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# NIA Project Registration and PEA Document

### Date of Submission

Dec 2015

### Project Reference Number

NIA_SHET_0018

## Project Registration

### Project Title

Transformer Intrascope Phase 2

### Project Reference Number

NIA_SHET_0018

### Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

### Project Start

December 2015

### Project Duration

3 years and 2 months

### Nominated Project Contact(s)

Peter Taddei, Joe McNeil

### Project Budget

£700,000.00

### Summary

This project seeks to improve upon and overcome the limitations of the phase 1 design to allow for better access, physical range, positional control and visual imaging capability, whilst accepting any improvements that can also be made to spectroscopic measurements. The scope of the project is to have a fully refined, assembled and functional intrascope probe system which has been both mechanically and functionally proven within a laboratory-based environment and via field trials.
This will be achieved by making the following developments to the Intrascope toolkit;

- Implementing alternative articulation methods of the intrascope for improved reach and control
- Selecting an improved visual imaging camera and light source for long range visibility within a transformer
- Redesign of the Intrascope delivery system in conjunction with the improved articulation to ease of deployment

On completion of field trials an inspection procedure will be created to determine the optimal inspection requirements and methods along with an effective way of storing and presenting findings from the inspection. Once the system has been assembled in a laboratory environment and gone through initial functional and mechanical testing, it will be trialled on a range of available transformers. Refinements will also be made to both the hardware and software based on the learning obtained from this test phase.

### Preceding Projects

NIA_SHET_0005 - Transformer Intrascope

### Nominated Contact Email Address(es)

transmissioninnovation@sse.com

### Problem Being Solved

SHE Transmission, and the other GB Transmission Network Operators (TOs), have an ageing infrastructure presently in use on the GB transmission network which means that asset management is becoming an ever-more important factor for the continued operation and

maintenance of the network. Many operational transformers are approaching the latter part of their lives so it is important to be able to monitor their condition and accurately estimate how much longer these units can be reliably and safely operated.

A useful measure of a transformer's estimated remaining life in service is through the assessment of its internal winding insulation. The condition and rate of deterioration of the transformer's internal insulation can be used as a factor to assess its remaining life which can then be used in making optimum asset replacement decisions. Presently, the only non-invasive method of assessing insulation condition available to SHE Transmission as Business as Usual practise is through regular analysis of oil samples using Dissolved Gas Analysis (DGA). This method is important but has limitations including its level of accuracy and its reliance upon an up-to-date history of the transformer oil being assessed.

SHE Transmission does not have any other tools or systems at present which allow us to directly access and analyse the internal insulation of a transformer without the need to dismantle ("de-tank") the transformer in a factory off site. This is an expensive and time consuming option especially for larger transformers along with the major inconvenience and cost of a lengthy outage time required to inspect the transformer; as a result, a project was recently completed in which a prototype spectral analysis scope was developed which started to address some of the aforementioned challenges. The device managed to provide valuable learning about the viability of establishing internal asset condition through in-situ inspection. However, the device is currently limited due to inadequate image quality, lack of in tank manoeuvrability and a limited scope length due to the need to capture both images and spectral information without introducing signal attenuation. The trial activities for the closed phase of the project have demonstrated that the aforesaid limitations make accurate positioning of the prototype at the specimen rather cumbersome. This project aims to address these limitations.

## Method(s)

This project is a continuation of the development of the technical method which investigated the possibility of using an in-situ electrical insulation analyser. The project, with particular application to power transformers, is based on the technical development and demonstration of an in-situ electrical insulation analyser. GnoSys Global Ltd (GnoSys) has previously developed a methodology based on wide-wavelength spectroscopy which has been incorporated into a hand-held tool. It is however currently limited due to inadequate image quality and a lack of in tank manoeuvrability.

During the project, SHE Transmission will work with GnoSys to conduct further development of the intrascope probe system based on the concept of a clinical endoscope construction whilst employing the wide-wavelength spectroscopy methodology. This system will be designed to be much more suited to the end user practical requirements, permitting the in-situ testing of transformers on-site. The system aims to improve the imaging available by utilising a tip mounted camera and the use of "snake arm" technology or motion control to improve overall manoeuvrability of the system.

## Scope

This project seeks to improve upon and overcome the limitations of the phase 1 design to allow for better access, physical range, positional control and visual imaging capability, whilst accepting any improvements that can also be made to spectroscopic measurements. The scope of the project is to have a fully refined, assembled and functional intrascope probe system which has been both mechanically and functionally proven within a laboratory-based environment and via field trials.

This will be achieved by making the following developments to the Intrascope toolkit;
- Implementing alternative articulation methods of the intrascope for improved reach and control
- Selecting an improved visual imaging camera and light source for long range visibility within a transformer
- Redesign of the Intrascope delivery system in conjunction with the improved articulation to ease of deployment

On completion of field trials an inspection procedure will be created to determine the optimal inspection requirements and methods along with an effective way of storing and presenting findings from the inspection. Once the system has been assembled in a laboratory environment and gone through initial functional and mechanical testing, it will be trialled on a range of available transformers. Refinements will also be made to both the hardware and software based on the learning obtained from this test phase.

