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

Mar 2023

Project Reference Number

NIA_UKPN0089

Project Registration

Project Title

Fluid Cable Care Phase 3

Project Reference Number

NIA_UKPN0089

Project Licensee(s)

UK Power Networks

Project Start

March 2023

Project Duration

1 year and 7 months

Nominated Project Contact(s)

innovation@ukpowernetworks.co.uk

Project Budget

£809,433.00

Summary

The loss of oil from Fluid-Filled Cables (FFCs) is a significant technical and environmental challenge for operators. Across the GB approximately 375,000L of oil is lost annually from fluid-filled cables. This project aims to reduce non-catastrophic cable leaks through the introduction of self-healing fluids with the name Anagen. Under normal operation, Anagen will function as insulation oil, but upon the formation of a breach, it will crosslink within the defect to form a solid mass that will stop the leak and prevent further leaks, preserving both the cable and the local environment. This project seeks to advance the Anagen self-healing dielectric fluid to allow the fluid to be implemented in GB's FFC networks and become Business as Usual (BAU).

Nominated Contact Email Address(es)

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Problem Being Solved

FFCs are present throughout Great Britain (GB) distribution networks as legacy assets. They are insulated with a layer of cellulosic paper (or PPLP) impregnated with an insulating low viscosity dielectric oil, such as dodecylbenzene or T3788. To prevent void formation the cable is held under a positive fluid pressure (typically between 3-8 bar); as a result, any damage to the cable sheath or accessories will result in fluid leaking into the surrounding environment. This has an impact on the environment as well as asset integrity.

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 cases where an 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. As the FFC network ages further, it is anticipated that the severity of the leaks will worsen due to continued ageing and degradation of the cable sheaths and joints.

Method(s)

Prior to this project (Phase 3), Phases 1 and 2 were successfully delivered under the NIA. The results from phase 2 of the project were significantly positive, however, there are some results that require further investigation before the large–scale uptake of Anagen. As phase 2 did not complete live circuit trials, the long-term use in an operational circuit is unknown.

The project will undertake work to assess the potential for Anagen to be deployed into the cable in the same way as a standard cable oil (i.e. top up fluid). The result from this work has the potential to significantly lower the volumes of Anagen required for the successful deployment of Anagen as business as usual (BAU).

Phase 3 will cover the activities listed below and live circuit trial on a selected circuit, intended to allow the rapid deployment of the technology upon the completion of the project. The project will be split into stages, 3a and 3b which are to be stage-gated with a break clause. This will enable UK Power Networks to discontinue the project if the outputs from stage 3a are unsatisfactory. Both project phases will focus on the assurance required to ensure that the formulation is electrically compatible over a more extended period at a threshold of 10 years and that it doesn't negatively affect the cable system. This will include further development of procedures for safe handling and formulation performance, which will build on those currently in place for existing electrical insulation fluids.

The learnings and outputs from the course of the circuit trial for rapid leak mitigation will build further confidence in Anagen. If this technology is proven to be electrically and operationally consistent with ENA TS 09-04 and IEC 60141-1 and fully compatible with standard fluid-filled cables, it will enable DNOs to adopt it for BAU.

Scope

The primary aim of this project is to build upon the work carried out in phase two and demonstrate that the Anagen technology is ready for deployment within DNOs' FFC networks. This is primarily achieved through testing at Gnosys Kinetrics' test facility in Canada.

In summary, the key project outputs are:

· Assessment of Anagen performance when deployed as part of a progressive top-up solution and when leaking into bituminous compounds

· HV testing and thermal load cycling program (including second-level pressure testing) according to IEC 60141, ENA TS 09-04 and an extract from ENA TS C28-4

· A critical review of electrical properties

· Assessment of the effect of moisture content on breakdown voltage

· Ageing and compatibility testing with critical cable components

· Evaluation of self-healing efficacy under load cycling/long-term conditions

· Evaluation of operational procedures

· Evaluation of risk on maintenance equipment

· Environmental impact review

· Circuit Trial: As part of the project, a testing live circuit trial will be conducted by UK Power Networks, during which a rapid FFC leak mitigation will be carried out on potentially suitable circuits. This will assist in improving the assurance that UK Power Networks has in:

o Adopting the technology for a wider network deployment

Ensuring that all identified risks, if any, can be mitigated before the wider deployment

Objective(s)

The objectives of this project are as follows:

· Establish the efficacy of Anagen when deployed as a progressive top-up regime instead of the flushing approach considered in previous project phases

· Establish the efficacy and self-healing mechanisms of Anagen in healing leaks within bituminous compounds.

