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

Jun 2017

Project Reference Number

NIA_NGET0210

Project Registration

Project Title

EPRI Research Collaboration on Substations (P37) 2017 - 2020

Project Reference Number

NIA_NGET0210

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2017

Project Duration

4 years and 4 months

Nominated Project Contact(s)

Ruth Hooton, Gordon Wilson, & Andrew Roxbrough

Project Budget

£23,800,000.00

Summary

EPRI research projects span multiple years. The full scope of research within each work-stream for the next two years in respect of P37.111 and four years in relation to P37.101 & P37.108 is listed below.P37.101 - Transformer Life ManagementThe transformer programme develops new tools and knowledge to help utilities anticipate and prevent failures in transformers, extend transformer life, develop and retain key expertise. With the increasing need to maintain the same levels of reliability, managing ageing assets is a critical issue. This project addresses these key issues including transformer diagnostics, condition and ageing assessments and life extension by considering:

- Transformer on-line monitoring technologies
- Novel sensor development
- EPRI power transformer guidebook
- Improved accuracy of transformer remaining life estimation
- Transformer life extension
- Transformer forensics – linking diagnostics and maintenance with true internal condition
- Transformer ratings

P37. 108 - SF6 Management and Gas Insulated SubstationsThe SF6 and GIS programme is helping utilities reduce maintenance costs and uncertainties, minimise SF6 emissions through the application of new technology, and improve GIS and GIL life-cycle management through the following:

- Investigating more effective methods for locating and repairing SF6 leaks
- Developing a system for capturing SF6 when in-service repair is not viable
- Developing and documenting methodologies for accurately capturing SF6 data for regulatory reporting

- Developing a fleet management approach for optimal decisions regarding new investment, maintenance, repair and replacement of components
- Developing an approach to assess the impact of SF6 technology compared to alternative technologies and gases
- Development of an industry-wide failure database
- Develop guidelines for live filling of SF6 insulated equipment
- Development of a comprehensive guidebook to enhance the utility knowledge base and provide a one-stop reference for GIS and GIL equipment
- Create application guides to aid utility engineers and field personnel with SF6 diagnostic technologies
- Identify and evaluate available technologies for GIS and GIL diagnostics and evaluate emerging diagnostic technologies
- Develop a total life-cycle, systems based approach to compare gas-insulated and air insulated substation investments

Nominated Contact Email Address(es)

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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 aims to continue to address issues associated with three elements of substation plant:

1. Transformer life management, this will address key issues including transformer diagnostics, condition and ageing assessments and life extension
2. SF6 management and Gas Insulated Substations (GIS); this aims to help reduce maintenance costs and uncertainties, minimize SF6 emissions through the application of new technology, and improve life-cycle management
3. Risk based equipment asset management that conducts research with the goal of providing continually improved risk-based decision-support methodologies for substation equipment asset managers.

Following a benchmarking exercise in 2016, National Grid determined that within EPRI's Substations Programme 37 (P37) the largest leverage for the UK consumer can be achieved through involvement in specific projects; transformers (P37.101), SF6 (P37.108), and asset management (P37.111). The three areas have work-streams that 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 over the four year period of our involvement.

Method(s)

P37.101 - Transformer Life Management
The transformer project is looking at a number of different themes to improve the knowledge and methodology for managing transformer assets. Over the four 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.

P37. 108 - SF6 Management and Gas Insulated Substations

The SF6 research project is looking at a number of themes which will be delivered through different routes over the next four years, which:

- Research into SF6 leak sealing and detection technologies
- Full-sized testing at the EPRI Charlotte Laboratory
- Scaled laboratory testing.

P37.111 - Risk Based Substation Equipment Asset Management
This project conducts research with the goal of providing continually improved risk-based decision-support methodologies for substation equipment asset managers. It envisages that the developments will lead to an integrated framework for asset risk assessment, mitigation, and performance improvement. Developments in risk-based fleet management over the next two years will be addressed through these areas:

- Asset characterisation and performance information
- Industry wide equipment performance and failure database and analytics
- Asset health algorithms and software
- Evaluation of dissolved gas in oil analysis analytics
- Triggers/alarms for intervention actions
- Substation equipment asset management guidelines

Scope

EPRI research projects span multiple years. The full scope of research within each work-stream for the next two years in respect of P37.111 and four years in relation to P37.101 & P37.108 is listed below.

