Date of Submission

July 2016

Network Innovation Allowance Closedown Report

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

Project Closedown

Project Title	Project Reference
Assessment of Distributed Generation Behaviour during Frequency Disturbances	NIA_NGET0142

Project Licensee(s)	Project Start Date	Project Duration
National Grid Electricity Transmission	Apr 2014	10 Months

Nominated Project Contact(s)

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Scope

The work will provide a comprehensive view of distributed generation types and susceptibility to RoCoF for the entire GB synchronous network. The feasibility and implications of using revised protection settings to avoid coincident distributed generation losses during loss of infeed events will be established.

Objective(s)

The key objectives are to reduce operational costs and to enable increased system access for asynchronous generation types including renewable generation (wind, solar).

If measures are not taken to ensure distributed generation is less susceptible to RoCoF events, then increased operating costs are likely to result through the curtailment of large infeed risks or the operation of synchronous generation in favour of asynchronous generation to manage RoCoF risks. Potential increases in system operating costs by 2018/19 are forecast to be £250m per annum, rising to in excess of £1000m per annum by 2025.

Success Criteria

1) The provision of a comprehensive GB wide model (by DNO) for distributed generation installations of <5MW including the generation and loss of mains protection types.

2) A risk assessment that will enable decisions to be made on changes to protection settings on existing generation and what protections and settings should be used for further distributed generation.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

NGET ("NG") has endeavoured to prepare the published report ("Report") in respect of Assessment of DG behaviour during frequency disturbances as system inertia reduces NIA_NGET0142 ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NG and its Project partners ("Publishers"). Any intellectual property rights or confidential information developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NG and the Project partners). This Report contains confidential information owned by the Publishers such information should not be

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Project Overview

System inertia is reducing with increasing levels of asynchronously connected generation (including wind and solar). Industry agreed generation background scenarios indicate that this trend will continue as more renewables are connected. With reduced system inertia, higher rate of change of frequency (RoCoF) will occur on GB networks for unplanned events caused by large losses of infeed (e.g. loss of a large generating unit or an interconnector bipole) Without intervention, the higher RoCof will trip distributed generation where loss of mains protection is provided through RoCoF type protections.

Research

This work provides a clearer understanding of smaller (<5MW) distributed generation installations, how these would behave in the event of system disturbances and the techniques that can be applied to protect the distribution network and generators from damage in an islanding event. This will enable more efficient and reliable operation of the GB system both at transmission and distribution level. The work is supported by National Grid as National Electricity Transmission System Operator and the GB Distribution Network Owners (DNO's).

No comprehensive information existed for generation types and loss of mains protections for distributed generation installations of <5MW. The first stage of this work created a GB view (by DNO area) for such distributed generation. This utilised existing information sources including DNO data, DECC data, Supplier data etc. Putting in place this information enabled an appropriately representative model of system behaviour for events impacting system frequency (eg loss of infeed). Without intervention, lower levels of system inertia will result in higher RoCoF for secured infeed losses and coincident tripping of distributed generation. The second part of this work will evaluate the feasibility of using higher RoCof protection settings for distributed generation on DNO networks. This will involved the detailed modelling of distributed generator behaviour during events that gave rise to high RoCoF and islanding.

Project Plan

University of Strathclyde and Ecofys were appointed to undertake research in the following areas:

1. Identifying distributed generation of <5MW
2. Evaluating the risks of changing protection settings at installations where RoCoF is being used

Project Activities

The Project has delivered against its Aims. Conclusions and recommendations have been delivered in reports capturing the performance of and the risk of making protection setting changes to approximately 5GW of distributed generation capacity. Project timescales were extended by 12 months to allow further research and testing intended to fill gaps in the available information revealed in the initial research, and to capture generation capacity data up to the end of 2015. Both of these additional pieces of work have been captured in separate new reports. The four reports have been published on the Smart Networks portal.

Required Modifications to the Planned Approach During the Course of the Project

Changes to scope and approach

There have been no changes to approach or scope of this project.

Additional Work and Equipment

There were two areas of additional work identified during the project.

Review of the available literature supplemented by dialogue with manufacturers did not provide the information required to build the

models needed to assess distributed generation's performance in an island situation. The missing information was how their equipment would respond to a change in frequency in general and specifically how their chosen method of Loss of Mains detection affected how the equipment would respond to a change in frequency In the case of small scale inverter based photovoltaic systems, the information available was not sufficient to either support the required modelling, or to draw necessary general conclusions, to meet the project objectives. Additional domestic scale invertors were therefore purchased and further tests specified to get the necessary understanding of invertor behaviour.

