

NIA Project Registration and PEA Document

Date of Submission

Sep 2026

Project Reference Number

NIA3_NGET0019

Project Registration

Project Title

Q-STEP (Quantum Security-constrained Transmission Expansion Planning)

Project Reference Number

NIA3_NGET0019

Project Licensee(s)

National Grid Electricity Transmission

Project Start

October 2026

Project Duration

0 years and 8 months

Nominated Project Contact(s)

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Project Budget

£481,500.00

Summary

Q-STEP (**Quantum Security-constrained Transmission Expansion Planning**) will test whether quantum-informed optimisation can improve National Grid Electricity Transmission's Neptune reinforcement-planning workflow. The project will reformulate the Security Constrained Transmission Expansion Planning (SCTEP) problem as a mixed-integer linear problem and benchmark a quantum-informed solver against the Neptune heuristic and a classical MIP/MILP baseline. Over eight months, it will deliver a Proof of Feasibility and a Proof of Concept using IBM quantum hardware. The project will assess whether quantum-informed optimisation can improve runtime, solution quality and scenario throughput for reinforcement planning. If successful, it could enable planners to assess more network scenarios, improve reinforcement decision-making, support efficient network investment for the energy transition, and provide evidence on the applicability of quantum computing to future network-planning workflows.

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Problem Being Solved

National Grid Electricity Transmission uses the Neptune tool to support long-term transmission reinforcement planning by assessing future demand, generation and contingency scenarios. The current process identifies overloads, applies reinforcements, re-checks the network and repeats this across large sets of pre- and post-fault contingency cases. A study of 30–40 scenarios is stated to take around 11 hours of compute, and future studies are expected to become larger and more complex as the network changes.

This creates a planning challenge. Scenario coverage is limited by compute time, sequential reinforcement decisions may miss lower-cost combinations, and increasing network complexity is expected to make optimisation more difficult. Existing industrial MIP solvers are highly capable, but the hardest mixed-integer optimisation instances can remain computationally challenging at the scale and timeframes required for practical transmission planning. It is currently uncertain whether quantum-informed optimisation techniques can provide a practical improvement in optimisation performance for transmission reinforcement planning problems, and whether any such improvements can be realised using available quantum computing hardware and integrated into operational planning workflows.

The problem being addressed is therefore how to improve the speed, quality and scalability of reinforcement planning so that National Grid can assess more scenarios, maintain feasibility under contingency conditions and better understand potential for improved optimisation. This is important because electricity transmission reinforcement planning supports network modernisation, decarbonisation and the wider energy system transition.

Method(s)

The project will use a phased research and development approach.

Phase 1 – Proof of Feasibility will determine whether quantum-informed optimisation can improve National Grid’s Neptune reinforcement-planning process. The project will reformulate the Security Constrained Transmission Expansion Planning (SCTEP) problem as a mixed-integer linear programme, validate that it reproduces the behaviour of the existing Neptune workflow, and benchmark performance against both current planning approaches and classical optimisation methods. The phase will assess potential improvements in solution quality, optimisation performance and reinforcement outcomes, and produce a feasibility report identifying the most promising application areas for further development.

Phase 2 – Proof of Concept will implement and evaluate the most promising quantum-informed optimisation approach using IBM quantum hardware. The project will assess practical performance, refine the approach based on testing results, and evaluate the feasibility of integrating quantum-derived outputs into reinforcement planning workflows. The phase will produce a project completion report setting out the results, lessons learned and recommendations for future deployment.

Data Quality Statement (DQS):

· The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal sharepoint platform ensuring access control, backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

· The methodology used in this project will be subject to our supplier’s own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

Indicative Risk Rating: In line with ENA guidance, the project risk rating is expected to be low: TRL steps = 1, cost score = 1, suppliers = 1, and data assumptions = 1; total indicative score = 4.

Scope

The scope of the project is to determine whether quantum-informed optimisation can improve National Grid Electricity Transmission’s reinforcement planning process and to validate the most promising approach using quantum computing hardware. The project will focus on the feasibility, performance and potential value of applying quantum-informed optimisation to the Security Constrained Transmission Expansion Planning (SCTEP) problem within the Neptune planning workflow.

