SIF Round 3 Project Registration

Date of Submission

Mar 2024

Project Reference Number

SIF_SHET_024_SYSMET (1)

Initial Project Details

Project Title

SYSMET - SYstem Strength Measurement and EvaluaTion

Project Contact

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Challenge Area

Novel technical, process and market approaches to deliver an equitable and secure net zero power system

Strategy Theme

Net zero and the energy system transition

Lead Sector

Electricity Transmission

Other Related Sectors

Electricity Distribution

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

SSEN - Scottish Hydro Electric Transmission

Funding Licensee(s)

SSEN-T - Scottish and Southern Electricity Networks Transmission

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

UK Power Networks

National Grid Electricity Transmission

Technology Areas

Measurement

Electricity Transmission Networks

Resilience

Environmental

System Security

Project Summary

As the share of inverter-based resources including renewable generation increases, lower system strength can lead to uncontrolled voltage changes which can escalate to instability and risk widescale customer disconnections. To secure the net-zero grid, network operators urgently need to monitor system strength conditions to implement the most effective and economic mitigations. At present, neither the requirements for system strength monitoring nor the possible hardware and digital solutions are well defined. The SYSMET project brings together leading experts who will create the pathway to confident implementation of measurementbased tools that provide comprehensive visibility of system strength status for operational decision making.

Add Third Party Collaborator(s)

National Physical Laboratory

Project Budget

£110,914.00

SIF Funding

£99,733.00

Project Approaches and Desired Outcomes

Problem statement

Electronic power converters enable variable Inverter Based Resources (IBR) like wind, solar, and battery storage to interface with the grid, but don't provide the same inherent stability as traditional fossil-fuelled rotating generators. Consequently, fault levels are changing, and lower system strength is becoming an increasing concern moving towards net-zero. A weak system may not recover from faults, resulting in uncontrolled voltage changes which can escalate to network instability. Without reliable visibility of system strength, network owners need to take conservative, non-targeted mitigating actions such as curtailment of IBRs.

To secure the net-zero grid, network owners urgently need capabilities to monitor low system strength conditions to implement the most effective and economic mitigations. Traditionally, fault levels were an indicator of system strength, however, there is growing evidence that fault levels do not fully reflect the response to disturbances in IRB-dominated power grids. Other system strength indicators such as voltage sensitivity are under discussion but there is no agreed standard/approach on which physical quantities are suitable indicators of system
strength or how they can be measured. This is preventing network owners from selecting and implementing solutions for system strength monitoring and management.

SYSMET plans to address this problem and produce industry-ready solutions starting in Discovery by:
- Defining needs and use cases of network owners for system strength monitoring.
- Reviewing current industry practice, candidate indicators, and measurement techniques; engage with solution vendors.
- Identifying data sets, models, and test facilities necessary for solutions development in Alpha.

Followed by:
- Alpha: testing and developing measurement tools and digital/IT solutions.
- Beta: integrated demonstration with grid operation and control systems.

The project will lead to the deployment of novel monitoring solutions, leveraging AI and/or machine learning to give network owners increased visibility of system strength conditions (satisfying Theme2). The new operational processes established will enhance system strength condition monitoring reducing curtailment of converter-based renewable energy generation (Theme 1).

The project team has worked on several relevant network innovation projects and will ensure SYSMET's solutions are truly innovative and not duplicative. SSEN-T's NIA project 'Transmission System Fault Level Monitoring' trialled a passive fault level monitoring system. UKPN's NIA project 'Real Time Fault Level Monitoring' trialled active fault level monitoring in distribution networks. SSEN-T's ongoing SIF projects INCENTIVE and INSIGHT are also synergistic. The consortium will engage with National Grid ESO, leaders of the NIA project 'Strength to Connect' which is modelling system strength indicators.

Video Description

https://www.youtube.com/watch?v=w4GzHXEl4kI&feature=youtu.be

Innovation justification

Network owners have poor visibility of the power system strength status because of the rapid growth of IBRs, connected to the grid by converter technology. Neither the requirements for system strength monitoring nor the possible solutions are fully understood. This challenge cannot be met within business-as-usual activities as it goes beyond incremental extension of existing monitoring. This challenge is visualised in Appendix_Q3-Figure_1 and Figure_2.

