SIF Round 3 Project Registration

Date of Submission

Mar 2024

Project Reference Number

10104062 (1)

Initial Project Details

Project Title

Probabilistic Pathways for Energy System Planning

Project Contact

Paul Hurlock

Challenge Area

Whole system network planning and utilisation to facilitate faster and cheaper network transformation and asset rollout

Strategy Theme

Data and digitalisation

Lead Sector

Electricity Transmission

Project Start Date

01/03/2024

Project Duration (Months)

2

Lead Funding Licensee

National Grid Electricity System Operator

Funding Licensee(s)

National Grid Electricity System Operator

NGET - National Grid Electricity Transmission

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

National Grid Electricity System Operator

National Grid Electricity Transmission

Technology Areas

Electricity Transmission Networks

Project Summary

The FSO will be responsible for future whole energy system planning required to achieve net zero at lowest cost to consumers. Planning for an inherently uncertain future is complex and time consuming, significantly benefiting from the ability to quantify risk within planning decisions, and analyse more pathways.

This project will develop an enhanced end-to-end network planning methodology for the whole energy system. We will explore applying advanced computational techniques, such as artificial intelligence and probabilistic modelling, to capture risk and uncertainty within future energy pathways, enable rapid iterative network needs analyses, risk-based network options assessments, and deliver optimised planning decisions.

Add Preceding Project(s)

NIA_NGSO0028 - Study of Advanced Modelling for Network Planning Under Uncertainty

Project Budget

£168,640.00

SIF Funding

£149,544.00

Project Approaches and Desired Outcomes

Problem statement

The problem: Growing complexity, increasing uncertainty

One of NGESO's key responsibilities is planning the UK's future grid infrastructure to assure security, sustainability, and affordability of supply. As the energy transition accelerates, complexity and uncertainty associated with long-term planning and decision-making grows. Increasing complexity is driven by the need to co-optimise planning decisions across multiple energy vectors, while growing uncertainty is driven by the need to make high value decisions based on ranging projected system scenarios. Additionally, there will be an increasing need to consider system operability alongside network capacity in future planning decisions, escalating the need for managing of uncertainty, to enable risk-based decision making and the new mandate for the Future Systems Operator (FSO) to generate long-term strategic plans.

Our Solution

We propose combining advanced probabilistic modelling with Artificial Intelligence (AI) techniques to develop an enhanced whole energy system planning methodology. The additional functionality will include quantification of risk and co-optimisation for sustainability, affordability and security of supply.

Discovery Phase will evaluate existing methodologies to understand factors causing uncertainty and develop a comprehensive framework to deploy probabilistic techniques in future whole-system planning. We will assess:

Reduced-order models to improve analysis time, enabling recommendations and policy comparisons.
Reinforcement learning and AI for optimisation and to improve robustness of outputs.
Innovation Challenge(s)

This project primarily addresses "digital simulation and advanced modelling techniques to facilitate whole-system network planning and development". It also aligns to all other aspects of Challenge 1 as Beta outputs would support planning of a future whole energy system that maximises network capacity, increasingly utilise demand side flexibility and inform local and regional optionality for consumers.

Project focus will be on implementing advanced probabilistic uncertainty analysis, reduced-order modelling and novel AI techniques to enable optimised, efficient and low-cost network planning through risk-based decision-making.

Innovation Users

The process of transitioning to the FSO involves acquiring broader planning responsibility to encompass the whole energy system, whilst further developing key advisory roles for future energy and infrastructure policy. The energy transition is already driving changes to network design and system planning processes, including the need to integrate new whole-system design approaches and spatial considerations.

The primary user will be the FSO, with their needs being addressed through an enhanced planning methodology for delivering legislated responsibility for risk-based whole-system planning across energy vectors.

Video Description

https://www.youtube.com/watch?v=ZHsU1KmNG9o

Innovation justification

Innovative Aspects and Activities

Supply and Demand Modelling: Current network planning methodologies are underpinned by Future Energy Scenarios (FES), developed via complex analyses to determine credible pathways of supply and demand to 2050. FES analysis currently generates deterministic outputs, with limited quantification of uncertainties inherent in inputs and assumptions used.
This project will revolutionise FES methodology, developing enhanced risk-based network planning processes. It will implement

probabilistic techniques to capture uncertainty within the parameter space and account for how it propagates through the process; enabling increased confidence in outputs, based on lowest balance of cost and risk.

Network Needs: Currently, FES outputs are used to determine network requirements and capability over a 10-year period, identifying the need for network reinforcement. The detailed energy system analysis required to establish reinforcement needs is computationally and resource intensive, so only the most onerous pathway is currently analysed in detail.
The project will explore how reduced-order surrogate models can lower computation timescales, thereby maximising the number of pathways analysed, enabling an iterative analysis process.

