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

Jan 2014

Project Reference Number

NIA_NGET0084

Project Registration

Project Title

Optimisation of Node Configuration In Offshore Supergrids

Project Reference Number

NIA_NGET0084

Project Licensee(s)

National Grid Electricity Transmission

Project Start

June 2011

Project Duration

5 years and 1 month

Nominated Project Contact(s)

Paul Coventry

Project Budget

£106,000.00

Summary

Building an offshore grid in the North Sea has many advantages, the primary one being the increased penetration of renewable energy in Europe which will be essential to meeting its 2020 renewable energy targets. By using a meshed Grid, instead of connecting the wind farms radially, a level of redundancy and flexibility is introduced to the system. Additionally, through international interconnection, conventional power generation (gas, coal, hydro etc) can be distributed between countries using the offshore grid when there is little wind generation. There is also the opportunity to store excess wind generation by connecting to Norway, which has a significant amount of installed hydroelectric generation.

The greater distances from shore mean that much of this grid will be implemented using high voltage direct current (HVDC) technology, rather than the conventional AC transmission. A multi-terminal HVDC (MTDC) system will be required to allow interconnections between different wind farms and onshore locations. Thus the primary technology used will be voltage source converters as it is more suited to MTDC the conventional HVDC (Line commutated converters).

Nodes will be an important element of this offshore grid, as they will be used to join the paths of the grid together and control the distribution of power. They will also enable cables of different voltage levels to be interconnected, and could allow competing converter types to be connected together.

However the main constraint of how this grid will be implemented will be its cost. Thus, there will be an economic trade-off between the level of redundancy and flexibility in the system of the system with the cost of not having it. This research intends to investigate the use of DC nodes in the proposed offshore grid. Alternative node topologies, and the technology used to build them, will be assessed based on reliability, capital and running costs, and fault capability.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

A new European Supergrid layered over existing transmission systems offers the opportunity to exploit the resource and load diversity on a continental scale, which, when supplemented with demand action or storage, can provide an optimal route to maintaining a balanced system with a high penetration of renewable energy. Much of this new layer will be offshore, cable based and operated with DC. Almost any network configuration could be built but investment costs are huge and optimisation is essential. This is a balance between flexibility and reliability on one hand, and capital and running costs on the other. The process of joining 'routes' together to form the supergrid is assumed to be straightforwards, but at the detail level it is not. Interfacing DC routes of different system voltages requires almost as much equipment as linking via an AC node. Nodes may well be large areas not points, because they must join large area windfarms (such as 10 x 1GW arrays in Dogger Bank) and nodes may be heavily symmetric (Dogger Bank with, say, 10GW connections to GB; 2GW connection to Hornsea and 1GW connection to Norway). Decisions between competing structures will depend on detailed issues such as platform size and losses (running costs) of DC/DC versus AC/DC converters and the value placed on security of connection to wind versus hydro. This project uses case studies to explore the issues of what will drive the topology and technology of interconnection of Supergrid routes, and examine the evolutionary paths that could bring us to a near optimal format.

Method(s)

Research

- A comprehensive literature review will be completed, based on the following topics:
  - Modelling a high power DC/DC converter using MATLAB, further developed into a bi-directional DC/DC converter
  - Examine the H-Network simulink model of the multi-terminal set-up. Based on this model, a similar model with different voltage levels will be connected using the aforementioned DC/DC converter model.
  - Building on this model is the next stage, creating a multi-terminal system that has different voltage levels and incorporate the DC/DC converter in the node, acting like a transformer.

Scope

Building an offshore grid in the North Sea has many advantages, the primary one being the increased penetration of renewable energy in Europe which will be essential to meeting its 2020 renewable energy targets. By using a meshed Grid, instead of connecting the wind farms radially, a level of redundancy and flexibility is introduced to the system. Additionally, through international interconnection, conventional power generation (gas, coal, hydro etc) can be distributed between countries using the offshore grid when there is little wind generation. There is also the opportunity to store excess wind generation by connecting to Norway, which has a significant amount of installed hydroelectric generation.

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Objective(s)

The objective of this project is to better understand the considerations that are to be taken when considering further infrastructure with regard to offshore DC connections.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be successful on receipt of the deliverables - these will be in the form of interim reports.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project is focussed on a laboratory scale.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This project will deliver in London.

Revenue Allowed for the RIIO Settlement

Zero

Indicative Total NIA Project Expenditure

NGET NIA project expenditure is £106,000

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)

The concept of a North Sea grid has been highlighted as a priority by the European Commission in its Energy Infrastructure Package. The benefits would be the facilitation of sustainable low-carbon energy supplies and a competitive energy market, securing cost-efficient and secure energy for consumers.

Furthermore, National Grid has studied the benefits of an integrated onshore - offshore transmission network solution compared to an equivalent 'uncoordinated' radial offshore transmission system and identified potential savings in capital investment of around 25%, in addition to reduced environmental impact and planning issues, maximised deliverability and future proofing of the network.

By exploring the possible technologies and topologies for offshore supergrids and the associated performance and costs, the proposed work will identify optimum solutions. Given the scale and cost of the investments required, savings of millions of pounds could be achieved by the early identification of optimum solutions. The work will also contribute to the development of National Grid's technical 'know-how' in a rapidly developing area.

Please provide a calculation of the expected benefits the Solution

Research project - not required.

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

This would affect all of the onshore Transmission system through the System operation of the Tranmission assets, and the effect the offshore Transmission systems would have on the onshore transmission assets. Furthermore, future offshore infrastructure projects will need to be guided and informed in order to deliver the most appropriate overall solution.

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

This work will be rolled out as part of the project in the know how of the technical leaders.

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 following areas of the innovation strategy:

Reliability : Optimising Asset Management

Environment : The environment and reducing emissions

Environment : Enhanced Capacity

Connections : System Access

Connections : Smarter Transmission Philosophy

Connections : Facilitating Connections

Customer Satisfaction / Commercial : Regulatory Framework Changes

Strategic : Long Term Research

System Operability : Smarter System Operation

System Operability : Ancillary Services and Energy Storage

☑ 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