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NIA Project Registration and PEA Document

Date of Submission

Dec 2013

Project Reference

NIA_NGET0047

Project Registration

Project Title

Dynamic Ratings for improved Operational Performance (DROP)

Project Reference

NIA_NGET0047

Project Licensee(s)

National Grid Electricity Transmission

Project Start

April 2012

Project Duration

4 years and 5 months

Nominated Project Contact(s)

Dan Morrice

Project Budget

£341,000.00

Summary

This issue is to improve on providing a concise cable rating sheet as part of the CUP package which can be readily used by Network Operations. While this approach works well where the level of load to be transferred is known in advance, it provides for only a limited number of rating combinations based on a series of assumptions about the cable system thermal environment. Given the increasing variability of the UK climate, coupled with the trend towards higher generation of electrical energy from renewable sources, this may not always lead to the best utilisation of a cable asset as its true power transfer capability over periods of 24 hours or less may be under-estimated through this traditional approach.

Nominated Contact Email Address(es)

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Problem Being Solved

This issue is to improve on providing a concise cable rating sheet as part of the CUP package which can be readily used by Network Operations. While this approach works well where the level of load to be transferred is known in advance, it provides for only a limited number of rating combinations based on a series of assumptions about the cable system thermal environment. Given the increasing variability of the UK climate, coupled with the trend towards higher generation of electrical energy from renewable sources, this may not always lead to the best utilisation of a cable asset as its true power transfer capability over periods of 24 hours or less may be under-estimated through this traditional approach.

This study will investigate the development of dynamic rating algorithms applicable to a variety of common cable circuits through both numerical modelling, simulation and laboratory based experiments. The proposed work will be carried out within the Tony Davies High Voltage Laboratory at the University of Southampton. Principle targets for this study include:

1. The development and experimental verification of an algorithm for dynamic ratings applicable to buried cable circuits
2. Further development of (1) for application to cables in air, for example troughs and tunnels.
3. The examination of possible integration of tunnel dynamic ratings with ventilation control options under investigation in the CCTV (Control of Cable Tunnel Ventilation) project.
4. Development of a framework detailing the data collection requirements and other pre-requisites for any future deployment of dynamic cable ratings within National Grid.
5. An analysis of the potential benefits of using dynamic ratings, particularly in terms of constraint cost reduction.

   A four phase plan is proposed to investigate the target areas listed above, eventually leading to the derivation of a framework for how dynamic cable ratings could be utilised within National Grid and the associated costs and benefits of doing so.

Method(s)

The method that has been proposed for this project includes; Phases 1 & 2 (Years 1 & 2)

- Initial review of current understanding of the impact of using dynamic
- Interim report on algorithm development for buried cables
- Interim report on algorithm development for cables in air
- Report on the benchmarking of algorithms against laboratory experiments

Phases 3 & 4 (Year 3)

- Interim report on the integration of dynamic ratings algorithms with tunnel ventilation control philosophy
- Report on recommended framework for algorithm input data from the system
- Interim report on the potential for constraint cost reduction through use of dynamic ratings algorithms
- Final recommendations and Report

Scope

A four phase plan is proposed to investigate the target areas listed above,

Phase 1 requires the derivation of suitable algorithms to represent both the cable and the relatively unknown thermal environment. Previous cable ratings projects have examined transient cable models and hence some benchmarks already exist. Modelling of the cable environment is much more complex, involving a large range of parameters, some of which may not be clearly defined. As a result the project would investigate the development of both deterministic and statistical approaches for representing the cable environment, each of which may be more suitable depending on the cable installation. Seasonal conditions and trends would also become important; hence predictive techniques will be developed to account for expected future changes in the thermal behaviour of the cable environment based on recent operational and meteorological history. This is particularly important for cables installed in air, where changes in the ambient conditions have a much shorter time constant than would be the case for buried circuits. The principle installations considered, in increasing order of complexity, would be directly buried, filled and unfilled trough environments. It is considered likely that several different approaches would be developed and tested during phase one, ranging from relatively “conventional” ratings models based on the thermal network models used for static calculations through to more complex numerical tools which have seen success in areas such as partial discharge characterisation. This would allow comparison of the benefits of different modelling techniques, including those developed by other organisations (for instance EPRI). **The work in this phase would be undertaken by a PhD student, with some input from a Research Assistant.**

Phase 2 would advance the study further to apply to forced-ventilation cable tunnel installations. These systems require a slightly different approach as some of the environmental parameters (such as air velocity) are actually controllable. The impact of such control inputs for a benchmark tunnel system, are currently being investigated as part of the CCTV (Control of Cable Tunnel Ventilation) project between the University of Southampton and National Grid. This second phase would investigate the integration of tunnel

ventilation controls to the dynamic rating algorithm to determine how best to respond to planned emergency loading requirements and also how to predict in advance what short term ratings might be available given knowledge of the ventilation operating history and prevailing ambient conditions. **The work in this phase would be undertaken by a PhD student, with some input from a Research Assistant.**

