SIF Alpha Round 2 Project Registration

Date of Submission

Jan 2024

Project Reference Number

NGET/Whole Energy System Resilience Vulnerability Assessment/SIFIESRR/Rd2_Alpha

Initial Project Details

Project Title

Whole Energy System Resilience Vulnerability Assessment (WELLNESS)

Project Contact

Sean Coleman

Challenge Area

Improving energy system resilience and robustness

Strategy Theme

Whole energy systems

Lead Sector

Electricity Transmission

Other Related Sectors

Electricity Distribution

Project Start Date

01/10/2023

Project Duration (Months)

6

Lead Funding Licensee

NGET - National Grid Electricity Transmission

Funding Mechanism

SIF Alpha - Round 2

Collaborating Networks

Electricity North West

National Grid Electricity System Operator

UK Power Networks

National Grid Electricity Transmission

Scottish and Southern Electricity Networks Transmission

National Grid Electricity Distribution

Technology Areas

Low Carbon Generation

Modelling

Distributed Generation

Electricity Transmission Networks

Energy Storage

Resilience

Substations

System Security

Project Summary

Physical climate risks will affect existing infrastructure in the next decades. The nature and scale of risks will become more uncertain over longer time scales.

WELLNESS sets out to provide core evidence and a coherent approach to resilience standards, assessment, and quantitative metrics that can inform the decision-making process of electricity network stakeholders. The intent is to fairly and transparently to value the resilience contribution from different resources with a multi-energy background on a level playing field. This therefore can provide means and tools for network owners and operators to justify their resilience-orientated investments in front of the regulator.

Add Preceding Project(s)

NIA_NGT0049 - Forward Resilience Measures (Stage 1)

Add Third Party Collaborator(s)

University of Cyprus

Imperial College London

Ove Arup & Partners Ltd

The University of Manchester

Project Budget

£543,998.00

SIF Funding

£471,725.00

Project Approaches and Desired Outcomes

Problem statement

GB faces significant challenges to upgrade the energy networks to achieve a net-zero and resilient whole energy system. There has been significant efforts to (i) develop pathways for a net-zero future (e.g., future energy scenarios) and (ii) improve system resilience (e.g., the UK government resilience framework and risk register). An opportunity exists to embed greater coordination of network investments envisioned for a net-zero future, recognising system resilience. That is, existing investment alternatives that could improve system resilience are not considered and, as a result, large volumes of additional (often expensive and uncoordinated) investments are also needed to maintain or improve system resilience. WELLNESS will tackle this grand challenge by providing a framework to provide core tools, metrics and information to explicitly embed resilience in network decision making.

The WELLNESS framework is being designed to capture the new technologies that are emerging at the distribution network side due to the planned net-zero transition, such as flexibility from renewable generation and different types of storage which offer **novel approaches to improve resilience using multi-energy systems**. Based on our discovery work, this flexibility can offer the most cost-effective options to improve transmission and distribution network resilience and **strengthen the GB's energy system robustness to support efficient roll out of new infrastructure**. That said, the effective use of flexibility to improve network resilience requires expert knowledge of the emerging flexible technologies, and the whole energy network (i.e., transmission and distribution networks).

Understanding the impacts that extreme shocks (e.g., windstorms, floods and lightning as well as long periods with low availability of renewable energy generation) can have on the whole energy system should be based on advanced network, hazard and load models. WELLNESS will explore the **potential of extreme shocks to cause cascading failures**, which is a more realistic representation of the impacts of shocks. The different effects of hazards would be considered, such as the potential of floods to cause structural network damage (not only inundate assets), which is critical to identify the most effective options to improve network resilience. The **geo-spatial impacts of network failures**, such as potential disconnection of critical loads, and the alternatives to minimise impacts through the coordination of flexible resources will be modelled. Developing these advanced modelling features requires key network expertise and knowledge of the latest innovations from academia, including the world-renowned academic partners of WELLNESS.

It is important to note that, as our discovery work highlighted, systematically and consistently modelling and quantifying system resilience is not enough to embed resilience in whole energy network decision making. That is, the **existing tools for decision making** (e.g., currently RIIO2 CBA templates) **must be enhanced to facilitate consideration of resilience metrics, as well as to properly and adequately value demand side flexibility**. Furthermore, these tools must be **transparent and accessible** to facilitate their use by network operators and the regulator. To address this challenge, WELLNESS will provide a detailed **analysis of the areas of improvement of the current RIIO2 CBA templates** (i.e., for transmission and distribution network investment), and provide a first prototype of an accessible cloud-based resilience assessment framework.