The state-of-the-art of system strength assessment is summarised by a lack of standardisation. Various versions of the short circuit ratio (SCR), defined fundamentally as the fault level divided by nominal active power, have been proposed and trialled. However, the results don't necessarily provide consistent conclusions for network operation, and fault level monitoring is not yet universally available. Moreover, there is a consensus that metrics based on fault levels alone are not a sufficient predictor for the range of problems arising from low system strength.

The core innovation of the proposed SYSMET project is a pathway to the implementation of measurement-based tools that provide visibility of system strength for operational decision-making. The three technical work packages scope out the challenge of achieving system strength visibility to ensure the reliability of an IRB-dominated power system, fully aligned with the SIF Discovery Phase both in scale and technical risk. The project will expand to testing and development of identified novel solutions in Alpha and Beta, see Appendix_Q3-Figure_2.

The SYSMET project will consider additional candidate indicators such as small and large signal impedance under investigation in the NIA project 'Strength to Connect' concluding March-2024.

For the most suitable indicators, measurement requirements and approaches will be identified leveraging existing measurement techniques through the application of machine learning and AI.

The project will utilise the learnings of the 'Real-time Fault Level Monitoring' project to assess if existing commercial offerings trialled in distribution networks can be applied to transmission.

We are aware of high CRL system strength tools available, but these have not been adapted/proven in the UK. These and other novel SYSMET solutions for different system strength indicators are at low CRL for the UK market. TRL progression planned:
- Current: TRL2/3 relevant processes understood in other applications.
- Alpha: TRL4/5 is targeted through proof-of-concept validation.
- Beta: TRL6/7 achieved through prototype demonstration in the field.

Currently IRL2, it is expected to reach IRL3-4 in Alpha by mapping the compatibility with other system monitoring tools, and IRL6-7 in Beta through demonstrated integration with operational systems.

Appendix Q3 - SYSMET.pdf (opens in a new window) (/application/10102960/form/question/36580/forminput/99771/file/630500/download).

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Environmental - carbon reduction – direct CO2 savings per annum

New to market – products

Impacts and benefits description

Current Position

Power system strength status indicators are poorly defined and ill-understood. Whilst there are monitoring tools and digital solutions available in the UK and internationally, they are immature in the UK system where fault level is used which is inadequate for IBRs. Adopting a standardised approach to system strength monitoring enables manufacturers of grid monitoring systems to develop new and innovative devices that are fit-for-purpose and industrially relevant. It also provides network owners with a set of requirements that can be issued to prospective monitoring tool providers who must demonstrate compliance with functionality and measurement accuracy requirements.

Reliable, widespread, and consistent monitoring of system strength indicators will enable network owners to address problems arising from lower system strength to ensure the availability of the power system. Furthermore, greater knowledge of real-time or near real-time system stability will allow better decision-making when disturbances occur so mitigating actions minimise the overall cost and impact on customers.

The qualitative high-level net benefits are:
a) Reducing constraints and costs for renewable generation customers,
b) Increasing system resilience due to improved system stability, thereby reducing the risk of severe disruption,

c) Optimising network operating costs and reducing consumer bills.

Financial- future reductions in network operational costs

Accurate quantification and measurement of the strength of the network allows efficient and targeted real-time deployment of stability services. Low system strength can cause issues with network stability and the default countermeasure is constraining generation and implementing stability services to increase the fault level or inertia of the system. These reactive actions can have high operational costs (£millions/annum); a consumer cost.

Environmental- carbon reduction - direct CO2 savings/annum against a business-as-usual counterfactual

Improvements in the management of grid stability build operational confidence in the stability of the network, allowing increased system capacity for renewable generation, and reducing CO2 emissions if it avoids the need to use synchronous fossil generation for system strength.

New to market - products

SYSMET defines a new way to measure system strength, measurement requirements, and test methods. These requirements and test methods will feed into standards development and pave the way for developing new monitoring products. Standards play a pivotal role in power grids, ensuring consistency, reliability, and efficiency in electrical measurements. SYSMET will build the foundation for a standardised methodology to measure system strength promoting confidence for manufacturers, with several UK vendors already identified, and offers comparability across system owners and networks.

Teams and resources

SSEN Transmission has established an exceptional team for this innovative SYSMET project. We have previously worked with all partners and built positive and productive working relationships through collaboration in previous SIF and other large-scale projects. The partners involved are experts within their fields and best placed and committed to working together to progress this Discovery phase project, full descriptions and biographies are in Appendix_Q7.

Lead

SSEN Transmission is the owner of the electricity transmission network in the north of Scotland, maintaining and investing in the high voltage 132kV, 220kV, 275kV, and 400kV electricity transmission of both the AC and DC networks. SSEN-T is the overall project leader and will lead WP1 and WP3.

