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

Aug 2017

Project Reference Number

NIA_NGSO0003

Project Registration

Project Title

Assessing the stability of small-scale inverter connected PV generation

Project Reference Number

NIA_NGSO0003

Project Licensee(s)

National Grid Electricity System Operator

Project Start

August 2017

Project Duration

0 years and 9 months

Nominated Project Contact(s)

Xiaoyao Zhou

Project Budget

£90,000.00

Summary

This innovation project is intended to extensively assess the stability of small scale inverter based PV generation. It is aimed at articulating PV inverter performance during system disturbances and its output will, among others, inform the “Frequency changes during large system disturbances” GC0079 Workgroup.

Nominated Contact Email Address(es)

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Problem Being Solved

Distributed generation plays an important part in balancing system demand. Studies have shown that Loss of Mains protection i.e. Rate of Change of Frequency (RoCoF) and Vector shift on these generators is unstable and too sensitive to faults on the GB transmission system. Under GC0035, protection settings for distributed generators greater than 5MW have been changed. The GC0079 Workgroup is currently exploring options which may lead to changes to protection settings and techniques for distributed generators of less than 5MW. The aim is to ensure that they are able to withstand secured events on the transmission system.

Photovoltaic (PV) generation constitutes the majority of distributed generators below 5MW. Estimates show that at least 4.2GW of PV capacity was installed as at the end 2015 under this category. While protection settings are likely to change under GC0079, this will not be effective as the performance of PV inverters is still unknown. It is possible for these inverters to fail to ride through transmission faults and thus still lead to loss of this category of distributed generation which may require intervention from the System Operator.

There is a need to independently assess the performance of these inverters during system disturbances and to quantify the risk, if any, to enable the System Operator to take the appropriate mitigation measures. All the current innovation projects have investigated the overall transmission and distribution system equipment, generators, protection relays and their performances but none has yet explored PV inverter performance.

Method(s)

It is proposed to test seven most commonly used PV inverters (single and three phases) of different capacities up to 10kVA. The key objective of this work is to assess inverter connection stability under the two main influencing factors, namely, voltage dips and voltage vector shift. The project will be done in a laboratory environment and the test network prepared to simulate real system conditions.

A systematic hardware testing of the most commonly used inverters on PV installations will be carried out. This will characterise PV inverter resilience to various voltage excursions as well as voltage vector shift conditions.

Scope

This innovation project is intended to extensively assess the stability of small scale inverter based PV generation. It is aimed at articulating PV inverter performance during system disturbances and its output will, among others, inform the "Frequency changes during large system disturbances" GC0079 Workgroup.

Objective(s)

1. To assess inverter connection stability under the two main influencing factors, namely, voltage dips and voltage vector shift.
2. A report will be produced at the end of the project. This report will be published on the ENA Smarter Networks portal and also on the National Grid Website in the GC0079 Grid Code Workgroup Section. This report is important and will enable, among others, the GC0079 Workgroup to make informed recommendations to industry and Ofgem.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

1. Obtain a clear understanding of the inverter technology on PV installations which will then drive the technical requirements for future installations and influence the decision on existing installations.
2. Be in a position to assess the performance of these inverters during system disturbances and to quantify the risk, if any, to enable the System Operator to take the appropriate mitigation measures.

Project Partners and External Funding

This project involves collaboration with the University of Strathclyde's Power Network Demonstration Centre which offers the required expertise, equipment and laboratory facilities ready to perform the testing proposed during this project in a timely manner.

There is no external funding for this project.

Potential for New Learning

This report to be produced as a result of this project will be published on the ENA Smarter Networks portal and on the National Grid Website in the GC0079 Grid Code Workgroup Section. This report will enable, among others, the GC0079 Workgroup to make informed recommendations to industry and Ofgem.

The GC0079 Workgroup is a joint Distribution Code and Grid Code workgroup comprising of National Grid and representatives from Industry including DNOs. The aim of the workgroup among others is to ascertain, through research and industry consultation as in this case, the suitability of vector shift protection on distributed generators. From this research a recommendation will be made whether to retrofit, ban or for manufactures of inverters to make appropriate changes to ensure smooth operation of the electricity grid.

Scale of Project

This project will involve the Electricity Policy and Performance team from National Grid who has representatives part of the GC0079 Workgroup. The outcomes from the project are likely to also benefit other teams and stakeholders involved in setting the Electricity Network Strategy.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

GB network.

Revenue Allowed for the RIIO Settlement

None.

Indicative Total NIA Project Expenditure

NIA: £90,000

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 results from this project are expected to deliver savings in the range of £2.86m - £5.14m per year during the period 2019/20 to 2026/27.

Please provide a calculation of the expected benefits the Solution

The cost of managing vector shift post 2020 for all types of embedded generation is estimated to be in the in the range of £149M-£241M from the GC0079 Working Group figures.

From the 2016 Future Energy Scenarios data, PV is estimated to contribute about 40% output of total distributed generation. About 30% of this solar PV output is from solar PV with inverters that would be under investigation in this project. This category covers mostly small domestic installations.

Based on the analysis of all FES scenarios and the above assumptions, if appropriate PV behaviours cannot be established then it will not be possible to avoid at approximately £20M - £36M in Balancing Service costs from year 2019/20 to 2026/27. These figures reflect the potential benefits from this project through realising avoided costs.

Assuming a flat distribution of savings over the period, this equates to £2.86m - £5.14m per year, though in reality this is likely to be weighted more heavily towards the end of the period as solar PV deployment continues.

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

The outputs of this project will be used directly by the GC0079 Workgroup.

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

No additional costs.

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

The results and report to be produced from this project will be published on the ENA Smarter Networks portal and on the National Grid Website in the GC0079 Grid Code Workgroup Section. This report will enable, among others, the GC0079 Workgroup to make informed recommendations to industry and Ofgem.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

As per the 2016 Future Energy Scenarios (FES) document published by National Grid, the growth of PV has had an impact on the overall system demand, particularly during sunny days, and this in turn has an effect on the nature of investment required to operate an efficient, economic and well-coordinated GB system.

A clear understanding of the inverter technology on PV installations will drive the technical requirements for future installations and influence the decision on existing installations. At the moment, no independent tests have been done to understand the performance of these inverters. Without this, it is hard for the System Operator (SO) to predict the behaviour of such a growing source of embedded generation. A conservative approach by the SO, in the absence of any information, will be to factor this risk into the Balancing and Services cost.

This innovation project will provide an approach which is better informed through an assessment of the performance of these inverters during system disturbances and to quantify the risk, if any, to enable the System Operator to take the appropriate mitigation measures.

☑ 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.

No unnecessary duplication will occur as a result of this project. There are no known innovation projects investigating the particular

problem identified which this project seeks to resolve.

This project is complementary to other innovation projects that have been running under the Ofgem NIA scheme, namely Vector Shift Initial Performance Assessment (NIA_NGET0205) and Assessment of Distributed Generation Behaviour during Frequency Disturbances (NIA_NGET0142).

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