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NIA Project Registration and PEA Document

Date of Submission

Jan 2014

Project Reference Number

NIA_SHET_0005

Project Registration

Project Title

Transformer Intrascope

Project Reference Number

NIA_SHET_0005

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

April 2013

Project Duration

2 years and 1 month

Nominated Project Contact(s)

SSEN Future Networks Team

Project Budget

£400,000.00

Summary

The initial objective of the project is to have a fully developed, assembled and working intrascope probe system which has been both mechanically and functionally tested within a laboratory-based environment. Once this is complete the intrascope system will be put through field-based testing on a number of spare, non-operational primary and supergrid transformers. This field based testing will provide practical experience in operating the intrascope system and allow for refinements to be made to either software or hardware if required. The system operation will be verified through destructive testing of the internal transformer winding insulation.

Providing this is successful and SHE Transmission is confident in the intrascope system, an investigation of an operational transformer will be planned. SGT3 at Tealing Substation (S/S) has been chosen based on the historical problems associated with it and the age of the asset. The final aim of the project is to investigate SGT3 using the intrascope system to analyse and assess the condition of the internal insulation.

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

SHE Transmission, and the other GB Transmission Network Operators (TOs), have a vast amount of 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 ageing and approaching the latter part of their lives so it is important to be able to monitor their condition and accurately estimate how much longer we can reliably and safely operate them.

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 to assess its remaining life which can then be used for making optimum asset replacement decisions. Presently, the only non-invasive method of assessing insulation condition 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. A valuable
tool would be a probe that we could use in-situ, to directly access and assess the internal winding insulation on site without the need for de-tanking and in doing so, minimise potential outage time. The benefit of having a more accurate assessment of transformer health is the possibility of deferring asset replacement and also a better knowledge of transformer ageing and health which could be used to correlate/verify the DGA results.

Method(s)

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 in practice to de-tanked transformers which severely restricts its application and suitability for on-site transformer testing.

During the project, SHE Transmission will work with GnoSys to conduct further research prior to developing and assembling a new 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. Once the system has been assembled in a laboratory environment and gone through initial functional and mechanical testing, it will be trialed on a number of spare, tanked primary and supergrid transformers. During this stage, the technology will be verified through destructive testing of the internal insulation. Refinements will also be made to both the hardware and software based on the learning obtained from this test phase.

Following the initial primary transformer trial, further trials of the intrascope system on spare supergrid transformers are required. This is needed to better assess the intrascope's suitability for application on one of our operational supergrid transformers and reduce the risk of damage to one of our operational assets by acquiring further operational knowledge and practical experience of using the intrascope system. Overall budget and project duration remain unchanged.

Providing the testing phase of the project is successful, investigation of an operational transformer on the network will be planned and investigated using the intrascope system. This will be an important stage in the operational application of the intrascope and transfer to business as usual. A suitable transformer will be selected based on age and performance history; SGT3 (a transformer at Tealing Substation Dundee) has been provisionally identified.

The project therefore involves the research, development and operational demonstration on the network of the intrascope system.

Scope

The initial objective of the project is to have a fully developed, assembled and working intrascope probe system which has been both mechanically and functionally tested within a laboratory-based environment. Once this is complete the intrascope system will be put through field-based testing on a number of spare, non-operational primary and supergrid transformers. This field based testing will provide practical experience in operating the intrascope system and allow for refinements to be made to either software or hardware if required. The system operation will be verified through destructive testing of the internal transformer winding insulation.

Providing this is successful and SHE Transmission is confident in the intrascope system, an investigation of an operational transformer will be planned. SGT3 at Tealing Substation (S/S) has been chosen based on the historical problems associated with it and the age of the asset. The final aim of the project is to investigate SGT3 using the intrascope system to analyse and assess the condition of the internal insulation.

Objective(s)

The objectives for the project are:

- Conduct research into an intrascope probe system based on the concepts of clinical endoscopy and wide-wavelength spectroscopy which can be used for the in-situ analysis of the condition of power transformers' internal insulation
- Develop a prototype of the system and perform laboratory tests for functional, mechanical and optical performance

- Test and demonstrate the prototype on out-of-service transformers and perform necessary enhancements/refinements for testing on operational transformers
- Test and demonstrate the prototype in the field on an operational transformer on the SHE Transmission network
- Evaluate the method's suitability as a condition monitoring tool for transformers and its impact on asset management

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The three distinct stages of this project are research, development and demonstration. Successful completion of each stage, with sufficient results to inform viability of subsequent stages, will represent success for that stage.

Successful demonstration of the system's suitability or lack of, on an operational transformer will provide enough knowledge about the system and hence indicate overall success of the project.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The project involves a specific piece of new equipment for assessing transformer health and involves research and development followed by testing on an operational transformer. The value and benefit from this probe based system is for the testing of larger supergrid and grid transformers. This is because of their high capital value and importance and also considering the disruption of a failure of a unit or the inconvenience of a lengthy outage from needing to de-tank a unit off-site for inspection purposes. A direct entry probe would provide a quicker and more accurate inspection of a transformer's internal insulation on-site.

The testing phases of the project are essential as the intrascope systems is a new piece of equipment and these are needed to verify the probe's operation and suitability prior to use on the network.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

Research and development, probe assembly and initial testing stages will be carried out at Gynosys' laboratory in Guildford, England.

Once the functional, mechanical and optical testing has been completed within a laboratory environment, field testing will be carried out to demonstrate the system in the SHE Transmission area at Tealing S/S.

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.

Indicative Total NIA Project Expenditure

The total expenditure expected from the project is £400k, 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)

Significant labour and financial costs will be saved by avoiding the need to de-tank a transformer off-site for internal winding inspection. 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)

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 all substation locations containing power transformers. Each transformer inspection will require individual planning but it is envisaged that the intrascope system will be suitable for use on all units. In SHE Transmission there are at least 110 grid transformers which were

manufactured before 1983 and are currently in service. Having been in service for at least 30 years, such transformers are the ones most likely to have potentially deteriorating insulation. Using this figure as representative of the three major TO's, 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.

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):

- [x] 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)
- [x] 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 and other DNOs. 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

- [x] Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

- [x] 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