Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Dec 2021

Project Reference Number

NIA2_NGET0008

Project Registration

Project Title

EPRI Substations (P37) and Analytics (P34) 2021-2025

Project Reference Number

NIA2_NGET0008

Project Licensee(s)

National Grid Electricity Transmission

Project Start

December 2021

Project Duration

4 years and 1 month

Nominated Project Contact(s)

Gordon Wilson (Box.NG.ETInnovation@nationalgrid.com)

Project Budget

£2,470,000.00

Summary

High voltage (HV) assets, such as power transformers, do not have simple condition assessment tests that reliably inform us of remaining life. This information must be inferred from indirect measurements such as oil sampling and interpretation of electrical test results. In this project, NGET will collaborate with EPRI and its utility members to focus on activities that help to improve our understanding of ageing mechanisms and diagnostics and improve management of these assets, with the goal of achieving longer asset lives and greater visibility of when assets need to be replaced. This will be achieved through a wide-ranging research program making use of collated data sets, application of new data analysis approaches and developing new laboratory techniques

Preceding Projects

NIA_NGET0210 - EPRI Research Collaboration on Substations (P37) 2017 - 2020

Third Party Collaborators

Electric Power Research Institute

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

National Grid recognises that the challenges faced by the electricity industry can be more efficiently and cost-effectively addressed when approached through international collaboration initiatives. It is particularly useful when addressing challenges where the solutions require statistically diverse data sets and/or significant trialling and testing in different environments, under various conditions and/or diverse ways.

The Electric Power Research Institute (EPRI), with its wide international membership, is one of the routes through which these initiatives can be delivered, thereby maximising stakeholder value. The approach of managing collaborative projects within an internationally driven research and development initiative is beneficial to National Grid and consumers alike, because it provides valuable information, learning and knowledge that would be considerably more expensive if approached on an individual basis.

This project will focus on specific substation plant items (transformers, circuit breakers and gas insulated substations) where the value in this approach is greatest and on development of analytics approaches for transmission substation and underground assets (P34)

EPRI work-streams span across multiple years. Consequently, this NIA Project will benefit National Grid and our stakeholders by continuing to deliver the valuable research and development activities of P37 and P34 over the five-year period of our involvement.

Method(s)

The project will deliver through workstreams under two different programs. The workstreams will employ similar methods within each program

P37 Substations

The Substations program will look at a number of different themes to improve the knowledge and methodology for managing assets. Over the five years these will be delivered through:

- Collating worldwide knowledge and experience
- Researching and developing new technologies with academic organisations and research institutes – and deploying laboratory successes in field trials within substations
- Computer modelling of scenarios and risk
- Substation trials of technologies
- Understanding root-causes of failure and ageing mechanisms through forensic studies
- Developing software algorithms and comparing them with models and case-studies.

P34 Transmission Asset Management Analytics

The Analytics program will develop analytics, methodologies and asset knowledge enablers, such as failure rates and asset health assessment algorithms and future performance models.

The proposed research focuses on:

- Designing, developing, populating, maintaining, and extracting information from industrywide databases for transmission assets that could help aggregate and quantify historical performance
- Developing condition assessment algorithms to understand and evaluate existing condition states
- Developing metrics to better assess and quantify equipment performance
- Constructing tools and methodologies to project future performance and manage risk

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.

Risk Assessment

TRL Steps = 2 (3 TRL steps)

Cost = 3 (£2.47m)

Suppliers = 1 (1 supplier)

Data Assumption = 2 (Assumptions known but will be defined within project)

Assessed risk score 8 - Medium

Scope

EPRI research laboratories and expertise feed the development of new tools and knowledge to help substation owners anticipate and prevent failures of substation assets, extend asset life, retain key subject knowledge and specify new diagnostic equipment with confidence. Increasingly, the energy transition will lead to greater electrification of energy needs and more reliance on electricity reliability. This research project will focus on maintaining the highest levels of system reliability through effective and efficient management of ageing assets. Society and industry benefits from reliable energy sources and this has to be delivered such that the cost of investment in assets for the energy transition are apportioned fairly.

Objective(s)

The project objective is to provide accurate and useful research results to enable better specification, operation and maintenance of assets. Results will take the form of reports detailing research results, hardware, software, and guidebooks. Research results are made available to EPRI members providing an enduring record of the work that may be useful for further studies or for direct application. Hardware prototypes are tested first in the laboratory and then piloted in substations, allowing for easy future adoption. Algorithms are integrated into software solutions—again, allowing for easy adoption. Online monitoring technologies are thoroughly assessed using repeatable test protocols.