WP1 – Proof of Feasibility

This work package will assess whether quantum-informed optimisation can provide practical improvements over existing reinforcement planning approaches. Activities will include data onboarding, problem reformulation, development of optimisation methods, benchmarking against current planning workflows, and evaluation of potential improvements in optimisation performance, solution quality and reinforcement outcomes. This phase will generate evidence on technical feasibility, applicability and potential value.

WP2 – Proof of Concept

This work package will implement and evaluate the most promising quantum-informed optimisation approach using IBM quantum hardware. The project will assess practical performance, integration considerations and deployment requirements, while generating evidence on the benefits and limitations of the technology for operational reinforcement planning workflows.

The scope does not include deployment into operational planning systems, automated reinforcement decision-making, or wider rollout

across National Grid. Any future implementation phase will be considered separately based on the evidence generated through the project.

Objective(s)

The objectives of the project are to:

- Reformulate the Neptune SCTEP reinforcement planning problem as a MIP/MILP approach suitable for benchmarking.
- Validate that the reformulated method reproduces relevant Neptune feasibility behaviour on representative scenarios.
- Test whether quantum-informed solver guidance can reduce search effort or solve time relative to default classical MIP/MILP approaches.
- Benchmark runtime, feasibility, solution quality and potential reinforcement cost difference against the current Neptune heuristic and classical MIP/MILP baseline.
- Demonstrate quantum sampling components execute on IBM quantum hardware and assess the practicality of integrating samples into the MILP pipeline.

Consumer Vulnerability Impact Assessment

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having a **neutral impact** on customers in vulnerable situations. This is because it is a transmission-focused process innovation project rather than a direct consumer-facing intervention. The project will not directly change network access arrangements, consumer services, tariffs, supply arrangements or the way individual consumers interact with National Grid. The project is not expected to create adverse technical, financial or wellbeing impacts for consumers in vulnerable situations. While direct impacts are not expected, any future improvement in reinforcement planning efficiency may contribute indirectly to more efficient network investment and delivery of infrastructure required for the energy transition, which could benefit all consumers.

Success Criteria

Success will be assessed against the following criteria:

- Demonstrate that the SCTEP reinforcement planning problem can be successfully reformulated as a MIP/MILP while reproducing the behaviour of the existing Neptune workflow.
- Demonstrate that quantum-informed optimisation can improve solver performance relative to existing approaches.
- Demonstrate that the new approach produces reinforcement plans that are at least as good as, and potentially better than, the current method.
- Demonstrate that quantum-derived information can be generated on real hardware and integrated into the optimisation workflow.
- Generate sufficient evidence to support an informed decision on a future demonstrator and broader deployment.

Project Partners and External Funding

No external project partners are contributing equity funding to the project.

National Grid Electricity Transmission (NGET) is the project sponsor and use-case owner and will provide project oversight, domain expertise, representative planning data and access to relevant transmission planning use cases.

Phasecraft is the external supplier supporting delivery of the project and will lead development, implementation and benchmarking of the quantum-informed optimisation approaches assessed through the project.

IBM will provide access to the quantum computing hardware platform used during the Proof of Concept phase.

Project costs comprise £403,000 of external supplier costs, £24,000 of internal National Grid costs and £54,500 of indirect costs, giving a total project cost of £481,500.

Potential for New Learning

Understanding the suitability of quantum methods for transmission planning: The project will establish whether the SCTEP reinforcement planning problem can be successfully reformulated as a mixed-integer optimisation problem and solved more effectively using quantum-informed techniques. This will provide learning on the suitability of quantum approaches for transmission planning problems.

Quantifying potential performance improvements: A major area of learning will be whether quantum-informed heuristics can reduce optimisation runtimes and improve solution quality compared with both the current Neptune heuristic and conventional optimisation solvers.

Understanding the potential business value: The project will generate evidence on whether improved optimisation could lead to:

- Faster planning studies and decision-making.
- Assessment of a wider range of network scenarios and contingencies.
- Potential for more efficient reinforcement strategies and reduced planning bottlenecks.

Assessing the readiness of quantum hardware: Through implementation on IBM quantum hardware, the project will provide learning on the practical capabilities and limitations of current quantum platforms, including the effectiveness of error mitigation, efficient compilation techniques and integration with classical optimisation workflows. This will help determine how close the technology is to supporting operational use cases.

