SIF Discovery Round 2 Project Registration

Date of Submission

Aug 2023

Project Reference Number

10061033 ; NGET/Whole Energy System Resilience Vulnerability Assessment/SIFIESRR/Rd2_Discovery

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Project Title

Whole Energy System Resilience Vulnerability Assessment (WELLNESS)

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10061033 ; NGET/Whole Energy System Resilience Vulnerability Assessment/SIFIESRR/Rd2_Discovery

Project Licensee(s)

National Grid Electricity Transmission

Project Start

Apr 2023

Project Duration

3 Months

Nominated Project Contact(s)

Tinashe E Chikohora; Sean Coleman

Project Budget

£160,642.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£142,820.00

Strategy Theme

Whole energy systems

Challenge Area

Improving energy system resilience and robustness

Lead Sector

Electricity Transmission

Other Related Sectors

Electricity Distribution

Funding Licensees

NGET - National Grid Electricity Transmission

Lead Funding Licensee

NGET - National Grid Electricity Transmission

Collaborating Networks

Electricity North West, National Grid Electricity Distribution, National Grid Electricity System Operator, National Grid Electricity Transmission, Scottish and Southern Electricity Networks Transmission, UK Power Networks

Technology Areas

Distributed Generation, Modelling, Resilience

Equality, Diversity And InclusionSurvey

Yes

Project Summary

WELLNESS will provide core evidence and a consistent approach to develop resilience standards that inform whole energy decision making, which capture multi-energy flexibility, to create a cost-effective and consistent UK resilience strategy.

This proposal will build on the resilience assessment framework developed in the "Forward Resilience Measures" NIA project The framework provides mechanisms to consistently identify, using state-of-the-art statistical approaches, conditions that cause the most extreme impacts on the transmission network. However, the framework is missing the latest resilience modelling innovations. More importantly, it disregards flexibility from the multi-energy technologies that are emerging in the distribution network. These flexible resources can offer a cost-effective measure against the more extreme network impacts.

WELLNESS brings together a team of experts with complementary skills to deliver the following strategic innovations:

- Investigate whole system application of demand side flexibility to support transmission and distribution networks. This will be led by NGET and ENWL who have vast experience operating transmission and distribution networks, deploying the latest innovation, in the face of extreme events such as Storm Arwen.
- Explore effective applications of flexibility (e.g., from EVs, mobile generators and storage and multi-energy sources) to support network operation. These activities will be led by ICL, which has vast experience in multi-energy flexibility modelling, and developing evidence to support regulation.
- Assess requirements to embed existing and emerging resilience measures into whole system decision making (operation and planning). UoM, building on their expertise on network decision making studies (operation and investment) and relevant requirements, will lead this task.
- Explore, considering stakeholder inputs, the importance of the latest resilience modelling innovations, e.g., enhanced fragility curves, cascading impact modelling coupled with machine learning, detailed restoration practices, etc. UCY will lead this activity based on their world leading expertise on resilience modelling, including proposal of relevant metrics.
- Quantify based on formal CBA, and different use cases, the economic benefits that proper resilience standards can bring to GB (e.g., resilience-informed investments). The task will be led by ARUP which specialises in business cases and CBA, and has experience shaping practice and sharing learning to support resilience best practice.

Our outputs will inform the Alpha phase, where the most attractive use cases will be identified for a practical demonstration in the Beta phase. Ultimately, the findings of WELLNESS will be critical for network operators and Ofgem.

Project Description

The Whole Energy System Resilience Vulnerability Assessment (WELLNESS) project will run from April to June 2023 to establish both the foundations for, and evidence to develop the first resilience vulnerability assessment for whole energy system across Great Britain (GB) for the purpose of improving efficiency relating to investment decisions and resource allocation.

Improving the resilience of our power system is critical as we face more, and more severe, events such as floods, windstorms and lightning, as well as extended periods without renewable generation. Systematically and consistently quantifying resilience is still a challenge, especially across the whole energy system. The forerunner Forward Resilience Measures, Network Innovation Allowance (NIA) project developed a systematic approach, building on formal stochastic methods and stakeholder feedback, to consistently represent extreme events and assess corresponding network resilience at transmission level only.

