SIF Discovery Round 2 Close Down Report Document

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Project Reference Number

UKRI10051585

Project Progress

Project Title

INSIGHT (Innovative Network Status Intelligence Gathered by Holistic use of Telemetry and Simulation)

Project Reference Number

UKRI10051585

Lead Funding Licensee

SSEN-T - Scottish and Southern Electricity Networks Transmission

Funding Licensee(s)

NG ESO - National Grid ESO

Project Start Date

April 2023

Project Duration

3 Months

Nominated Project Contact(s)

SIFProjects@SSE.com

Project Summary

INSIGHT addresses SIF Innovation Challenge 2 Theme 2 "Novel ways to reliably support low stability systems" by developing innovations in technology and standards that help the power system be ready for Net Zero by 2035. INSIGHT seeks to understand, classify, predict, and define actions to manage potential new forms of instability (e.g oscillations in voltage, power and/or frequency) on a system dominated by power electronic sources (such as wind generation, HVDC converters, STATCOMs etc). The overall aim is 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.

INSIGHT will also recommend to industry new standards and codes to manage these emerging stability risks.

Network innovation
Currently, there is only a reactive approach to combatting oscillations on the network and no real-time monitoring or control is in place. Instability risks related to new phenomena are not underpinned by normal practices/analysis and not covered by existing industry classifications, codes and standards, therefore the networks do not have enough understanding or the correct tools to react effectively to new instabilities and reduce their impact.

Experience/capability
The consortium has all the necessary skills to deliver Discovery (see AppendixQ12_Project_Management_Book_INSIGHT):

SSEN-Transmission (SSEN-T) - leading INSIGHT with expertise from the

System Performance team; Operational Planning team; and the National HVDC
Centre. The HVDC Centre has extensive experience with modelling and derisking the existing network. The System Planning and the Operational Planning teams are experts in current oscillatory instabilities on the network and can share real event data.

University of Strathclyde (UoS) - extensive experience in power system monitoring, modelling and control, along with expertise in converter control, interaction of converters, and system oscillation, which are all critical to the Project's scope. The team has been involved extensively with major projects focusing on power system digitalisation for addressing challenges with integration of renewables.

National Grid ESO (NGESO) - the Network Operability team will share system operator expertise and ensure that learnings from their DOME project (NIA desktop study on early warning of emerging oscillations) can feed into INSIGHT.

Users
The innovation will prepare the above outlined internal users, NGESO and other networks to deal with new oscillatory instability in a future Net Zero system, and better plan and operate the networks to an improved level of risk management. Therefore, providing a more reliable and stable service to customers.

Project Description

A key policy commitment within the UK government's Net Zero strategy is to fully decarbonise the power system by 2035 and therefore the volume of renewable generation on the networks is expected to increase dramatically. However, most renewable forms of energy, such as wind and solar, are types of non-synchronous generation, meaning they do not produce a consistent amount of electricity all the time. An increase in the volume of non-synchronous generation on the network combined with more high voltage direct current (HVDC) systems to transport the electricity, will lead to new types of network stability challenges, particularly
increases in the prevalence and severity of fluctuations in voltage, frequency and
power (system oscillations). The oscillations will occur in new areas of the system and be driven by different factors compared to historic instability events.
Without innovation to address these new stability challenges, there will likely be a significant decrease in system strength and security, increasing the potential for severe instability events such as electricity blackouts. This problem would also hinder our ambitions to achieve Net Zero because we would continue to rely on synchronous fossil fuel generators to be on stand-by. Currently, there is no systematic real-time monitoring directed at the identification
of, and response to, these new oscillations. There are also no classifications, codes, or standards for how to predict, plan against and manage these new oscillation events experienced in a renewable generation dominated network. A standardised approach across the industry is required.

INSIGHT aims to deliver a virtual, real-time alert and control system that can monitor and mitigate different types of oscillation events experienced on the networks. The Project will combine experience and learnings from past events with new modelling and simulation techniques to better understand the nature of these new oscillations; how to predict them; and how to address them in network design and operation for future events. The first phase of the Project (Discovery) will develop a comprehensive understanding of the problem and the current best practice from across the world. It will also investigate the models/tools that could be used to simulate network oscillation patterns; assessing their suitability; and
developing a list of the key datasets that would be required for a new model/tool. The outputs of INSIGHT will improve the network strength, stability, and reliability, and will avoid alternative operations that would reduce the levels of renewable generation able to run on the network.

