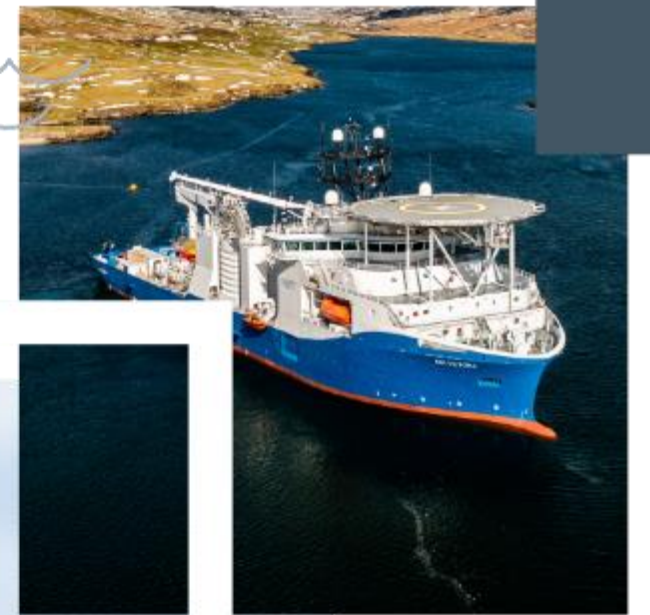


# INSIGHT

## Innovative Network Status Intelligence Gathered by Holistic use of Telemetry

Alpha Phase: 'Show and Tell'

22<sup>nd</sup> April 2024



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



TRANSMISSION

# Problem Statement

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

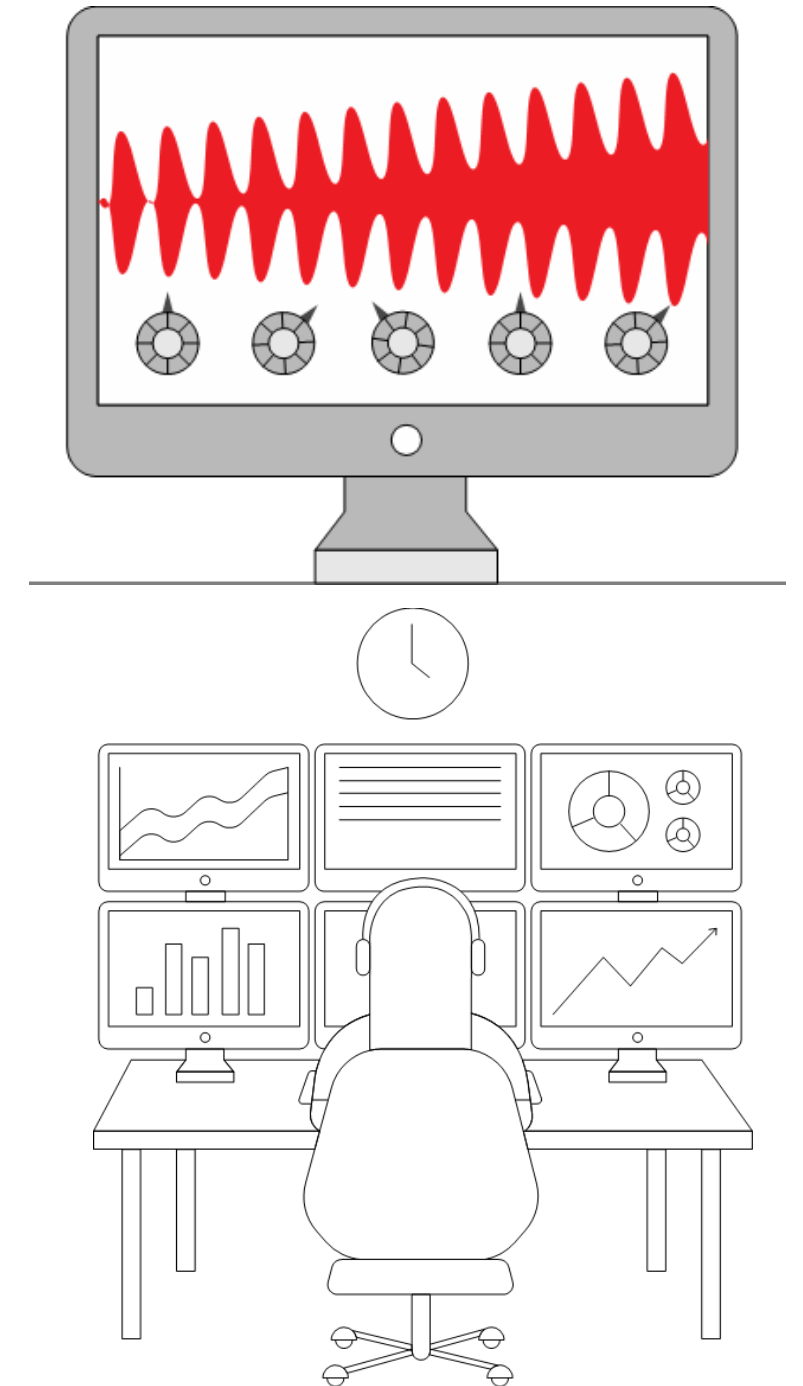
## What is the problem?