To meet the requirements of a future net-zero carbon power system which will include large volumes of flexible, multi-energy distributed energy resources, the aforementioned work needs to be expanded. According to the latest research, these flexible energy resources can offer some of the most cost-efficient resilience measures against extreme network shocks (e.g., windstorms, lightning and floods) and must be included in an effective GB resilience view. We will also incorporate the latest developments and innovations in resilience (e.g., from CIGRE, cross sector best practice, the UK government, and relevant international research projects), specifically:

- multi-energy demand side flexibility modelling and deployment to provide resilience measures,
- aggregation of flexibility to be traded at the interface between the transmission and distribution networks to support whole system resilience,
- advanced fragility modelling, such as the latest flooding impact models which consider structural damage, and
- comprehensive transmission and distribution power network modelling in the context of resilience, including cascading impacts and detailed restoration.

The WELLNESS project will deliver standardised, whole energy system assessment methodologies and systematic performance metrics, to ensure resilience in fully integrated across both operational and investment decision-making.

The Discovery Phase will see us define criteria for success, establish detailed user requirements for resilience assessment, identify clear gaps and opportunities, produce an evidence-based business case with a cost-benefit analysis building upon reasonable counterfactuals, and finally develop a detailed delivery plan for Alpha and Beta Phases to ensure electricity continues to reach consumers safely, reliably, affordably and efficiently.

Preceding Projects

NIA_NGT0049 - Forward Resilience Measures (Stage 1)

Third Party Collaborators

The University of Manchester

Imperial College London

Ove Arup & Partners Ltd

University of Cyprus

Nominated Contact Email Address(es)

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Project Description And Benefits

Applicants Location (not scored)

National Grid Electricity Transmission(lead)

Warwick Technology Park

Warwick,

CV34 6DA

Partner 1: Electricity North West Limited, ENWL(partner)

Stockport,

SK1 2JD

Partner 2: The University of Manchester, UoM

Oxford Rd,

Manchester

M13 9PL

Partner 3: University of Cyprus, UCY

University House

2109 Aglantzia, Nicosia

Cyprus

Partner 4: Imperial College London, ICL

South Kensington,

London

SW7 2BX

Partner 5: Ove Arup & Partners Limited, ARUP

8 Fitzroy Street,

London

W1T 4BJ

Project Short Description (not scored)

Project WELLNESS will inform regulation of resilience related investments and develop a standardised approach to embed resilience into whole energy network decision making.

Video description

https://youtu.be/qNmLsgSX9LU

Innovation justification

Innovation Foundations:

Our team has been researching opportunities to develop a resilient energy system to support the UK's net-zero carbon future. This is a significant challenge as there are no existing resilience standards to guide planning and assessment of measures to improve system resilience to the increasingly harsh extreme events (e.g., floods, windstorms and lightning) experienced in GB.

To tackle this challenge, our team members lead significant work:

- Modelling impacts that extreme events and stresses have on the power network.
- Identifying key aspects of system resilience that matter to different stakeholders.
- Proposing metrics to quantify power system resilience which can be embedded in decision making.

Gaps in Knowledge:

Building on our expertise, we proposed the first standardised approach to consistently assess resilience measures for GB's transmission network in the "Forward Resilience Measures" (FRM) NIA project. However, this only considered windstorms and did not include the contributions of distribution networks to capture and deliver flexibility from multi-energy technologies to support whole system resilience. Deployment of flexibility can be the most cost-effective mitigation measure under extreme conditions. However, the use of these resources is not well understood and, currently, risky.

Innovation Opportunities:

To address the gaps, WELLNESS will deliver the following innovation:

- Develop models, within the FRM framework, to capture the operation and coordination of multi-energy flexibility as a means to provide resilience services at the distribution and transmission level.
- Update the FRM outputs to be included in a risk- and resilience-aware investment approach to plan GB's energy critical infrastructure, explicitly considering the need and opportunities for TNO-DSO coordination.

In addition, building recommendations from our latest UK and international work, (e.g., CIGRE Working Group C4.47 "Power System Resilience", CS-NOW, etc.), WELLNESS will maximise the impact of the above innovations by:

- Capturing the impacts of multiple extreme hazards through enhanced fragility and vulnerability assessment modelling (e.g., flood modelling considering structural damage) including extreme stresses such as long periods without renewable energy generation.
- Considering detailed network operation and restoration, such as cascading impacts of extreme events coupled with machine learning approaches in a net-zero world.
- Developing open-access resilience assessment tools that can be readily adopted by stakeholders.