· Develop a greater understanding of how disparate cable oils flow, mix, and dilute within a cable system (including, where applicable, cable oil ducts), allowing better prediction of the efficacy of Anagen and the optimal conditions for deployment.

· A critical review of electrical properties of Anagen

· Valuation of effects of high/different concentrations of Anagen formulations (increasing tung oil percentage) to establish the minimum concentration required for Anagen to effectively seal different levels of leakages

· Second level cable ageing and compatibility test at elevated temperatures

· Second level electrical pressure testing to assess electrical integrity

· Evaluation of long-term sealing effectiveness (effects of load cycling) to potentially identify limitations of circuits that Anagen could be deployed on.

· Evaluation of Anagen handling process/procedures

· Evaluation of operational risk and maintenance of the fluid

· First level review of the environmental impact of Anagen/T3788

· A greater understanding of Anagen interactions with perfluorocarbon tracers (PFT), allowing leaks on Anagen-containing cable systems to be located

Deploy a live circuit trial in UK Power Networks' area to test the rapid FFC leak mitigation in suitable circuits

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

N/A

Success Criteria

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

· Successful assessment of the electrical properties of the Anagen

· Anagen is operationally consistent with ENA TS 09-04 and IEC 60141-1 and is fully compatible with standard fluid-filled cable oil.

· Delivery and approval of operating procedures and risk assessments directed to aid accredited operatives to make sure handling and operations are safe.

· Successful demonstration of long-term compatibility of Anagen with critical cable components

· Approved adoption of a self-healing cable fluid that can significantly reduce the leakage, repair, and replacement of FFCs.

Project Partners and External Funding

· EIC – Energy Innovation Centre (No External Funding provided)

· Northern Powergrid – (£312,005 contribution through NIA)

Potential for New Learning

Throughout the project, there is significant opportunities to develop a greater understanding how cable oil flows, mix and dilute with Anagen deployment allowing better prediction of the efficacy of Anagen and the optimal conditions for deployment. There will be significant learning on the effectiveness of local leak site repair by Anagen in actual FFCs. Additionally, the effectiveness of the containment mode of action prevents leaking fluid from causing widespread environmental contamination. This learning is expected to lead to widespread adoption of the SHF technology on networks operating FFC circuits.

Scale of Project

The project will involve the production of a fully evaluated standard SHF formulation which will be proven in both rig and field circuit trials. Sites will be selected within UK Power Networks' licence areas to conduct the field trial on short and long circuits. Testing in the lab will be performed at a test facility at Gnosys Kinetrics, with UK Power Networks assuring the successful testing.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

All live circuit trials will be carried out within UK Power Networks' licence areas and NPg won't carry out any trials within the project scope. Research and lab testing work will be carried out at Gnosys Kinetrics laboratory in Canada.

Revenue Allowed for the RIIO Settlement

No funding was included in the current RIIO settlement

Indicative Total NIA Project Expenditure

The project will require £728,490 of NIA funding, having a total budget of £809,433, with a breakdown of:

UKPN: £497,427

NPg: £312,006

10% of UKPN contribution: £80,943

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. The costs associated with these activities is usually very substantial. An average oil repair cost of a typical single leak is around £45K. Furthermore, the cost of replacing EHV FFC circuits is approximately £500k per km. Introducing the SHF into the leaking fluid-filled cable (a 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

The current accepted best practice for stopping leaks on poor condition cable is to either carry out a repair on a localised area (if practicable) or replace the full length of cable in that section as the whole section becomes unusable and needs to be changed.

The potential **benefits** are calculated as the sum of:

· Maintenance cost: 21% of our current leakages are associated with cable sections that have known minor leaks and it is not cost effective to repair/replace these cable sections. These sections are regularly topped up to maintain operating pressure. These minor leaks can be mitigated by deploying this technology. The savings through life extension of assets associated with this solution leads to £670k per annum on FFC top-ups avoided.

· Capital Investment deferral cost: 100% cost savings through deferring the replacement schemes after introducing oil additive in the circuit.

Baseline Costs: £15.77m

The above figure represents the baseline method for dealing with oil-filled cable leaks involves replenishment of the cable section, cable replacement cost, and environmental clean-up cost.

