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NIA Project Registration and PEA Document

Date of Submission

Aug 2015

Project Reference Number

NIA_NGET0165

Project Registration

Project Title

Transformer Rating Modelling Tool Enhancement

Project Reference Number

NIA_NGET0165

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2015

Project Duration

1 year and 9 months

Nominated Project Contact(s)

Gordon Wilson

Project Budget

£500,000.00

Summary

Research and the fundamental re-development of TRALC will form the key deliverable. Testing of the new modelling tool, TRALC3, containing the new algorithms will necessitate the development of a new test case specification as the specification for the current TRALC2 will no longer be applicable. A TRALC3 user guide will form a piece of the new specification:

- Numerical library completed, updated TRALC specification, client application developed
- Model enhancements integrated, test case development for TRALC3 UAT, report on feasibility study for linking condition to capability for transformers, server framework application completed
- TRALC3 deployment and User Guide

Hosting of TRALC3 and software support will be provided throughout the duration of the project to enable implementation and bug fixes. There is potential scope to provide support for software development outside of the initial specification. To ensure compatibility with existing systems within National Grid, TRALC3 will be made ready to integrate with the Strategic Asset Management (SAM) system.

- Key deliverable - bug fixes complete

The upgraded TEFLOW tool will be delivered in a format no longer requiring a dongle for access, with a new graphical user interface and a user guide for calculation of thermal parameters for use within TRALC3.

- Key deliverable - TEFLOW User Guide and deployment

The feasibility study looking at the links between condition and capability will deliver two reports.

1. An interim report examining the key variables that are indicative of loss of thermal performance and the sensitivity of rating to these parameters.
2. A final report outlining the potential for the use of monitoring degradation of the parameters of the indications of ageing pertinent to thermal performance.

Nominated Contact Email Address(es)

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Problem Being Solved

The ability to harness thermal capacity of electrical equipment under emergency conditions is essential for the operation of the Transmission system. This approach enables critical system access for maintenance and construction activity and saves £millions of constraint costs each year.

The enhanced rating modelling tool for transformers, TRALC2 (TRAnsformer Loading Code), was developed nearly 20 years ago. TRALC2, and the models that underpin the tool, is still used on a regular basis to provide enhanced rating advice to GB System Operator for transformers. NGET has identified an opportunity to make significant improvements to the underlying models, which go beyond the capabilities of commercially available transformer rating models. Once thoroughly validated to be able to be implemented into business as usual operations in National Grid, these improvements and the innovation of new models will increase the resilience of the tool to future changes and make it more accessible to other systems as they are produced.

The innovative models that will underpin the new TRALC3 tool will provide a solid base for further developments as they arise – better estimations on thermal distributions and changes in equipment design, changes in the approach to static ratings to confront the issues of rising ambient temperatures owing to climate change and greater availability of monitoring technology and availability of data.

In addition to development of TRALC3, two other innovation pieces of work will be carried out into transformer thermal ratings:

- TEFLOW is a thermal-hydraulic network modelling (THNM) program for transformer windings. It calculates a large range of physical parameters relating to heat transfer and fluid flow and these are saved for later analysis. It is a dynamic modelling program that enables the behaviour of winding temperatures and time constants to be studied under variable load and oil flow conditions. The graphical user interface (GUI) for the existing TEFLOW program has reached its end of life. It is no longer supportable and will not run on 64-bit versions of Microsoft Windows. In addition to updating the graphical user interface a guide will be produced so that TEFLOW can be used relatively easily to produce input parameters for TRALC3 for specific transformer designs, rather than using default parameters from IEC standards. It will also be used to support the thermal modelling work within another NIA project (NIA_NGET0088 - Transformer Consortium Research) by validating the results of the thermal calculations using an alternative technique.
- In conducting enhanced rating calculations for transformers some assessment is carried out as to the potential increase in asset life consumption that may result in an overload situation. However, it is always assumed that every transformer is in an 'as new' condition when determining the overload capability. This may be an unrealistic assumption, especially if transformers are known to have wet solid insulation. A feasibility study is to be carried out in to the relationship between transformer condition and thermal capability with the longer term aim of generating condition factors that may be used in TRALC3.

Method(s)

The ability to maximise utilisation of thermal capacity of assets in emergency situations is an important tool for the system operator in managing the network; this is primarily achieved through the use of static rating schedules for circuits and leads to significant benefits to the customer through the avoidance of constraint costs. Whilst the tool is used by the system operator, the scenario modelling using component models such as TRALC for transformers is necessarily owned, developed and maintained by the asset manager who needs to understand the condition and capability of assets, the risk to the asset of carrying out emergency overloads and the benefits of allowing them to do so. The benefits to the asset manager of agreeing to enhancements include the following:

- Work may go ahead that might otherwise be deferred
- Generator constraint costs can be reduced or eliminated
- Load-related transformer schemes may be deferred
- Demand at risk outages can be assessed and found to be more secure
- The need for changing load flows on the LV network may be reduced

This project aims to maintain and improve National Grid's capability to perform enhanced ratings evaluation of transformers to maximise utilisation of thermal capacity. In migrating the system to a platform which is more resilient to changes of operating systems the opportunity will be taken to update the base algorithms in line with international guidance, improve the usability of the software and increase the number of situations where it can be used.