Consumer Vulnerability Impact Assessment

The research programs with EPRI are intended to enable utilities to understand the life of assets better enabling investment in asset replacement to be planned as efficiently as possible and to improve the understanding of developing faults to prevent asset failures. Efficient investment ensures that the cost of transitioning to a low-carbon energy network is not unfairly shouldered by vulnerable consumers.

Within the substation program there will be longer term research on developing SF6 leak repairs at lower cost and evaluation of new technologies for SF6 replacement, including looking for the most environmentally sound options possible as alternatives to SF6. The goals of these elements of the work are to reduce carbon dioxide equivalent emissions which will benefit all consumers as they impact on climate change.

Success Criteria

The project will be considered successful if it delivers accurate and useful research results to enable better specification, operation and maintenance of assets. In particular, investigation of the following for transformers:

- ageing mechanisms
- ageing markers
- end of life criteria
- investigation and comparison of data from different utilities
- analysis of data collected during scrapping activity
- application of new algorithms for data analysis

should lead to a better understanding of when transformers have reached end of life and enabling deferral of asset replacement until the optimum time.

Project Partners and External Funding

Investment in EPRI programs enables NGET to achieve significant leverage of its innovation funding as other utility members with common objectives are able to pool resources (funding, data and knowledge). Across both programs to be funded under this project, there could be as many as 65 other utilities investing in the same programs (based on 2020 information). The gearing of the leveraged in funding for 2020 was approximately 10:1 for P37 and 12.5:1 for P34. Assuming a similar gearing for the period of this project the total contribution to both projects over 5 years would be more than £22m.

Potential for New Learning

The following topics under the EPRI programs will deliver new knowledge expected from carrying out this project:

- Statistical analysis using power transformer database of industry wide information
- Development of PTX - power transformer expert system software
- Research into new DGA (dissolved gas analysis) markers for improved risk assessment
- Evaluation of new insulating fluids – natural and synthetic esters, nanofluids and bio-based oils
- Piloting membrane technologies for lifelong moisture removal
- Investigation of bushing and bushing monitoring performance for improved diagnostics
- Assess useful life of 'O' rings, seals and gaskets for circuit breakers
- Develop new algorithms for the dielectric condition assessment of circuit breakers
- Develop and assess SF6 leak location and leak sealing techniques
- Investigation of SF6 alternatives – handling and control of potential by-products
- Development of advanced testing and diagnostics for gas insulated substations
- Develop asset health algorithms for underground cables

Scale of Project

The work-streams associated with P37 and P34 are predominantly laboratory or desk based projects, with site trials as the research develops, these are typically conducted as supplemental initiatives alongside the research programs. The scale of individual workstreams are discussed regularly with participating members and adjusted according to the relative success of work as it proceeds and how the developments align with members' innovation objectives. This ensures that research workstreams may be 'course-corrected' to ensure they deliver the most value and are scaled appropriately.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The research undertaken in the EPRI Substations programme is predominantly carried out in the US, with some work in the UK and Canada. The programme also reviews the latest research from across the world.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

£2,223,000

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:

This project supports the energy transition through efficient investment of capital to ensure transmission reliability is maintained as more of the UK's energy needs are met through electricity rather than other vectors.

An element of the project is all focussed on reducing direct, Scope 1 emissions of SF6 through leak location and repairs. Reducing SF6 losses has a direct impact on transitioning to a low carbon network.

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

Not applicable

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

Not applicable

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

NGET has, over many years, used research to improve its understanding of the ageing mechanisms of transformers and how to detect when a transformer is approaching end of life. In combination with a strategy for analysis of retired assets, the knowledge gained through innovation has enable NGET to extend transformer asset lives and reduce capital investment. Part of the research into transformers has been in partnership with EPRI over 20 years and continued research under a new project is expected to continue to develop our understanding and provide analytics and tools to continue to deliver benefits.

Extending transformer asset lives and deferring investment in new transformers in T3 by carrying out research in T2 will deliver benefits to consumers through reduced expenditure.

In examining the benefit of carrying out the project it has been assumed that further innovation on transformers will lead to further life extension and investment deferral. A combination of innovation and continued business as usual activities through the current regulatory period is expect to lead to a reduction of asset replacements in the next of one unit per year compared with the number to be carried out without conducting these activities. Assuming a five-year RIIO-3 period and conservative estimates of the benefit the EPRI project will bring on its own, the net benefit is anticipated to be £3.9m over ten years.