Identifying the pathway to deployment: The project will create a clearer understanding of the resources, scaling requirements and implementation steps needed to move from research and experimentation to a solution integrated into National Grid's planning processes.

The learning generated through the project will be disseminated through standard NIA knowledge-sharing routes, including publication of project outputs through the ENA Smarter Networks Portal, project reports, technical summaries, presentations and knowledge-sharing events. This will enable Network Licensees and other interested parties to benefit from the evidence generated through the project.

Scale of Project

The scale of the project is proportionate to the learning required before any decision is made on deploying quantum-informed optimisation within National Grid's network-planning processes. The project will be delivered over eight months through a Proof of Feasibility phase followed by a Proof of Concept phase, enabling the team to evaluate the reformulation of the SCTEP problem, validate quantum-informed optimisation methods, and assess their performance on quantum computing platforms.

A smaller project limited to theoretical analysis or simulation would not generate sufficient evidence on technical feasibility, optimisation performance, scalability, integration with existing planning workflows, or the practical capabilities of current quantum hardware. The proposed scope is therefore necessary to test the approach using representative National Grid planning problems and to establish whether quantum-informed optimisation can deliver sufficient technical, operational and economic value to justify future deployment.

The total project cost is **£481,500**. This investment is considered proportionate to the expected learning and potential benefits, as the project will determine whether quantum-informed optimisation can improve planning speed, solution quality, scenario analysis capability and reinforcement decision-making, while also providing a pathway towards a future solution and potentially wider application across National Grid's optimisation challenges.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project will be delivered within National Grid Electricity Transmission's licence area in Great Britain. Project activities will utilise representative transmission network planning data and reinforcement planning use cases from NGET's Neptune planning process. The learning generated is expected to be applicable more broadly across electricity transmission planning activities and may be

relevant to other GB network licensees undertaking similar network planning and optimisation challenges.

Revenue Allowed for the RIIO Settlement

No funding currently allowed within the RIIO-3 settlement is expected to become surplus to requirements as a result of this project. The value is therefore assessed as £0.

Indicative Total NIA Project Expenditure

The total project budget is £481,500. This includes external supplier cost, associated National Grid internal cost and indirect cost. In line with the PEA guidance, the indicative NIA expenditure is calculated as 90% of the total project budget, which equates to £433,350, rounded to £433,000. The detailed expenditure breakdown by work package is set out below.

WP1 – Proof of Feasibility

- External supplier cost: £147,000
- Associated internal cost: £12,000
- Indicative indirect cost allocation: £21,500
- Total WP1 project cost: £180,500
- Indicative NIA expenditure at 90%: £162,450

WP2 – Proof of Concept

- External supplier cost: £256,000
- Associated internal cost: £12,000
- Indicative indirect cost allocation: £33,000
- Total WP2 project cost: £301,000
- Indicative NIA expenditure at 90%: £270,900

Total Project

- External supplier cost: £403,000
- Associated internal cost: £24,000
- Indicative indirect cost: £54,500
- Total project cost: £481,500

Indicative NIA expenditure at 90%: £433,350, rounded to £433,000

Project Eligibility Assessment Part 1

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

The project has the potential to facilitate the energy system transition by improving the speed, quality and scalability of electricity transmission reinforcement planning. As demand, generation and contingency scenarios become more complex, planning tools need to assess a wider range of future network conditions within practical timescales.

Q-STEP will test whether quantum-informed optimisation can improve reinforcement planning by enabling more scenarios to be assessed, maintaining feasibility under security-constrained conditions, and identifying potentially more efficient reinforcement options. If successful, this could support better-informed network investment decisions, reduce planning effort, and help National Grid deliver reinforcement required for decarbonisation, electrification and connection of low-carbon generation more efficiently.

The project does not directly deliver network reinforcement, but it will generate evidence on whether this approach could improve future planning capability and support more efficient delivery of the energy system transition.

How the Project has potential to benefit consumer in vulnerable situations:

The project is expected to have limited direct impact on consumers in vulnerable situations because it is a transmission-focused planning and optimisation innovation project rather than a direct consumer-facing intervention. The project will not directly change consumer services, tariffs, access arrangements or the way consumers interact with National Grid.