In summary, WELLNESS aims to address the following problems:

- How can we embed resilience needs in investment decision-making process?
- How can we align networks investments to develop a net-zero and resilience energy system in a cost-effective manner?
- How can we use flexibility to improve network resilience?
- Can advanced hazard, demand and energy network modelling allow us to better capture the impacts that extreme shocks have on the energy system (stress testing)?
- Can we update our network planning tools, while still maintaining accessibility and transparency?

Innovation justification

This is a continuation from the Discovery Phase where the WELLNESS team pursued researching opportunities to develop a consistent and standardised approach to embed resilience in network decision making to support the GB's net-zero carbon future whilst tackling the impact of emerging physical climate risks (e.g., floods, windstorms, and heatwaves) on the critical national infrastructure, i.e. the long-lived and rapidly changing energy infrastructure.

This project addresses the "Improving energy system resilience and robustness" challenge theme by directly providing a methodology that will enable resilience to be embedded into network decision making in a fair and standardised way across transmission and distribution networks. Such a framework does not currently exist as recognised by National Infrastructure Commission, and the industry is falling behind the recommended timelines. WELLNESS aims to bridge this gap as a matter of urgency. The project's core objective is to incorporate resilience and robustness as key and measurable considerations into system design (subsequently influencing investments) and to provide innovative open-source tools.

Previous work on resilience has typically focussed on individual aspects to create tools for specific tasks, for example quantifying resilience of networks to flooding events. There is, however, a significant innovation gap with respect to a holistic approach which can be applied to assess network and energy system resilience across different networks, exposed to different physical climate risks. This approach should provide decision making tools which are comparable and enable fair investment decisions. For example, currently there is not a standardised assessment to value the resilience contribution from different interventions such as flood defence systems for distribution substations, or rapid overhead line restoration technologies in the wake of windstorms. Let alone, whether advanced technologies and use of flexible resources can provide a more effective mitigation of resilience risks. Delivering this type of innovation requires coordination across the networks (NGET and ENWL), as well as with experts in resilience (provided in this project by the universities and ARUP). This project has been challenged and refined by internal and external stakeholders as well as building upon learnings and findings from previous projects to make sure that it is fit for purpose.

It is, however, very challenging and carries risk -- which is why SIF funding is sought. At present, networks are making resilience-based investments and this will continue under business-as-usual activities (as was noted during Discovery submission feedback). What this project offers is the potential to coordinate this to a much greater extent across networks by introducing a standardised approach for aiding resilience investments as well as focusing on how emerging physical climate risks affect long-lived infrastructure (which may not be design to these risks). It will also enable resilience-based decisions to become part of the justification for wider network investments, linking in directly with decarbonisation and flexibility investments instead of remaining separate and detached as standalone processes. A coordinated approach will result in a more efficient and cost-effective investments for customers. The level of coordination required, pushing the state-of-the art in this area, and the risk associated with the underlying complexity are a strong justification for SIF funding.

This project will deliver the state-of-the-art in this area (more information can be found in the appendix). Resilience quantification and assessment exists, but it has never been combined in this way into form a standardised approach for the industry. Furthermore, it will advance the individual aspects which come together to build the framework advancing the physical climate risks modelling, the asset fragility assessment, the cascading failure simulators, the decision making tools and developing a single open-source prototype platform to bring these together into one tool for the first time

Impact and benefits (not scored)

Financial - future reductions in the cost of operating the network

Environmental - carbon reduction – direct CO2 savings per annum

New to market – products

New to market – processes

New to market - services

Impacts and benefits description

Financial -future reductions in the cost of operating the electricity transmission and distribution networks, leading to a reduction in costs to consumers of energy and network services.

By embedding resilience in network decision making, alongside other drivers of net zero and reliability, investments required to meet current net-zero targets can be strategically selected to also improve whole system resilience. As a direct result, the cost of reactive resilience investments reduces, for example deployment of mobile generation, flood defences, construction of assets - leading to an overall reduction in cost to consumer.

Various new to market benefits associated with the investment in, and use of new products, processes and services.