Network Design: Currently, Transmission Owners (TOs) propose network design options with the potential to address the network needs identified by NGESO. These are assessed by NGESO for efficiency and cost-effectiveness which are based on fluctuant future costs, adding further uncertainty. The project will develop probabilistic cost-benefit analysis for long-term strategic plans for network development, with reinforcement learning and AI to analyse the greatest opportunity for strategic prioritisation of initiatives that will accelerate whole energy system development and operability.
Project Scale

It will consider the end-to-end planning process to develop AI-augmented flexible tools and probabilistic methodologies to de-risk the range of potential pathways. This will reduce resource requirements and increase the depth of analysis, meeting scales needed for future whole energy system planning. TRL, CRL and IRL for this project is 4 but anticipated progression to 5 during Discovery.

SIF Funding

This project aims to address limitations in deterministic models and enhancing them with probabilistic modelling and state-of-the-art AI techniques. The high level of innovation, whole-energy system benefit and natural progression through Discovery to Beta makes SIF the most appropriate funding mechanism for this project.

Counterfactuals

The project will assess several advanced modelling techniques, applied across the entire future whole energy system planning process, opposed to a single technique and application. The counterfactual of assessing one technique provides fewer benefits, compared to the ambitious and innovative simultaneous integration of multiple complementary techniques.

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum on energy bills for consumers

Financial - cost savings per annum for users of network services

Environmental - carbon reduction – indirect CO_2 savings per annum

New to market – processes

Impacts and benefits description

1. New processes: The pre-innovation baseline relies on mostly deterministic approaches, from FES to cost-benefit analysis, with only a single, most arduous pathway explored in greatest detail.
Integration of probabilistic and advanced AI modelling with new holistic planning processes will improve confidence in network design decisions, by embedding uncertainty analysis through the end-to-end process, and by increasing the quantity and range of pathways analysed in detail.

Probabilistic modelling will give insight to the likelihood of each pathway being realised, highlighting policy gaps. This will support the FSO advisory role, and subsequently produce clearer recommendations for efficient implementation by policy makers.

2.Operation Costs: Pre-innovation baseline uses deterministic outputs to inform network reinforcement options. Instead, our approach allows risk quantification, associated with investment and planning decisions. This enables adoption of long-term plans, which optimally balance cost, risk and performance across all credible pathways, whilst simultaneously empowering true leastregrets investment decisions. For example, the initial Accelerated Strategic Transmission Investment framework encompassed 26 projects, worth roughly £20bn. This equates to £200m benefit for every 1% reduction unlocked through risk-based approaches.

Also, increasing analysis speed, as we are proposing, allows for the range of policy options to be better understood and compared, supporting cost-effective policy implementation.

3.Consumer Costs: Facilitation of faster low-cost and low-carbon generation connections, risk-based decision-making and more efficient network operation will reduce consumer bills. Reducing curtailment through strategic grid capacity improvements and/or storage connection would also reduce bills, as about £800m relating to curtailment was added to bills in 2022.

Running different pathways more quickly helps to support long-term development planning based on a balance of multiple factors, including societal costs such as consumer bills.

4.Network Service Costs: Lower risk planning decisions will allow better coordination of network services and give greater confidence to supply chains.

Enhanced long-term development planning will permit more strategically located flexibility, improving cost-effectiveness of network services. In 2021, Carbon Trust reported flexibility as a no-regrets decision, providing potential net savings up to £16.7bn/annum.

Reduced-order models which allow decreasing analysis times, will result in better informed policy decisions and market arrangements, such as targeted incentivisation and highlighting the existing gaps in market requirements.

5. Indirect Carbon Reduction: Holistic planning processes will improve connection times for low carbon energy resources, whilst a risk-based planning approach will help to optimise the strategic siting locations for distributed storage and flexibility providers, reducing curtailment of low carbon energy generation.

Teams and resources

Project Team

- National Grid ESO (NGESO) - Project lead: NGESO is the Electricity System Operator and is responsible for operating the GB electricity system, including the secure operability of the system. NGESO lead the development of FES, whilst also defining network requirements and assessing TO network design options. This role will soon extend across the whole energy system, incorporating offshore, distribution-level and gas strategic network planning as FSO. NGESO will be the project lead, and ultimate end user of the final outputs from this project. Highly experienced personnel from teams with responsibilities across the current end-to-end planning process will be involved with inputting requirements, expertise and assessment of the project, together with the newly formed teams delivering additional FSO roles.
- National Grid Electricity Transmission (NGET): NGET is a TO and therefore a highly important stakeholder in the planning process. NGET resources from the network options and design teams will be involved with inputting to the business process modelling through attending workshops and providing invaluable insight to the work undertaken, to create network design options for cost-benefit assessment by NGESO.
- Frazer-Nash Consultancy: Technical aspects will be led by their Strategic Modelling group, winners of Team of the Year Award, at Energy UK's Young Energy Professionals awards 2023. This group combines whole energy modelling and analysis capability (see Q3 Appendix for further details), combining AI and probabilistic techniques with strategic advisory expertise. In addition, Frazer-Nash's Information Systems team will provide expert elicitation experience and end-to-end process modelling capability. Relationship