Funding justification:

The scope of the project in whole systems goes beyond NIA applications, whereas the aim to develop tools with high TRL levels are outside the scope of research funds (EPSRC).

Appendix – Innovation justification

We need a resilient energy system that can safely support a net-zero carbon future even in the face of harsher extreme events in GB such as windstorms, floods and lightning. This will only be possible if we secure sufficient evidence and methods to develop resilience standards to inform power system decision making (operation and investment), which currently do not exist anywhere in the world.
To fill this gap in knowledge we (NGET, ARUP, UCY and UoM) proposed the “Forward Resilience Measures” GB work (£427k, NIA) to produce evidence and a standardised approach to assess transmission network resilience in GB. The key novelties of the work include:

- Moving away from selecting specific “extreme events” to statistically capturing how different combinations of events and network condition cause “extreme network impacts” by exploiting network vulnerabilities, as recommended in the RESNET UK project (£415k, EPSRC
- Using risk assessment techniques, borrowed from finances, to quantify extreme network impacts, and produce metrics (e.g., Conditional Value at Risk of Energy Not Supplied) as shown in the disaster management and resilience in electric power systems UK project (£241k, EPSRC).
- Capturing stakeholder feedback to identify areas of interest, e.g., vulnerable customers.
- High spatial resolution modelling, using forecasted (hourly) demand profiles produced at the primary substation levels, to capture impacts on specific areas of the network, e.g., location of critical loads (hospitals) and vulnerable customers.

The project provided key evidence to develop transmission network resilience standards against windstorms, with focus on assessing (not proposing) resilience measures and without capturing interactions with the distribution network and its emerging flexible multi-energy resources. This is not sufficient to inform the future GB resilience strategy which must capture the benefits brought by decarbonisation, e.g., electrified heating and transport, and multi-energy systems.
WELLNESS builds on our previous work, and brings expertise on distribution networks (ENWL) and flexible multi-energy demand side resources (ICL), to develop adequate resilience standards that can be used by network operators and regulators to support decision making aligned with a cost-effective GB whole system resilience strategy. For this purpose, the following innovations are pursued:

- Optimisation and coordination of multi-energy technology operation to provide whole system resilience services. These technologies offer cost-effective services by deploying already
existing resources that can shift to different energy vectors to provide system services without compromising customer needs, e.g., smart EV charging and storing electricity as heat, etc.
- Moving from only assessing resilience measures to also embedding them in network decision making in consideration of flexibility exchanges (at TNO/DSO interfaces), effectively trading risks between different networks.

In addition to maximise the impacts of the above innovation, WELLNESS:

- Adopts the latest resilience research and stakeholder feedback from leading resilience groups led or supported by our team, e.g., CIGRE (Working Group C4.47 “Power System Resilience” and C1.33 “Multi-energy system interactions in distribution grid”) and BEIS (CS-NOW: “Climate services for a Net Zero resilient world”, £5m) and EPSRC (Supergen “Energy Networks Hub”).
- Captures a wide range of extreme events in GB, including windstorms, floods and lightning, supported by novel fragility modelling, e.g., capturing power network structural damage caused by floods by implementing key research outputs such as from TERSE (£1m, EPSRC).
- Couples novel spatial and temporal cascading event simulators (both dynamic and quasi-static) with advanced machine learning algorithms for the accurate and fast (close to real time) assessment and identification of high risks to national system resilience, also considering restoration challenges in a net-zero world

Benefits Part 1

Environmental - carbon reduction – direct CO2 savings per annum against a business-as-usual counterfactual
Financial - cost savings per annum for users of network services
Financial - cost savings per annum on energy bills for consumers
Financial - future reductions in the cost of operating the network
New to market – products, processes, and services

Benefits Part 2

There are currently no resilience standards that can be used for network decision making in the UK. Accordingly, the effectiveness of current network reinforcement projects, such as the Network Option Assessment (NOA), may be wrongly assessed, which can lead to additional investments and purchase of network services to meet the resilience needs of the UK energy system. Considering that large volumes of investments in new infrastructures (e.g., traditional resilience measures) and flexibility services (e.g., emerging resilience measures) will be required to further support a net zero energy system, proper resilience standards would lead to more cost-effective investments and significant savings.