By way of example, increasing network capacity through investment in, and use of novel conductors, cross arms and associated

equipment from the start of the next price control where the metrics would include percentage of capacity increased against cost to build new circuits. During the course of this project, a range of appropriate and realistic new products, processes and services will be identified and built into the assessment.

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

This will be based on historical data or industry baselines from the start of the next price control. For example, emissions relating to backup diesel generators. Scope 2 emissions savings will also be factored into the whole energy system assessment. During this project, a range of Scope 1 and Scope 2 emission reductions will be identified and factored into the assessment and its outputs.

Teams and resources

Lead partner: National Grid Electricity Transmission, NGET

National Grid House, Warwick Technology Park, Gallows Hill, Warwick CV34 6DA

NGET brings a knowledge and experience of enabling the energy system transition to net zero, and maintaining a reliable high voltage transmission network, to further embed resilience in decision making.

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

Borron Street,

Stockport,

SK1 2JD

ENWL bring knowledge of distribution network requirements and the role of demand side flexibility in enabling network resilience.

Partner 2: The University of Manchester, UoM (research institution)

Oxford Rd,

Manchester

M13 9PL

UoM possess power system assets research, modelling and testing expertise in resilience, as well as experience delivering open-source and cloud-based modelling and assessment platforms.

Partner 3: University of Cyprus, UCY (research institution)

University House "Anastasios G. Leventis" 1 Panepistimiou Avenue 2109 Aglantzia, Nicosia P.O. Box 20537, 1678 Nicosia, Cyprus

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.

Partner 4: Imperial College London, ICL (research institution)

Exhibition Road,

South Kensington,

London SW7 2BX

ICL have expertise related to the assessment of the role of smart multi-energy micro grids and mobile sources in fundamentally enhancing resilience.

Partner 5: Ove Arup & Partners Limited, ARUP (Consultant)

8 Fitzroy Street,

London W1T 4BJ

Arup have developed novel approaches for the holistic management of resilience of complex systems including cities, water and energy, Arup has been at the forefront of infrastructure resilience thought leadership during the last 15 years (e.g. Resilience Shift is Arup's not-for-profit resilience think tank aiming to create a movement to bridge the infrastructure systems gap, to create a safe, resilient and sustainable future for all). A large portion of the knowledge created have been the result of multidisciplinary delivery and partnerships, requiring significant strategical alignment, requirements mapping and integration. This makes Arup the ideal partner to ensure that Wellness requirements and outputs are clearly defined and understood across all stakeholders.

Project Plans and Milestones

Project management and delivery

For effective delivery of WELLNESS Alpha, clear project goals, and work package aims have been carefully crafted and assigned to project partners with the relevant expertise and track records. Furthermore, considering the complexity and tight deadlines of the work, project management expertise (Frazer-Nash) is also being subcontracted.

WELLNESS's goal is to develop a framework to embed resilience in whole energy system decision making. At the alpha phase, our goal is to develop a prototype of such tool. Building on lessons learned during WELLNESS Discovery, such a framework must (i) capture different risks faced by the network and emerging network conditions and resources (e.g., multi-energy flexibility), (ii) accurately model the impacts of risks on and their propagation across the networks, (iii) offer different mechanisms to capture resilience and which may be suitable for different types of decision making, regulation, etc., and (iv) be accessible so that the WELLNESS framework can be readily use by network operators, regulators, and other stakeholders.

Based on the above, WELLNESS Alpha comprises the following Work Packages (WPs):

WP1: Project management

As the name suggests, this WP will manage, coordinate and, if needed, revise the activities and goals of the project. The WP is led by NGET which has experience working and managing the project partners, and which is now supported by Frazer-Nash.

WP2: Spatial and Temporal Modelling and Quantification of Network Shocks and Stresses

This WP will provide (to all other WPs) the different network risks and stresses models and portfolios of resilience metrics that can be used to fit different types of assessments and regulation. The WP is led by UCY, an internationally recognised institution for their work on Resilience (see team).

WP3: Modelling and quantification of Whole System impacts

This WP will provide (to WPs4-6) validated whole network models with enhanced functionalities to capture the impacts of different weather shocks (e.g., cascading failures) and emergence of different technologies associated with our net-zero transition. The WP is led by UoM which has vast power network modelling expertise (see team).