P37.101 - Transformer Life Management
The transformer programme develops new tools and knowledge to help utilities anticipate and prevent failures in transformers, extend transformer life, develop and retain key expertise. With the increasing need to maintain the same levels of reliability, managing ageing assets is a critical issue. This project addresses these key issues including transformer diagnostics, condition and ageing assessments and life extension by considering:

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- Novel sensor development
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- Improved accuracy of transformer remaining life estimation
- Transformer life extension
- Transformer forensics – linking diagnostics and maintenance with true internal condition
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- Investigating more effective methods for locating and repairing SF6 leaks
- Developing a system for capturing SF6 when in-service repair is not viable
- Developing and documenting methodologies for accurately capturing SF6 data for regulatory reporting
- Developing a fleet management approach for optimal decisions regarding new investment, maintenance, repair and replacement of components
- Developing an approach to assess the impact of SF6 technology compared to alternative technologies and gases
- Development of an industry-wide failure database
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- Development of a comprehensive guidebook to enhance the utility knowledge base and provide a one-stop reference for GIS and GIL equipment
- Create application guides to aid utility engineers and field personnel with SF6 diagnostic technologies
- Identify and evaluate available technologies for GIS and GIL diagnostics and evaluate emerging diagnostic technologies
- Develop a total life-cycle, systems based approach to compare gas-insulated and air insulated substation investments

P37.111 - Risk Based Substation Equipment Asset Management

The P37.111 project conducts research with the goal of providing continually improved risk-based decision-support methodologies for substation equipment asset managers. It envisages that the developments will lead to an integrated framework for asset risk assessment, mitigation, and performance improvement. Developments in risk-based fleet management are addressed through the following tasks:

- Asset characterisation and performance information
- Industry wide equipment performance and failure database and analytics
- Asset health algorithms and software
- Triggers and alarms for intervention actions
- Substation equipment asset management guidelines
- Evaluation of DGA Analytics
- Asset management workshop (each year)

Objective(s)

The objectives over the next four years include the delivery of a selection of reports and guidance documents associated with the three work-streams.

P37.101 - Transformer Life Management

- Transformer on-line monitoring technologies

  Technology approaches to on-line gas analysis will continue from previous years of research, the scope will be extended to include the length of sampling lines and the temperatures of the environment as, through the previous studies and testing they have been found to be influential in the success of the techniques

- Novel sensor development

  Research new sensors for assessing the condition of a transformer. The scope will be extended to include technologies used within other industries for gasses such as methane

- EPRI power transformer guidebook

  Develop improved knowledge in the area of technological advances. The development of the guidebook is built upon, year on year

- Improved accuracy of transformer remaining life estimation

  Continue to research the dynamic behaviour of new chemical markers in oil and whether it has the potential for improving transformer life estimates

- Transformer life extension

  Continue to research life extension and seek to quantify potential cost savings of any new technology so that it can be accurately benchmarked

- Transformer forensics – linking diagnostics and maintenance with true internal condition

  Continue to examine retired or failed transformers and relate the evidence to both historic transformer operations and diagnostics data

- Transformer ratings

  Continue to develop EPRI's rating enhancement software (PTLoad) which will be integrated into the Transmission Ratings Workstation (TRW) to move towards facilitating common transmission rating practices across equipment boundaries

P37. 108 - SF6 Management and Gas Insulated Substations
The intent of this programme is to help users of SF6 circuit breakers and gas insulated substations through research and development of methods and processes to reduce maintenance costs. It will also help to minimise degradation of equipment, minimise the risk of equipment failure, and minimise the potential for SF6 emissions by applying new technologies and improving GIS and GIL equipment life-cycle management.

