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

Oct 2017

Project Reference Number

NIA_UKPN0030

Project Registration

Project Title

Development of Oil-filled Cable Additive- Phase 2

Project Reference Number

NIA_UKPN0030

Project Licensee(s)

UK Power Networks

Project Start

November 2017

Project Duration

2 years and 2 months

Nominated Project Contact(s)

Maxi Faridi

Project Budget

£1,988,128.00

Summary

The aim of Phase 2 is to trial few circuits and confirm the satisfactory operation of the new SHFs in fluid filled cables representative of those in distribution networks and in FFC circuits. The project will also ensure SHF production and quality assurance at industrial production level.

Northern Power Grid is a project partner and will supply cable and oil samples from their network for testing in the project.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

There are over 4,750 km of fluid filled cables (FFCs) within GB DNOs with initial installation dating back as far as the 1930s. These cables are of various design types (e.g. AEI, BICC, Pirelli, Sumitomo, Dainichi-Nippon) and are deployed on distribution network at voltages ranging from 33kV up to and including 400kV. FFCs are insulated by a layer consisting of tightly-lapped cellulosic paper, impregnated with a low-viscosity dielectric fluid that enhances the insulation system electrically and thermally. The cable is typically sheathed in lead to provide armouring and to contain the fluid. Due to the age of the FFC network, the increasing fragility of these sheaths, plumbed cable joints and associated oil circuit is of concern. If the sheath is breached, fluid will leak from the insulation layer to the surrounding environment. This also represents a hazard to the cable insulation, as the loss of a sufficient volume of oil will cause the cable insulation to degrade electrically and thermally.

Although the lost fluid can be replaced, leaks represent an environmental hazard, particularly if the cable is sited within an environmentally sensitive region or close to groundwater. In some cases, where FFC is located close to groundwater the leaks may also cause environmental contamination which is of concern to the public, water authorities and the Environment Agency that could enforce the closure of cable circuits or impose limits on their operation.
The many causes of cable leaks have resulted in an uncertain outlook for the future reliability of fluid filled cables. However, there are

still many of these circuits in operation, and the challenge remains to improve the condition and reliability of existing cable circuits to reduce failures, outages and the associated liability costs of outage and environmental pollution.

Method(s)

Prior to this project (Phase 2), Phase 1 Stages 1 to 4 were successfully delivered under the NIA. Phase 1 Stages 1 to 3 assessed a number of different chemistries for the self-healing fluid (SHF) and helped identify the chemical technologies for fluid systems that are capable of providing a repair function for a variety of cable sheath defects and damage types that may occur. Stage 4 of Phase 1 helped accelerate Phase 2 (i.e. this project) by informing the scope, objectives and planning for it.

Phase 2 will cover a wide range of activities, intended to allow the rapid deployment of the technology upon the completion of the project. During the first stage, the project will focus on mobilisation and scale up prior to testing within Stages 2 and 3, including the transfer of the SHF formulation to a large-scale fluid supplier and the construction and commissioning of primary and secondary rigs. During this phase, fluid samples will be collected from FFC network for analysis, and provide short lengths of cable for cable aging and compatibility trials.

During Stages 2 and 3, the volume-produced SHF will be tested within the primary and secondary rigs to establish the performance of SHF over a range of conditions expected within operational cables. Upon the successful conclusion of rig trials, the SHF formulations will progress to circuit trials. During the final stages of the project, the system will be transitioned to business as usual to ensure that the system can be taken up quickly upon its conclusion.

Activities of this project will be carried out within the following 3 Stages and 9 Work Packages:

Stage 1: (Project mobilisation and construction of test rigs)
Work Package 1: SHF Consolidation and Industrial Scale-up
Work Package 2: FFC Cable circuit oil sampling for oil characteristics and gas content & sourcing of cable samples
Work Package 3: Cable aging and compatibility - short length thermal aging with variable oxygen concentration, ageing temperature and time with oil analysis
Work Package 4: FFC Rig construction and commissioning - primary and secondary

Stage 2: (SHF Cable Rig Trialling)
Work Package 5: FFC Rig Leak Repair testing
Work Package 6: Containment testing and Rig 2 testing programme

Stage 3: (SHF Cable Circuit Trialling and transition to Business as Usual)
Work Package 7: FFC Circuit trialling
Work Package 8: Project Management, Coordination, and Reporting
Work Package 9: Transition to business as usual

Scope

The aim of Phase 2 is to trial few circuits and confirm the satisfactory operation of the new SHFs in fluid filled cables representative of those in distribution networks and in FFC circuits. The project will also ensure SHF production and quality assurance at industrial production level.

Northern Power Grid is a project partner and will supply cable and oil samples from their network for testing in the project.

Objective(s)

Stage 1 concerns the sourcing and preparation of cable test samples, equipment necessary to carry out rig and laboratory testing throughout the remainder of the project. During this stage, circuits will also be nominated for future circuit trials pending the completion of rig trials.