Project Partners

National Physical Laboratory (NPL) is a world-leading research organisation with excellence in measurement, data, computing, and digital science disciplines and is well-placed to lead the review and evaluation of system strength measurement techniques in the SYSMET project. NPL will lead WP2 to engage with complimentary projects and better understand current industrial practices, and WP4 to understand the state-of-the-art solutions, relevant vendors, and suppliers and specify tools that can be developed in the Alpha stage.

UK Power Networks owns and maintains electricity cables and lines across London, the South East and East of England, and makes sure power flows reliably, safely, and securely. UKPN's priorities are to tackle the climate crisis by connecting renewable energy, electric car chargers, and low carbon heating, meet their customers' evolving needs by improving their services, support their customers in vulnerable circumstances, and go above and beyond for the communities they serve.

UKPN will support WP3 which determines the requirements of the partner networks and ensures data is accessible to distribution system operators and owners.

National Grid Electricity Transmission owns the transmission network in England and Wales and owns approximately 4,500 miles of overhead lines, and 900 miles of underground cables all connecting 350 substations. NGET has extensive experience in leading innovation projects within areas of digitalisation, asset management, and network condition monitoring.

National Grid contributes to WP2 and WP3 to capture their network requirements, current practices, and previous experience in system strength determination.

Sub-contractor and equipment

No sub-contractors or equipment will be needed for the Discovery phase.

Project Plans and Milestones

Project management and delivery

The four project work packages in the *Project_Management_Book_R3D_SYSMET* are described in *Appendix_Q7*_SYSMET_Figure 3 with WPs 2-4 directly addressing the selected Innovation Challenge aims and focus area.

Approach to Project Management

SSEN-T will follow its well-established robust and proven project management processes successfully applied to previous SIF Discovery Phase projects by applying an agile, flexible, and adaptable approach throughout the project. Moreover, an SSEN-T SIF Governance Document is followed in the execution of all SIF projects.

WP1: Project Management (Lead: SSEN-T):

(Funding request: £18,057)
- Hold weekly partner project meetings to discuss progress, risk, and issues and ensure all funding requirements are met.
- Delivery of all project milestones and deliverables and development of an Alpha plan and a decision on proceeding with the application.

WP2: Review of Current Industry Practices (Lead: NPL):

(Funding request: £20,139)
- Review of relevant innovation projects investigating system strength to establish their key outputs to date and their key personnel.
- Collation of network practices considering aspects such as TRL, third-party engagement, challenges experienced, and future plans.

WP3: User Requirements and Data Accessibility (Lead: SSEN-T):

(Funding request: £8,436)
- Determine the set of indices that are needed for system strength determination.
- Compile a statement of requirements incorporating the collective views of the networks.
- Establish the barriers or limitations associated with data accessibility for system strength measurement and analysis.

WP4: Review of Measurement Techniques (Lead: NPL):

(Funding request: £53,101)
- Review published resources to identify existing techniques and map the type of measurements required such as RMS values, phasors, and waveform samples.
- Based on the Statement of Requirements(WP3), identify any gaps in current measurement capability.
- Map requirements for testing system strength measurement tools in the Alpha phase.

Risk Management Strategy

The risks have been compiled in the *Project_Management_Book_R3D_SYSMET* covering technical, management, and commercial aspects with no policy or regulatory risks expected through Discovery. Top 3 risks:

1. Target data is unavailable in the timeframes. Mitigation: early engagement (SSEN-T).
2. Lack of suitable technology vendors: Mitigation: understand capabilities early and identify technology gaps (NPL).
3. Resources reassigned to other projects. Mitigation: identify key staff and potential back-up personnel (All Partners).

Planned or unplanned supply interruptions

The project has no detrimental effect on the consumer and will not require access to the electricity or gas network.

Consumer Interactions

Whilst there is no direct consumer contact anticipated, the project will help enhance system strength understanding to drive better system operation decisions, thereby, improving network efficiency.

Appendix Q7 - SYSMET.pdf (opens in a new window) (/application/10102960/form/question/36584/forminput/99795/file/630507/download).

Project Management Book R3D SYSMET.xlsx (opens in a new window) (/application/10102960/form/question/36584/forminput/99795/file/630969/download).

