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## NIA Project Registration and PEA Document

### Date of Submission

Dec 2018

### Project Reference Number

NIA\_NGTO028

## Project Registration

### Project Title

EPRI Research Collaboration on Underground Transmission (P36+ P34 part) 2018 - 2021

### Project Reference Number

NIA\_NGTO028

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

January 2018

### Project Duration

3 years and 4 months

### Nominated Project Contact(s)

Judith Robinson

### Project Budget

£1,677,000.00

## Summary

The electricity industry faces challenges that National Grid recognises can be more effective and cost-beneficial if dealt with through international collaboration initiatives. In particular, challenges where 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 this type of initiative can be delivered. This collaborative approach is beneficial to National Grid and our customers, providing valuable expertise and learning, which would be more expensive to formulate on an individual basis.

This project supports two programmes of work: EPRI Underground Transmission Programme 36 (P36) and EPRI Transmission Asset Management Analytics Programme (P34).

The outputs from these two programmes of work will provide the following:

- asset characterisation and performance data models and failure form
- Industry-wide transmission and substation asset failure and performance database
- framework for underground transformer asset management analytics
- report into Reliable Performance of Transmission Cable Accessories - Long-term Ageing Test
- underground transmission workstation: Functional and Technical Enhancements and Developments

### Nominated Contact Email Address(es)

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## Problem Being Solved

The electricity industry faces challenges that National Grid recognises can be more effective and cost-beneficial if dealt with through international collaboration initiatives. In particular, challenges where 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 this type of initiative can be delivered. This collaborative approach is beneficial to National Grid and our customers, providing valuable expertise and learning, which would be more expensive to formulate on an individual basis.

As an owner of underground transmission assets, National Grid faces challenges around asset life, development of innovative and fit for purpose monitoring, maintenance practices and understanding what novel technologies could be applied to improve efficiencies. The EPRI Underground Transmission Programme 36 (P36) aims to develop this work via five supported project work-streams. In addition to this, one of the EPRI Transmission Asset Management Analytics Programme (P34) workstreams is developing analytical tools for Underground Transmission.

## Method(s)

### P34.004 - Underground Transmission Asset Analytics

This work package aims to provide decision support algorithms, tools and technologies based on evaluating current and future equipment performance by:

- designing, developing, populating, maintaining and extracting information from industry-wide databases to quantify historical performance
- developing condition assessment algorithms to understand existing performance
- developing metrics to better assess and evaluate equipment performance
- developing tools and methodologies to project future performance and manage risk

### P36.001 - Design, Construction, Ratings and Operation of Underground Transmission Systems

This workstream will apply industry knowledge, enhance and validate existing solutions, and investigate and develop tools and technologies by adopting the following method:

- investigating transmission cable accessory performance issues and perform aging tests on outdoor terminations with composite insulation
- analysing field aged cables and accessories and collect failure and performance data to investigate long-term performance issues
- developing methodologies and software tools related to design, engineering, system planning, ratings and operations of underground cables
- investigating underground transmission vault inspection techniques to improve worker safety and reduce circuit outage requirements.

### P36.002 - Extruded Dielectric Cable Systems

This work package will investigate methods and technologies for extruded dielectric transmission cable systems. Solutions are applicable to design, selection, installation, commissioning, testing, operation and maintenance of these systems. This work package aims to answer research questions and address industry questions through the following approach:

- laboratory testing to validate engineering design models and to understand failure mechanisms
- development and evaluation of innovative inspection and assessment tools, methods and technologies
- laboratory testing and field demonstration of developed or available diagnostic methods.

### P36.003 - Laminar Dielectric Cable Systems

This work package will investigate and develop condition assessment methods and procedures for laminar dielectric cable systems. Efforts will focus on life extension, improved reliability, reduced operations and maintenance costs and improved support for asset management decision making protocols. This workstream will focus on:

- studying buried steel pipe coating degradation as a function of coating types, coating ages, pipe installation environments and stray current conditions
- evaluating and developing methods to effectively detect and mitigate coating damage
- investigating detection and mitigation techniques, and developing technical basis for best practices to improve effectiveness of cathodic protection systems
- evaluating and demonstrating advanced diagnostic techniques through laboratory testing to assess conditions of laminar dielectric cables.

### P36.006 - Technology Transfer for Underground Transmission

This work package aims to assist in transferring EPRI research and development results to meet technical and educational requirements by:

- producing and updating the EPRI Underground Transmission Systems Reference Book (the Green Book)
- producing and updating the Increased Power Flow Guide Book (the Platinum Book).