- 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 malfunction, 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.



# Project Overview

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

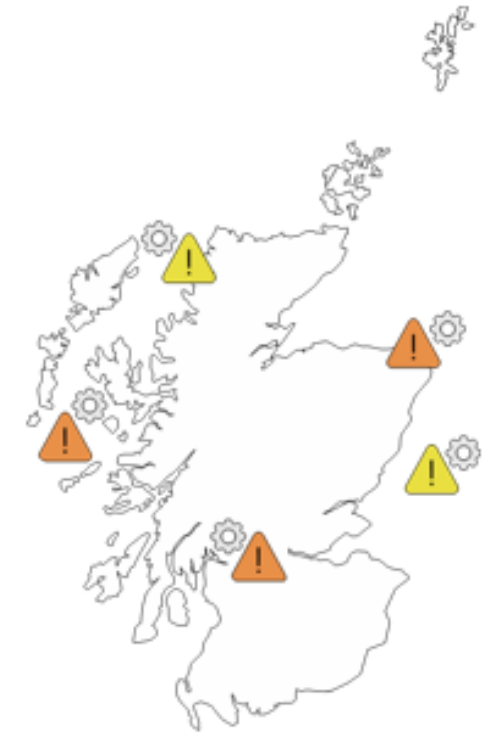
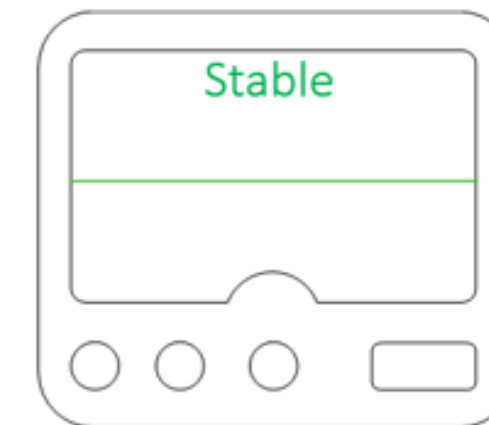
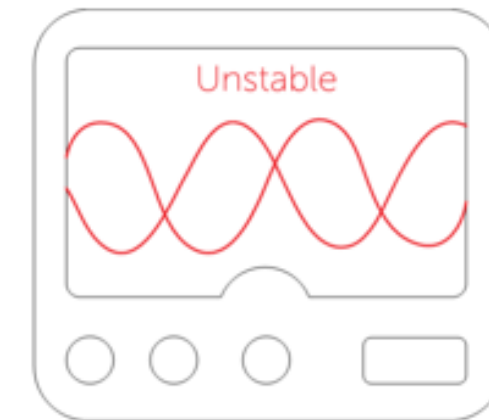
- The nature of these new oscillations.
- How to detect and address them in network design and operation for future events.

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.

## Oscillation Management

Monitor ► Detect ► Interpret ► Mitigate



# 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.





# 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**

# 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

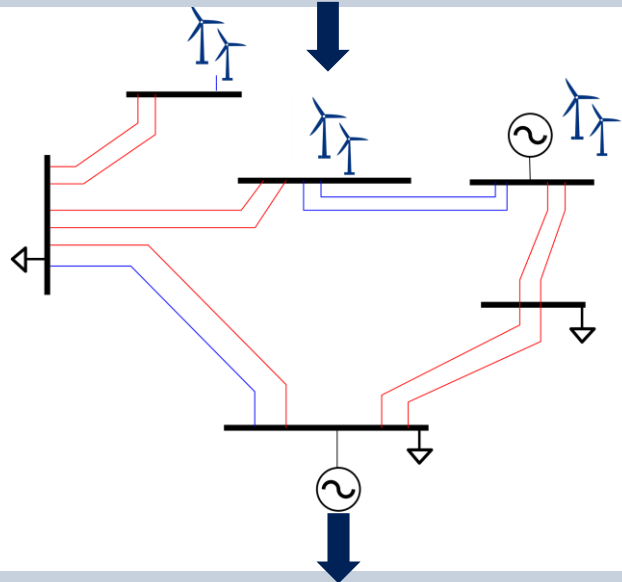
# WP3 Oscillation Events - Modelling and Simulation Studies

