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_NGET0060

Project Registration

Project Title

Application of DC circuit-breakers in DC Grids

Project Reference Number

NIA_NGET0060

Project Licensee(s)

National Grid Electricity Transmission

Project Start

July 2012

Project Duration

5 years and 5 months

Nominated Project Contact(s)

Paul Coventry

Project Budget

£233,000.00

Summary

The European Union Renewable Energy Directive has committed the Member States to National targets for renewable energy production such that at least 20% of the EU's energy will be produced from renewable sources by 2020. Meanwhile, the creation of an internal market for energy remains one of the EU's priority objectives. The development of an interconnected internal market will facilitate cross-border exchanges in electricity and improve competition. The potential role of HVDC in integrating renewable energy generation and cross-border electricity exchanges is widely recognised and many ideas for dc grids linking the transmission systems of different countries and renewable generation are being promoted.

At present, no dc circuit-breaker is commercially available and any dc fault will affect the entire dc network. A dc grid is, therefore, restricted to a single protection zone at present and the capacity of generation connected to it may not exceed the infrequent infeed loss risk limit prescribed by the Security and Quality of Supply Standard. The dc circuit-breaker is therefore an essential technology in enabling the concept of a dc grid to develop.

Nominated Contact Email Address(es)

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Problem Being Solved

Although the dc circuit-breaker is not yet commercially available, one supplier published developments in the area towards the end of 2011 and it is to be expected that other suppliers will follow. It is therefore timely that the research and development proposed below be initiated in order that the dc circuit-breaker is introduced in a risk-managed way.

In contrast to an ac network, the inductance of a dc network is unable to prevent the voltage collapse that occurs in the event of a fault from propagating rapidly throughout the network. It is imperative; therefore, that the dc circuit-breaker should be able to operate fast enough to block the voltage collapse. As a consequence, the protection philosophies normally applied to an ac network are not applicable to a dc network.

One of the objectives of the proposed work is to identify the requirements of a dc circuit-breaker, including breaking current and fault clearance time. Since dc circuit-breakers will be expensive, dc fault isolation with the aid of ac circuit-breakers and fast dc isolators can be used to minimise the number of dc circuit-breakers in a dc grid. The proposed work will address fault isolation schemes and post-fault restoration of the dc grid. Various types of voltage sourced converters (VSC) will be studied and compared along with dc switchgear in fault analysis and system restoration.

The impacts of dc faults on dc and ac grids will be studied. Fault currents, dc voltages, system restoration time and interruption of power supply are some key quantities to evaluate the performance in ac grids. Grid Code requirements, loss of power transmitted between dc and ac grids, ac frequency and stability will be used to identify the ac system performance due to dc faults and corresponding fault isolation schemes with different dc switchgear.

Method(s)

The method that has been proposed for this project includes;

1. literature review
2. Development of models – (24 months) – this is the key/essential to the research and will therefore is expected to continue over the whole period of research
3. Fault response and post-fault restoration
4. Voltage, current and power characteristics, response times
5. Impacts of dc fault handling on dc and ac grids
6. Verification of fault response scheme and fault handling strategies
7. Experimental verification – (36 months) – a series of experiments will be carried out over a number of months towards the end of the project to verify and confirm expected findings.

Scope

The European Union Renewable Energy Directive has committed the Member States to National targets for renewable energy production such that at least 20% of the EU's energy will be produced from renewable sources by 2020. Meanwhile, the creation of an internal market for energy remains one of the EU's priority objectives. The development of an interconnected internal market will facilitate cross-border exchanges in electricity and improve competition. The potential role of HVDC in integrating renewable energy generation and cross-border electricity exchanges is widely recognised and many ideas for dc grids linking the transmission systems of different countries and renewable generation are being promoted.

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Objective(s)

The objective of the proposed work is to understand the application issues associated with dc circuit-breakers in dc grids. The work will study the impact of dc circuit-breaker operation on the dc system, the HVDC converters and the connected ac systems. In particular, the challenges presented by protection and fault clearance in dc grids will be addressed. The work forms an essential component of the risk-managed introduction of the dc circuit-breaker onto the transmission system in accordance with PS(T)013. The results of the work will inform technical specifications and risk-registers for the dc circuit-breaker and for the protection and control of dc grids.

The project will deliver reports on the results of studies of the system behaviour and the results of experiments performed on a model (low voltage simulation) dc circuit-breaker in the analogue HVDC test facility at Cardiff University. The work complements a closely-related project at the University of Manchester which aims to study the electrical operating environment of the dc circuit-breaker and derive design and test requirements for the device itself.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project is successful if we improve the understanding of the issues associated with application of dc circuit breakers. There is a high likelihood that such studies will allow application issues to be identified, better understood and enable their mitigation to be evaluated. The work will contribute significantly to the specification of requirements for dc circuit breakers and protection for dc grids.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This is a laboratory scale project

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

This work is being delivered in Cardiff.

Revenue Allowed for the RIIO Settlement

Zero

Indicative Total NIA Project Expenditure

IFI £8,000.

NIA expenditure is £225,000

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)

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Please provide a calculation of the expected benefits the Solution

Research Project - Not applicable

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

Any area where a DC link or multi-terminal DC system could be implemented. Assumes the DC breaker can be produced successfully on the correct scale.

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

This understanding can be rolled out with the costs associated with this project. It aims to have a base knowledge for us to build on with experience and further research in the future.

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 the theme of system operability with specific focus on smarter system operation as part of enabling innovative transmission assets through HVDC links in a coordinated way to manage the network challenges posed by generation changes.

☑ 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