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

Apr 2019

Project Reference Number

NIA_UKPN0049

Project Registration

Project Title

Phase Switch System

Project Reference Number

NIA_UKPN0049

Project Licensee(s)

UK Power Networks

Project Start

June 2019

Project Duration

3 years and 10 months

Nominated Project Contact(s)

Peter Lang

Project Budget

£1,055,700.00

Summary

National Grid's Future Energy Scenarios show that irrespective the scenario, demand is going to increase by 25% between now and 2038; it is expected that most of the new demand will be connected to low voltage distribution networks. This in turn is likely to cause a larger phase imbalance than currently observed. Domestic load is normally connected to one phase. Once one phase of a transformer or underground cable reaches its maximum rating then LV network reinforcement needs to be considered.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

National Grid's Future Energy Scenarios show that irrespective the scenario, demand is going to increase by 25% between now and 2038; it is expected that most of the new demand will be connected to low voltage distribution networks. This in turn is likely to cause a larger phase imbalance than currently observed. Domestic load is normally connected to one phase. Once one phase of a transformer or underground cable reaches its maximum rating then LV network reinforcement needs to be considered.

Method(s)

During the Catapult Energy Systems funded Smart Urban Networks project, Low Carbon Electric developed a Phase Switch System (PSS) which unlocks current and voltage headroom by switching phases between adjacent distributor segments in real time. This addresses load unbalance caused by rapid/uneven uptake of LCTs. The PSS has been demonstrated at the Power Networks Demonstration Centre (PNDC) and has reached the physical LV network demonstration phase. The project will identify transformers and/ or LV feeders where the PSS could be used to release capacity by correcting the unbalance.

Following the October 2020 update a time extension has been requested due to the PNDC test facilities and suppliers' factories being closed affected by COVID-19. The project is running approximately 8 months late. As a contingency an additional 4 months have

been requested as additional closures could happen especially as the suppliers are based in the Greater Manchester area.

An additional £96,700 is required to cover the costs of redesigns caused by moving the printed circuit board manufacture from China to the UK due to COVID-19 as well as associated support for prolongation costs.

Scope

The project will select approximately sixteen locations where a PSS could deliver deferment of asset replacement. About seven PSS will be installed on LV networks and complementary network monitoring will be installed at distribution substations. The project will demonstrate the amount of capacity released when a PSS is deployed as an alternative to network reinforcement. The project will develop a range of solutions that should be considered to defer network reinforcement which includes cross-jointing, installing link boxes and PSS.

Objective(s)

The project will:

· demonstrate that the PSS can become a solution to reduce unbalance between phases and monitor its impact on the LV feeder or distribution transformer.

· demonstrate that the benefits delivered by the PSS of releasing capacity and estimating its longevity are realistic.

· assess the impact of moving demand from one phase to another.

· develop a methodology that will indicate how long the benefits are likely to deliver benefits based on the Future Energy Scenarios demand growth.

· validate the CBA showing the benefits of this alternative solution.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be consider a success when:

· Approximately seven PSS are installed on LV networks and have operated to release capacity. The project will identify distribution transformers with high MDI levels of utilisation (80% - 90%) and the network analysis predicts phase balance correction will release capacity.

· Monitoring of transformer demand and downstream of the PSS position, demonstrates that the PSS has the ability to transfer demand from one phase to another and release transformer capacity headroom.

· The PSS demonstration confirms that initial CBA assumptions were correct or the CBA will be revisited with actual costs to determine whether the PSS can become a network solution to resolve high levels of LV demand unbalance.

Project Partners and External Funding

Low Carbon Electric (LCE)

Potential for New Learning

The project will demonstrate that the PSS is a solution to defer transformer replacement and/or LV mains cable overlays by improving the level of unbalance between LV phases.

The CBA will confirm that benefits can be realised and the PSS can be used by distribution planners to resolve network issues expected over the next 20 years as demand increases by 25%.

Scale of Project

Nine PSS will be built by LCE, circa seven installed on LV networks, one installed for training and one kept with LCE for diagnostics and spare parts. It is expected that seven installations will give the project a range of different network conditions to ensure that the monitoring is varied, analysis is rigorous and the benfits in the CBA can be realised.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The seven trials will be spread across all three licence areas. LV networks with high levels of varying unbalance due to EVs, PVs and heat pumps will be identified for trial purposes to demonstrate the unbalance caused by low carbon technologies can be improved.

Revenue Allowed for the RIIO Settlement

During RIIO-ED1, transformer replacement and LV mains cable overlays may be deferred through the deployment of a PSS.

Indicative Total NIA Project Expenditure

Total cost of project £1,056,000 less 10% = £950,120 reclaimed from customers.

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)

· Gross Annual savings following full scale deployment for UKPN across 3 license areas
· This will just be savings and not accounting for any costs or maintenance associated with the roll out of the solution across UKPN

By using transformer MDI readings as a proxy for individual feeder phase load imbalance levels, the number of LV feeders needing reinforcement may be understated, as they will average one another out. Monitoring equipment used in recent innovation projects have shown the variation of demand between phases. It is expected that fuse operations make provide early indications of load unbalance. Early analysis estimates some 22% of transformers and LV feeders may require intervention by 2040.