Stage 1 Objectives:

- Scale-up, transfer, and qualification of the SHF formulation to a major cable oil supplier. This will ensure that sufficient volumes of SHF are available for circuit and rig trials.
- Understand electrical characteristics, oxygen and particulate content of oil samples drawn from across the network.
- Understand thermal ageing on cables with SHF. Preparation of cable aging trials to have cable samples filled with degassed SHF.
- Construct and commission primary and secondary FFC test rigs in preparation for SHF rig trials.
- Develop test geometries necessary to produce suitable leak rates for testing for both primary and secondary rigs.

- Nominated circuits and sourcing of cable samples that match the design of the length for testing.

In Stage 2 SHF samples will be trialled on the primary and secondary FFC rigs. This period will also cover initial field trials which will commence upon the successful completion of a complete set of rig trials on a given circuit. Laboratory trials, including ageing studies will continue to progress.

Stage 2 Objectives:

- Determine the effects of ageing on SHF-soaked cable samples.
- Planning and preparation for rig trial testing. Carry out contaminated testing and cable repair and jointing trials on secondary cable test rigs.
- Prepare selected circuits for rig trial testing. Train cable operators in handling and injection of SHF blend.
- Initial circuit trials, including flushing the cable with new SHF blend and assessment of both asset and SHF health.

The final stage is primarily concerned with the completion and collection of data from cable rig and circuit field trials, with the aim of demonstrating the efficacy of the selected SHF formulation under operational conditions prior to transfer to business as usual. During this period laboratory trials will also be completed, which will provide valuable information regarding the long-term stability of the selected formulation under operational conditions.

Stage 3 Objectives:

- Removal and dissection of the final samples within the ageing study, to assess changes in the SHF blend and cable over the course of the trial.
- Completion of assessment of selected samples within primary and secondary rigs. The rigs will still remain in place to allow for future testing if required.
- Completion of field trials. This will include the long-term assessment of circuits treated with SHF during the course of Stage 2 as well as demonstrations of sheath repair and jointing. The completion of this work package will demonstrate the efficacy of the SHF formulation operating within a decommissioned cable including compatibility with common cable repair techniques.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be deemed successful if following objectives are successfully delivered:

1- Development of a self-healing cable fluid formulation that proves successful in achieving FFC leaks repair and fluid containment in cable rigs and circuit trials.

2- Demonstrate that the SHF formulation can be produce in volumes necessary to meet demand and are compatible with cables under operational conditions and a wide range of temperatures.

3- Demonstrate that the SHF developed is capable of significantly reducing or eliminating leaks and widespread environmental contamination arising from damage to the cable sheath or plumb joints.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The project will involve the production of a fully qualified SHF formulation which will be proven in both rig and field circuit trials. Sites will be selected within UK Power Networks' licence areas to do the field trial on short and long circuits. Testing in the lab will be performed with UK Power Networks and Northern Power Grid cable and oil samples to ensure additive developed is for all the different types of fluid filled cables.

Technology Readiness at Start

Technology Readiness at End

TRL4 Bench Scale Research	TRL8 Active Commissioning

Geographical Area

All cable sample testing work will be carried out within UK Power Networks' licence areas. Research and lab testing work will be carried out at Gnosys laboratory.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£1,988,128

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)

When a fluid filled cable starts leaking, operational staff are mobilised to initially locate the leak and then (depending on its severity) repair it or replace the fluid filled cable. Both activities are very costly. Introducing the SHF into the leaking fluid filled cable (cheaper method than repairing or replacing FFCs) could reduce or even eliminate the need for repairing or replacing the cable.

Please provide a calculation of the expected benefits the Solution

Baseline Costs: £967,040
The baseline method for dealing with oil-filled cable leaks involves either repairing the cable or, if the leak is severe, replacing the cable. This is the cost of two identical schemes at project scale spread across four years.

Method Cost: £88,484
The method cost includes the cost for treating oil-filled cable circuit with the self-healing fluid blend (i.e. oil plus self-healing cable additive). This takes into account the operational costs associated with the treatment as well as the cost of the actual fluid blend for two identical schemes calculated in baseline.

Financial Benefits: £878,555
The main benefit of undertaking the proposed solution derives from avoiding oil leakages following a failure within fluid filled cables. This is the NPV value of calculated from formula provide in the CBA.

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

The technology developed could be applied across all network licensees for use on their FFC asset base. This is over 4,750km across the entire GB network

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

There are over 4,750 km of oil filled cables across all the GB Network Licensees which could be affected by leaks, which means the GB rollout costs for additive treatment would be over £23m assuming the technology is adopted as the sole solution to leakage problems.

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 Distribution Network Operators in GB that operate fluid filled cables will be able to use the product delivered at the end of the project (i.e. the self-healing fluid). Other DNOs outside of GB might be able to use the SHF as well, if their FFCs operate within the pressure range that FFCs in GB do.
The SHF will be commercially available for all DNOs to purchase. All learning related to its use will be shared with all other GB DNOs to make their adoption of the technology easier.

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

n/a

☑ 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.

n/a

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