Scottish and Southern Energy
Power Distribution

Date of Submission

September 2013

NIA Project Registration and PEA Document

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.

Project Registration

Project Title		Project Reference
DC/DC Converter		NIA_SHET_0009
Project Licensee(s)	**Project Start Date**	**Project Duration**
Scottish Hydro Electric Transmission	Sep 2013	3 Years 6 Months
Nominated Project Contact(s)		**Project Budget**
David MacLeman		£210,000

Problem(s)

"DC/DC converters could be important if HVDC grids with different voltages should be interconnected or if existing point to point HVDC schemes should be connected to an HVDC grid and the voltages do not match."*

As the number of HVDC systems in GB increases (as described in National Grid's 10-year Statement, 2012) there may be opportunities to interconnect HVDC systems. However, current technology does not allow the interconnection of HVDC systems that are at different voltages.

AC transformers are used to connect AC systems of different voltages. However the same technology cannot be applied to High Voltage DC systems (HVDC) to connect DC systems at different voltages.

A DC/DC converter could connect HVDC systems at different voltages, potentially enabling, for example:

- Multi-voltage, Multi-terminal HVDC schemes;
- Where 2 HVDC links terminate in close proximity, they could be connected on the DC side, reducing losses (and potentially the need for a converter station for each link);
- Off-shore renewables directly connecting into a DC link without the need for an on-shore converter station; and
- Multi-voltage DC Grids

*Extract from 'Review of Worldwide Experience of Voltage Source Convertor (VSC) High Voltage Direct Current Technology (HVDC) Installations' Sinclair Knight Merz, March 2013.

Method(s)

The Method is Technical.

This project will investigate the potential of DC/DC converters to provide HVDC voltage stepping, HVDC hubs (connecting 3 HVDC links), power flow control and fault management, and refine the conceptual design for optimal performance.

To achieve this, the project will develop software models of various DC/DC converter configurations, and undertake a range of studies on their operation and performance.

SHE Transmission will collaborate with the University of Aberdeen to complete this project.

The resulting optimised design proposal will be reviewed by SHE Transmission engineers to assess suitability for progression to further laboratory-based development and demonstration.

Scope

The scope of the project comprises:

- Design and develop the software models of high power DC/DC converter
- Study DC/DC converters, DC hubs and their integration with HVDC systems
- Optimise the design of a DC/DC converter.
- Produce conclusions and recommendations on the design of DC/DC converters and their use integrating HVDC systems.

This project is intended to complement our 2013 NIC submission (the MTTE), however neither of the projects are dependant on the other.

Objective(s)

The overall objective of the project is to develop a design for a DC/DC converter which could subsequently (as part of a potential separate project) be developed further into a laboratory demonstration.

More specifically the objectives of the project are to:

- Develop an optimal DC/DC converter suitable for high power applications
- Study the integration of DC/DC Converters and DC hubs with HVDC systems

Success Criteria

The project will be successful, if it produces robust conclusions on the design of a high power DC/DC converter.

Technology Readiness Level at Start	Technology Readiness Level at Completion
2	3

Project Partners and External Funding

Not applicable

Potential for New Learning

This project aims to provide all Transmission Network Owners (TOs & OFTOs) with new knowledge on the potential high-level design of a DC/DC converter, to facilitate the future development of such technology for the benefit of future Transmission customers.

The project will produce 5 reports:

- MMC Converter Design report;
- DC/DC Converter Design report;
- DC hub Design report;
- DC hub integration study report; and
- Concluding Report.

These reports will be shared with the other TOs/OFTOs during the project.

The results of the project are also expected to be shared through standard academic routes (e.g. the publication of academic papers).

Scale of Project

The project was originally conceived at a larger scale, with more hardware development/demonstration. However, given the early TRL level of this technology, it was decided that a smaller scale investment was
appropriate to investigate the technology and develop a design. This provides a break point at which the design's suitability and potential benefits can be assessed, before committing funding to further development or demonstration.
Given the future investment levels anticipated in HVDC technology, this level of funding is considered

appropriate.

Geographical Area

This project will be undertaken within the SHE Transmission area, at the University of Aberdeen's research facilities.

Revenue Allowed for in the RIIO Settlement

This project is an early investigation into a technology that may, in the future, save significant capital expenditure. However at this stage no saving on expenditure can be assumed.

Indicative Total NIA Project Expenditure

The project expects to fund the full project from SHE Transmission's NIA allowance.
The total expenditure is expected to be £210k, 90% of which is allowable NIA expenditure.

Project Eligibility Assessment

Specific Requirements 1

1a. A 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 systems and 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	☐

Specific Requirements 2

2a. Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees ☒

Please answer one of the following:

i) Please explain how the learning that will be generated could be used by relevant Network Licenses.

The learning will assist Network Licensees in the further development of DC/DC converters, DC hubs and HVDC multi-terminal power flow control.

ii) Please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the Project.

SHE Transmission's innovation strategy identifies the challenge of: "Remain at the forefront of innovation to maintain our record of providing the highest standards of service at the lowest possible cost" and within this the need for an "HVDC Control Centre" to be able to integrate HVDC with the AC system. This project supports the future integration of HVDC within the network.

2b. Is the default IPR position being applied?

Yes	☒
No	☐

If no, please answer i, ii, iii before continuing:

i) Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties

ii) Describe any potential constraints or costs caused or resulting from, the imposed IPR arrangements

iii) Justify why the proposed IPR arrangements provide value for money for customers

2c. Has the Potential to Deliver Net Financial Benefits to Customers ☒

i) Please provide an estimate of the saving if the Problem is solved.

This project will help facilitate the development of a DC/DC converter.

A DC/DC converter could connect HVDC systems at different voltages, potentially enabling, for example:

- Multi-voltage, Multi-terminal HVDC schemes; - Where 2 HVDC links terminate in close proximity, they could be connected on the DC side, reducing losses (and potentially the need for a converter station for each link);

- Off-shore renewables directly connecting into a DC link without the need for an on-shore converter station; and

- Multi-voltage DC Grids

With between 20 and 45 new HVDC links are anticipated in GB (based on National Grid's Ten Year Statement, 2012), if successful, and this technology is developed to be commercially available, then it may offer alternative approaches to the integration of HVDC schemes, with the potential for significant cost savings.

Successful development of a commercial DC/DC converter may also offer the potential for fault isolation within multi-terminal HVDC systems, which could improve systems' resilience.

ii) Please provide a calculation of the expected financial benefits of a Development or Demonstration Project (not required for Research Projects). (Base Cost – Method Cost, Against Agreed Baseline).

Not required for Research Projects

iii) Please provide an estimate of how replicable the Method is across GB in terms of the number of sites, the sort of site the Method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.

Between 20 and 45 new HVDC links are anticipated in GB (based on National Grid's Ten Year Statement, 2012), a number of which could benefit from a DC/DC converter. This project is an early investigation into a technology and is at too early a TRL level to estimate the extent to be which it could be effectively deployed.

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

This project is an early investigation into a technology that may, in the future, save significant capital expenditure, and is at too early a TRL level to estimate the roll-out costs.

2d. Does Not Lead to Unnecessary Duplication ☒

i) Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

Based on published IFI and NIA information, discussion with leading UK academia and discussion with National Grid and Scottish Power; there are no known research projects being undertaken by other network licensees to progress the use of high-power modular multilevel converters to develop DC/DC converter design.

ii) If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

Not Applicable