NGESO and NGET currently work closely through the network planning process, as well as other operational functions. Frazer-Nash has a strong working relationship and are highly trusted by both NGESO and NGET, having partnered on several previous projects, both in SIF and NIA.

External Parties

Dr Priya Donti from the Massachusetts Institute of Technology (MIT) Faculty of Electrical Engineering and Computer Science has provided a letter of support and will be inputting to workshops and reviewing project outputs. Dr Donti is co-founder and Executive Director of Climate Change AI (CCAI), a global nonprofit initiative to catalyse impactful work at the intersection of climate change and machine learning, which includes power system optimisation.

Government and Regulator stakeholders will be interested in outputs, as the use of probabilistic techniques permits greater insight to the risks associated with policy recommendations, in turn improving the quality of evidence provided during policy development.

Project Plans and Milestones

Project management and delivery

WP1 - Project Management and Communications

Project Management will be led by NGESO, with Frazer-Nash providing support in a project management and coordination role. A waterfall approach has been applied, with some overlap between WP1 and WP2, and with minimal slip time due to project time scales.

The project will adopt a rigorous risk management process to identify, manage, mitigate, monitor, and communicate project risks throughout delivery. Risks are defined in the PMTemplate and will be updated weekly throughout Discovery phase.

Prior to application, we have undertaken a pre-project scoping, to identify potential risks (see risk register) that need to be factored into the project's design.

Weekly progress meetings will be held between partners to effectively monitor the status of ongoing tasks, and ensure partners are prepared to mobilise appropriately for upcoming tasks.

Milestones/Deliverables: End of Phase Report and Risk Register.

WP2 -- Business process modelling

We will develop and refine an end-to-end process map for how the enhanced methodology is integrated, through a series of business process modelling workshops to capture the fine detail associated with the existing processes and the anticipated changes during the transition from NGESO to FSO. WP2 contains four in-person workshops, at NGESO offices.

Milestones/Deliverables: Workshops and end-to-end process model.

WP3 -- Process enhancement identification and definition

Frazer-Nash Data Science and AI experts will appraise the identified techniques against the proposed applications for enhancing existing processes from WP2, using multicriteria decision analysis.

Milestones/Deliverables: Option list of suitable advanced modelling approaches.

WP4 -- Road mapping -- Technology management and digital transformation

The project will assess barriers, enablers, risks and opportunities associated with implementing techniques within a future whole energy enhanced network planning process. This will enable us to plan future project phases with a focus on de-risking the highest risks. An implementation strategy and roadmap for future project phases will be created, in parallel to projected FSO, wider industry, policy and technology developments, and will be used to support engagement with and dissemination to the industry.

Milestones/Deliverables: Process/Methodology Definition and roadmap.

Dependencies

The key dependencies exist between WP2 process modelling and WP3 enhancement identification, whilst WP4 road mapping is dependent on outputs of WP3.

Specific policy or regulatory risks

Currently

- No evident policy and regulatory challenges to deployment.
- No derogations will be required.
- No obvious need to request changes in regulation.

Consumer Interaction

Due to the project's nature, there will be no consumer interruptions or interactions.

Key outputs and dissemination

Planned Achievements

By the end of Discovery Phase, the project will have generated a clear map of the end-to-end planning process, with areas of uncertainty and potential for enhancement, using advanced modelling techniques. The primary project achievement will be a strategic recommendation of the optimal advanced modelling techniques and process architecture that should be applied to future whole energy system planning. The project will road map this set of recommendations against upcoming process and market changes to identify the most impactful and timely implementation of the identified approaches.

Outputs

Business process model: Includes identified areas where there is potential for advanced techniques and requirements for the whole energy system planning.
Process Enhancement Recommendations: Prioritised list of techniques based on a multicriteria decision analysis approach. These will be ranked with respect to their appropriateness for development during SIF project timescales.
Cost Benefit Analysis: Undertaken for the modelling technique(s) to identify those most suitable for development during subsequent project phases.
Implementation Roadmap: Roadmap identifying the most suitable modelling enhancements and how their implementation best aligns with ongoing changes to process, policy, alignment to whole energy system and market reform.
Alpha Phase Vision: Commencement of most risky and novel advanced model(s) for enhancement of whole energy system planning with spatial considerations.

