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## NIA Project Registration and PEA Document

### Date of Submission

Sep 2017

### Project Reference Number

NIA\_UKPN0027

## Project Registration

### Project Title

LoadShare

### Project Reference Number

NIA\_UKPN0027

### Project Licensee(s)

UK Power Networks

### Project Start

September 2017

### Project Duration

2 years and 5 months

### Nominated Project Contact(s)

Maxi Faridi

### Project Budget

£2,418,081.00

## Summary

The pre-requisite work of raising the temperature of the circuit to run at 70 degrees will be required before installing Power Guardian and PowerLine Guardian devices which is outside the scope of this project. This will be done as part of business as usual activity and will increase the capacity of only the PJ route. Unfortunately the impedance variation will simply attract the same overload condition on the PJ in the coming years, thus the need to trial innovative solutions to balance power flows in 132kV overhead line networks.

### The scope of this project is as follows:

- Detailed curtailment studies to confirm the actual reactance required on PJ route of Bramford GSP to Lawford Grid substations;
- Add approximately 1.8 ohms (to be confirmed following detailed studies) onto PJ route of Bramford to Lawford 132kV Grid substation. This will include:
  - Install PowerLine Guardian units on PJ route;
  - Install Power Guardian units onto PJ route at Lawford Grid substation. This includes carrying out civils and foundation works at Lawford Grid substation to support the equipment;
- Commissioning of the modular power flow control solution and integration of the units within UK Power Networks' control system;
- Testing of the control modes for the SmartWire solution to balance impedance on the circuit;
- Unlock additional capacity on PJ route by adding SmartWire solutions in combination; and
- Publish a paper on the work undertaken to share the knowledge with GB DNOs (via ENA or other forums).

### Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

## Problem Being Solved

The connection of increased Distributed Generation is paramount as we move towards a low carbon economy. There has been a significant increase in renewable generation connections and applications at distribution level in Great Britain. However, this brings a number of emerging challenges for distribution network operators including system reliability and circuit overloading which could lead

towards renewable curtailment and delays in new connections. This could slow down the transition to a low carbon economy.

Traditional solutions to add additional network capacity include increasing operating temperature with infringement clearance works, re-conducting existing lines or building new circuits. These approaches incur significant cost, can take longer time to complete as they require substantial network outages and have significant stakeholder impact.

However, a number of cases have been identified where there is spare capacity available on the existing network. This capacity can be difficult to release and make available to the market and new connecting parties under existing network configuration.

UK Power Networks have identified Lawford Grid, a 132kV meshed network within the Eastern Power Network area, where such system capacity issues and network constraints exist. A circuit known as "PJ route" between 132kV Bramford GSP and Lawford grid substation is expected to exceed its current rating due to the number of distributed generation connected in this area, with the PJ and PEC route imbalanced power flow between these two grids. The conventional approach includes re-conducting the existing circuit at significant cost and requires lengthy outages to complete which will pose an overload condition on the parallel PEC circuits, this route also includes significant landowner challenges for this solution.

## Method(s)

This project will design and deploy new business processes and power electronic technology to equalise the impedance between the two substations to balance the power flow, resulting in unlocking capacity available on the existing network without the need of re-conducting. The project will aim to do this faster than conventional approaches and to develop a project strategy that can be scaled across the country.

Smart network solutions will be adopted for this project which includes the use of modular power flow control using SmartWire's two newly developed innovative technology devices called Powerline Guardians and Power Guardians. These devices in combination will be deployed to the 132kV distribution network on the PJ route between Bramford GSP to Lawford Grid substations. PowerLine Guardian is designed to be clamped onto the overhead conductors without the need to acquire any land or do any civil works. Power Guardian is a ground mounted device which can be installed within the substation and controlled remotely on how much impedance to be added to the circuit and does not require civil works.

Early studies show approximately 1.8 ohms of reactance is required to balance the impedance on the circuit which can be achieved by installing the innovative technologies in combination which can optimise the power flow on the grid in real time, balancing the impedance and is expected to release approximately 19 MW of additional capacity without reinforcement. The two newly developed SmartWire devices have the ability to control power flow in modular fashion using the technology which has not been proven on a GB distribution network before.

In order to balance the impedance of circuits and maximise the utilisation of circuits between Lawford Grid and Bramford GSP substations, a pre-requisite is to increase the running temperature of PJ route to 70 degrees (This work will not attract innovation funding). This will be done as part of business as usual activity. Following this work, a NIA funded trial of two innovative technologies PowerLine Guardian and Power Guardian will be trialled in combination on the PJ route.

The combination of these technologies has not been previously utilised in Great Britain before. By adding the ability to balance flows on parallel paths, UK Power Networks can leverage the additional physical capacity delivered by balancing the power flow across the group of three 132kV Overhead lines between Bramford and Lawford grid. Without the ability to balance the networks, transfer capacity remains constrained by the most overloaded element even if there is spare capacity available on parallel paths.