## 1. Modelling and Simulation

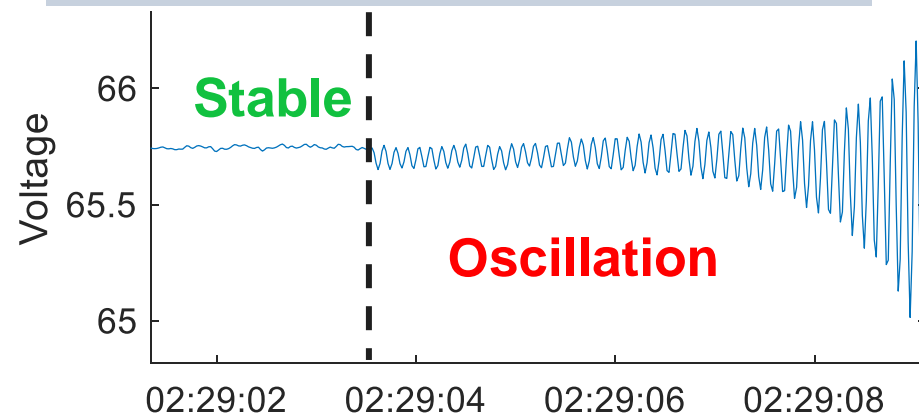
Analytical model of oscillation mechanism