Dissemination

Internal: A key aspect of the project is ensuring that all internal stakeholders at NGESO and NGET are kept updated, allowing for iterative input to the project's progress. This will involve workshops but also dissemination of outputs, to highlight the future roadmap for implementing the proposed enhancements.
External: Outputs from the project will be disseminated in accordance with SIF governance requirements, including the End of Phase report and through show and tell sessions. The project will also be sharing findings directly with identified stakeholders, e.g. other networks and policy makers, to ensure they can sufficiently incorporate whole energy system planning processes, and understand their role in engaging with FSO. Lastly, the outputs will be more widely disseminated to stakeholders who may be valuable partners in future phases, to build on the collaborative approach required to make this ambitious project a success.
Competitive Markets

Role 2 of NGESOs Roles and Principles is to Facilitate Competitive Markets, therefore any project that undermines competitive markets would breach their licence obligations. This project does not undermine competitive markets because it explores novel advanced modelling approaches to enhance whole energy system planning processes.

Commercials

Intellectual Property Rights (IPR) (not scored)

All project partners will use the default IPR arrangement. Compliance with the IPR arrangements as defined in the SIF Governance document will be ensured for each of the project partners via the contract that they will each sign with NGESO to participate in the project.

It is understood by the project partners that knowledge transfer is one of the key aims of the SIF. Where relevant, transferable benefits of the project will be maximised by engaging with other network licensees to identify further areas where the developed processes and models could be deployed for enhanced certainty in long-term whole energy system planning decisions. This has the potential to further reduce costs for the GB consumers.

Foreground IPR which is produced by the project, such as a description of the approaches and the benefits that can accrue, will be outlined in the Discovery Phase reporting in sufficient detail to enable others to identify whether they wish to use that IPR. Confidential details of IPR, such as model development, will not be disclosed. However, sufficient information will be provided to enable other licensees to understand the model being developed and its applicability to their own networks, if required.

Value for money

Total project cost

The overall cost for Discovery Phase is £168,640 (NGESO: £46,750, NGET: £15,306 and Frazer-Nash: £106,584), with no subcontractors.

SIF Funding and Contribution

Total SIF funding requested is £149,544 (NGESO: £39,850, NGET: £13,775 and Frazer-Nash: £95,919), the remaining 11.3% (£19,096) contributed from private funds. NGET and Frazer-Nash will contribute 10% (NGET: £1,531 and Frazer-Nash: £10,665) from internal funds to offset labour costs, providing assurance that the costs compare favourably to normal industry rates. Furthermore, NGESO will contribute £6,900 (14.8% contribution) from internal funds relating to time required to provide expertise and ensuring coordination and successful delivery of the project.

Electricity Network Commissioner Recommendations

New advanced tools and techniques are required to enable the FSO to tackle the growing uncertainty and complexity associated with changes in the planning process and empower robust evidence and risk-based planning decisions. The heart of the highly innovative project, proposed here, intends to increase certainty and confidence in future whole energy system planning and improve pace of delivery.

The Electricity Network Commissioner has recommended the development of methodologies, processes and tools to improve the efficiency and pace of infrastructure delivery. This project will enable this by improving certainty in decision-making, and by assuring holistic decisions are made, considering both network and policy options. This project will drive the required change in increasing insight to future long-term development by incorporating advanced probabilistic techniques, reduced-order machine learning models and AI to create a risk-based planning process.

This innovation project, with steer from the end users at the FSO, will ensure significant value for money and guarantee outputs that are fit for purpose in supporting the delivery of our future decarbonised and secure energy system at least cost.

Other External Funding

There is currently no other innovation funded projects that intersect with this project's scope.

Pre-existing Assets and Facilities

The only preexisting assets relevant to this project are the NGESO and the TO's current models, processes and procedures.

Commercialisation

The roadmap, which is an output of this project, will identify suitable routes to BAU for the different models and the overall end-to-end process, taking into consideration the most suitable timing for greatest benefit of the deployment, based on changes to whole energy system planning and upcoming market reform. The FSO will be the end user for the new models and processes and therefore will be ideally placed to set their requirements and steer their development.

Supporting documents

File Upload

Probabilistic Pathways - Discovery - Risk Register.xlsx - 18.5 KB
Probalistic Pathways WP3 Technique Appraisal (1).pdf - 504.4 KB
Probabilistic Pathways WP4_Roadmap.pdf - 862.7 KB
Probabilistic Pathways - Show and Tell Slides.pdf - 911.9 KB
SIF Round 3 Project Registration 2024-03-11 1_44 - 63.7 KB

Documents uploaded where applicable?

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