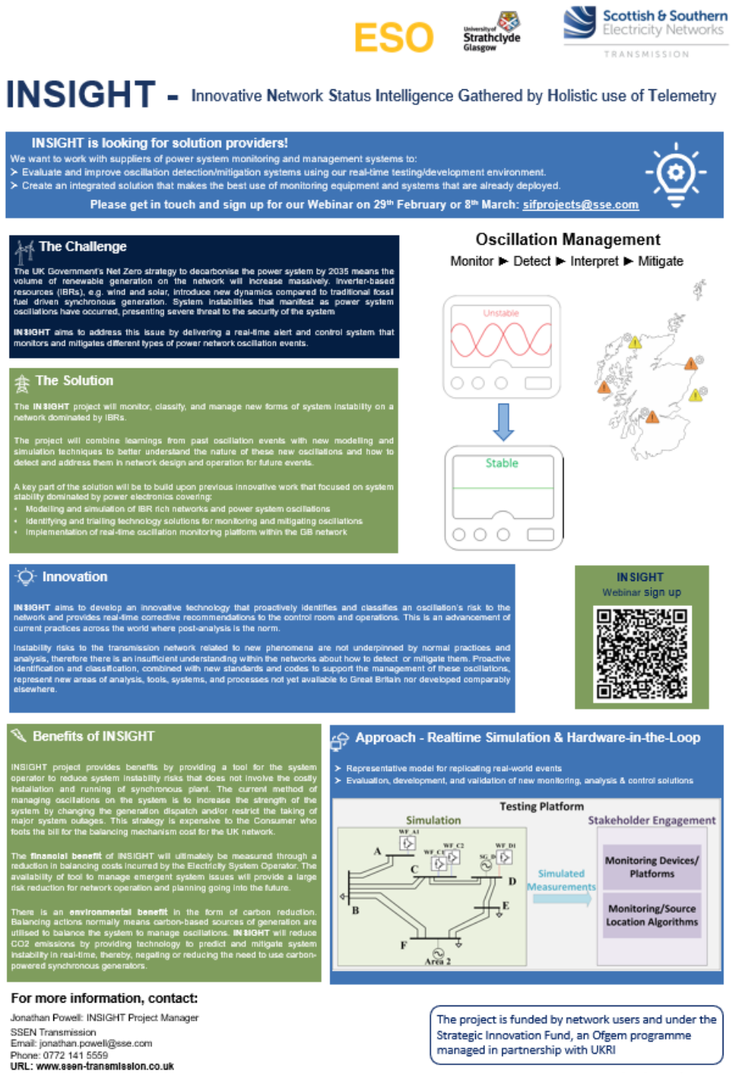
What Next

- Project partners will develop the project definition for the next phase: NIA

- Engagement with other Transmission Operators

- Strengthen relationships with Technology Providers

- Promote the project through new communication and dissemination opportunities



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