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

May 2014

Project Reference Number

NIA_NGET0148

Project Registration

Project Title

Network Reliability Asset Replacement Decision Support Tool

Project Reference Number

NIA_NGET0148

Project Licensee(s)

National Grid Electricity Transmission

Project Start

July 2014

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Phil Haywood

Project Budget

£315,000.00

Summary

This project is intended to produce a DST which enhances existing processes to manage the end of life issues and risks associated with the power transformer population National Grid has responsibility for in England and Wales.

The DST will build on existing value and experience gained by The University of Manchester and National Grid in carrying out work on "Transformers and System Reliability" which specifically looked at a limited section of the network. This work assessed the reliability of the test network based on a Non-sequential Monte Carlo approach.

Nominated Contact Email Address(es)

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Problem Being Solved

National Grid has a licence obligation to maintain a safe, reliable and economic electrical transmission system. The electrical system is made up of high value capital assets: high voltage overhead lines, cables, switchgear and transformers. In order to transmit electricity efficiently it is necessary to increase the voltage, hence lowering the electrical current and reducing corresponding transmission losses. Over 700 Super Grid Transformers (SGT) are employed on National Grid's system to carry out these step-up and step-down voltage transformations. Transformers are utilised on a 24/7 basis and are only taken out of service for necessary maintenance and inspections. They are physically large assets, consisting of copper windings, iron cores, insulation materials and cooling equipment. A typical ex works cost for a transmission transformer can be up to £2.5m and take 10 to 18 months to be manufactured and installed.

Transformers are key assets requiring careful management to ensure their continued reliability and safe working. The National Grid network was originally designed and built in the late 1950s and 60s, with many transformer assets now approaching 50 to 60 years of age. Transformers have a finite asset life: National Grid has carried out research in the field of transformer condition assessment over many years in order to determine condition and predict the likelihood of failure with increasing levels of certainty. Whilst deterioration is

usually slow, it is inevitable and proceeds over a wide range of rates, determined by transformer design, utilisation and asset care. A single transformer failure carries safety, environmental and system reliability risks. Redundancy (multiple transformers feeding a particular load), asset condition and system topology greatly influence customer loss of load probability following a transformer failure. These interdependent factors make the accurate targeting of transformer asset replacement due to condition to achieve a sustainable level of system reliability and optimal capital efficiency a complex problem.

There are some 80 SGT replacements planned over the next 8 years. The resulting transformer replacement expenditure budgets can be up to £40m per year, with a single transformer replacement including transport and installation costing up to £4m per unit. A significant loss of demand incident caused by operating transformer failure would affect National Grid customers to an extent far beyond the value of the electricity not supplied. The alternative option is to replace transformers early; this is inefficient losing financial value for customers and does not necessarily improve reliability. Some transformers can become more critical to the system at certain points in time due to circuit outages for necessary maintenance and construction work. Whilst the system is designed to be resilient for the loss of a subsequent single transformer due to a fault, if there are other transformers in the local area which are sufficiently deteriorated, this first failure could cause cascading failures, which would result in serious widespread issues within the electrical network.

National Grid has already developed a risk and criticality based methodology applied to transformer replacement, however this depends on a relatively simple and generalised method of combining asset health and system criticality to produce a replacement priority. This methodology does not take into account the possible consequences sympathetic failures, the interaction with the wider power network (HV/LV) or the actions of the system operator.

The level of MWhrs lost and the resultant financial impact can only be predicted manually on a localised basis with a limited number of scenarios. ‘What if’ scenarios for the whole network can only be carried out using unconnected power system analysis tools and limited manual statistical modelling and analysis.

In testing the technical challenges of this project, the work will aim to answer, but not be limited to, the following questions:

- Can National Grid’s transformer asset replacement prioritisation be improved?
- Can value and risk be quantified and explained to stakeholders?
- Will this work enable commercially available software to be produced?
- Once the work is complete, who could and should deliver this service?
- How will this work affect other network users, such as Distribution and generation companies?
- What is the impact on the end consumer?
- How would such an approach be implemented?

The answers to these questions will provide an understanding of the viability and value of these techniques in managing an ageing complex power system.

Method(s)

Research

The proposed work will provide an independent method and Decision Support Tool (DST) that directly combines asset condition and system HV/LV topology to identify which clusters of assets contribute the most to potential unreliability. The DST will work within the established system design commercial software used by National Grid. Using this DST on the whole system has the potential to refine replacement candidate selection and replacement timing to enable further value to be obtained from the capital plan.

The DST, carries out network reliability analysis, using

- individual asset reliability estimation (from condition assessment)
- Power system network model, sequenced and non sequenced automatic and operator post fault actions
- Monte Carlo simulation techniques

The DST will then output

- The quantity and financial value of lost load.
- Probabilistic criticality indicators of individual and cascading asset failure

Specifically, the work will aim to meet:

- The technical challenges of accurately predicting the priority order of transformer asset replacement candidates
- The technical challenges of modeling a large interconnected system from an electrical and statistical perspective.

The methodology and DST will then lend itself to the studies of other critical assets such as cables, overhead lines and switchgear.

Scope

This project is intended to produce a DST which enhances existing processes to manage the end of life issues and risks associated with the power transformer population National Grid has responsibility for in England and Wales.

The DST will build on existing value and experience gained by The University of Manchester and National Grid in carrying out work on "Transformers and System Reliability" which specifically looked at a limited section of the network. This work assessed the reliability of the test network based on a Non-sequential Monte Carlo approach.

Objective(s)

1. Upgrade and document the existing reliability assessment software (based on Non-Sequential Monte Carlo approach) for application to the whole National Grid network model in DIgSILENT/Power Factory environment. Test and debug the model and software by collaboration between National Grid and The University of Manchester staff.

2. Provide a prioritised list of transformer replacement candidates (rank transformers based on criticality for system reliability as defined by Energy Not Supplied Index) across the whole National Grid network under a variety of scenarios.

3. Report on results of performed sensitivity studies to give a clear understanding of the required level of detail of network modelling and accuracy of input parameters for power system and asset condition to validate the model outputs and indicate areas where additional data may be required.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success criteria for the project will be;

· Proof that the methodology can be applied to the whole network

· Provision of a new prioritised list of replacement candidates that can be benchmarked against existing methodology to show value of approach

The development of software which is fit for purpose, user friendly, documented and supportable

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project will require a desktop assessment and software development.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

This research will be undertaken in the UK, predominantly in Manchester.

Revenue Allowed for the RIIO Settlement

Zero

Indicative Total NIA Project Expenditure

The total NIA expenditure is expected to be £315,000

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)

Upon successful completion of the methodology and DST in 2018, as well as optimizing replacement expenditure (a potential saving of £3m to £4m or 1 replacement candidate), the project is expected to deliver an enduring benefit in terms of optimized replacement expenditure in future periods. If successful this methodology could be applied to other transmission assets such as HV cables, overhead lines and switchgear.

Please provide a calculation of the expected benefits the Solution

It is anticipated that if this project is successful a minimum saving of 1 replacement transmission transformer can be made. At this point in time it is not possible to estimate which transformer candidate this will be. However using historic transformer replacement ex-works costs as a benchmark the expected savings could be between £3m to £4m

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

Following successful completion of the project the methodology and DST could be used by the 3 transmission companies that make up the British transmission network.

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

The costs of using the DST for companies who already use the prerequisite software would only be those associated with installation and training as the DST would be available without commercial charge.

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

It is envisaged that the DST developed under this project could be transferred without commercial charges to other network licenses using the same commercial software (Power Factory).

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