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

Oct 2018

Project Reference Number

NIA_UKPN0043

Project Registration

Project Title

Faraday Grid Deployment Trial

Project Reference Number

NIA_UKPN0043

Project Licensee(s)

UK Power Networks

Project Start

October 2018

Project Duration

3 years and 1 month

Nominated Project Contact(s)

Alex Davenport

Project Budget

£534,985.00

Summary

Transformers are fundamental assets on electricity networks that have facilitated the development and growth of AC transmission and distribution networks. Though the asset technology has matured over time, with numerous established market players investing in its R&D, the conventional design may no longer be sufficient to tackle the challenges of the changing energy landscape at the lowest possible cost.

With the increasing penetration of Distributed Energy Resources (DER), networks require an enhanced toolkit to manage their system effectively. Though numerous innovation projects have been developed around different asset types to maximise their utilisation and potential to facilitate balancing services, transformer design has remained relatively stable. Some potential issues that may be associated with transformers include:

- With increasing volume of generation and demand connected to the distribution network, transformers may need to be scaled up (MVA capacity) and replaced before the end of their life

- Network losses and carbon footprint associated with a conventional transformer will increase with an increase in MVA capacity.

- Conventional transformers were not designed with balancing and flexibility provision in mind.

Faraday Grid Limited (FGL) is developing a product called 'Faraday Exchanger' (FE); this is an innovative device, which occupies the position of a traditional transformer in the network. An FE provides the traditional functionality of a transformer and could potentially provide:

- Voltage control over a much broader range of variation
- Removal of harmonics
- Correction of power factor
- Phase-balancing

Furthermore, FEs have the potential to address many of the challenges faced by licensees in a more cost-effective manner than has previously been thought possible, including:

- Improving congestion management
- Increasing availability and network capacity

- Increasing the ability of the network to manage higher levels of EV deployment, including Vehicle-to-Grid
- Increasing renewables capacity
- Reducing network losses

The aim of this project is to trial a small number of FEs to assess the potential benefits described above.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

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Method(s)

The project will follow three stages:

1. A trial and monitoring deployment of this technology across our three networks, to verify the successful and reliable operation of the FE.

2. Modelling of different sizes of FEs, comparing results with standard transformers (500kVA, 3-phase)
Commercial model for the deployment of FEs with a larger penetration on our networks and the commercialisation of wider benefits that include system balancing.

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Scope

The project will be looking to trial/monitor a deployment of the FE technology (circa seven units), utilising power electronics, across our three networks to verify the successful and reliable operation of the FE. Additional consideration will be given to the development of a commercial model for deployment at scale.

Objective(s)

The objectives of the project are:

- To verify the successful installation and reliable operation of the FE on live networks
- To compare the performance of 500kVA 3-phase FEs with standard transformers and with FGL's own feasibility study results (see 'Success Criteria')

To consider options for a commercial model for the larger scale deployment of FEs within the EPN, SPN and LPN networks, including consideration of the wider benefits of the new technology such as system balancing.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Determine whether:

- FEs can be installed in place of traditional transformers within the network
- FEs operate reliably within the network
- The performance of the FEs on the network is favourable to that of traditional transformers and comparable to that achieved in the FGL feasibility study (relative to location and operational conditions), such that an overall cost and performance benefit is evident. The results of the FGL feasibility study (based on IEEE networks) are summarised below for reference:

- Net reactive power generation is reduced by 34% (average)
- Net active power generation is reduced by 0.12% (average)
- MW losses are reduced by 7% (average)
- Network carrying capacity is increased by 25% (average)
- Violated security constraints are reduced by 30% (average)
- Balancing services (both MW and MVar) are reduced by 40% (average)
- Carbon Emissions are reduced by 3% (average)

Additionally, commercial and regulatory analysis is undertaken to inform large scale deployment assessments for the EPN, SPN, and LPN networks.

Project Partners and External Funding

FGL are the developer, patent owner, and supplier of the FEs. There is no external funding for this project.