## Objective(s)

The objectives of the project will aim to provide:

1. An imaging system that:
a) Has a working distance capability from a few centimetres to a couple of metres with controlled field of view and magnification.
b) Allows for the attenuation, scatter, and shading of the oil on at least a semi-automatic basis to yield true colour images.

2. A delivery system that:
a) Can be introduced through a single top entry plate (or valve) and provide access to the bottom of the tie rods.

b) Has an intuitive guidance system that can be used by relatively untrained engineers.
c) Has sufficient flexibility and control to manoeuvre the tip to otherwise inaccessible locations in the tank.

3. An optimal inspection procedure that:
a) Determines and documents the best practices for using the inspection probe.
b) Documents, stores and presents inspection findings in an easily understandable format.

4. A business case that:
a) Demonstrates if the system will have value and relative priority compared to alternative initiatives.

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

n/a

## Success Criteria

The project will be deemed as successful if the items in the methodology are met and the TRL level is increased to TRL 9; or if the project clearly shows that this methodology is not suitable for full scale deployment.

## Project Partners and External Funding

There are no project partners. This project is wholly funded under SHE Transmission's NIA allowance

## Potential for New Learning

The project has potential to provide valuable new learning relating to;

• New more effective methods of condition monitoring and assessment of transformer health by providing a direct access tool.
• Capacity of the intrascope probe system to provide more accurate actionable information about the internal insulation of transformers.
• The systems potential to help extend the life of transformers and hence levels of financial benefits achievable by such condition based asset management.

The learning provided from the project will be disseminated to the other Network Licensees and DNOs through an online learning portal, dissemination workshops and annual conference.

## Scale of Project

This project is designed to get maximum learning for minimal cost and is expected to take this technology through to TRL 9 at which point it is ready for full-scale deployment. The outcomes will be applicable to both the GB transmission network and the distribution network. Any smaller scale project would limit the possibility of conducting a full-scale field deployment of this technology directly after this project.

## Technology Readiness at Start

TRL7 Inactive Commissioning

## Technology Readiness at End

TRL9 Operations

## Geographical Area

This project will be undertaken mainly within SHE transmission area in Scotland and may include other distribution licensees in England if an appropriate opportunity arises.

## Revenue Allowed for the RIIO Settlement

Under RIIO-T1, an overall revenue allowance of £45M has been set to carry out replacement/refurbishment of 16 transformers over 8 years in SHE Transmission. No savings are expected during project implementation, future savings may be possible depending on the outcomes of the project and transfer to BAU.

## Indicative Total NIA Project Expenditure

The total expenditure expected from the project is £700,000. 90% of which is allowable NIA expenditure.

# 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)

An estimated cost saving of using the intrascope compared with having to drain, transport and de-tank a large transformer off-site to assess its internal insulation could potentially save around £200k and upwards per transformer. On average, at least one transformer is de-tanked per year to assess internal insulation. Another significant benefit is the reduced transformer outage time which helps maintain system security. The cost estimate of overheads associated with a transmission asset outage is at least £275k which can be significantly reduced by limiting outage periods.

Using this method, asset replacement can be deferred because there will be a more accurate assessment of remaining life. If DGA results tested by conventional means can be validated by use of the probe, there is potential to use DGA more and the probe/detanking less thereby providing savings through assured use of the cheapest option.

## Please provide a calculation of the expected benefits the Solution

The costs identified below calculate the typical cost saving from each transformer inspection using the intrascope probe compared with the current base case cost;

Base case cost per transformer = £200k
Approx. cost of de-tanking large transformer to assess internal insulation

Method cost per transformer = £15.8k
Approx. cost of assessing internal insulation using intrascope probe system (based on GnoSys cost estimates taken from SGT3 inspection & quote for inspection of A1MTB transformer.)

Estimated cost saving per transformer insulation assessment = Base cased cost - Method cost = £184.2k

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

Providing the demonstration of the intrascope system on the network is successful, the system could potentially be used at most substation locations containing power transformers. In SHE Transmission there are at least 110 grid transformers which were manufactured before 1983 and are currently in service. Such transformers are the ones most likely to have potentially deteriorating insulation. Using this figure as representative of the three major TOs, this method will likely affect at least 300 grid and supergrid transformers in GB.

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

The costs detailed above indicate the cost saving of using the intrascope probe per transformer inspection over the current base case cost. The costs of GB roll out of this method will depend on how frequently other GB network licensees wish to inspect their transformer health and the approach taken to roll out if the project is successful.

SHE Transmission envisage roll out by using GnoSys as a service provider for inspection of transformer health, rather than through purchase of an intrascope probe. If other licensees take a different approach, roll out costs will vary.

### 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

As all the other Network Licensees will encounter the same problem of assessing transformer asset condition, as they own and operate power transformers, the learning generated from the project will directly benefit all Network Licensees. The learning provided by the project will include the operational and functional experience of using a direct entry probe which will be useful to other Network Licensees. The intrascope can potentially provide better and more accurate knowledge of an operational transformer's health and condition.

### 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.

The project is focused around the refinement of an innovative system which has completed an NIA project for phase 1. The project is unique and therefore unproven in and out with GB, so there will be no duplication as a result of the project.

### 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