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

Nov 2023

Project Reference Number

NPG_NIA_046

Project Registration

Project Title

BESS P28

Project Reference Number

NPG_NIA_046

Project Licensee(s)

Northern Powergrid

Project Start

November 2023

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Francs.Shiliitoe@northernpowergrid.com

Project Budget

£220,000.00

Summary

As more Battery Energy Storage Systems (BESS) are being connected to distribution networks it is becoming apparent that there are weaknesses in the current approaches to assessing the voltage fluctuations they cause. The project will assess EREC P28 Issue 2 and recommend methodologies and approaches for assessing voltage fluctuations caused by BESS taking into account the commercial services BESS provide.

Nominated Contact Email Address(es)

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Problem Being Solved

Northern Powergrid (NPg) is starting to connect BESS, generally sized between 10 and 100MW, to its EHV network (or connected at the HV busbars of a EHV/HV substations). Here we consider EHV to be 132kV, 66kV and 33kV and HV to be 20kV, 11kV and 6.6kV. These are typically designed to be able to enter into frequency response services with the Electricity System Operator (ESO) where fast changes in active power output or input are required. The same BESS can also be used to provide other services such as commercial energy arbitrage. During the initial connection assessment NPg uses simple and conservative step voltage calculations to determine the maximum active power swing that a BESS should be limited to in order to be compliant with EREC P28. EREC P28 prescribes the voltage fluctuation planning limits that customers must adhere to. BESS developers sometimes carry out their own EREC P28 studies which are usually delivered close to the date of first energization of the project. These studies often challenge the maximum active power swings determined by NPg during the initial connection assessment. Reactive power also has a significant effect on system voltages and consequently voltage fluctuations. Changes in reactive power can either worsen or improve voltage fluctuations associated with the changes in active power swings depending upon how the BESS control system is configured. Reactive power considerations are not mentioned in EREC P28. GB DNOs have different policies for considering active and reactive power operating modes and setpoints of BESS control schemes. Developers may wish to operate their BESS to manage reactive power in order to maximise the permissible active power swing and ramp changes whilst ensuring voltage fluctuations are minimised and within the requirements of EREC P28. There is a need to establish i) a common method applied by DNOs and developers for

calculating voltage fluctuations to ensure compliance with EREC P28 and ii) a set of solutions acceptable to the BESS developer and the DNO to manage voltage fluctuations and determine an appropriate operating regime and control system for the active and reactive power input and output of a BESS.

BESS are becoming a significant tool for the ESO to use to manage system frequency as the electricity generation portfolio moves to low carbon generation. This is an opportune moment to study how BESS operation effects system voltage, how the functions of BESS control systems can be utilised to minimize voltage fluctuations, and to consider whether EREC P28 together with DNO policies and procedures associated with assessing EREC P28 compliance of the connection of BESS need updating.

Method(s)

Methods used to deliver the project include:

· Developing representative EHV network models in DIgSILENT PowerFactory to include demand, generation and BESS schemes;

· Carrying out steady-steady and dynamic studies to understand voltage fluctuations;

· Liaising with BESS developer(s) and manufacturer(s) to understand BESS operation and control methods in order to properly model active power and reactive power flows;

· Liaising with the ESO and BESS developer(s) and operator(s) to understand BESS commercial operation;

· Liaising with transformer AVC supplier(s) to understand the operation of AVC schemes associated with NPg and NGET transformers in order to properly model their behaviour and the potential interaction with BESS control methods; and

· Publishing study reports and presenting the project findings to NPg staff and at relevant ENA working group(s).

Scope

The project's scope is to:

· Study the effect of BESS connections on the EHV system, and connections to EHV/HV substations;

· Critically assess EREC P28 requirements and current DNO policies and procedures;

· Recommend methodologies and approaches for assessing voltage fluctuations of BESS taking into account the commercial services BESS currently and in the future may provide;

· Examine available BESS reactive power control modes and setpoints and the effect of reactive power on voltage fluctuations and operation of the distribution system; and

· Recommend BESS reactive power control modes and setpoint evaluation that could be used to manage voltage fluctuations in accordance with the requirements of EREC P28.

To achieve this scope, the project will:

· Develop representative power system models at EHV (including EHV/HV substations) that incorporate multiple BESS systems, as well as other sources of generation and demand;

· Study the effect off BESS current and future operation on voltage fluctuations with due consideration for co-incident behaviour of multiple BESS connected to the same distribution system;

· Consider the operation of BESS current and future operating in fixed power factor, fixed reactive power output and voltage control modes; and any other control modes that emerge as being viable;

· Consider the effect of BESS control modes on existing generation and demand customers e.g. stability issues;

· Consider the effect of BESS operation providing frequency response services e.g. Dynamic Containment, Dynamic Modulation and Dynamic Regulation, operation in the balancing mechanism and providing arbitrage in the wholesale market. This will include examining BESS ramp rates;