However, if successful, the project could provide indirect benefits by improving the efficiency and quality of transmission reinforcement planning, helping to support more effective network investment decisions and delivery of infrastructure required for the energy transition. More efficient network planning may contribute to reducing avoidable network costs while maintaining a secure and reliable electricity system, which may benefit all consumers, including those in vulnerable situations.

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved

n/a

Please provide a calculation and/or description of the expected benefits of the solution

The solution has the potential to deliver net benefits by improving the efficiency and quality of transmission reinforcement planning. If successful, quantum-informed optimisation could reduce the time and effort required to assess reinforcement options, enable a wider range of network scenarios to be evaluated, and support more informed reinforcement planning decisions.

The project cost-benefit assessment estimates an innovation project cost of approximately £481.5k and a financial benefit NPV of approximately £2.101m over a ten-year appraisal period, indicating a potential benefit-cost ratio of approximately 5.4:1. These benefits are expected to arise through planning efficiencies, improved optimisation outcomes and reduced effort associated with reinforcement studies.

The project will generate evidence on whether quantum-informed optimisation can provide sufficient operational and economic value to justify future deployment. If successfully adopted, more efficient reinforcement planning could support more effective network investment and contribute to reducing future costs borne by electricity consumers.

Please provide an estimate of how replicable the Method is across GB

The method has the potential to be replicable across GB because transmission and distribution network licensees undertake similar network planning and optimisation activities when assessing future network requirements, reinforcement options and system constraints. While the project is focused on the Neptune reinforcement planning workflow within National Grid Electricity Transmission, the learning generated on optimisation methods, problem reformulation, benchmarking approaches and application of quantum-informed optimisation could be applied to a wider range of network planning and operational optimisation challenges.

If successful, the approaches developed through the project could be adapted for use by other electricity transmission and distribution licensees facing increasingly complex planning scenarios associated with decarbonisation, electrification and changing network requirements. The project will generate evidence that can help determine where quantum-informed optimisation may provide value and where conventional optimisation methods remain more appropriate.

Please provide an outline of the costs of rolling out the Method across GB.

The exact cost of rolling out the method across GB cannot be determined at this stage because a primary objective of the project is to establish whether quantum-informed optimisation provides sufficient technical, operational and economic value to justify wider deployment. The project will generate evidence on performance, scalability, hardware requirements, integration requirements and deployment considerations that are currently uncertain.

Any future rollout would depend on the outcomes of the Proof of Feasibility and Proof of Concept phases, the maturity of available quantum computing platforms, the scope of the target planning processes, and the integration requirements of individual network licensees. Potential future costs could include software development, system integration, hardware access, user adoption activities, operational support and ongoing maintenance.

The project will provide the information required to assess whether wider deployment is justified and, if so, support development of a future business case and implementation roadmap.

Requirement 3 / 1

Involve Research, Development or Demonstration

Projects must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

- ☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).
- ☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)
- ☐ A specific novel operational practice directly related to the operation of the Network Licensees system
- ☐ A specific novel commercial arrangement

Involve Research, Development or Demonstration - Please select all that apply

- ☐ A specific piece of new equipment (including monitoring, control and communications systems and software)
- ☒ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven
- ☒ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)
- ☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology
- ☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution
- ☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

The learning generated by this project could help relevant Network Licensees understand whether quantum-informed optimisation can provide practical value for network planning and other complex optimisation challenges. The project will generate evidence on the

suitability of reformulating transmission reinforcement planning problems as mixed-integer optimisation problems, the potential benefits and limitations of quantum-informed optimisation techniques, and the circumstances in which these approaches may provide value compared with conventional optimisation methods.

The project will also provide learning on benchmarking methodologies, integration of quantum-derived information into optimisation workflows, scalability considerations, and the practical capabilities of current quantum computing hardware. This learning could help transmission and distribution network licensees assess whether similar approaches may be applicable to their own planning, operational and investment decision-making activities.

In addition, the project will generate evidence on deployment considerations, implementation challenges and the potential business value of quantum-informed optimisation, helping Network Licensees make informed decisions on future research, development and adoption activities.

n/a

Is the default IPR position being applied?

☒ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed. Networks must explicitly mention similar projects that they have considered and how these differ.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

The project is not expected to lead to unnecessary duplication of existing innovation activity.