WP4: Analysis of the role of distribution networks and demand side flexibility

This WP offers innovative approaches to capture flexibility from multi-energy resources (used in WPs 3, 5 and 6) as a means to improve resilience at the distribution and transmission network levels. The WP is led by ICL, which is an internationally recognised expert in this topic (see team)

WP5: Embedding resilience in investment decision making process

This WP brings together the outputs and expertise from other WPs and key information from stakeholders to identify the key requirements to embed resilience in decision making (and informs WP6). The WP is led by ARUP who brings multi-disciplinary expertise to resilience assessment (see team)

WP6: Demonstration: Prototype software platform

This WP offers an accessible means (WELLNESS prototype platform) to use the models from the above WPs by embedding them in an interactive cloud-based jupyter platform. This WP is led by UoM which has expertise developing open-access and cloud-based tools (see team and resources)

WP7: Limitations and areas of improvement of current CBA tools

This WP provides a practical information about the requirements for a decision making tool to be effective from the perspective of utilities. This task is led by ENWL, the operator for the North West of England (see team)

The WPs were designed to provide valuable standalone outputs, but which offer great value when used across WPs. This coordination can be challenging considering the short duration of Alpha. Weekly meetings (and bespoke meetings based on

needs) and a stage gate process will allow us to track progress and ensure successful delivery.

Key outputs and dissemination

Lessons learned:

During WELLNESS discovery, we explored the value and challenges associated with embedding resilience in network decision making and producing relevant information to inform regulation. Based on our findings:

- The WELLNESS framework must have functionalities to evolve in response to changes in the energy sector.
- Requirements vary across different locations as particular stakeholders are interested in specific risks, and different resources and critical loads can be found in various locations.
- Our understanding or resilience, and the aims of decision making constantly change.
- Network investments towards a net-zero future and a resilient GB network should be coordinated
- Flexible multi-energy resources are emerging as a means to decarbonise the energy sector. These resources provide potentially valuable options to improve network resilience.
- Large investments will be required to accommodate low carbon technologies, if assessed, some of these investments could contribute to network resilience
- Current decision making tools (e.g., Ofgem's CBA template) are not adequate to assess network resilience
- Network risks and investments in resilience investments must be assessed on a level playing field
- The WELLNESS platform must be accessible
- Frequent changes to the framework may introduce uncertainties, reduced clarity
- Open-access and cloud based approaches can improve acceptance of the framework

Key outputs of WELLNESS Alpha:

The key output of the project is an accessible (e.g., cloud based) prototype framework to embed resilience in decision making.

That said, in order to produce the above product, the following outputs will also be produced:

- Extreme shocks scenario simulator
- List of resilience metrics that may be suitable for regulation purposes
- Calibrated GB network model with advance functionalities, e.g., cascading analysis, consideration of demand side flexibility, etc.
- Simulator of weather shock impacts on the whole network
- Networked-microgrid and mobile source models
- Load restoration model
- Limitations of Ofgem's CBA in the context of resilience
- Requirements for decision-making metrics
- Principles for embedding resilience in the investment decision-making process.

Planned dissemination activities:

WELLNESS is being disseminated within each project partner's institution, with different UK stakeholders (e.g., energy systems catapult), and internationally (PowerTech 2023 conference). We will continue disseminating this work in different presentations. We are also considering preparing WELLNESS publication to be presented in conference or sent to journal papers.

Commercials

Intellectual property rights, procurement and contracting (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 not found IP issues during the Discovery Phase. The Alpha Phase still continue to comply with the default IPR conditions as defined in Chapter 9 of the SIF governance document. WELLNESS partners will revisit the IPR, procurement and contracting position during the Beta Phase Application.

Commercialisation, route to market and business as usual

Building on the Discovery discussions the Alpha phases will continue to identify the most attractive business cases and uses cases to demonstrate the value of resilience standards. This activity will pursue more intentional targeted roundtable discussions with academic, 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)
- Ofgem
- Government
- Other related SIF projects (including WARN, Scenarios for Extreme Events, CReDo+, NIMBUSS)

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, supported by a cloud-based resilience quantification and planning platform. 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 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.

Policy, standards and regulations (not scored)

Based on the WELLNESS work so far, and inputs from different stakeholders (e.g., utilities, academia, etc.), no regulatory barriers have been identified for this project. That said, we will continue exploring potential regulatory barriers and approaching relevant stakeholders (e.g., Ofgem) during the Alpha phase of the project.

