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

Mar 2017

### Project Reference Number

NIA_UKPN0022

## Project Registration

### Project Title

Global Earthing Systems (GES)

### Project Reference Number

NIA_UKPN0022

### Project Licensee(s)

UK Power Networks

### Project Start

March 2017

### Project Duration

2 years and 1 month

### Nominated Project Contact(s)

Stephen Tucker & Maxi Faridi

### Project Budget

£483,000.00

### Summary

The project will research the behaviour of 11kV networks under fault conditions to understand the earth fault current return paths as well as exploring the effect of nearby urban/suburban networks on safety (step and touch) voltages and the concept of the 'global earthing system'.

Accurate knowledge of the network, earth fault current flows and whether a global earthing system applies will be used to optimise the earthing design process. The output will ensure that earthing systems are designed to ensure safety, whilst allowing more efficient use of copper electrodes at secondary distribution substations. It is anticipated this will result in a cost saving (both materials and installation cost) for each new/upgraded substation going forward.

The project output will also better inform the wider industry, allowing DNOs to optimise their designs to avoid such problems. The findings may ultimately be used to inform future updates of industry standards including ENA TS 41-24 and ENA EREC S34.

The project will be validated by applying the revised secondary substation earthing design approach developed by the project to a sample of existing projects in recent year(s) that were designed using the UK Power Networks' existing earthing design approach. The assessment between two approaches will determine the difference on the amount of copper electrodes required.

### Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

### Problem Being Solved

Dense urban cable networks, by their very nature, create difficulties for earthing measurements. Given that earthing design relates directly to the safety of DNO staff and members of the public, it is important to have detailed and accurate measurements to confirm a) that a substation is safe and b) satisfies the requirement established by third party services and utilities with regards to earthing e.g. their metallic fences.

In addition to the measurement difficulties, there is also a fundamental lack of understanding in the way that earth fault current flows within an HV interconnected cable network which is also termed a ‘global earthing system’. Theoretical benefits of such a system (earth resistance contribution and limitation of safety voltages) are often overlooked, or cannot be fully realised during the design of secondary (11kV) substations earthing systems due to lack of data.

Currently, a number of assumptions are made during the earthing design of secondary substations, which err on the side of caution. Consequently, earthing systems may be ‘overdesigned’, i.e. they are more comprehensive than they need be.

This leads to inefficiencies both at the design and installation stage, which potentially leads to more copper being installed and excavations being larger than necessary. This lack of knowledge and understanding about the earthing systems in the network may also lead to incorrect assumptions and inadequate designs. In some rare circumstances, earthing designs may be produced which are not adequate to ensure safety (i.e. may increase the likelihood of injury to staff or member of the public to unacceptable levels). A good understanding of network behaviour is necessary to demonstrate compliance with The Electricity Safety, Quality and Continuity (ESQC) regulation and other relevant regulations.

## Method(s)

The project will carry out following activities:

- Literature review to identify previous research work on global earthing systems.
- Measurements within different types of urban/suburban networks to obtain a better understanding of earth fault current flows and the overall performance of a global earthing system.
- Trialling of novel measurement methods to better de-couple the local system (under test) from the overall earthing system, and to explore contributions from parallel paths (e.g. sheath current flows via normally open points).
- Network modelling to validate the measurements and to develop an approach that can be used in every day earthing design.

## Scope

The project will research the behaviour of 11kV networks under fault conditions to understand the earth fault current return paths as well as exploring the effect of nearby urban/suburban networks on safety (step and touch) voltages and the concept of the ‘global earthing system’.

Accurate knowledge of the network, earth fault current flows and whether a global earthing system applies will be used to optimise the earthing design process. The output will ensure that earthing systems are designed to ensure safety, whilst allowing more efficient use of copper electrodes at secondary distribution substations. It is anticipated this will result in a cost saving (both materials and installation cost) for each new/upgraded substation going forward.

The project output will also better inform the wider industry, allowing DNOs to optimise their designs to avoid such problems. The findings may ultimately be used to inform future updates of industry standards including ENA TS 41-24 and ENA EREC S34.