The risk outcomes for changing protection settings are proportional to generator capacity. The rate of distributed generation growth during the period of the research meant there was a risk that conclusions were significantly out of date before they could be acted upon. An additional report was therefore requested from Ecofys to provide an update to the numbers, capacities and types of PV units. The report was able to quantify PV capacity growth in terms of output capacity and site numbers. It highlighted that the installed PV capacity at sites of less than 5MW at the end of 2015 was 4.2GW (compared to 2.6GW as captured in the original analysis up to the end of 2013). It also highlighted that the Feed in Tariff (FIT) register no longer captured all PV installations and that any further research in using PV capacity data would need to consider using additional sources.

Changes to Cost

Changes to cost arose due to the additional work and equipment described in the Additional Work and Equipnent section above.

Additional domestic scale invertors were purchased for testing to at a cost of £8.4k and an update on Solar PV data was requested at a total cost of £28k.

Changes to Programme

Project timescales were extended by 12 months to allow the additional work described above to be completed.

Lessons Learnt for Future Projects

The most significant lesson learnt during this project was that it was not possible to evaluate the behaviour of small scale invertors that would be used to connected PV systems using available information and dialogue with manufacturers. It became necessary to purchase and test the relevant equipment on a test network. Future projects which rely on dynamic models of invertors and other non-synchronous equipment should consider whether they need to allow for equipment tests in their programme.

A second lesson learnt was that the rate at which Solar PV generation was being installed meant there was a risk that research conclusions could be invalidated. In this case it was possible to deal with the risk with a simple update because conclusions were scalable which may not be the case for other projects.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

The project is now closed. Four reports have been provided.

The first of these has been provided by Ecofys and gives a general description and quantification of distributed generation performance with respect to Rate of Change of Frequency and is accompanied by a dataset of distributed generation at stations of a capacity of less than 5MW. Please see the document ECOFYS – Disitributed Generation Operation in an Islanded Network – Final Report.

The second report provided by the University of Strathclyde contains a risk assessment of changes to RoCoF based protection on generators at stations of a capacity of less than 5MW and an assessment of distributed generation behaviour under island conditions. The report's conclusions are presented in the form of the probability of harm arising from islanding, for different combinations of islanded generation, if new protection settings are applied. Please see the document University of Strathclyde – Asssesment of Risks Resulting from the Adjustment of RoCoF Based Loss of Mains Protection Settings Phase II.

This second report is supplemented by a report on the equipment tests required to evaluate invertor behaviour. The five inverters under test, chosen as they represented >80% of installed capacity, were able to successfully detect the islanding conditions and trip in less than a second from island initiation. The inverters were also stable to rate of change of frequency events of 1Hz/s and grid voltage vector shift of 5.5°, although one of the inverters reduced its active power output momentarily during these events. Due to the black box nature of these tests, the cause of these changes is unknown but is most likely due to the controls of the inverters. Please see the document Universtity of Strathclyde Power Networks Demonstration Centre – Experimental Evaluation of PV Inverter Performance during Islanding and Frequency Disturbance Conditions.

The fourth report is a brief update from Ecofys on the growth of Solar PV capacity relative to its original work, which showed a growth from 2.6GW to 4.2GW from the end of 2013 to 2015 in PV capacity at sites of less than 5MW. Please see the report ECOFYS Distributed Generation Operation in an Islanded Network (Update) Final Report.

The reports have been published on the Smart Networks portal and on the National Grid website at:

http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0035-GC0079/

The project has delivered the required outputs and will be used to inform the development of new requirements for Loss of Mains Protection Settings for distributed generators.

There is a risk that industry agreement cannot be reached on how best to make use of the assessment of changes to RoCoF based protection settings meaning that the initially estimated savings cannot be realised. However, even if savings cannot be realised, the industry has access to improved information on the risks of islanding and can use this to inform next steps and future developments in the management of islanding risks for distributed generation.

Planned Implementation

The conclusions of the research will be used to inform the approach taken by the industry in determining requirements for Loss of Mains protection at stations of capacity <5MW. New requirements will be implemented through a modification to the Distribution Code which is subject to normal industry process.

The settings are specified in DPC7.4.3.4 of the Distribution Code which can be found here:

http://www.dcode.org.uk/the-gb-distribution-code/

Other Comments

The work will be used to inform the development of new requirements for Loss of Mains Protection Settings for the small generators connected to the distribution networks in Great Britain, and may be of benefit to organisations outside Great Britain responsible for or affected by islanding protection on distributed generation (transmission companies, distribution companies and generators for example). It has been used to help scope similar assessments in Ireland where a programme Rate of Change of Frequency (RoCoF) related requirement setting and implementation is underway.