nationalgridESO

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

Jun 2016

Project Reference

NIA_NGET0187

Project Registration

Project Title

Transient Voltage Stability of Inverter Dominated Grids and Options to Improve Stability

Project Reference

NIA_NGET0187

Project Licensee(s)

National Grid Electricity System Operator

Project Start

June 2016

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Yun Li / Richard Ierna

Project Budget

£424,000.00

Summary

The work would be carried out in 2 phases and would comprise the following scope.

Phase 1 (End-October 2016 Completion):

1. Create a PSCAD model of the GB grid suitable for demonstrating inverter-induced instability phenomena. This would be based on an existing National Grid reduced equivalent model. The model will include a full representation of the network of the 400kV network on the South coast between Lovedean and Kemsley substations with the representation being simplified in areas further away from the Lovedean-to-Kemsely zone.

2. Run a series of study cases looking at realistic future GB operating conditions and generation/demand backgrounds to build a picture of likely voltage transient instability. Explore the use of synchronous compensation as a counter-measure to voltage instability. Provide a report describing the risk of inverter induced instability phenomena and limits for the operation of non-synchronous generation (NSG).

3. Carry out an analysis to benchmark the costs of maintaining voltage stability through the use of synchronous machines and the curtailment of inverter connected generation.

Phase 2 (End-June 2017 Completion):

1. Demonstrate a novel inverter control approach (“Advanced Converter Control”), with the demonstration focused on the South Coast area. Outline the potential wider GB benefits of this approach.

2. Provide a plan with recommendations on how the approach can be fully developed and implemented.

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

With increasing levels of inverter connected generation connected to the to the GB transmission system, there is evidence to suggest that the system will become susceptible to transient voltage instability in the event of system disturbances. Parts of the world with high levels of inverter-fed generation and few synchronous machines operating have already experienced equipment trips and damage to transmission equipment, and studies have shown a risk of widespread very fast transient voltage instability (<60ms) in such systems. At present, this risk is not understood for the GB system and mitigation options have not been identified.

Method(s)

With National Grid's support, a consortium including Transmission Excellence Ltd, HVDC Technologies and Power Technologies Ltd will carry out a programme of work to:

1) Demonstrate the extent to which fast transient voltage instability is likely to be a problem on the GB system in scenarios with high levels of inverter-connected generation and few synchronous machines in service. This analysis will use an Electromagnetic Transient (EMT) simulation tool, which uses very short time steps and so can capture features such as phase imbalance and waveform distortion which are important when grid systems are heavily dependent on inverter fed generation. The very rapid nature of the phenomena being investigated mean that traditional stability assessment tools (based on RMS values) are not suitable.

2) Develop and model an approach to improve stability and increase the levels of non-synchronous generation that can operate through an "Advanced Converter Control" approach.

The work will be carried out in 2 phases over a 13 month period. EMT modelling will be undertaken using PSCAD, the industry-standard package for the modelling of HVDC and other large power inverters.

Scope

The work would be carried out in 2 phases and would comprise the following scope.

Phase 1 (End-October 2016 Completion):

1. Create a PSCAD model of the GB grid suitable for demonstrating inverter-induced instability phenomena. This would be based on an existing National Grid reduced equivalent model. The model will include a full representation of the network of the 400kV network on the South coast between Lovedean and Kemsley substations with the representation being simplified in areas further away from the Lovedean-to-Kemsely zone.
2. Run a series of study cases looking at realistic future GB operating conditions and generation/demand backgrounds to build a picture of likely voltage transient instability. Explore the use of synchronous compensation as a counter-measure to voltage instability. Provide a report describing the risk of inverter induced instability phenomena and limits for the operation of non-synchronous generation (NSG).
3. Carry out an analysis to benchmark the costs of maintaining voltage stability through the use of synchronous machines and the curtailment of inverter connected generation.

Phase 2 (End-June 2017 Completion):

1. Demonstrate a novel inverter control approach ("Advanced Converter Control"), with the demonstration focused on the South Coast area. Outline the potential wider GB benefits of this approach.
2. Provide a plan with recommendations on how the approach can be fully developed and implemented.

Objective(s)

- Create a PSCAD model of the equivalent GB transmission network.
- Demonstrate whether fast transient voltage instability is a significant concern for the GB system given likely future generation backgrounds.
- Identify at what levels of non-synchronous generation (NSG), fast transient instability would occur.

- Assess the likely costs of stability restrictions based on conventional approaches using synchronous generation and synchronous compensation to maintain stability.
- Identify whether the proposed Advanced Converter Control solution can improve system stability.
- Provide a programme of work to further develop, test and implement the proposed approach.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be successful if we :

1. Create a functioning PSCAD model for the GB network that can be used for transient stability analysis.
2. Determine whether the GB system is likely to be at risk to voltage instability with high levels of NSG.
3. Identify the levels of NSG at which the GB network is likely to be susceptible to instability problems and the likely cost impacts of these restrictions if new mitigation approaches cannot be developed.
4. Confirm whether the Advanced Converter Control approach could be an effective mitigation strategy.
5. Identify how the improved control approach can be developed and implemented.

Project Partners and External Funding

The consortium is made up of Transmission Excellence, HVDC Technologies and Power Technologies. The work will be supported by National Grid. The work will be fully funded via the NIA.

Potential for New Learning

- The work will provide clarity on whether increasing levels of inverter connected generation introduce transient voltage instability risks for the GB system.
- The work will provide insight into the levels of NSG that can be connected to the GB system without mitigation.
- The work will indicate the potential economic costs associated with conventional solutions.
- The work will determine whether the “Advanced Converter Control” approach can be part of the solution to the risk identified

Scale of Project

The project encompasses detailed technical and economic assessments carried out by Transmission Excellence, HVDC Technologies and Power Technologies over 13 months with National Grid support.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

GB system with more detailed modelling of South Coast transmission elements.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The forecast NGET NIA expenditure for the this project is £424,000

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)

If transient voltage instability is a consequence of increased levels of inverter-fed sources, then it is likely that synchronous generation will be increasingly constrained in service and inverter-fed sources will be curtailed going forward. Alternatively, large volumes of synchronous generation may be installed. Given current generation background forecasts (eg Gone Green), the total costs of conventional mitigation measures could amount to several £bn by the mid 2020's.
If a converter control strategy can be implemented to mitigate transient voltage instability, some element of these costs could be avoided.

Please provide a calculation of the expected benefits the Solution

This is a fundamental research project for which it is currently not possible to provide cost benefit estimate based on the base minus method cost approach.

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

AC/DC Power converters are connected to the systems of all GB transmission and distribution systems. Thus improved converter control systems could potentially be deployed on equipment connected to all GB transmission and distribution systems.

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

Ways to roll out the Advanced Converter Control approach will be examined as part of this project and this will inform the assessment of the potential costs of roll out.

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)

The System Operability Framework identifies that National Grid faces a specific challenge in operating “a power system island with a significant volume of non-synchronous generation”, and this in turn leads to many technical issues which need to be managed. This project addresses one of these issues within the wider challenge of operating a grid with a significant volume of non-synchronous generation.

This work is included in the SO priority innovation theme of operating the system with high levels of non-synchronous 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.

There are no other projects underway that are exploring fast transient instability concerns and mitigation measures.

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