The project will be validated by applying the revised secondary substation earthing design approach developed by the project to a sample of existing projects in recent year(s) that were designed using the UK Power Networks’ existing earthing design approach. The assessment between two approaches will determine the difference on the amount of copper electrodes required.

## Objective(s)

The aims of the project are:

- Improve the knowledge of current flows and the earthing contribution from a nearby or surrounding network in terms of a global earthing system.
- Identify the tangible benefits and application of global earthing systems including the potential to reduce (or optimise) the cost of substation earthing.
- Trial various methods to ‘decouple’ the local substation earthing system from the overall combined network earthing system.
- Develop a revised methodology and/or set of parameters to update UK Power Networks’ substation earthing design tool and earthing design standards.
- Produce an interactive training package on how to use the revised process.
- Publish a paper on the work undertaken to inform others and (via ENA or other forums) share amongst GB DNOs

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

## Success Criteria

The project will be deemed successful if:

- The learning outcomes defined in “Objectives” are achieved.
- It can be shown that less earthing is required at distribution substations, when comparing the new substation earthing design tool with existing methods on a sample of sites.

## Project Partners and External Funding

n/a

## Potential for New Learning

n/a

## Scale of Project

The project includes measurements on the urban/suburban networks in the UK Power Networks’ area.

Measurements will take place at approximately 20 sites (spread across primary, grid and secondary substations), and will include a mix of new and existing techniques to establish earth resistance and current ‘splits’. The touch voltage (i.e. the voltage to which an individual may be exposed under fault conditions) will also be measured (as a percentage of the earth potential rise EPR) at 10 or more of these sites. It is felt this is the minimum number of sites which will be statistically significant and provide a useful representation of typical urban or suburban substations.

## Technology Readiness at Start

TRL3 Proof of Concept

## Technology Readiness at End

TRL8 Active Commissioning

## Geographical Area

All measurement work will be carried out within the UK Power Networks’ licence areas. Research and modelling work will be carried out at Edif ERA offices in the UK.

## Revenue Allowed for the RIIO Settlement

None.

## Indicative Total NIA Project Expenditure

£483,000

# 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 savings associated with the solution are from the better designing of earthing within substations and optimise asset investment. It is estimated the typical saving per secondary substation could be £300. During 2015/16 regulatory year, more than 800 new secondary substations were installed across UK Power Networks. Using an assumption that 75% of these substations can see the potential saving, this equates to £180,000 per annum. Similar savings will also apply to refurbished and upgraded secondary substations but the actual value of how much savings can be achieved is difficult to determine due to the variable nature of the work involved.

## Please provide a calculation of the expected benefits the Solution

**Base Cost: £1.16m**

Based on the capex expenditure for new substation Earthing design. This is the NPV value of base cost for 800 new secondary substations per year over ED1 period. The 800 is the approximate volume for 2015/16, which in the calculation has been assumed to be similar for the remainder of the ED1 period.

**Method Cost: £0.60m**

Benefits will arrive from better planning and efficient use of earthing rods within substations. It is assumed 75% of the substations currently designed for earthing will benefit from efficient designing and fewer rods. The method cost is the reduced cost that will be required by other network licensee if they want to deploy the tool after technology has been developed in this project. This is the NPV value over ED1 period calculated from the CBA document.

**Financial Benefits: £0.56m**

Financial benefits deriving from the formula provided in the CBA document

Base Cost - (Method Cost - Benefits)

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

The principles and methodologies developed from the project by doing real measurements can be applied to the earthing design in any DNO, however current earthing practices vary between DNOs and therefore it may not be fully applicable to all DNOs.

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

It is difficult to quantify this as each DNO has a different existing practice for earthing design. The knowledge and learning developed as part of the project would be useful for other DNOs as the knowledge on global earthing is very limited. The tools developed could be adopted by other DNOs at minimum cost but there would be additional costs associated with training and integration with IT systems.

### 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

If the project is successful, the knowledge and learning developed on earthing systems as part of the project can be used by other network licensees to improve their approach to substation earthing design. The methodology used to update the existing earthing design tool could also be adopted by other network licensees to develop similar earthing tools.

### 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

☑ 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