GIS and GIL equipment research and development focuses on developing methods, technologies, and support documentation to help

utilities make prudent asset management decisions. These decisions are necessary to minimise GIS and GIL equipment life-cycle costs and maximise equipment performance within an acceptable risk level.

P37.111 - Risk based substation equipment asset management
This programme conducts research with the goal of providing continually improved risk-based decision-support methodologies for substation equipment asset managers. It envisages that the developments will lead to an integrated framework for asset risk assessment, mitigation, and performance improvement. Developments in risk-based fleet management are addressed through the following tasks:

- Asset characterisation and performance information: Continued development for transformers, circuit breakers, relays, surge arresters, capacitor voltage transformer (CCVT), substation batteries and ground grid
- Industry wide equipment performance and failure database and analytics: Continued development of the database to include failure and performance data
- Asset health algorithms and software: Continued development of the software tools and algorithms within Power Transformer Expert (PTX)
- Substation equipment asset management guidelines: Continued development of the asset management and maintenance practice guidelines
- Triggers and alarms for maintenance actions: Continued development of the algorithms to ensure that international standards and guidelines are followed
- Evaluation of DGA analytics: Continued development of the performance assessments as new data is becoming available
- Asset management guidelines: Continued development to include the incorporation of additional case studies in order to enhance the guidelines
- Asset management workshop: Annual conference to assist technology transfer

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Continuing to expand National Grid's knowledge and deliver value to our stakeholders, participation in P37 during the next four years will provide access to rolling updates on the three project work-streams.

P37.101 –Transformer life management:

- Transformer on-line monitoring technologies

  Technology approaches to on-line gas analysis will continue from previous years of research. The scope will be extended to include the length of sampling lines and the temperatures of the environment as through the previous studies and testing they have been found to be influential in the success of the techniques.

- Novel sensor development

  Research new sensors for assessing the condition of a transformer; the scope will be extended to include technologies used within other industries for gasses such as methane

- EPRI power transformer guidebook

  Develop improved knowledge in the area of technological advances. The development of the guidebook is built upon, year on year. The updated guidebook will be published during 2017

- Improved accuracy of transformer remaining life estimation

  Continued research into the dynamic behaviour of new chemical markers in oil and whether it has the potential for improving transformer life estimates

- Transformer life extension

  Research life extension and will also seek to quantify potential cost savings of any new technology so that it can be accurately benchmarked

- Transformer forensics – linking diagnostics and maintenance with true internal condition

  Examination of retired or failed transformers relating the evidence found to both historic transformer operations and diagnostics

data

- Transformer ratings

  Develop EPRI's rating enhancement software (PTLoad) which will be integrated into the Transmission Ratings Workstation (TRW) to move towards facilitating common transmission rating practices across equipment boundaries

P37. 108 - SF6 Management and Gas Insulated Substations:

- Development of the research and development of methods and processes to reduce maintenance costs, minimise degradation of equipment, minimise the risk of equipment failure, and minimise the potential for SF6 emissions by applying new technologies and improving GIS and GIL equipment life-cycle management

P37.111 - Risk Based Substation Equipment Asset Management:

- Asset characterisation and performance information: Continued development of asset registries for transformers, circuit breakers, relays, surge arresters, CCVT, substation batteries and ground grid
- Industry wide equipment performance and failure database and analytics: Continued development of the database to include failure and performance data
- Asset health algorithms and software: Continued development of the software tools and algorithms within Power Transformer Expert (PTX)
- Substation equipment asset management and maintenance practices: Continued development of the asset management and maintenance practices to include an assessment into end of asset life
- Triggers and alarms for maintenance actions: Continued development of the algorithms to ensure that international standards and guidelines are followed
- Evaluation of DGA analytics: Continued development of the performance assessments as new data is becoming available
- Asset management guidelines: Continued development to include the incorporation of additional case studies in order to enhance the guidelines
- Asset management workshop: Annual conference to assist technology transfer

Project Partners and External Funding

Each project facilitated by an EPRI programme is funded through collaborators, including National Grid, that contribute to the development of the project portfolio and then express interest in to be involved with a specific project once the portfolio is decided. The total contribution to P37 from all of the EPRI members over the next four years is expected to be in the region of £23.8m (based on 2017 rates).