## Scope

The pre-requisite work of raising the temperature of the circuit to run at 70 degrees will be required before installing Power Guardian and PowerLine Guardian devices which is outside the scope of this project. This will be done as part of business as usual activity and will increase the capacity of only the PJ route. Unfortunately the impedance variation will simply attract the same overload condition on the PJ in the coming years, thus the need to trial innovative solutions to balance power flows in 132kV overhead line networks.

### **The scope of this project is as follows:**

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- Commissioning of the modular power flow control solution and integration of the units within UK Power Networks' control system;
- Testing of the control modes for the SmartWire solution to balance impedance on the circuit;
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- Publish a paper on the work undertaken to share the knowledge with GB DNOs (via ENA or other forums).

## Objective(s)

### The aims of the project are:

- Resolve existing system constraints between Bramford GSP and Lawford Grid substations;
- Utilise the underutilised circuits by controlling power flows and avoid the need for reinforcement;
- Create network capacity for new generation or demand customers through more efficient utilisation of existing assets;
- Trial various communication and control modes for the SmartWire solutions. This will include the observation of benefits of being able to dynamically control the power flow on the circuits with little or no control centre action;
- Increase ability for UK Power Networks to address system constraints quickly and meet short term network needs;
- Increase the infrastructure planners' toolbox of deployable smart solutions before traditional methods are deployed; and
- Publish a paper on the work undertaken to share the knowledge generated from the use of Power Guardian and PowerLine Guardian devices on the network (via ENA or other forum).

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

n/a

## Success Criteria

### The project will be deemed successful if:

- SmartWire technology PowerLine Guardian and Power Guardian trialled on the PJ route;
- SmartWire solutions demonstrate ability to control power flows on the circuits between Bramford GSP to Lawford Grid as required; and
- Documentation on installation and operation of SmartWire's Modular Power Flow Control solutions is completed and shared with other DNOs within Great Britain.

## Project Partners and External Funding

**SmartWire** – External Technology Provider – No external funding provided

## Potential for New Learning

The new learning developed as part of the project will be shared with the wider industry within Great Britain. This is a technical project requiring expert assessment of different concepts. A successful outcome will yield a solution that will benefit DNOs.

Learning that will be shared with other DNOs is expected to include improved knowledge of resolving network constraints in a manner that requires a reduced build solution. The trial of two innovative devices in combination, PowerLine Guardian and Power Guardian, to address network constraints and unlock additional capacity on overhead lines. A project report including device installation procedures, integration with control system and project trial to release network capacity.

Further learnings will include the ability to balance line reactance to avoid imbalance in currents (phase balancing) and gather active current and temperature measurements from the circuits in question.

Update May 2019:

The design of the overall project has been successfully completed and approved. During the design phase, the total number of PowerLine Guardian and Power Guardian units required to achieve the impedance specified by the project has been identified. A combination of 15 Power Guardian units and 54 PowerLine Guardian units have been manufactured in the US by the supplier Smart Wires and were shipped to the UK ready for installation. A detailed communication design on how the devices will communicate and

interact with UK Power Networks' SCADA system has been approved.

Circuit outages were secured to carry out the installation of the units in October 2018. However, the outages on 132kV circuits became unavailable due to a high priority operational work agreed with National Grid and it was no longer possible to release the circuit for installation at that time of the year.

Due to the above unexpected delay, it was not possible to complete the installations in October 2018 as originally planned. Therefore, it was required to reschedule the installation phase to the next available outage season in 2019, resulting in an extension of the project timescale by 8months.

The units are now planned to be installed on the network in June 2019 followed by commissioning. The project is expected to finish in December 2019.

## Scale of Project

The project will involve the deployment of modular power flow control units connected to the overhead-line conductor in the first spans out of Lawford Grid substation on PJ route and also the deployment of modular power flow control on ground-mounted structures within the substation footprint at Lawford Grid.

The control units will be deployed to integrate these devices with UK Power Networks' control system.

## Technology Readiness at Start

TRL4 Bench Scale Research

## Technology Readiness at End

TRL8 Active Commissioning

## Geographical Area

Lawford and Bramford Grid sites on Eastern Power Networks plc's network

## Revenue Allowed for the RIIO Settlement

£816k (2016/17 prices) was allocated in the ED1 settlement for work to be done on PJ route between Bramford GSP to Lawford 132kV circuit, this funding was to increase the temperature of the PJ route to create additional capacity. This is not claimed under NIA as the funding will still be required to carry out the pre-requisite work needed for the whole solution to work by raising the temperature of PJ line before installing two innovative devices.

Traditional Reinforcement would entail structural modifications to the PJ route and re-conductoring. The route crosses the A12 motorway, environmentally sensitive areas and railway lines and feasibility work in DPCR5 concluded this was not financially feasible as the cost was in excess of £10m to re-conductor and replace towers in position.

