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

Dec 2013

Project Reference Number

NIA_SHET_0002

Project Registration

Project Title

Prognostics and Health Monitoring of Grid Connected Assets

Project Reference Number

NIA_SHET_0002

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

December 2012

Project Duration

3 years and 7 months

Nominated Project Contact(s)

SSEN Future Networks Team

Project Budget

£158,550.00

Summary

Improving asset management capabilities in line with the Smart Grid principle e.g. more intelligent monitoring of assets' remaining life. PHM is, broadly speaking, the science of analysing the operating and environmental parameters of a system and using those data points to predict the remaining useful life of the system. PHM generally falls into three categories: Data Driven, Physics of Failure and Fusion. Data Driven prognostics uses historical knowledge of the system to build statistical models that can predict system condition and system life. Physics of Failure prognostics uses the underlying physics of an identified failure mechanism to predict the progression of the failure. Fusion prognostics take both of these models and fuse their results to obtain a broader and more accurate measure of failure.

Third Party Collaborators

Energy Technology Partnership

Engineering and Physical Sciences Research Council

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. Much operational plant is ageing and approaching the latter part of its life so it is important to be able to monitor condition and accurately estimate how much longer we can reliably and safely operate the asset.

A useful measure of a transformer's estimated remaining life in service is through the assessment of its internal winding insulation. This is done through oil monitoring since transformers tend to release contaminants generated by degradation of insulation into their

oil as they age. Through manual and periodic sampling of oil from transformers, chemical analysis of the composition of contaminants by tests such as Dissolved Gas Analysis (DGA) can be used to determine the extent to which insulation has deteriorated. That information is vital in helping planners to reach optimum asset replacement decisions. The problem with using this method of monitoring is that it is based on the rate of sampling and also on the quality of samples collected. If deterioration escalates between sampling intervals, it may not be detected until it is too late to intervene. In new transformer installations, this is being mitigated by installation of online DGA equipment on the transformers to provide continuous monitoring.

Commercially available online DGA measurement systems are very expensive and too prohibitive to be adopted grid wide. A less expensive means of online monitoring is therefore essential to provide business justification for a wider roll-out. This project proposes to take advantage of the extensive knowledge of Heriot Watt University's Micro Systems Engineering Centre (MISEC) in microfluidics and novel sensor design to develop a cost-effective online sensing technology for transformers and potentially other assets of a similar nature.

Method(s)

A technical method is proposed in this project and is carried out through a 3.5 year PhD at Heriot Watt University.

The project will commence with literature review of the science of Prognostics and Health Management (PHM) to identify optimal tools for determining asset health and forecasting remaining useful life (RUL). Knowledge from the review will initially be applied in the development of a small scale condition monitoring and prognostics system for predicting the RUL of an electromagnetic relay with a failure history which appears to exhibit a correlation between life expectancy and the applied voltage. Relays are portable and can easily be tested on a bench in the lab. It is anticipated that rigorously testing the conceptual system on this relay will allow most fine-tuning to be performed within the university lab. This stage will also inherently assist the researchers involved to develop deeper knowledge about the stages needed to link up the essential development tools of a functional PHM system.

Subsequently, an online oil condition monitoring and prognostics system prototype will be developed incorporating a dedicated intelligent sensor system with data handling and communication capability. Once tested in the lab and optimised, the prototype will be evaluated by testing on a decommissioned transformer in SHE Transmission's licence area.

Scope

To conduct a research study of the science of PHM, build a small scale system for use on relays and utilise the results to develop a cost-effective online transformer oil condition monitoring and prognostics system prototype for field testing on a decommissioned SHE Transmission grid transformer.

Objective(s)

· Conduct a literature review of PHM, gain understanding of the various tools used and identify optimal tools for use with this project

· Undertake a small initial relay based project using knowledge from the literature review to consolidate project researchers' experience in the concepts of PHM

- · Develop and optimise an online oil condition monitoring and prognostics system prototype

Test the prototype on a decommissioned SHE Transmission grid transformer and evaluate its cost-effectiveness

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success criterion for this project is to deliver sufficient data to enable evaluation of the PHM-based monitoring system's suitability to meet the requirements of TOs and its cost-effectiveness.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project involves development and trial of a new system of assessing transformer health and forecasting RUL and involves research and development followed by tests on a decommissioned grid transformer. Grid transformers have high capital value and their failure in service can have far reaching consequences for system security. The scale of this project is appropriate to perform all necessary activities aimed at providing sufficient confidence in the method's potential to solve the problem of online oil condition monitoring at a lower premium than is currently available.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

Initial research and development work will be undertaken within Heriot Watt University, Edinburgh, Scotland

Testing of the developed PHM system will be done on a decommissioned grid transformer in SHE Transmission's licence area in Scotland.

Revenue Allowed for the RIIO Settlement

A figure of £45 million has been allowed in the RIIO-T1 Settlement for the non-load related replacement/refurbishment of 16 transformers. There is potential to reduce this cost, but any reductions will depend on a successful outcome of the project.

Indicative Total NIA Project Expenditure

Total Project budget - £108,550

IFI - £27,460

NIA - £81,090, 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)

The average cost of replacing each of the 16 transformers scheduled for replacement under RIIO-T1 is £2.81 million.

If replacement of a unit can be delayed due to the development of a novel sensing system indicating there is useful life remaining in the asset then this level of investment could be expected to be deferred by at least one year (worst case) and potentially for many additional years, depending on the type of asset, its age and usage. The expected savings will therefore vary depending on these factors.

Please provide a calculation of the expected benefits the Solution

N/A for Research projects

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

Providing the demonstration of the system on the network is successful, the system could potentially be used at all substation locations containing power transformers. We anticipate this method could be applied to approximately 25% of transformers aged over 30 years.

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

There are in excess of 500 grid substations in GB, most with multiple transformers. Consequently the applicable asset base is estimated to be in excess of 1,000 units. The costs of GB roll out will depend on the final cost of an individual instrument as well as the number of assets the Method is applied to. While this research project will establish feasibility, further development will be required to give a realistic estimate of the cost of an instrument.

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

The learning generated from this project will directly benefit all Network Licensees, including Distribution Network Operators, since all run ageing assets. The system can potentially provide better and more accurate assessment of an operational transformer's health and condition and help system planners make informed asset management decisions.

Should the project be successful other Network Licensees could find the technology of use in assessing other assets on the grid thereby extending the potential financial benefits from the system.

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