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

Aug 2017

Project Reference Number

NIA_NGET0213

Project Registration

Project Title

Condition and Climatic Environment for Power Transformers (ConCEPT)

Project Reference Number

NIA_NGET0213

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2017

Project Duration

3 years and 11 months

Nominated Project Contact(s)

Gordon Wilson

Project Budget

£1,100,000.00

Summary

The ConCEPT project at the University of Southampton builds on completed elements of several projects, namely Resilient Networks (RESNET (NIA_NGET0053) – an IFI/NIA funded project at University of Manchester), FENCE (Facilitating Enhanced Network Capacity Evaluation, NIA funded project with University of Southampton) TeRMiTE (NIA_NGET0165) (Transformer Rating Modelling Tool Enhancements, NIA project with University of Southampton) and Improved Transformer Thermal Monitoring (IFI funded project with Southampton Dielectric Consultants). The aim is to take the findings from several of these projects and make them readily implementable.The specific areas from these projects that should be advanced are shown in the attached detailed project proposal.

Nominated Contact Email Address(es)

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Problem Being Solved

Power transformers are a significant component of the Electricity Transmission System, with over a thousand transformers and related static wound equipment in service today. Transformer capability is defined by its rating and the thermal capacity is exploited to enable overloads to be used for short periods of time. The ability of transformers to perform in this way for its lifetime is assumed but not understood and therefore ‘as new’ capability may be an unreasonable expectation as a transformer nears end of life.

Ambient factors also affect ratings and as the climate changes this may play a part in assumptions about transformer capability. Current assumptions about seasonal ratings should be challenged as the climate changes and expectations for the future need to be understood as more information becomes available.

Monitoring data required to support these issues may present opportunities for identification of defects in cooler system performance and early detection of some faults where individuals in transformer families are not performing as expected.

This project seeks to further understand the following:

- using a monitoring methodology (as proposed in the TERMITE project (NIA_NGET0165), is it possible to measure and quantify the extent to which transformer ageing affects thermal parameters measured in the factory? Can the results from this be used to accurately reflect the rating capability of aged transformers?
- through investigation into likely failure modes and loading guide algorithms is it possible to use already available monitoring data to determine whether winding temperature indicators are performing correctly and diagnose the problem when they are not? Is it possible to identify other cooling system defects if dissolved gas analysis (DGA) data is also included?
- there is evidence from previous studies that Urban Heat Island (UHI) effects may result in higher than expected temperatures at urban substations, what is the magnitude of this effect? Which substations are likely to be most affected? and what is the consequence i.e. should some transformers adopt different seasonal assumptions because of where they are located? What impact would this have on predictive ratings if they were to be replace static ratings?
- using historical weather data and climate change projections, can the current seasonal assumptions be justified? How and when might these need to change? Is there a risk that climate change will have an impact on the rating of National Grid transformers, taking into account variable cooling states?
- if transformers are reclaimed on load, what is the impact on the rating of the process? Is there a requirement to put a temporary rating in place for the duration of the work?
- are there opportunities to reduce the complexity of loading calculations and data requirements by using machine learning to answer any or all of the above questions?

Method(s)

Research
The University of Southampton will conduct a research project investigating the effects of transformer condition and the surrounding climatic environment for power transformer operation directly on behalf of National Grid in the following areas:

- Installation of sensors (WP1)
- Climate issues for transformers (WP2)
- Integration and Modelling of available data to diagnose transformer defects (WP3)
- Condition and operation (WP4)
- Alternative algorithms for predicting thermal response (WP5)

Scope

The ConCEPT project at the University of Southampton builds on completed elements of several projects, namely Resilient Networks (RESNET (NIA_NGET0053) – an IFI/NIA funded project at University of Manchester), FENCE (Facilitating Enhanced Network Capacity Evaluation, NIA funded project with University of Southampton) TeRMiTE (NIA_NGET0165) (Transformer Rating Modelling Tool Enhancements, NIA project with University of Southampton) and Improved Transformer Thermal Monitoring (IFI funded project with Southampton Dielectric Consultants). The aim is to take the findings from several of these projects and make them readily implementable.