· Consider the effect of BESS control modes on NPg systems in particular on transformer AVC schemes (both legacy and new) and the effect on NGET transformers at Grid Supply Points, including examining the effects on circulating currents;

· Consider the effect of future fault level reductions and changes to X/R ratios;

· Provide a methodology for NPg to carry out realistic simplified assessments of voltage fluctuations associated with BESS connections at the connection design stage;

· Provide a methodology for detailed EREC P28 assessments of BESS to be carried out post-acceptance. These should be capable of being carried out by the DNO or the developer (or their consultants), and the results should be able to be critically reviewed by the other party. The methodology will be suitable for presenting to the DCRP EREC P28 workgroup for consideration in future revisions of EREC P28;

· Consider recommendations for sharing generator and/or BESS technical details between parties where co-incident effects between different systems need to be assessed. Ways of sharing this information without compromising confidentiality need to be examined and recommendations proposed;

· Review NPg's and other DNOs' policies and practices (as informed by the DER Technical Forum BESS Group and/or the DCRP EREC P28 working group). Compare these with the assessment methodologies in EREC P28 e.g. in the application of shape factors that could be applied to ramp changes;

· Provide feedback to the DCRP EREC P28 workgroup and DER Technical Forum BESS Group as required relating to EREC P28 issues identified and solutions considered; and

· Provide material that can be disseminated to NPg staff and included in updates to NPg policies and procedures as required.

Objective(s)

The project's primary objectives are to:

· Develop simplified and advance methodologies for assessing the effects of BESS connections and operation on voltage fluctuations on distribution systems operating at EHV or connected at the HV busbars of EHV/HV substations;

· Examine optimal active and reactive power control modes and setpoints of BESS taking into account voltage fluctuations associated with BESS operation and the operation of the distribution network;

· Provide material that can be disseminated to NPg staff and included in updates to NPg policies and procedures, as required, to facilitate the assessment of voltage fluctuations from BESS connections taking into account active and reactive power flows that are expected to be seen from commercial service operations;

· Consider BESS active and reactive power control modes and set points; and

· Feedback to the DCRP EREC P28 workgroup on the project findings.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

sirio impact assessment: highly positive.

See attachment.

Success Criteria

The project will be considered successful if these criteria are met:

· A critical assessment is made of EREC P28;

· Methodologies and approaches for assessing voltage fluctuations of BESS are developed;

· The effects of applying different reactive power control modes and set points are assessed;

· The methodologies and approaches are modelled and analysed on a test network;

· Material is provided that can be used to update NPg policies and procedures to assess voltage fluctuations caused by BESS; and

· Project findings back to the DCRP EREC P28 working group.

Project Partners and External Funding

N/A

Potential for New Learning

The project will develop new methodologies for assessing voltage fluctuations caused by BESS connections taking into account realistic operation of BESS commercial services and allowing the full potential of BESS active and reactive power control schemes to be realised.

Scale of Project

Desktop research. No field triqals or asset installation.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project is applicable to both NPg's Northeast and Yorkshire licence areas. A representative power system model of the Ferrybridge GSP network in Yorkshire will be developed. Findings are apoplicable to all other distribution networks.

Revenue Allowed for the RIIO Settlement

None.

Indicative Total NIA Project Expenditure

£220, 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:

The project supports the safe and secure connection of increased volumes of second/third party battery energy storage systems.

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)

N/A

Please provide a calculation of the expected benefits the Solution

Nety benefits are the increased ability of networks to accommodate BESS systems. The precise chnage in volumes cannot be easily calculated and the savings associated with these tend to be commercially sensitive as they are not direct benefits to the network.

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

Methodology is applicable to the whole fo the GB network.

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

Roll out costs are trivial.

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 material developed by the project will allow DNOs to update their policies and procedures for assessing the connection of BESS to their networks.

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

N/A

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.

A search of existing projects has shown no unnecessary duplication will take place in the course of this project, to the best of our knowledge, but learning will be taken from all related research activities both within the UK and in the wider industry.

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

The project is innovative because it will set out to develop new methodologies for assessing voltage fluctuations caused by the operation of BESS. It has not been tried before as the connection of large BESS onto the network is recent. In the case of NPg's network the first BESS larger than 10MW was connected in 2020.

Relevant Foreground IPR

All foreground IP will be embodied in published reports. No background IP is required to support this.

Data Access Details

No new data-sets will be produced by this project.

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

No funding is allocated within BAU activities for this type of work which requires the use of specialised external consultants. The technology and economic case remain unclear and there is no clear and obvious mechanism for recovery of the expended costs with

in the proce copntrol period.

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

No funding is allocated within BAU activities for this type of work which requires the use of specialised external consultants. The technology and economic case remain unclear and there is no clear and obvious mechanism for recovery of the expended costs with in the proce copntrol period.

This project has been approved by a senior member of staff

- [x] Yes