## Indicative Total NIA Project Expenditure

£2,418,081

## 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 avoided reinforcement and not re-conductoring and tower replacements on the entire PJ route to accommodate the existing load on the circuit, which is a conventional solution. The innovative trial will potentially allow UK Power Networks to utilise the existing assets by dynamically controlling the flow of power to unlock the existing capacity. Using the conventional method of solving the challenge of overloading the circuit would have cost £2.7m for only re-conductoring the PJ route. If the innovative solution is successful, the benefits would be of approximately £1.31m at the scale of this project as noted in the Ofgem CBA. This is based on the assumption that the cost of the project is not included and the benefits are achieved from dynamically controlling the flow of power utilising the best use of existing assets.

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

**Base Cost: £2.72m:** This is the NPV value of the base cost calculated. It comprises of the cost of re-conducting the whole PJ route using the conventional approach.

**Method Cost: £1.40m:** This is the NPV value of the method cost calculated. It comprises of the total cost if the same project is replicated at the same scale and includes the cost of purchasing the devices and maintenance but not the cost of developing and proving the technology. This does not include the cost of proving the technology after which the price of device is expected to drop down.

**Benefits: £1.31m:** This is the NPV value of benefits deriving from the formula provided in the CBA. It comprises of benefits achieved from avoided reinforcement and unlocking additional capacity by balancing the impedance and utilising the existing assets.

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

The principles and methodologies developed from the project to relieve generation constraints through smarter utilisation of the existing network can be employed by any DNO using overhead lines. The deployment of line and ground-mounted modular power flow control devices opens up two options for all DNOs for this type of solution. Some DNOs may prefer to contain power flow control solutions within the substation environment, while some may want to exploit the approach to install directly onto the existing conductor. Pairing this with a re-profiling exercise to increase the rating of existing circuits, is a novel approach that can be replicated across the country.

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

If the configuration between two substations is as such they have different impedance circuits and the flow of power is not balanced between the circuits, PowerLine Guardian and Power Guardian devices can be used to balance the impedance and release additional capacity.

With the assumption that most DNOs will have at least one site with this configuration where SmartWire devices can be used to gain benefits, it is assumed the rolling out cost to the whole GB would be approximately £9.8m, more work will need to be done to reduce the costs of the technology to make them viable at this voltage

## 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 as part of the project can be used by other network licensees to improve their approach to resolving network constraints and opening up network capacity for new generation or demand customers. The methodology used to design and install modular power flow control solutions could also be adopted by other network licensees to achieve similar results.

### 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.**

UK Power Networks is not aware of any innovation project looking at balancing the impedance at 132kV distribution network by using newly developed power electronics technology of Power Guardian and PowerLine Guardian in combination as proposed to trial in this project.

### **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 units from Smart Wires (Power Guardian and PowerLine Guardian) are an advance innovative technology that have never been trialled before in combination to control power flow on the circuit. They are used to balance the impedance between three circuits resulting in unlocking additional capacity on the existing network without the need of re-conducting. It is necessary to carry out the testing of the newly developed technology as it is neither practical nor safe to install the unproven units developed on the live network. This project will trial a combination of these units which will enable an innovative approach towards the release of additional capacity on the existing network to allow more distributed generation connections at a cheaper cost to customers.

### **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**

The technology developed by Smart Wires is an unproven technology on the GB distribution network and needs to be trialled and tested before being adopted into business as usual as a safe practice. In section 3.2 of the NIA Governance document, the DNOs are encouraged to pursue different types of Methods and Solutions to deliver benefits to customers. The innovative approach trialled in this project to dynamically control the units and balance impedance between three circuits to release additional capacity, and the associated benefits, are in an area that has not received a great amount of attention from any innovation stimulus. Due to the risk involved in the project and not fully knowing whether the benefits can be delivered across UK Power Networks' our licence areas, these activities would not form part of our business as usual activities. In order to progress an innovation project which carries significant risk in implementation, additional innovation funding is required as a stimulus.

### **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**

The project can only be undertaken as an innovation pilot given the operational risks associated with the deployment of an unproven solution within the DNOs in Great Britain. The proposed approach towards the release of additional capacity by trialling a combination of Power Guardian and PowerLine Guardian units, controlling power flow between three circuits dynamically has an unproven business case, and the range of potential benefits should be tested before it can be deployed. As noted in the NIA guidance, certain projects are speculative in nature and yield uncertain commercial returns. This is the case for this project. There is a commercial risk that the whole solution developed as part of the project is not adopted by the stakeholders involved following the trial period. This could be due to the fact that the developed technology under trial has not reach the level of maturity required for business-as-usual application. If the project is successful, it will have proven an innovative technical solution and business processes which will improve network efficiency and allow to accommodate additional distributed generation on the constrained part of the network without the need of re-enforcement. The specific details regarding the benefits are captured under section 2b of this document.

### **This project has been approved by a senior member of staff**

Yes