The specific areas from these projects that should be advanced are shown in the attached detailed project proposal.

Objective(s)

The overall objectives of this project are:

- to develop understanding of phenomena that could materially affect the operation of transformers in the coming decades
- to explore how greater value that can be extracted from existing data and potentially new sensors to optimise maintenance interventions, and
- ensure that we make the most of the thermal capability of ageing transformers without compromising their reliability.

This project compliments the research that will be undertaken under the NIA funded project Optimised Asset Life and Asset Management of Transformer and Transformer Oil Through Analysis and Modelling.

Specific objectives for each of the work packages in this project are as follows:

WP1 – Installation of sensors on selected transformers to support the other packages of work
WP2 – Investigation of climate issues, this will include investigation of the urban heat island effect and challenge seasonal assumptions of static ratings to ensure transformers are not at risk of optimistic rating enhancements and evaluate the potential accuracy of predictive ratings to mitigate rising temperatures owing to climate change.
WP3 – Leveraging data warehouse resources along with monitoring data to ensure that transformers are operating correctly, specifically using rating software to flag automatically where winding temperature indicators (WTIs) and cooling are not operating

correctly so that condition based maintenance interventions can be planned.
WP4 – Use of thermal monitoring to investigate condition and operation of transformers to identify where condition issues should result in reduced rating assumptions to maintain transformer reliability and investigation of any impacts of on-load oil regeneration on ratings
WP5 – Investigation of alternative algorithms to establish whether machine learning tools could replace detailed thermal models for transformer ratings, the same approach will also be applied to dissolved gas analysis (DGA) from online monitoring and in combination identify divergent behaviour within transformer families for early detection of potential faults.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be successful if the work enables the following:

- proposals for seasonal ambient conditions for static ratings taking into account urban heat islanding
- an evaluation of the likely accuracy of predictive ratings
- an indication of reduction of thermal performance resulting from transformer degradation
- a model for assessing WTI performance and identification of defective instruments
- a review of the application of alternative algorithms for transformer condition based on thermal performance
- a view on the likely effects of climate change on static ratings for transformer until the end of the 21st century.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project is focused on a laboratory scale, but will take into account system issues.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project will be delivered at the University of Southampton.

Transformer monitoring is planned for City Road, St Johns Wood and Fleet substations but this may be subject to change for Operational or Logistical reasons

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£1,100,000

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)

Transformers are a critical part of the electricity network. Improvements in management of existing assets are expected to lead to more efficient day to day operations, improved reliability and/or life extension. The benefits expected from this project are closely related to the benefits expected from the complimentary NIA project Optimised Asset Life and Asset Management of Transformer and Transformer Oil Through Analysis and Modelling (NIA_NGET0214).

Both projects are undertaking research into phenomena that, if successfully understood and mitigation measures identified, could enable National Grid to extend the operational life of some transmission transformers. In practice any future decisions to extend the life of transformers will be made on the basis of information arising from both of these projects, so the potential benefits have been assessed collectively.

An estimated CAPEX expenditure of £11.5 million over the next 17 years could be avoided if these projects are successful.

Please provide a calculation of the expected benefits the Solution

The estimated CAPEX reduction of £11.5 million over the next 17 years is based on the relatively conservative assumption that the reliable operational life of just one transformer a year is extended by 5 years and one transformer replacement can be removed from the RIIO T2 plan every three years.

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

The work form this project will be fully applicable to GB Transmission transformers and would have some relevance to distribution transformers.

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

At the onset of the project is it anticipated that the cost of rolling this method out could be in the region of £5k per transformer. Detailed costing associated with rolling out the method will be investigated and better understood as the project progresses.

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 University of Southampton will disseminate information and new learning generated by the project (as described in the Success Criteria section above) through conferences and publications, and at open forums to which Network Licensee representatives will be specifically invited.

Other Network Licensees will have the option to learn from the research and to integrate any relevant learning in their own asset management of transformers.

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

This project fits within the Managing Assets - Managing assets throughout their lifecycle value area of the Electricity Innovation Strategy.

☑ 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