The third phase of the project would examine the deployment requirements of such a system, paying particular attention to the methods available to obtain the input data for the rating algorithm. This would review the type, quantity and, most importantly, quality, of data sources already available on the National Grid network. Using historical data from the system it would be possible to investigate how well the algorithms would perform with realistic system inputs. Where insufficient input data sources are available for a particular application, recommendations would be given for future installations. **The majority of the Phase 3 work would be completed by a Research Assistant.**

Once the algorithms are operational and have been benchmarked against experimental data sources within the Laboratory, the final phase of the project would seek to define the benefits available from such a system based on previous operational circumstances. Circuits which are primarily constrained by cable would be identified and investigations set up within National Grid to determine whether these particular circuits have been linked to constraint costs in the past. Based upon system loadings and the prevailing environmental conditions at the time, the dynamic rating algorithms will be applied to ascertain what level of load could have been realistically supported by the system for the duration of the constraint. This will permit an outline financial analysis to be undertaken within National Grid to discover whether the constraint cost could have been reduced had it been possible to utilise the dynamic rating algorithm at the time. This phase will also involve working with Network Operations to both obtain data, but also to help identify potential target deployments which would offer the greatest operational benefit in terms of constraint relief. **Phase 4 work will be mostly undertaken by the Research Assistant, with small components completed by the PhD student**.

Ultimately, the project will lead to the description of dynamic rating algorithms suitable for application to a wide range of transmission cable circuits, along with analysis of the potential benefits in terms of both cost reduction and increased system flexibility that would be available to National Grid were such a system to be used.

Objective(s)

The objective for this project is to investigate, develop and experimentally validate methods for the calculation of dynamic (real time) cable circuit ratings within the transmission network, to investigate potential deployment scenarios for such methods within the National Grid network and to determine the potential benefits of using such systems as the penetration of intermittent renewable generation grows within the network.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project is successful if we build on the already successful record of work relating to modeling of HV cable systems at the University of Southampton.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project is a laboratory scale.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This project will be delivered in Southampton

Revenue Allowed for the RIIO Settlement

Zero

Indicative Total NIA Project Expenditure

IFI £100,000.

NIA expenditure is £241,000

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)

Cable circuit ratings have been, and continue to be, the subject of active research within National Grid, with a number of important changes to standards having already been identified in previous projects. While this has led to significant advances in the cable rating calculations required for system planning, when it comes to the application of short term ratings it is difficult to ascertain whether the static calculation provides a true picture of the system capability. The future deployment of dynamic rating algorithms as an operational tool will both reduce system risk (through providing a more detailed picture of the actual status of a cable circuit) while potentially allowing higher short-term emergency ratings than the existing calculation methodology. This could offer major financial impacts in terms of reduced generation constraint costs in the future. For example recent cable rating enhancement requests have resulted in cost savings of between £41k to up to £4M based on estimated constraint costs avoided. The ability to apply enhancements dynamically could potentially avoid this level costs routinely. In addition the increased use of renewable generation in the future will require the need for highly flexible operation. Dynamic rating methods will enable flexibility by making best use of favourable ambient conditions.

Through the course of this project, National Grid will gain:

- Understanding of how to develop dynamic ratings algorithms
- Recommended dynamic rating techniques for a variety of installations, with results verified by

experiments.

- A framework for the future implementation of dynamic cable circuit ratings, including an assessment

of the optimum input data provision.

- Quantifiable investigation into the benefits of using such a system operationally, with an indication of

the possible reduction of system constraint costs. The above will bring the following benefits:

- National Grid will be clearly informed of where the use of dynamic ratings techniques on an operational basis could provide a constraint cost saving.

- National Grid will be in possession of a framework for implementing such algorithms on candidate cable circuits.
- The deployment of such algorithms would also assist in identifying cable circuits which have suffered a change in thermal environment.
- The use of dynamic ratings algorithms would reduce the risk to the system from the use of emergency ratings through a more comprehensive understanding of the thermal condition of the cable circuit.

Please provide a calculation of the expected benefits the Solution

Research Project - N/A

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

This can be applied to the whole of the transmission system where Cables are installed or the limiting factor in a circuit.

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

This project will not provide a methodology that can be rolled out GB wide. The learning will feed into other projects.

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 addresses both asset management and system operability, enabling optimized asset management to reduce infrastructure development and smarter system operation.

☑ 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