By developing this resilience assessment framework, both transmission and distribution networks will be able to properly leverage the outputs to deliver optimised, integrated whole energy system resilience investment into the network. It's perceived that this level of co-ordination will help to reduce the costs associated with network reinforcement, leading to a reduction in operation expenditure from any one network. Additionally, by building resilience into the network, the impacts of any extreme events will be effectively mitigated, avoiding any maladaptation thus leading to a reduction in both customer interruptions (CI) or Customer Minutes Lost (CML) and the operational costs associated with responding to them. The use of flexibility to provide cross boundary support, in conjunction with more traditional reinforcement, will provide a cost-effective means of securing the network against the impact of these events.

Once the assessment framework is developed, and the project passes into the Alpha and Beta phases, the proposed solutions will be compared against current methodologies to demonstrate the benefits, cost effectiveness and the enhanced resilience of the outcomes.

Project Plans And Milestones

Project Plan and Milestones

Pre-project preparation:

- Engage stakeholders to form groups of advisors and users.
- Collect outputs from existing resilience projects.
- Identify use cases for Cost Benefit Analysis (CBA).

Project management:

NGET and ENWL will provide strategic guidance, management and coordination during the discovery phase of the project. Building on the outcomes of the work, key risks that may arise at the Alpha and Beta phases will be identified and mitigated. The progress, risks, stage gates and deliverables will be closely monitored in weekly meetings.

Work Packages (WPs):

WP1 -- Project management, led by NGET, weeks1-2, (£14,000):

1.1 Define planned actions, stage gates and success criteria.

1.2 Define project requirements.

WP2 -- Demand side flexibility, led by ENWL, weeks3-9, (£36,000):

2.1 Review scenarios for integration of demand energy resources (DER) at the local and national levels.

2.2 Review applications of flexibility of multi-energy for distribution and transmission network resilience support.

WP3 -- Identification of requirements, led by UoM, weeks3-9, (£43,000):

3.1 Review definitions of resilience and assessment methods.

3.2 Identify aspects of resilience that matter to different stakeholders.

3.3 Confirm key extreme scenarios and stress conditions in the UK.

3.4 Confirm importance of cascading failures and system restoration modelling.

3.5 Identify gaps in data availability, quality and accuracy.

WP4 -- CBA, led by ARUP, weeks3-9, (£50,000):

4.1 Review costs of resilience measures and define counterfactual.

4.2 Explore the value of emerging resilience measures, such as DER flexibility.

4.3 Identify trade-offs between costs, resilience and other metrics.

Milestones (M), deliverables (D) and success criteria:

M1.1 Project requirements: Gantt chart (D1.1) and list of resource requirements (D1.2).

M2.1 Demand side flexibility: Report on resilience through flexibility D2.1.

M3.1 Modelling requirements: Stakeholder, modelling and scenarios report, D3.1.

M4.1 CBA: Counterfactuals, use cases and CBA of resilience standards, D4.1

Main risks and mitigation actions:

- Availability of personnel with the required expertise. Additional experts from the partner institutions will be available.
- Obtaining timely stakeholder inputs. Stakeholders will be identified and approached before the beginning of the project.
- Defining a proper counterfactual that represents current resilience enhancement practices. A list of options, such as the Network Options Assessment (NOA), will be built and the most adequate counterfactual will be selected based on expert opinion and stakeholder feedback.

Additional work is identified. Stage gates will be defined for the main resilience modelling aspects to be explored in different phases of the project.

Project plan and risk register are located in PM template

Regulatory Barriers (not scored)

There are no expected regulatory barriers for this project. This project will complement existing and future regulatory arrangements for supporting the assessment of options across several mechanisms, including Extreme Weather, Electricity System Restoration and could be used to support Large Onshore Transmission Investment (LOTI) submissions.

The long-term implementation from this project will support future policy options for resilience centric mechanisms.

Commercials

Route To Market

For project partners responsible for transmission and distribution networks decision making in GB, the main benefits of the WELLNESS project will be the adoption of resilience standards into Business-as-Usual practices. For example, by adopting the proposed resilience assessment methodologies to produce inputs for the different RIIO-2 CBA frameworks and offer network operators clear and consistent resilience decision making guidance.

During the Discovery and Alpha phases, we will identify the most attractive business cases and uses cases to demonstrate the value of resilience standards. For this activity we will liaise with our academic and industrial partners and key stakeholders, such as Energy Networks Association (ENA), the Energy Systems Catapult and octopus energy, with expertise on resilience or the use of flexibility as a source of power system support.