Summary Key Findings

The Discovery Phase of the INSIGHT project addresses the SIF Round 2 Innovation Challenge area 2 'Preparing for a net zero power system. Specifically, the focus has been on understanding the global perception of network instabilities due to the increased penetration of Inverter Based Resources (IBRs) through a literature review and engagement with a range of international stakeholders. Whilst potential solutions exist, they are not thoroughly tested or proven.

The project sought to understand, classify, predict, and define actions to manage potential new forms of instability in a system dominated by power electronic sources. Post-analysis has been demonstrated; however, INSIGHT aims to develop a proactive identification and classification of oscillation risks and recommendations to inform planning operation and mitigation strategies. Stakeholder engagement was instrumental in helping to confirm the industry-wide extent of the problem and included attending ESO-TO work groups and the Scottish System Performance Work Group (SSPWEG) to share the project scope and discuss the problem.

In addition, a State-of-the-Art review identified the latest in real-time oscillation monitoring, rapid analysis, and automated response.

The main innovation is the ability to proactively, in real-time, identify system oscillations and manage them such that the operation of the network is not compromised. The Discovery Phase yielded new learning across several areas:

- Technical solutions are available but are limited mainly to post-oscillation detection and they cannot pick up the entire frequency range of the disturbances.

- Modelling of oscillations in a simulated environment is essential to understanding measurement techniques and the response of potential technology solutions.

- Stakeholder engagement has clearly shown there is a definite need for the INSIGHT technology.

User needs

Work Package 4 of the project focused on 'Stakeholder Engagement' to understand the user needs which began with the compilation of a stakeholder engagement survey that was refined and sent electronically1 to user groups including (i) Network Owners, (ii) Developers, (iii) Vendors (instrumentation, monitoring or protection equipment), and (iv) Suppliers of primary equipment (e.g., turbines, HVDC cables). The survey or questionnaire was complemented by an expert workshop held by the project partners to gather stakeholder feedback. The responses highlighted growing concerns that the current oscillatory damping capability is insufficient for the future network with an increased risk of oscillation events.

INSIGHT will combine experience and learnings from past events/projects with new modelling and simulation techniques to better understand the origin and nature of different types of oscillations and investigate potential methods for predicting them. State-of-the-art techniques for detecting, classifying, and responding to oscillation events will be reviewed, evaluated, and trialled. The project will also inform codes and standards relating to new oscillations, and potentially lead to a new form of service targeted at control actions for oscillation damping.
Whilst stability in systems dominated by power electronics is currently an industry focus area, there are no projects developing the type of solution to manage system oscillations and disturbances proposed in INSIGHT.

Projects like TOTEM and other initiatives like Grid Code Modification GC0141 have progressed GB activities in modelling and simulation, supporting the further investigation of oscillatory stability proposed herein.

Current projects like INCENTIVE, or past projects like Phoenix and EFCC, have developed and demonstrated the types of technologies that could be used to mitigate oscillations, with the ESO's Stability.

Past projects like VISOR and MIGRATE, and subsequent code modification like that to STCP 27-01 on sharing of real-time monitoring data, have advanced the TOs' and ESO's approach to real-time measurement, with an ongoing programme through RIIO-T2 to deploy more equipment and collate data.

Synergy with these projects will be explored thoroughly during Alpha using key contacts.

Impacts and benefits

Financial - future reductions in the cost of operating the network
The current process of managing oscillations on the system is to restrict the output of generation (which is suspected to be the source of the oscillations) or to operate TO devices in a way that prevents them from interacting with the oscillations.
The cost of these options is two-fold:
1. There is a need to buy off generation in the balancing mechanism.
2. Restrict the capability of the system and therefore introduce constraints that require costly intervention to manage flows within the imposed limit.

These mitigations need to be in place for an unspecified time, until investigations have concluded the source of the oscillations and put mitigations in place.

A CBA has been developed as part of the Project Management Book to demonstrate the improvements to the network's system operability because of the INSIGHT solution. The annual balancing mechanism cost for the UK network is £2.406 billion (2022/23). Implementing the INSIGHT technology could deliver an annual cost saving of over £20 million (based on an assumption of a 1% cost

saving).
One example of balancing costs incurred previously is the actions taken after significant oscillations, most evident in northern Scotland, in August 2021. The response included paying hydro generators to switch on, constraining wind off, and adjusting outage plans. These types of events are expected to become more frequent unless projects like INSIGHT can identify appropriate mitigation.
The benefit of INSIGHT will ultimately be measured through a reduction in balancing costs incurred by the Electricity System Operator due to the occurrence, or the perceived risk, of oscillatory instability. Short of the financial metric, the benefit could be measured by the number of actions taken to address oscillatory instability, which may include instructions to TOs that do not incur balancing costs.