#### P36.008 - HVDC Cable Systems

This work package aims to investigate and develop methods and tools for the effective application on HVDC cable technologies for system integration and interconnection. This workstream will focus on:

- evaluation of operational practices in the application of HVDC cable technologies based on technical and economic benefits and increased power transfer capability requirements
- investigating and evaluating design tools for engineers to prepare feasibility studies and verify proposals and implementations
- evaluation of condition assessment, maintenance, inspection and fault location techniques to meet operation and maintenance requirements
- evaluation of cable insulation materials and ageing characteristics to extend the life of HVDC cables.

### Scope

The full scope of research within each project workstream for the duration of this project is listed below:

#### P34.004 - Underground Transmission Asset Analytics

##### Asset Characterisation & Performance Information

- **Definition and Data Models for Utility-Wide Underground Transmission Asset Sharing:** This task will develop and update the underlying data models of underground transmission cables, joints and terminations for efficient and effective collection of test diagnostics, performance and failure data for use in industry and utility database applications and performance analytics. The data model is utilised in the EPRI Industry-wide Database (IDB). The data models for cables, joints and terminations for extruded dielectric systems as well as cables for pipe-type cable systems will be updated. The data models for joints and terminations for pipe-type systems are anticipated to be added.
- **Underground Transmission Failure and Performance Database:** This task will compile and analyse historical failure and performance data on underground transmission assets in a common format using information gathered. Results will be distributed in the form of a subscription.

##### Asset Health Algorithms

- **Development of a Framework for Determining Underground Transmission Asset Conditions:** This task will develop the underground transmission asset condition analytics framework that will include identifying inputs and outputs needed for asset condition aggregate ranking algorithms on components and lines. The framework will also address triggers (or alarms) of underground transmission assets for maintenance practices. This task is anticipated to begin with addressing pipe-type cable conditions.

##### Asset Management Program Decision Support

- **Asset Management Training and Knowledge Transfer:** This task will provide utilities with training and knowledge transfer of EPRI R&D results on asset management through workshops, webcasts, and conferences.

#### P36.001 - Design, Construction, Ratings and Operation of Underground Transmission Systems

- Investigate transmission cable accessory performance issues and perform ageing tests on outdoor terminations with composite insulation
- Analyse field aged cables and accessories and collect failure and performance data to investigate long-term performance issues
- Develop methodologies and software tools related to the design, engineering, system planning, ratings, and operations of underground cables
- Investigate underground transmission vault inspection techniques to improve worker safety and reduce circuit outage requirements.

#### P36.002 - Extruded Dielectric Cable Systems

- Laboratory testing to validate engineering design models and to understand failure mechanisms
- Development and evaluation of innovative inspection and assessment tools, methods, and technologies

- Laboratory testing and field demonstration of developed or available diagnostic method

#### P36.003 - Laminar Dielectric Cable System

- Better understanding of failure mechanisms and prevention procedures will result in longer asset life, reduced customer outages, and lower operations costs
- Effective inspection and monitoring of assets may lead to increased asset utilization, rapid maintenance intervention prior to spontaneous failure, higher reliability, and lower repair costs
- New inspection techniques and tools may increase staff productivity and reduce overall maintenance costs.

#### P36.006 - Technology Transfer for Underground Transmission

- Improved underground transmission system designs
- Improved cable project execution
- Retention and/or transfer of institutional knowledge

#### P36.008 - HVDC Cable Systems

- Use of the reference books, design tools, and other investigative results will result in more effective designs and applications for power grid integration and interconnection
- Effective inspection and monitoring of assets may lead to increased asset utilization, rapid maintenance intervention, higher reliability, and lower repair costs

Better understanding of failure mechanisms and prevention procedures will result in longer asset life, reduced customer outages, and lower operating costs

### Objective(s)

- P34.004 -: to provide effective decision support algorithms, tools and technologies to advance the understanding of the future performance of underground transmission.
- P36.001 -: to provide adequate tools and information for the design, construction, ratings and operation of underground transmission systems.
- P36.002 -: to investigate methods and technologies for extruded dielectric transmission cable systems and identify suitable solutions for application to the design, operation and maintenance of these systems.
- P36.003 -: to develop suitable condition assessment methods and procedures for laminar dielectric cable systems.
- P36.006 -: to support the transfer and adaptation of EPRI research and development results to meet technical and educational requirements.
- P36.008 -: to develop suitable methods and tools for system integration and interconnection for application on HVDC cable technologies.

### Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

### Success Criteria

Continuing to expand National Grid's knowledge and to deliver value to our stakeholders, participation in P36 during the period means the provision of a range of specific outputs across the workstreams.