Other unquantified benefits are expected to arise from the project such as:

- improved condition monitoring techniques for bushings, circuit breakers and cables
- lower cost SF6 leak repairs
- evaluation of leak monitoring techniques for SF6 alternatives
- novel transformer and substation inspection techniques such as robots and drones

The current TRL of additional benefits make it more difficult to quantify potential benefits.

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

Assets containing SF6 and power transformers are present at all substations throughout the transmission and distribution networks.

Although the majority of EPRI members are based in the US, NGET has chosen the areas most nearly aligned with assets common to the UK or where the learning is directly applicable. Therefore, directly applied learning from this project is likely to be applicable in all cases for transmission assets and, in most cases, for distribution assets.

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

The direct cost of making a policy or procedure change could range from as little as ten thousand to hundreds of thousands of pounds depending on the complexity of the change implications. The wider cost implications arising from such changes will be dependent on the specific outcomes generated from the project and typically will be subject to further stages of demonstration prior to roll out. Further information regarding roll out costs can be provided prior to demonstration stage.

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

All GB electricity licensees own and manage substations containing power transformers, circuit breakers, cables as well as have assets containing SF6. They all face similar challenges around estimating remaining asset lives for these equipment types.

Not applicable

Is the default IPR position being applied?

☐ Yes

Please demonstrate how the learning from the project can be successfully disseminated to Network Licensees and other interested parties.

Research outcomes and summary reports will be published each as required for NIA projects. In addition, each year National Grid and EPRI organise a conference in the United Kingdom to present and disseminate results and outcomes from all the projects that GB Network Licensees subscribe to. The conference is open to all transmission operators and Distribution Network Operators, irrespective of their involvement in the projects. Information from each project is made available to all relevant parties to ensure an open environment for learning to be shared.

Other opportunities for dissemination will be explored such as webinars or presentations to an open forum or non-member utilities and conference publications sharing results.

Please describe how many potential constraints or costs caused, or resulting from the imposed IPR arrangements.<

The IPR arrangements do not present any constraints or costs in relation to collaborative projects with EPRI. Some of EPRI's products are freely available and all are available for non-members to purchase on commercial terms.

Please justify why the proposed IPR arrangements provide value for money for customers.

The Electric Power Research Institution (EPRI) is a non-profit organisation which facilitates a variety of research projects relating to substations within the electricity industry. EPRI's operating model is to retain ownership of IPR for the benefit of EPRI members and value from IPR is realised through a reduction in cost of the ongoing research programme. This arrangement also provides a high level of funding leverage as of the collaborative approach facilitated by EPRI. This justification has been approved by Ofgem as per the 'Non Default Intellectual Property Rights (IPR) Arrangements for Electric Power Research Institute (EPRI) Projects' letter dated 8th February 2017.

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.

EPRI research programmes are developed based on utility needs and address both new and longstanding issues, there may be other research working in similar fields but EPRI seeks to build on the research of others and not duplicate it. The research programs as a whole will deliver novel research, even if some elements may seem superficially similar to research ongoing elsewhere. It should be noted, however, that innovation at low TRLs often requires that results are replicated before they are generally accepted by the research community, especially for groundbreaking or disruptive research.

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

EPRI's governance, through the Research Advisory Committee, provides guidance on policies and issues that impact the power industry to inform the content of the research programmes. Many utility members are engaged in ensuring that the research programmes deliver valuable research results to the industry. Individual members within programmes direct the research work in detail and suggest new approaches and topics that ensure the work is innovative and beneficial. In the event that the work is no longer sufficiently innovative or delivering value individual members can withdraw from the program the following year.

Relevant Foreground IPR

The foreground IPR will be the knowledge gained through the various workstreams covered under EPRI research programs P37 and P34 mentioned under section 2.8 above. The IPR will relate to the investigation of asset management improvements for transformers and bushings, circuit breakers, gas insulated substations and underground cables.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

EPRI membership provides highly leveraged funding and address a wide range of issues. The research tends to be longer term and/or higher risk. Investment in the individual workstreams would be too great for an individual member. Business as usual activities would generally require greater control over the work rather than agreeing the work directions with other utilities.

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

There are technical risks associated with any innovation project as the proposed solution may not work. As some of the work is higher risk and can take many years to deliver outcomes the projects would not offer sufficient guarantee of the benefits to attract business funding.

Previous experience working with EPRI suggests that there will be sufficient benefit in supporting and helping to direct the work to justify this project. It is most likely that benefits will be accrued in the area of understanding transformer ageing and replacement needs. However, at the start of a five year investment of research in EPRI programmes it is not always clear which aspects of the work will deliver most value and where else benefits will be achieved.

This project has been approved by a senior member of staff

☑ Yes