TRALC3 will be an entirely new product underpinned by a set of innovative new models, developed by Oxford Computer Consultants (OCC) with technical support from Southampton Dielectric Consultants (SDC). The requirements of a revised TRALC have been identified but there will need to be an initial phase of identifying the business requirements in detail. Based on the detailed requirements TRALC3 will build on the learning from earlier work to produce transformer thermal rating algorithms in the Circuit

Thermal Monitor (CTM) module in the Energy Management System (IEMS) to produce a cloud-based “ratings as a service” tool on a secure server.

These improvements will increase the resilience of the tool to future changes in platform and make it more accessible to other systems as they are developed. For example:

- The SAM initiative creates an innovative opportunity to provide transformer ratings as a web service in a platform independent way (“Ratings as a Service”) getting rid of dependencies on platforms and creating one repository of ratings data
- With an update of the existing rating algorithms from IEC 60354 to IEC 60076/7 the model is brought into line with current international best practice.
- The circuit rating tool, CUP2, is also undergoing review and a new TRALC would be able to generate transformer ratings automatically
- Whilst National Grid is not currently looking to develop a dynamic ratings approach, research within the NIA project “RESNET” has identified that this could provide some mitigation of the impact of climate change on ratings. This development would mean that the transformer rating tool was already well positioned for dynamic ratings in the future
- Whilst there is no quantified method for taking into account the effect that deteriorated transformer condition might have on ratings, TRALC3 could be developed such that condition factors could be included once they have been developed
- The proposed solution can act as a design template for ratings of other asset types in the future.

TEFLOW development and transfer to a new platform will be conducted by SDC and the feasibility study into the assessment of the impact of condition on the thermal capability of transformers will be carried out over six-months by a Research Associate at Southampton University.

Project meetings will involve all parties concerned to foster collaboration and innovation between the project partners.

Scope

Research and the fundamental re-development of TRALC will form the key deliverable. Testing of the new modelling tool, TRALC3, containing the new algorithms will necessitate the development of a new test case specification as the specification for the current TRALC2 will no longer be applicable. A TRALC3 user guide will form a piece of the new specification:

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Objective(s)

In keeping with the innovation strategy for enhancing capacity, we have identified the opportunity to significantly improve the existing transformer thermal rating tool through the development of new modeling algorithms, all of which will future proof TRALC as well as improve the overall capability.

Enhancements will be made to associated tools which feed into TRALC; the TEFLOW thermal-hydraulic network modelling program and a feasibility study on linking condition to capability.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The research, development and trial of TRALC3 and the TEFLOW user interface, as well as a set of recommendations identified on the value of linking Condition to Capability to TRALC3. Completion of the scope of deliverables across the three correlated areas of development for this project:

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- TRALC3 deployment and User Guide
- TEFLOW User Guide and deployment
- Completion of bug fixes

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The scope of work has been chosen specifically to balance immediate requirements, the risks associated with delivery of the increasing complexity involved in redesign/development of the TRALC model, and the value and efficiency provided by the development of models situated in the same area (ratings), which require similarly based transformation and will benefit from being developed alongside each other by a specialized, cohesive collection of project partners.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project does not relate to a specific geographic area, the research, development and trials are desk based activities, managed from Warwick, Oxford and Southampton.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Total project cost £500,000

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)

The monetary value of enhanced ratings isn't easily quantified; as the benefits, whilst significant, are realised in avoided costs which the business then passes on to the customer. In order to provide an estimate of savings, two example scenarios to show where benefits have been identified within a given year:

1. A rating enhancement calculation resulting in changes to Winding Temperature Indicators on two sister transformers on the same substation meant that capacity could, in a safe, controlled way, be further increased for a brief period up to the replacement of the transformers. Once the settings were enacted the constraint costs, which had already mounted to approximately £800k over a two week period, were no longer required to continue at a projected rate of a further two months.
2. Series reactors cannot currently be modelled in TRALC2 without careful construction of the thermal model (this constraint will be addressed in TRALC3). A particular enhancement on a new reactor was required urgently during a period of significant reinforcement works to enable a series of weekend construction outages to go ahead. The reactor capability was evaluated using the data from the heat run test and, with appropriate WTI settings implemented, the work was allowed to proceed without incurring penalty costs for delays, which were estimated to start at ~£500k-£1m.

It is anticipated that TRALC3 would, like its predecessor, provide the necessary information to continue to realise avoided costs associated to similar scenarios as the two listed above, with an estimated savings of ~£500k - £2.1m per scenario.

Please provide a calculation of the expected benefits the Solution

Not required – Research project.

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

This solution/method is applicable to asset management and the system operations within National Grid, as well as other network licensees and interest has already been generated by Scottish Power.

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

The cost to outsource the TRALC server for one year is in the region of ~£25k, this cost may be reduced if brought in-house. The enduring costs associated with hosting TRALC3 will be determined by whether the model is hosted on the external server it was developed and trialed upon, or if it is brought in-house. The relative cost of each option will be a factor in the decision but will be borne by the business on an enduring basis. There are already support contract arrangements in place for bespoke ratings models and this

will be extended to cover TRALC3 once it has been implemented.

There are no training costs, nor hardware or software costs associated with this roll-out.

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

n/a

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 seeks to address the Managing Assets value area within the Electricity Transmission 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