Representative test network:  
North Scotland transmission system

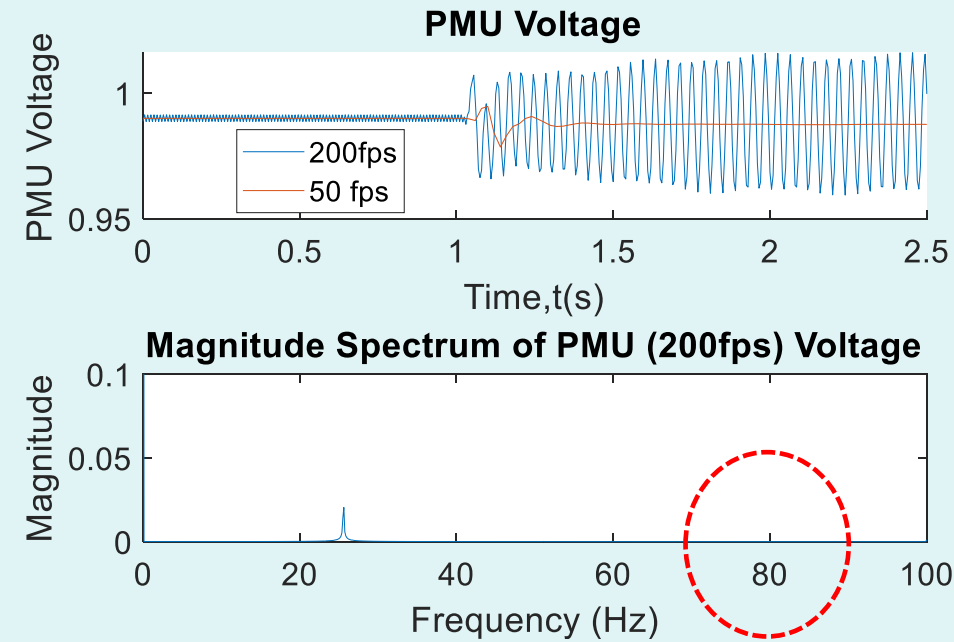


Simulation case studies

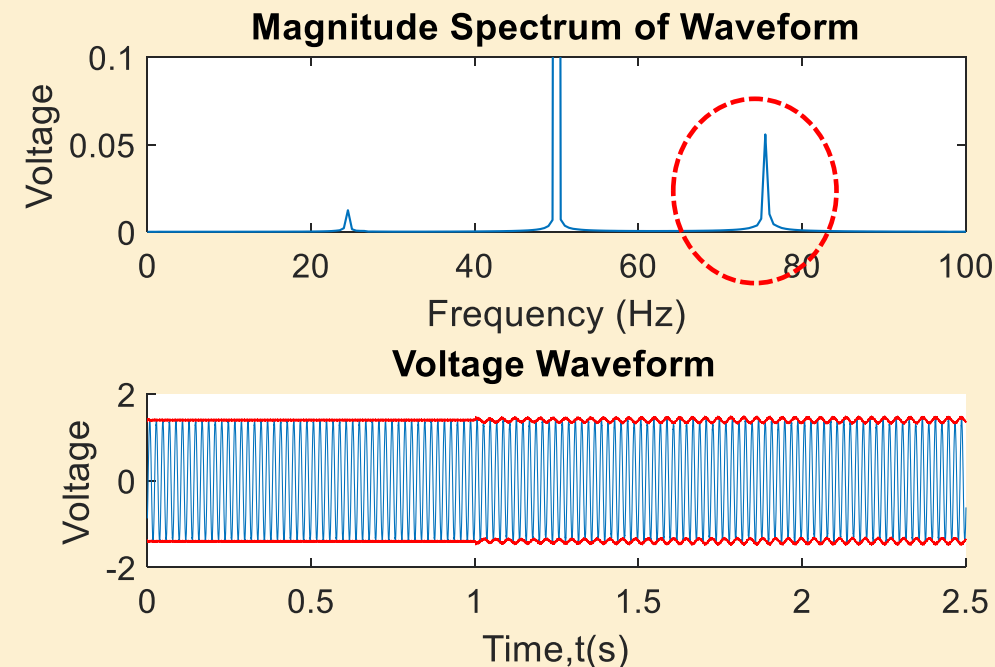


## 2. Analysis of IBR-based Oscillations

Phasor Measurements - streamed in real time

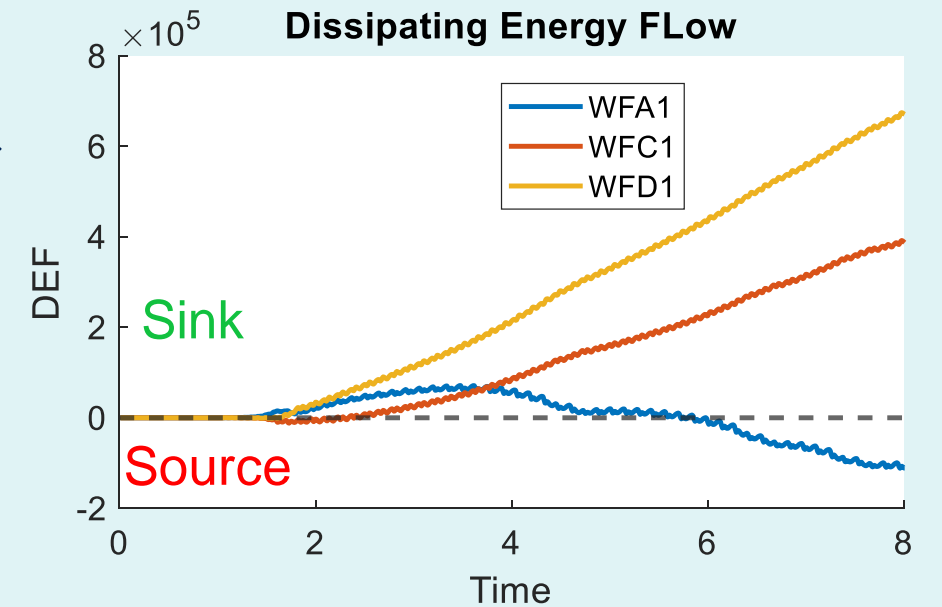


Waveform: not typically used in real-time

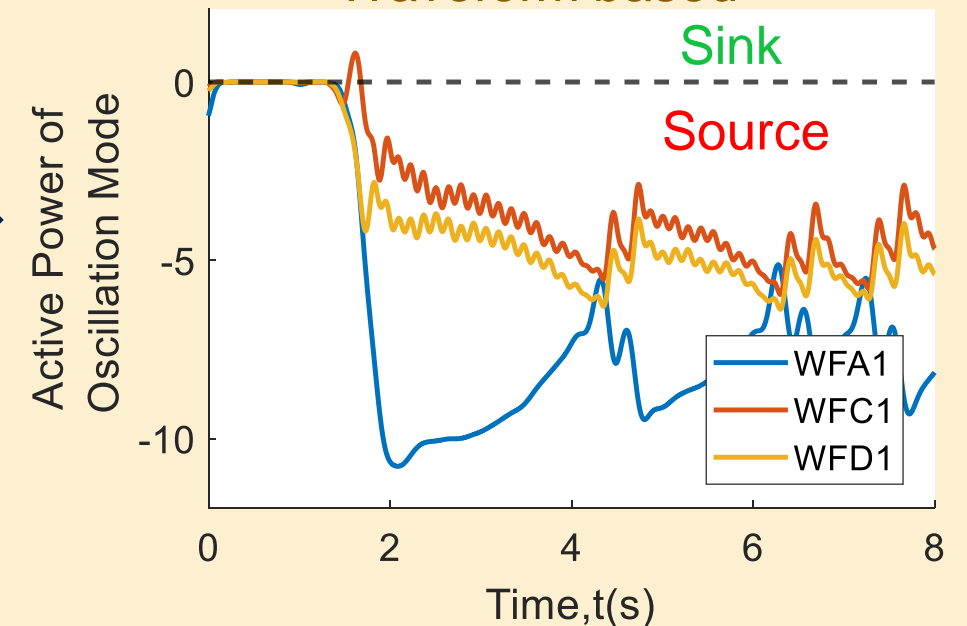


## 3. Evaluation of Oscillation Location Methods

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

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

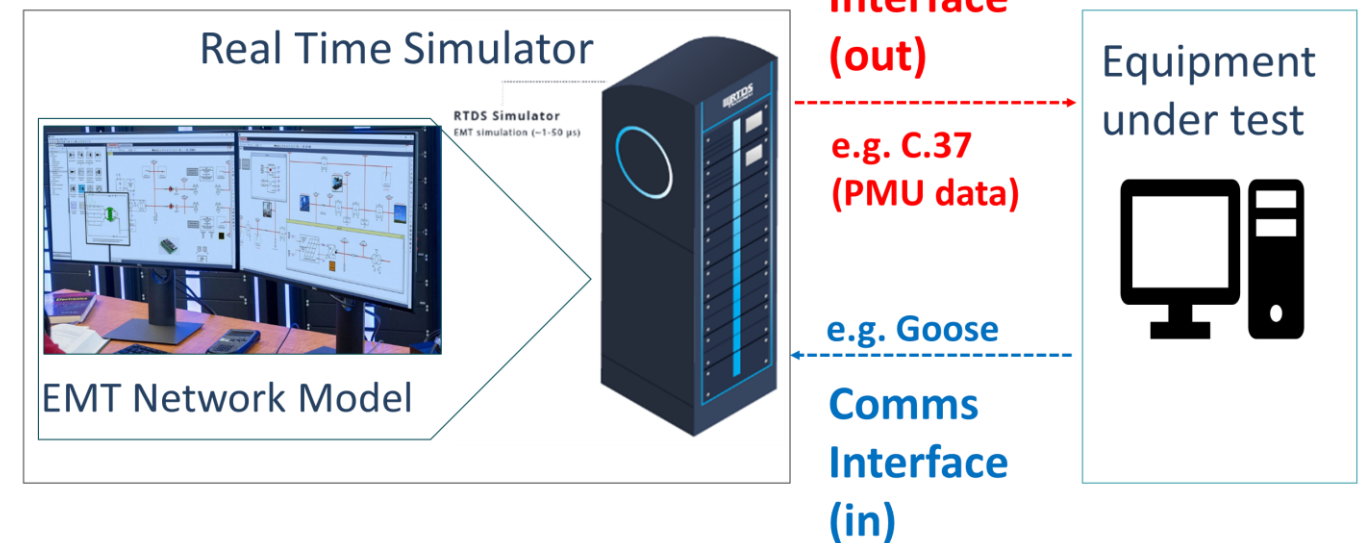
PMU – Phasor  
Measurement  
Unit

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

DFR – Digital  
Fault Recorder

NOW

2030



# 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.

Potential annual savings: £29.6million

Balancing  
Mechanism  
saving  
£25.5m

Localised  
blackout  
£0.5m

Black Start  
risk  
reduction  
£3.6m

# 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**

# 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

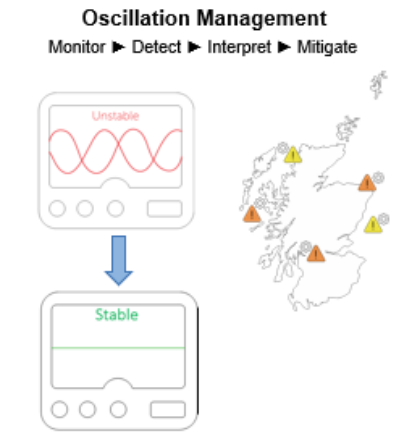
## INSIGHT - Innovative Network Status Intelligence Gathered by Holistic use of Telemetry