Potential for New Learning

The proposed project has the potential to demonstrate a step change in the performance of distribution networks through the deployment of 'next generation' technology to:

- Improve performance and reduce costs when compared to currently deployed technology
- Defer reinforcement and enable the introduction of larger scales and quantities of DER onto distribution networks
- Achieve system balancing without the need to introduce additional switchgear on distribution networks.

Provide operational network data for distribution networks for improved planning, operations and maintenance

Scale of Project

The deployment of the FEs on UK Power Networks' network will initially be small scale in order to prove the technology on a live network, and that the outcomes and benefits seen in FGL's feasibility study are comparable.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The FEs will be deployed at locations within the EPN, SPN and LPN networks; specific locations are to be determined as part of the project.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£534,985

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)

We expect that if deployed across our networks, the proposed solution could deliver savings across the following:

- Reduction in net reactive power generation
- Reduction in net active power generation
- Reduction in MW losses
- Increase in network carrying capacity
- Reduction in violated security constraints
- Facilitation of local balancing
- Reduction in carbon emissions

Please provide a calculation of the expected benefits the Solution

NPV for RIIO-ED1 = Base Cost – (Method Cost – Benefits)
= £18.12m – (£18.85m – £0.35m)
= £ –0.37m

NPV for RIIO-ED2 = Base Cost – (Method Cost – Benefits)
= £80.45m – (£83.67m – £5m)
= £1.78m

NPV for RIIO-ED1 and RIIO-ED2 = NPV for RIIO-ED1 + NPV for RIIO-ED2
= £(0.37m) + £1.78m
= £1.41m

Note: all figures rounded to two decimal places

Based on an assumption that FEs will be installed & commissioned to replace 25% of transformers pending replacement in ED1. Subsequently this figure will increase to 50% in ED2 price control period.

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

The method is estimated to be directly replicable across all GB DNOs given the nature of the work expected to be undertaken, the standardised solution expected to be deployed, and the proposed approach to determining the replacement schedule for traditional transformers. It is not anticipated that there would be any site limitations that would not otherwise exist with like-for-like transformer replacement.

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

The rollout could take place on a transformer-by-transformer basis and dependent on the normal replacement schedule. The FE costs are currently estimated to be 10% higher than a traditional transformer; this may be reduced were economies of scale to take effect, or additional functionality is valued.

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 new FE technology could be applied to all DNOs, replacing their traditional transformers, with the defined benefits subsequently achievable. The learning from the development, installation and testing phases will be available should other DNOs choose to undertake commercial scale installations of FEs. We expect that undertaking the development stages ahead of full operational deployment will enable refinement and improvement of the FE design, including potentially faster deployment for any 'follower' DNOs as the development work is unlikely to need repeating.

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 – part (i) answered

☑ 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.

FGL are the sole developer and supplier of the FE technology and we are unaware of any other projects to trial this technology. There are other projects trialling related technology that may offer similar benefits such as solid state transformers and power electronic distribution, however these are at a varying stages of development and with similar risk levels. Given the early development stage and

associated risk, we consider it a reasonable approach to pursue more than one solution to be able to assess which offers the greatest benefits.

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 FE technology is new and proven only by FGLs testing of a ~3kVA FE at PNDC and a feasibility study using a model of FE behaviour within a network. The nature of the new technology is such that it could enable other new technologies, particularly DER and other localised solutions, to be connected to the network and managed efficiently and effectively. The project is being initiated now as it is believed the FE technology has reached sufficient maturity to warrant live network trials.

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

Due to the risks involved in the project given the new technology, and not fully knowing whether the benefits can be delivered across our licence areas without undertaking this work, these activities would not form part of our business as usual activities. In order to progress an innovative 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

As noted in the NIA guidance, certain projects are speculative in nature and yield uncertain technical, operational and commercial returns; this being the case for this project. There is a technical and operational risk that the FE technology may not prove as effective on a live network as has been seen in FGL's feasibility study and that reliability may not be comparable with traditional transformers. There is a commercial risk that scaling up the trialled solution may not prove sufficiently cost effective either at all, or until such time as other new technologies (such as DER) are further developed and implemented.

This project has been approved by a senior member of staff

☑ Yes