After a successful Beta phase, our ambition is to have the methodologies, evidence and metrics developed in the WELLNESS project informing existing network regulation (e.g., RIIO-2) and being integrated into future GB network regulation. For this purpose:

- Interactions with existing and emerging markets will be explored. Sources of flexibility, coming from the markets, would be considered as measures to enhance system resilience. The proposed solution is not expected to directly impact competitive markets, but investments associated with resilience measures to indirectly affect some markets.
- The methodologies and tools developed within the project will be developed as open-access tools to be readily usable by different network operators and other stakeholders (e.g., Ofgem).
- Building on stakeholder feedback and expertise from the team, economic and minimum acceptable values will be identified for the different resilience metrics proposed in the project.

The project team will engage with the Energy Networks Association (ENA) to fine tune the outputs of the WELLNESS project with the aim of embedding them into the relevant best practice guides and engineering recommendations.

Intellectual property rights (not scored)

Across all stages of the project all partners will act in line with the SIF governance on the handling of IPR. We have identified nothing in the Discovery Phase however, partners will revisit this during Alpha Application.

Costs and value for money

Network investments and operation are currently planned without a standardised resilience assessment methodology that supports the development of a unified GB resilience view. The WELLNESS project will provide unprecedented evidence and outputs required to develop the resilience standards for network decision making required to meet GB's net-zero future. Innovation funding is required based on the risks and significant potential value associated with bringing together the different tools, information and know-how required to propose and trial network resilience assessment standards.

The costs of the WELLNESS project are mainly based on labour costs of the lead partner and project partners during the duration of the project. The costs of the project amount to £160,642; however, the requested funding is £142,820 as the team is making a combined contribution of £17,822 in the form of reduced labour fees. These costs only represent a small fraction of the benefits (value for money) that resilience standards will bring to GB as will be quantified in the discovery phase.

NGET will receive £15,726 of the requested funding. The team brings key transmission network expertise and will use their valuable experience to manage the project, set stage-gates and assess success criteria.

ENWL will receive £13,920 of the requested funding. The team will bring essential experience in responding to the design and operational challenges posed on DNOs by extreme events. This will assist the other partners with ensuring that the framework developed is truly applicable to both transmission and distribution networks.

ICL will receive £23,650 of the requested funding. The ICL team will bring unique expertise related to the assessment of the role of smart multi-energy micro grids in fundamentally enhancing resilience of supply cost effectively.

UoM will receive £24,543 of the requested funding. The UoM team brings critical network decision-making and resilience assessment expertise which has been developed over the last decade, harnessing the valuable outputs of research projects with a value of over £15m.

UCY will receive £22,200 of the requested funding. The UCY team brings internationally recognized expertise in resilience assessment

and enhancement, and innovation know-how on the topic of energy resilience from international research projects with a total value over £1.5million.

ARUP will receive £42,781 of the requested funding. The ARUP team will bring over 75 years of critical infrastructure resilience design and engineering expertise; and strong modelling capabilities building on ARUP's overall resources as a major multidisciplinary engineering consultancy.

Document Upload

Documents Uploaded Where Applicable

Yes

Documents:

10061033 WELLNESS_ End of Phase Meeting_ 27 June 2023..pdf

10061033 WELLNESS_ Show and Tell Webinar Slides_vFinal 12 June 2023.pdf

Gantt chart_WELLNESS.pdf

Mid-Point Check In Report IMO_IL Presentation_040523_WELLNESS.pdf

NGET WELLNESS_ Sharing Project Plan to UKRI_ for the record.pdf

Ofgem_UKRI - Project Direction_WELLNESS.pdf

Project Management Book Template_WELLNESS_DR2_2023.xlsx

WELLNESS - SIF Discovery Application Submission - 23-11-22.pdf

SIF Discovery Round 2 Project Registration 2023-08-03 2_03

SIF Discovery Round 2 Project Registration 2023-08-04 3_54

NGET WELLNESS - Discovery WP3 Final Report_ Identification of Requirements.pdf

NGET WELLNESS - Discovery WP2 Final Report_Demand Side Flexibility.pdf

NGET WELLNESS - Cost Benefit Analysis - ISSUE 1 - Public.pdf

This project has been approved by a senior member of staff

☑ Yes