Environmental - carbon reduction - indirect CO2 savings per annum
Currently, the balancing actions taken to manage oscillations on the system have the potential to increase CO2 emissions, as low-carbon sources of generation are replaced with carbon-based sources of generation as they can be turned on/off and up or down as needed to balance the system.
INSIGHT will help reduce the CO2 emissions that occur when trying to manage oscillations on the network by providing the technology to predict or mitigate them ahead of time.

New to market - services
As described above, oscillations on the system are currently managed in a way such that the source(s) of the oscillations are located, and mitigations put in place. There is work underway to implement a stability market, though this doesn't address oscillations directly as it aims to address exacerbating factors (a gradual "weakening" of the transmission system), to prevent oscillations from happening.

A future outcome of INSIGHT is that users may be contracted to modify their operating point, adjust settings, or activate different control functionality to mitigate oscillatory stability risks. The development of a market for these new types of services is dependent on the learning expected from the project.

Risks, Issues and Constraints

Technical
There are no specific constraints technically, rather Discovery helped to gain a greater understanding of the magnitude of the challenge, and the importance of surveying all activities already underway in this space such that INSIGHT builds upon that learning and avoids any duplication. This work includes (i) the expansion of system monitoring facilities and the sharing of real-time data as specified by STCP 27-1 informed by past projects such as VISOR, and (ii) the modelling and analysis in the NIA project TOTEM, amongst others plus and the ongoing work in the Joint Planning Committee sub-groups which will provide essential inputs to the proposed work.

Commercial
Again, not a constraint as such more of a recognised focus for future phases. The identification and initial evaluation of different solution providers will form an integral part of the Alpha phase resulting in a list of the most promising solution(s) that could be explored and potentially evaluated/ tested within the Beta phase.

Regulatory
There are not considered to be any regulations, policies or standards presenting barriers to the delivery of this project. It is anticipated that project learning will inform future Grid Code and STCP modifications to fully harness the opportunities and this will follow the normal code management processes.
It is not anticipated that there will be a need for any changes to government policy or to standards outside of Ofgem's remit.

The system monitoring roadmap being developed in Alpha (WP4) will consider more fully any impacts and possible changes to industry codes and standards. This will include looking at improving the clarity of obligation, specificity of requirement, and general improvement of the standards to cover oscillatory instability events.

The attached Risk Register is for at the end of the Discovery Phase and includes an estimation of Probability (likelihood) and impact along with a mitigation strategy.

Working in the open

The approach to working throughout the Discovery Phase has been:
- Collaborative
- Open wherever possible
- Impact driven

Within the project, work has been openly shared through a common SharePoint and via weekly update meetings which all partners

attended regularly throughout the Discovery Phase. The short duration of the project meant that an agile-type approach was used to help ensure its successful delivery.

The focus of the work was to better understand the extent of the problem for which Stakeholder engagement was instrumental in confirming it to be industry wide. This included issuing an open questionnaire and inviting comments on the Project. During discovery, meetings of the two GB ESO-TO working groups with the greatest interest in the Project have been attended: the Scottish System Performance Working Group (SSPWG)and the ESO-TO Forum on System Events. The review of the State-of-the-art identified the targeted area of innovation, a significant technological advancement in real-time oscillation monitoring, rapid analysis, and automated response.

Transparency across the project partner and beyond was demonstrated, in summary, through:
- Weekly project meetings
- Several face-to-face reviews including the kick-off meeting and Stakeholder workshop session
- Sharing of project Deliverables on the SharePoint
- 'Show and Tell' event, open to any interested party
- Uploading of selected documents onto the ENA smart portal.

Costs and value for money

A summary of the project expenditure that was required to deliver the Discovery Phase of INSIGHT, is shown in the table below. Overall, the project was underspent, but this did not affect the quality of the results which were reviewed by the Ofgem-UKRI representatives.

The Project is not using any subcontractors for the Discovery phase, and INSIGHT did not request the full amount of funding available (only ~55% of the full £150k available was requested). The consortium carefully planned and delivered the Discovery phase project so that the fewest number of days to deliver a quality output were used. The day rates are considered competitive, and no subcontractors which are often expensive resources, where required to deliver the work.

Attached is a spreadsheet demostrating breakdown of project partners costs.

Special conditions

The four Specific Conditions forming part of the Project Direction have all been met. They centre around financial control and contributions, meeting participation and dissemination.

Documents uploaded where applicable

Yes

Documents:

Cost and Value for Money attachment.pdf

INSIGHT Risk Register.pdf