#### P34.004 - Underground Transmission Asset Analytics

- Report into asset characterisation and performance data models and failure forms
- Industry-wide transmission and substation asset failure and performance database
- framework for underground transformer asset management analytics

#### P36.001 - Design, Construction, Ratings and Operation of Underground Transmission Systems

- Report into Reliable Performance of Transmission Cable Accessories - Long-term Ageing Test
- Underground Transmission Workstation: Functional and Technical Enhancements and Developments
- Report into Pipe-Type to XLPE Cable Conversion – Technology, and Design and Construction Options
- Report into Underground Transmission Vault Inspection Using Robotic Techniques

- Industry-wide Performance and Failure Database for Underground Transmission Cables and Accessories

#### P36.002 - Extruded Dielectric Cable Systems

- Guidelines for Thermo-Mechanical Design of Extruded Dielectric Cable Systems
- Design, Testing, Operation and Monitoring of Sheath Bonding Systems
- Asset Vintage Guide for Extruded Dielectric Cables, Terminations, and Joints
- Advanced Sensors and Inspection Techniques for Extruded Dielectric Transmission Cable Systems
- Ageing Characteristics of Extruded Dielectric Cable Systems and Components

#### P36.003 - Laminar Dielectric Cable Systems

- Inspection, Assessment, and Mitigation of Buried Steel Pipe Corrosion
- New Technique Development for Online and Off-line Condition Assessment of Laminar Dielectric Cable Systems
- EPRI Dissolved Gas Analysis Guide for High Voltage Cables and Transformers – Case Studies
- Evaluation and Documentation of Vintage Pipe-type Cable Performance and Experience
- Failure Root Cause Study of Laminar Dielectric Cables

#### P36.006 - Technology Transfer for Underground Transmission

- Underground Transmission Education Workshops
- EPRI Underground Transmission Systems Reference Book (The Green Book)
- Increased Power Flow Guide Book (The Platinum Book) – 2018 Update
- Pressurization Procedures for High-Pressure Fluid-Filled and High-Pressure Gas-Filled Cable Systems

#### P36.008 - HVDC Cable Systems

- EPRI High Voltage Direct Current (HVDC) Transmission Reference Book (The Olive Book)
- Methods and Case Studies for HVDC Cable Ampacity and Cable Insulation Electric Stress Calculations for Utility Users
- HVDC Cable Systems with Extruded Dielectrics

### 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 from all EPRI Underground Transmission members over the next three years is anticipated at £1.25m

### Potential for New Learning

Each project provides opportunities for extensive learning and knowledge generation through collaboration which would not be economically feasible if carried out independently.

### Scale of Project

The project work-streams associated with P36 are predominantly laboratory or desk based projects, with a minimal amount of site trials, if required. Because of this approach, there is no scope to reduce the scale of the projects any further.

### Technology Readiness at Start

TRL2 Invention and Research

### Technology Readiness at End

TRL3 Proof of Concept

### Geographical Area

The research undertaken in EPRI P36 is predominantly carried out in the US with some in the UK, however, the programme carries out reviews of the latest research from across the world.

### Revenue Allowed for the RIIO Settlement

None

### Indicative Total NIA Project Expenditure

The total indicative NIA expenditure for the three year programme is £1,677,000

## 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)

Each project work-stream will have different financial savings based on the outcomes and potential benefits gained. 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 which provide potential value from a GB perspective as part of an annual review of which programmes to participate in. The work-packages within P36 are expected to generate valuable learning which can improve and maintain the reliability of the 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

Each project can be applied to the maintenance and reliability of underground transmission and strategies throughout the transmission and distribution network.

#### 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 underground cables. They all face similar challenges around estimating remaining asset life, development of new monitoring and maintenance practices and understanding what novel technologies could be applied to improve efficiencies.

#### 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 Efficient Build value areas of the electricity transmission owner (ETO) 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

The work being undertaken in the underground transmission programmes is low TRL research covering a wide variety of topics seeking to address problems with underground transmission identified by EPRI which has a worldwide membership with participation from more than 35 countries.

## 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**

The Electric Power Research Institute (EPRI) conducts research, development, and demonstration projects for the benefit of the public in the United States and internationally. EPRI is independent and non-profit making. The P36 and P34 programmes consist of low TR level work which National Grid would not necessarily fund due to the level of uncertainty in the value of the findings for application on the transmission network. Without participation in these programmes we would not have access to the findings which could result in a wide range of benefits for the TOs, DNOs and ultimately the consumer.

### **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**

The research carried out through the EPRI programme would not normally be undertaken by National Grid unless there was a specific business case. There is a risk that the studies will not provide outputs that can be implemented or deployed on the UK transmission system. Because of this National Grid would be unlikely to subscribe to this programme without NIA funding.

### **This project has been approved by a senior member of staff**

Yes