The project builds on an internal quantum discovery phase which established the problem statement, potential use case and high-level opportunity for applying quantum-informed optimisation to transmission reinforcement planning. This NIA project will not repeat that work; it will assess the technical feasibility, performance and practical applicability of the approach using representative National Grid planning problems.

The project team has considered existing research and innovation activity relating to quantum computing and optimisation. While quantum optimisation has been explored within academic research and broader industrial applications, no evidence has been identified of a project that combines quantum-informed optimisation, mixed-integer transmission reinforcement planning and validation against operationally relevant electricity transmission planning workflows.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

Not applicable.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

The project is innovative because it applies quantum-informed optimisation to a real-world electricity transmission reinforcement planning challenge and evaluates its performance against operationally relevant planning workflows. While quantum optimisation has been explored within academic research and broader industrial applications, its practical application to Security Constrained Transmission Expansion Planning (SCTEP) and integration with transmission reinforcement planning processes remain unproven.

The project will test whether quantum-informed optimisation can provide practical benefits compared with existing reinforcement planning approaches and conventional optimisation methods. The innovation uncertainty relates not only to the performance of the optimisation approach itself, but also to its scalability, suitability for transmission planning applications, integration requirements and the practical capabilities of current quantum computing hardware.

The project has therefore not been tried before within National Grid Electricity Transmission and is expected to generate new learning on the applicability, benefits and limitations of quantum-informed optimisation for electricity transmission planning.

Relevant Foreground IPR

Relevant Foreground IPR is expected to include the SCTEP problem reformulation methodology, benchmarking framework, project reports, performance assessments, implementation recommendations, lessons learned and knowledge-transfer materials generated through the project. Foreground IPR may also include project-specific methods, analysis and evidence developed to evaluate the applicability of quantum-informed optimisation to transmission reinforcement planning.

The project will utilise existing Background IPR, including National Grid's Neptune-related knowledge, data structures and planning processes, together with supplier-owned quantum optimisation algorithms, software and associated tools where required for project delivery. Any use of Background IPR will be managed in accordance with the applicable project agreements and the default NIA IPR arrangements.

Data Access Details

Data and learning generated through this project will be shared in line with National Grid's innovation data sharing approach and standard NIA dissemination requirements.

The project is expected to generate outputs including project reports, benchmarking results, methodological findings, implementation recommendations, performance metrics and lessons learned. Where appropriate, these outputs will be made available through National Grid innovation channels and the ENA Smarter Networks Portal.

The project may utilise representative Neptune-derived network planning datasets, optimisation models, solver outputs and quantum computing benchmark results. However, raw network planning data, detailed network models, security-sensitive information, commercially confidential information, personal data and supplier proprietary information may be subject to restrictions and may not be suitable for external release. Any information shared externally will be reviewed and, where necessary, aggregated, anonymised or de-sensitised before publication.

Please identify why the Network Licensees will not fund the project as a part of it's business and usual activities

The project is not being funded as business-as-usual because it involves the research, development and demonstration of a novel quantum-informed optimisation capability that is not currently established or proven within National Grid Electricity Transmission's reinforcement planning processes. Significant technical, operational and commercial uncertainties remain regarding the performance, scalability and practical applicability of the approach.

The project is therefore appropriately classified as innovation activity rather than business-as-usual expenditure. The objective of the project is to generate evidence on whether quantum-informed optimisation can provide sufficient benefits, value and operational applicability to justify any future deployment. Until these uncertainties have been addressed, the project cannot be justified as a standard operational investment.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks (e.g. commercial, technical, operational or regulatory) associated with the project

NIA support is appropriate because the project carries technical, operational and commercial uncertainties that need to be tested before any wider deployment decision can be made.

Technical uncertainties include whether quantum-informed optimisation can improve the performance of optimisation solvers, whether benefits can be replicated at scales relevant to National Grid planning problems, and whether current quantum hardware is capable of supporting practical applications.

Operational uncertainties relate to integration with existing planning workflows, deployment requirements and the resources needed to scale the solution.

Commercial uncertainties remain around the extent of achievable cost savings, planning efficiencies, wider organisational applicability and whether the benefits of future deployment would justify the associated implementation and operating costs.

These uncertainties can only be resolved through the proposed Proof of Feasibility and Proof of Concept activities.

This project has been approved by a senior member of staff

☒ Yes