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_NGET0046

Project Registration

Project Title

Flexible rating options for DC operation

Project Reference Number

NIA_NGET0046

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2012

Project Duration

4 years and 6 months

Nominated Project Contact(s)

Dan Morrice

Project Budget

£290,000.00

Summary

Modelling the complex interactions of thermal and electrical parameters is essential if National Grid is to make a thorough assessment of tenders for HVDC cable schemes. The modelling of transient thermal conditions and the behaviour of the cable insulation under reversals of power flow will provide guidance for the development of dynamic rating algorithms and operational regimes suitable for high power HVDC cable circuits. The thermal and electrical models will be constructed in such a way that the outcomes of planned R&D work on pressure transients and partial discharge ageing can readily be incorporated at a later date.

The models will also be suitable for assessing the effect of fast polarity reversals on the cable system. This will provide guidance on more flexible operation of existing and future HVDC links. In some circumstances the opposite scenario will apply (a cable link where the direction of power flow is rarely if ever reversed). In this case the outcomes of this project could allow restrictions on cable voltage or overload capability to be lifted; again increasing the flexibility of the link.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

The calculation of current ratings for DC cable is significantly more complex than that for AC cable. The rating is often determined by electric stress constraints rather than considerations of thermal ageing. Ratings are also strongly influenced by thermally induced pressure transients within the cable. In some cases the rating of the cable can be restricted by the cable being too cold.

As the normal operating voltage of the cable increases the cable can experience high levels of electric stress while the cable is hot. As the cable cools it is susceptible to electrical failure. Some manufacturers require the converter station to reduce its operating voltage if the current on the link is reduced. The implementation of these current dependent voltage control systems may help protect the cable, but this approach does not align well with the concise cable rating sheet used as part of the CUP package. This introduces an additional level of complexity for Network Operations.

Method(s)

The method that has been proposed for this project includes;

- Initial review of the modelling techniques and materials parameters applicable to HVDC cable ratings
- Interim report on algorithm development for thermal rating of MI cables
- Interim report on algorithm development for steady state modelling of electric in non-linear insulating

materials

- Report on temperature and electric field modelling for rating MI cables

Scope

Modelling the complex interactions of thermal and electrical parameters is essential if National Grid is to make a thorough assessment of tenders for HVDC cable schemes. The modelling of transient thermal conditions and the behaviour of the cable insulation under reversals of power flow will provide guidance for the development of dynamic rating algorithms and operational regimes suitable for high power HVDC cable circuits. The thermal and electrical models will be constructed in such a way that the outcomes of planned R&D work on pressure transients and partial discharge ageing can readily be incorporated at a later date.

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Objective(s)

To develop tools for the rating and technical assessment of high power HVDC cable options. The work will initially concentrate on cables with mass impregnated insulation.

To provide National Grid with techniques to evaluate continuous, transient and dynamic (real time) ratings for DC cable circuits and to evaluate the options and limits for features such as current dependent voltage control.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Development of a tool for rating and technical assessment of high power HVDC cable options.

Project Partners and External Funding

University of Southampton

There is no external funding being brought to this project.

Potential for New Learning

The project will generate more learning as it is investigating the basic understanding of DC cables. This will likely lead to further projects being scoped as a result of this project. All learning will be disseminated through the standard channels - ENA portal, NationalGrid.com/innovation website, and conferences.

Scale of Project

This project focuses on DC systems, but is being completed at a Laboratory scale.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The work will be undertaken in Southampton

Revenue Allowed for the RIIO Settlement

Zero

Indicative Total NIA Project Expenditure

IFI= £104k

NIA= £186k

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)

Without sophisticated time-dependent models it is not possible to carry out a full assessment of tenders for HVDC cable. As converter station and cable control systems become more sophisticated, analysis of the complex interactions between the electrical and thermal ratings are needed to ensure that DC links operate efficiently and reliably.

This research project will allow tenders to be analysed to ensure that cable design is appropriate for the expected burial conditions. This will ensure that capital is invested efficiently and the risk of cable system failure is minimised. The estimated costs of a failure on a major HVDC submarine link are in excess of £15m due to the timescales to affect a cable repair.

Please provide a calculation of the expected benefits the Solution

Currently no base case as this will lead to new knowledge for direct application reducing the risk of an early cable failure (£15m estimated) with this project contributing to managing this risk.

Method cost will be the project costs and then application via a cable engineer, however we do not have details of these costs until the tool is developed.

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

The method will be relevant to all DC cables and is therefore applicable to all Network Licensees planning for DC cables.

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

This learning will be rolled out as part of the project via business best practice and technical know-how.

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 connections with focus on smarter transmission philosophy and facilitating connections due to projected increases in renewable generation.

☑ 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.

Having checked our standard supply base, including Universities, EPRI and the ENA Smart portal, National Grid confirm that this work has not been undertaken before.

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