The annual savings is dependent on the number of transformer replacements and cable overlays that get deferred. An annual saving delivered by installing a PSS based on the deferral of 34 transfomer and 326 cable overlays each year is over £1,845k.

Please provide a calculation of the expected benefits the Solution

- Benefits will be for the RIIO ED1 period up to 2022/23
- This is at project scale excluding developments
- Break down: Base cost, Method Cost and Benefits (Base cost – (Method cost – Benefits)
- This will show the discounted benefits, discounted base cost and discounted method cost. This will provide an NPV for the remainder of the 8 year ED1 period.
- Add high level assumptions for the Base cost, Method cost and Benefits

The base cost to resolve LV network imbalance is to replace a transformer or overlay a LV cable. The difference in cost of replacing a transformer or overlaying part of LV feeder is greater than the Method cost of installing a PSS is expected to be £10,500. The expected deferment of reinforcing the network on average is 11 years when the asset will be replaced. The PSS will be recovered, refurbished and re-deployed. The benefit is calculated based on the saving realised by installing the PSS and deferring the installation of transformer or underground cable.

Benefits assumed to be realised from 2021/22 with 14 transformers and 140 cable overlays deferred for 11 years, each year up to 2024, increasing to 34 transformers and 326 cable overlays from 2026 onwards as demand profiles increase as forecast in the National Grid Future Energy Scenarios. During RIIO-ED1 the total difference between the base cost and the method cost is £1,580k

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

- This should be scaled based on the UKPN roll out solution
- This should be a high level estimation, not too specific
- This is just the scaling factors that can be applied not the total benefits of rolling out the solution
- This should be a conservative estimation

The FES estimates demand growth to be 1.25% per annum from 2020 to 2040 when the scenarios diverge. (60GW to 75GW). The FES assumes that demand growth is distributed across the whole of GB. Demand profiles and populations of distribution transformers and LV cables are likely to be similar to those of UKPN.

In UKPN about 12% of transformers have an utilisation factor greater than 0.8. These will be at risk if they experienced 25% load growth. Analysis estimates some 576 transformers upgrades and 5,590 LV cables overlays may be required by 2040. The PSS might be effective in releasing between 9% and 20% additional headroom (an avg. of 14%) for around 22% of at risk transformers or LV distribution feeders. 14% headroom is equivalent to 11 years of load growth. So 2.6% (22% of 12%) of transformers upgrades could be deferred. This is equivalent to deferring 576 transformer upgrades and 5590 cable overlays over next 20 years saving £1,608k.

If UK Power Networks accounts for 25% of GB population then a scaling factor of 4 can be used. At a national level assuming growth is evenly spread across all DNOs could save £6.4M.

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

- Using the scaling factor above create an estimate of the roll out costs excluding any development costs associated with the project
- Need to sense check the costs associate with GB rolls out. Anything that costs more than £25M needs serious consideration.
- This will NOT include the benefits.
- This does not need to be discounted over a period of time

Assuming the forecast demand increased predicted by National Grid's Future Energy Scenarios will be spread across the country the number of transformer replacements and cable overlays deferred could be 2304 and 22,360 respectively. This results in 1440 PSS being deployed each year, approximately 100 PSS per DNO. Assuming similar costs, a spend of £240M could defer £360M of reinforcement for an average of 11 years.

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

A updated CBA will be developed based on actual costs showing whether the initial expected benefits were realised. This will provide sufficient information to other GB Network Licencees to make a decision on whether to procure PSS solution or not.

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

Preparation for EV readiness to accommodate the expected demand increase predicted in all National Grid's Future Energy Scenarios.

☑ 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.

[Having carried out sufficient research note here whether there is similar work in GB or not]
A PSS does not currently exist as a commercial product. LCE approached UK Power Networks to demonstrate that the PSS is an appropriate solution to defer asset replacement when demand growth is still uncertain.

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

LCE have developed the PSS to move customer demand from one phase to another without causing a supply interruption which is innovative.

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

There is a risk that the demand transferred from one phase to another is insufficient to allow a highly utilised transformer replacement to be deferred for a number of years. There is uncertainity on the amount of capacity that is released and its longevity. Only once this is better understood can the PSS solution be considered for BAU activites. There is uncertainity on the amount of capacity that is released and its longevity. Only once this is better understood can the PSS solution be considered for BAU activites.

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

There is a risk that the demand transferred from one phase to another is insufficient to allow a highly utilised transformer replacement to be deferred for a number of years. The ability to identify heavily utilized substations based on previously recorded maximum

demand indications may understate when the solution needs to be deployed. Not knowing which phase a customer is connected to may distort the network analysis necessary to determine whether the PSS is an appropriate solution. There is a risk that asset deferment assumptions are optimistic, causing reinforcement to be carried out earlier. The ability to identify heavily utilized substations based on previously recorded maximum demand indications may understate when the solution needs to be deployed. Not knowing which phase a customer is connected to may distort the network analysis necessary to determine whether the PSS is an appropriate solution.

This project has been approved by a senior member of staff

☑ Yes