Method costs: £1.81m

The above figure represents the method cost which covers the cost for treating oil-filled cable circuits 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 the schemes calculated in the baseline. Costs include treating oil-filled cable circuits with Anagen.

· Cost of Anagen: £12/L after a 15% discount from the market price, assuming the volume required equals to the annual leakage (480L) for a conservative estimate

· To ensure that Anagen is handled/deployed correctly, training session every five years at £8,000 per session

· Dedicated Anagen processing van = £200,000 (one-off applied in the first year of deployment)

Benefits: £13.95m

The calculation of the above figure was made based on the following:

• The benefits are achieved by deferring the cable replacement cost 100%. Due to the introduction of oil additives into the identified circuits, the allocated cost of cable replacement can be 100% deferred.

• Anagen is a no dig repair system that treats the complete hydraulic segment simultaneously. This could potentially reduce costs associated with locating and resolving leaks.

• In addition, indirect costs (including disruption, interruption of supply, and environmental impacts) could also be significantly reduced.

Arresting small leaks early can prevent the leak from developing into a more significant one.

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 7,800km across the entire GB network.

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

There are over 7,800 km of oil-filled cables across all the GB Network Licensees that could be affected by leaks, which means the GB rollout costs for additive treatment would be over £290m assuming an oil capacity of 3,100 litres per km, cost of additive of circa £12 per litre and that 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). The Anagen 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

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.

This project is Phase three of the fluid cable care project and is carried out in partnership with Energy Innovation Centre. At the time of preparing this document, UK Power Networks is not aware of any innovation project looking to develop a self-healing cable fluids technology and trial it on a distribution network.

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

This project will establish a new technique i.e self-healing cable fluids for use in low viscosity fluid-filled cables within the GB distribution network. After investigating a number of potential solutions, it was determined that the most feasible approach would be to develop a replacement insulation fluid that was based upon historic investigations carried out but never produced to practice. Here, common cable fluids (including T3788) were blended with different drying oils to produce a system that would cross-link on contact with oxygen, resulting in the formation of a solid mass that seals the leak site and prevents further loss of fluid.

However, in the case of more serious damage, the fluid leaking through the sheath will cure upon contact with oxygen within the backfill which will both block the defect and provide a barrier to the transport of fluid away from the leak site, so preventing further loss of fluid and greater environmental contamination. In this secondary ‘containment’ mode of action, the SHF works synergistically with the backfill material to produce a hardened, oil-proof barrier that prevents further loss of oil. Together, these functions “primary leak site repair” and “secondary containment” are expected to substantially mitigate the loss of fluid, providing significant benefits to the cable operator and the local environment.

Relevant Foreground IPR

This Section is not to be completed until we receive IPR guidelines from Ofgem.

Data Access Details

To view the full Innovation Data Sharing Policy, please visit UK Power Networks’ website here:

http://innovation.ukpowernetworks.co.uk/wp-content/uploads/2021/11/UK-Power-Networks-Innovation-Data-Sharing-Policy-.pdf

UK Power Networks recognises that Innovation projects may produce network and consumption data, and that this data may be useful to others. This data may be shared with interested parties, whenever it is practicable and legal to do so, and it is in the interest of GB

electricity customers. In accordance with its Innovation Data Sharing Policy, UK Power Networks aims to make available all non-personal, non-confidential/non-sensitive data on request, so that interested parties can benefit from this data.

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

There is risk associated with developing and testing a new method for network use. Developing and designing the third phase of Fluid Cable Care method is an innovative activity that is beyond the business as usual activities of UK Power Networks due to the modifications required for both network automation and the protection equipment located on site.

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 project can only be undertaken as an innovation pilot given the operational risks associated with the deployment of an unproven solution on the network.

As noted in the NIA guidance, certain projects are speculative in nature and yield uncertain commercial returns. This is the case for with this project, as there is a commercial risk that the solution developed, as part of the project is not adopted by the stakeholders involved following the trial period. This could be due to the fact that the solution has not reached the level of maturity required for business-as-usual application or that the benefits are not as strong as forecasted. This risk is being mitigated against, through early engagement with stakeholders and ensuring requirements are clearly defined and documented. If the project is successful, it will produce a strong technical solution, which will lead to customer benefits. The specific details regarding the benefits are captured under section 2b of this document.

This project has been approved by a senior member of staff

☑ Yes