Potential for New Learning

These projects in their totality will help National Grid and GB utilities by providing new learning in the following areas:

P37.101 - Transformer life management
Transformers are a key component of substations and participation in P37.101 provides the potential to unlock new learning through:

- Improved understanding of how to maximise value from emerging condition-monitoring techniques, including a better understanding of climate control in order to more closely simulate the substation environment
- Novel sensors to measure parameters presently not available for on-line measurement – including substation demonstrations of the successes from the laboratory
- Improved estimates of the remaining life of transformers, providing improved insights into likely end-of-life scenarios for the increasing population of aged transformers.
- Extended transformer life potential through the application of novel filtration materials and techniques.
- Improved support for decision making on replacement, diagnosis or refurbishment of transformers through the growing forensics database.
- Novel methodologies for rating transformers and other equipment on the same circuit.

P37. 108 - SF6 Management and Gas Insulated Substations
Gas-Insulated Substations (GIS) and Lines (GIL) offer many benefits including compact size, modularity, physical security and protection from pollution and harsh environments. This project will provide new learning in the areas of:

- Reducing cost and potential of SF6 emissions.
- Developing improved handling and live filling techniques.

- Improving diagnostic techniques for reduction of life cycle costs.

P37.111 - Risk based substation equipment asset management

The research will enhance asset management decision making processes and improve their results. The development provides tools and methodologies that can be used by substation equipment asset managers for improved decision support, including the following:

- Provides an analytical framework for asset management principles of substation equipment.
- Reduces overall maintenance costs, forecasts operations and maintenance needs, minimises unplanned expenses, and maximises the benefit and value of planned work.
- Improves reliability and availability via reduced reliance on time-based maintenance by using analytics based on asset health and risk and condition analysis to determine intervention actions.
- Enables more effective use of existing infrastructure and data, as well as efficient use of maintenance personnel to manage operational risk.
- Collectively, the developed suite of algorithms serves as the framework for Analytics for Substation Asset Management.

Scale of Project

The work-streams associated with P37 are predominantly laboratory or desk based projects, with a minimal number of site trials, if and when required. Because of this approach, there is no scope to reduce the scale of the work packages any further.

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, although the programme also reviews the latest research from across the world. Additional testing facilities in Canada may be used, where appropriate.

Revenue Allowed for the RIIO Settlement

None.

Indicative Total NIA Project Expenditure

The total indicative NIA expenditure for the four year programme is £1880k.

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

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

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

n/a

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

n/a

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 (RIIO-1 projects only)

The three P37 project work-streams that form this NIA project - transformers (P37.101), SF6 (P37.108), and asset management (P37.111) - offer different financial savings, based on the associated outcomes and potential benefits gained, year on year.

Each EPRI programme that National Grid joins has been through several stages of review that consider the potential to deliver financial benefits. In the first instance, within EPRI's governance, the Research Advisory Committee provides guidance on policies and issues that impact the power industry to inform the content of the research programmes. Within National Grid, the technical lead for each aspect of the GB transmission network undertakes a review of the proposed EPRI programme relevant to their technical expertise and responsibilities, and evaluates based on which programme will provide potential value from a GB perspective as part of an annual review of programmes to participate in.

Following previous participation in P37, it is expected that enduring involvement in P37 will facilitate the continued generation of valuable learning that will improve and maintain the reliability of the GB transmission System.

Please provide a calculation of the expected benefits the Solution

Not required for research projects.

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.

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

A RIIO-1 NIA Project 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

RIIO-2 Projects

☐ 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 and protection and control as well as have assets containing SF6. They all face similar challenges around estimating remaining transformer life and minimising the risks of mal-operation of protection and control systems

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

This project sits within the Managing Assets and Corporate Responsibility value areas of the electricity transmission owner innovation strategy.

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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.

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

By participating in collaborative projects through EPRI, National Grid can ensure that unnecessary duplication with other projects under NIA is avoided.

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

n/a

Additional Governance And Document Upload

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

n/a

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

☑ Yes