This project will complement existing and future regulatory arrangements for supporting the assessment of options across several mechanisms. Recognising the resilience needs due to threats including physical climate risks and changing needs of consumers, the outcomes of WELLNESS will be able to aid major investment decisions such as Large Onshore Transmission Investment (LOTI) submissions building in requirements to ensure that network resilience is incorporated properly.

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

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 £543,998; however, the requested funding is £471,725 as the team is making a combined contribution of £72,273 (13.3%) in the form of reduced labour fees.

NGET will receive £55,000 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 £36,725 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 £80,000 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 £100,000 of the requested funding. The UoM team brings critical network decision making and resilience assessment expertise, as well as experience developing open-source and cloud-based modelling and training platforms, which have been developed over the last decade, harnessing the valuable outputs of research projects with a value of over £15m.

UCY will receive £30,000 of the requested funding. The UCY team brings internationally recognized expertise in resilience assessment and enhancement, spatial and temporal modelling of extreme events, including cascading analysis and quantification, and innovation know-how on the topic of energy resilience from international research projects with a total value over £1.5million.

ARUP will receive £170,000 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.

Associated Innovation Projects

- ○ Yes (Please remember to upload all required documentation)
- ◉ No

Supporting documents

File Upload

WELLNESS_SIF Alpha R2_End of Phase Report equivalent.pdf - 3.9 MB
WELLNESS_WP5_Final Report_ISSUE_Redacted.pdf - 964.3 KB
WELLNESS_WP5_Call for Input Workshop 2 - Summary Report_ISSUE_Redacted.pdf - 4.1 MB
WELLNESS_WP5_Call for Input Workshop 1 - Summary Report_ISSUE_Redacted.pdf - 4.2 MB
Wellness Alpha Phase Show & Tell 22_Apr_2024.pdf - 1.9 MB
WELLNESS_ Alpha EoP Monitoring Officer Meeting_ 12 Apr 2024.pdf - 2.7 MB
10084557 WELLNESS_ Alpha R2 K-Off Meeting Slides_ 06 October 2023 vF.pdf - 609.6 KB
Project Management Book v3_WELLNESS Alpha R2.xlsx (1) - 837.2 KB
WELLNESS Alpha R2 End of Phase_Risk Register.xlsx - 19.9 KB
WELLNESS_ Alpha R2_Midpoint Meeting_ 18 Jan 2024.pdf - 774.7 KB
WELLNESS_Alpha R2_Project Direction_10084557.pdf - 235.2 KB
WP6 - Demonstration_Guide_Monte Carlo Simulation - WELLNESS - SIF Alpha Report.pdf - 783.1 KB
WP6 - Demonstration_Guide_Collaboration between WPs 2-4 - WELLNESS - SIF Alpha Report.pdf - 900.0 KB
WP6 - Demonstration_3 Video Slide Snaps - WELLNESS - SIF Alpha Report.pdf - 247.6 KB
WP5 - Embedding resilience in investment decision-making processes - WELLNESS - SIF Alpha Report.pdf - 973.3 KB
WP4 - Analysis of the Role of Flexible Distribution Networks in Enhancing Resilience of Supply - WELLNESS - SIF Alpha Report.pdf - 936.5 KB
WP3 - Modelling and Quantification of Impacts_Guide_Windstorm modelling - WELLNESS -SIF Alpha Report.pdf - 1.1 MB
WP3 - Modelling and Quantification of Impacts_Guide_Power Network Model - WELLNESS -SIF Alpha.pdf - 645.1 KB
WP2 - Spatial and Temporal Modelling and Quantification of Network Shocks and Stresses -WELLNESS - SIF Alpha Report.pdf - 1.1 MB
SIF Alpha Round 2 Project Registration 2024-01-17 4_13 - 74.6 KB
WELLNESS Alpha Phase Submission_05072023_.pdf - 0.0 bytes
Project Management Book v3_WELLNESS Alpha R2.xlsx - 0.0 bytes
Project Direction_10084557 - WELLNESS- alpha.pdf - 0.0 bytes
10084557 WELLNESS_ Alpha R2 K-Off Meeting Slides_ 06 October 2023 vF.pptx - 0.0 bytes
10061033 Whole Energy System Resilience - Expert Assessor Feedback.pdf - 441.1 KB

Documents uploaded where applicable?

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