Key outputs and dissemination

Key Outputs
The main outputs will be a better understanding of network system strength by; (i) identifying the important indices, (ii) engaging with the key stakeholders and projects, and (iii) discovering the measurement techniques that could be evaluated in subsequent Phases.

Considering the outputs on a partner level:
a) Agreement on the scope and approach of the Alpha Phase including a project plan and an initial Cost Benefit Analysis **(All Partners)**.
b) An appraisal of relevant innovation projects; an enabler for enhancement in this area and a steer for this project **(NPL).**
c) Establish a set of network requirements that are used to inform technology providers of the requisite measurement parameters, their resolution, and accuracy **(UKPN, SSEN-T, NGET).**
d) Understanding of the data accessibility challenges experienced by the networks in the context of system strength measurement and cyber security **(UKPN, SSENT, NGET).**

Dissemination Opportunities
- Each organisation has its own corporate website which is a platform for sharing the outputs of the project.
- Discovery 'Show and Tell' Webinar, expected to take place May 2024.
- Publication of key project documents on the ENA Smarter Networks Portal which is publicly available.
- Energy Innovation Summit Autumn 2024: All networks would plan to attend this unique UK event to potentially present a poster showcasing the findings of the SYSMET Discovery phase.
- NPL, in collaboration with network partners, plans to disseminate the project learnings through relevant professional networks such as the CIGRE UK and the European Metrology Network on Smart Electricity Grids.

Commercials

Intellectual Property Rights (IPR) (not scored)

To ensure transparency is provided to the Project Partners, UKRI, and Ofgem regarding the IP landscape, the Project will employ an IP register to capture the Project Background IP and any Foreground IP that is generated during the Discovery Phase of the Project.

The default position for the governance of the project (Collaboration Agreement) in terms of IP will be that described in the latest SIF Governance Document (currently Version 2.1) as part of Chapter 9.

It is not anticipated that IP will be generated during the Discovery stage with IP more likely in the future phases plus the development of a UK standard for system strength determination and measurement.

Value for money

Costs Summary

The total project cost for the Discovery phase is £110,914, and in seeking £99,733 SIF funding, which is well under the maximum permitted funding request.

The project is requesting £99,733 of funding (90% of the total cost), with the remaining £11,181 (10%) being provided by SSEN-T, UKPN, and NGET from internal resources. This level of funding will lead to outcomes that provide value to the consumer.

The £11,181 (10%) of the total cost being contributed to the project by private funds satisfies the minimum 10% compulsory contribution giving excellent leverage of SIF funds.

SSEN-T costs are £25,190 to lead this project. SSEN-T is requesting £15,366 (61%) of funding and will contribute £9,824 (39%) from internal funds. The SYSMET project proposal has been developed to complement and be additional to SSEN-T's business-as-usual (BAU) activity.

UKPN costs are £5,300 to support this project representing the Distribution Network Operators and ensuring the DNOs are recognised as part of the solution. UKPN will contribute £530 (10%) funding.

NGET costs are £8,269 to support this project and will contribute £827 (10%) funding.

NPL costs are £72,155 to carry out their significant project scope using a range of resources necessary to deliver the project. As a research organisation, NPL is seeking 100% funding.

No sub-contractors are required to deliver this project.

Value for money

SYSMET is an ambitious project and SIF funding provides the incentive to bring together a consortium of leaders in their fields. The consortium has carefully prepared the Discovery phase project plan and the resources used are necessary to fulfil the scope and to deliver a quality output. We are confident that the likely benefits of the project significantly outweigh the initial cost of launching the project through Discovery and then developing it through later phases. The future Alpha and Beta phases are realistic and achievable and will aim to commercialise solutions ready for adoption as BAU by Network Owners to significantly improve operations and resilience delivering value for money.

This project was borne out of prior research by NPL so will benefit from other investments in the solutions proposed and is not 'starting from scratch'. Project learnings will be widely relevant and beneficial and will be shared publicly allowing for the best insight and value for money in the solution developed for project SYSMET.

The finances of all project partners are included in the milestones summary (/application/10102960/milestones-summary).

Supporting documents

File Upload

SYSMET Discovery Show and Tell 2024-06-05.pdf - 646.6 KB
SYSMET Discovery End of Phase 2024-05-23.pdf - 1.6 MB
SYSMET Discovery - Risk Register.xlsx - 47.9 KB
SIF Round 3 Project Registration 2024-03-08 2_42 - 74.3 KB
SIF Round 3 Project Registration 2024-02-28 3_08 - 75.0 KB

Documents uploaded where applicable?

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