**INSIGHT is looking for solution providers!**  
 We want to work with suppliers of power system monitoring and management systems to:  
 > Evaluate and improve oscillation detection/mitigation systems using our real-time testing/development environment.  
 > Create an integrated solution that makes the best use of monitoring equipment and systems that are already deployed.  
 Please get in touch and sign up for our Webinar on 29<sup>th</sup> February or 8<sup>th</sup> March: [sifprojects@sse.com](mailto:sifprojects@sse.com)

**The Challenge**  
 The UK Government's Net Zero strategy to decarbonise the power system by 2035 means the volume of renewable generation on the network will increase massively. Inverter-based resources (IBRs), e.g. wind and solar, introduce new dynamics compared to traditional fossil fuel driven synchronous generation. System instabilities that manifest as power system oscillations have occurred, presenting severe threat to the security of the system.  
 INSIGHT aims to address this issue by delivering a real-time alert and control system that monitors and mitigates different types of power network oscillation events.

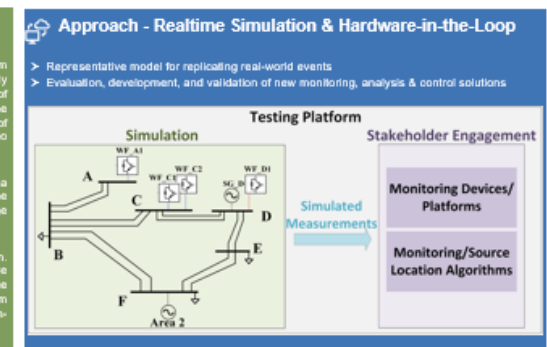
**The Solution**  
 The INSIGHT project will monitor, classify, and manage new forms of system instability on a network dominated by IBRs.  
 The project will combine learnings from past oscillation events with new modelling and simulation techniques to better understand the nature of these new oscillations and how to detect and address them in network design and operation for future events.  
 A key part of the solution will be 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 and trialing technology solutions for monitoring and mitigating oscillations  
 • Implementation of real-time oscillation monitoring platforms within the GB network

**Innovation**  
 INSIGHT aims to develop an innovative technology that proactively identifies and classifies an oscillation's risk to the network and provides real-time corrective recommendations to the control room and operations. This is an advancement of current practices across the world where post-analysis is the norm.  
 Instability risks to the transmission network related to new phenomena are not underpinned by normal practices and analysis, therefore there is an insufficient understanding within the networks about how to detect or mitigate them. Proactive identification and classification, combined with new standards and codes to support the management of these oscillations, represent new areas of analysis, tools, systems, and processes not yet available to Great Britain nor developed comparably elsewhere.



**INSIGHT**  
 Webinar sign up

**Benefits of INSIGHT**  
 INSIGHT project provides benefits by providing a tool for the system operator to reduce system instability risks that does not involve the costly installation and running of synchronous plant. The current method of managing oscillations on the system is to increase the strength of the system by changing the generation dispatch and/or restrict the taking of major system outages. This strategy is expensive to the Consumer who foots the bill for the balancing mechanism cost for the UK network.  
 The financial benefit of INSIGHT will ultimately be measured through a reduction in balancing costs incurred by the Electricity System Operator. The availability of tool to manage emergent system issues will provide a large risk reduction for network operation and planning going into the future.  
 There is an environmental benefit in the form of carbon reduction. Balancing actions normally means carbon-based sources of generation are utilised to balance the system to manage oscillations. INSIGHT will reduce CO2 emissions by providing technology to predict and mitigate system instability in real-time, thereby negating or reducing the need to use carbon-powered synchronous generators.



**For more information, contact:**  
 Jonathan Powell: INSIGHT Project Manager  
 SSE Transmission  
 Email: [jonathan.powell@sse.com](mailto:jonathan.powell@sse.com)  
 Phone: 0772 141 5559  
 URL: [www.sse-transmission.co.uk](http://www.sse-transmission.co.uk)

The project is funded by network users and under the Strategic Innovation Fund, an Ofgem programme managed in partnership with UKRI

# Contact details:

Jonathan Powell

[jonathan.powell@sse.com](mailto:jonathan.powell@sse.com)