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NIA Project Registration and PEA Document

Date of Submission

Sep 2019

Project Reference Number

NIA_NGTO035

Project Registration

Project Title

Power Electronic Enabled Transformers (PEETs)

Project Reference Number

NIA_NGTO035

Project Licensee(s)

National Grid Electricity Transmission

Project Start

October 2019

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Oliver Cwikowski

Project Budget

£835,000.00

Summary

Power system constraint payments are one of the main economic drivers for investment in the network. These are based on the limitations of the system operation and the individual assets within each circuit. Being able to alleviate asset level constraints will result in system constraints being removed or reduced; with the end result being that constraint payments go down, reducing consumer bills.

Transformer tertiary connections are presently used to connect Static Var Compensators (SVCs), and other voltage control technologies to the network. These voltage control systems are used to remove voltage constraints from the network.

In the future, tertiary connections will be used to connect Battery Energy Storage System (BESS) to the transmission network. The connection of these additional loads to the transformer may also result in the transformer further limiting the network; due to the additional load.

These additional loads have the potential to alter system voltages, affect fault levels, and interfere with ancillary service provision. This will be of particular concern with respect to local voltage regulation as the newly connected BESS will be able to absorb and inject reactive power locally at the transformer with potential impacts on tap-changer performance and control. Care must also be taken that neighbouring BESS do not interfere with each other.

The connection of BESS to the tertiary windings of transformers, while potentially imposing some additional constraints on the network, also provides the opportunity to exploit the versatility of the power electronics systems to alleviate risks imposed by the BESS and to further explore how the BESS systems could be used to benefit the wider network.

This project proposes to investigate how tertiary connected BESS, or other power electronic based assets, can be used to facilitate the reduction of system level constraints.

Nominated Contact Email Address(es)

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Problem Being Solved

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Method(s)

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The combination of power electronics and transformers into a hybrid system is called Power Electronic Enabled Transformers (PEETs). PEETs are seen to provide the opportunity to:

1. Remove thermal constraints from the network
2. Uplift reverse power flow constraints
3. Remove harmonic constraints and suppress low frequency oscillations
4. Help balance power system flows
5. Increase emergency ratings of transformers
6. Remove or reduce risks from tertiary connected BESS
7. Influence local fault levels

There are a number of different conceptual ways to alleviate various types of constraints imposed by a transformer, through the use of a PEET. This project will use specific NGET case studies to evaluate the potential that each conceptual design has to support the network and compare the performance of PEETs to a traditional network investment option.

Scope

This project will investigate:

- 1, A range of novel PEET systems
- 2, Investigate the potential they offer to alleviating power system constraints.
- 3, Review the impact that PEETs may have on the existing systems and propose methods to mitigate those risks; focusing on three areas:
 - a. The impact on the existing transformer; from an electrical, thermal and magnetic point of view.
 - b. System analysis with respect to voltage, power flow performance and fault levels.
 - c. The impact on existing protection systems.

Objective(s)

The objectives are:

- 1, To understand the potential benefits that can be achieved by using PEETs in the power systems
- 2, To understand the risks that's PEETs pose to the network and what methods are available to mitigate those risks.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be deemed successful if it:

- 1, Evaluates a range of PEET topologies.
- 2, Identifies potential risks to the existing assets, wider network, and protection systems.
- 3, Compares the performance of PEET topologies to traditional investment methodologies.

Project Partners and External Funding

-

Potential for New Learning

BESS has traditionally been connected through its own dedicated network connection, and how it generally interfaces with the network is well understood. However, scenarios where BESS is connected to the transformer tertiary and is then attempting to provide a wide range of non-standard power system functionality (such as helping to balance loads by modifying the impedance of the transformer) has never been studied in detail.

The learning from this project could result in novel transmission investment technologies being developed, providing the industry with new ways to alleviate system level constraints.

Scale of Project

The scale of this project was chosen as the need for the knowledge is required in the short term, due to tertiary connected BESS becoming a reality in the next few years. The project scale was chosen to allow key questions to be answered in a reasonable time scale and with sufficient technical depth to provide confidence in the performance of these concepts, enabling further evaluation as part of the transmission investment process.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

Desktop Study

Revenue Allowed for the RIIO Settlement

none

Indicative Total NIA Project Expenditure

Total Cost: £835k

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 benefits from PEETs can come from a wide range of sources. However, a study undertaken within NGET has identified five investment schemes which could be influenced by the use of PEETs. This study identified that a modest reduction in the system level constraints could save consumers £40m through deferred investment and through the reduction of constraint payments.

Please provide a calculation of the expected benefits the Solution

An example CBA is alleviation of thermal constraints imposed by a transformer. Using the Unit Cost Allowances (UCA) for transmission investment and specific instances of thermal constraints from the Energy Ten Year Statement (ETYS), a 10% increase in the maximum rating of an example transformer would result in a cost saving of £6m for consumers per site. A number of potential sites across the country where this could be applied have been identified.

The costs of a PEETs is presently uncertain, and the costs will remain uncertain until the required technical performance is understood; which is a major output of this project. Once the technical performance is understood, estimations on costs can be made and a detailed cost benefit analysis can be performed.

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

The outputs of this projects could be used to provide an operational specification for tertiary connected BESS. Once this specification has been produced, this information can be adopted by all licensees who wish to exploit the operation of a PEET on their own network.

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

The development of a standard would cost around £50,000. This standard could then be rolled out across the GB network, at a further cost of around £25,000 per licensee in order to adopt this new type of technology/service.

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

This project offers the opportunity to explore novel uses for BESS connected to transformer tertiary. Any beneficial action that the BESS can provide to the network can be applied across the GB network at transmission and distribution levels.

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

This project fits within the (chose from below) value area of the Electricity Innovation Strategy:

Service Delivery - Developing new service-based propositions and business models

- 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.

There is no project duplication.

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

This project is innovative as it is attempting to develop and evaluate novel ways to exploit BESS connected to the tertiary of transformers; these concepts have never been explored for power systems. They have not been previously attempted as the concept of providing customer connections via transformer tertiary has only recently become available. BESS is also a new type of load on the network and in recent years has shown that it can operate more flexibly than other types of load. The combination of BESS, its connection to the tertiary, and the novel use of the technology to alleviate system level constraints, results in a new area for innovation.

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

This project will explore a number of concepts, which have yet to be tested fully. We do not currently know the performance required and the cost of these concepts. As the outputs of this project cannot be directly related to benefits for consumers in the short term, there is significant risk in attempting to develop novel investment methods using business funds.

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 funded through the NIA as there are significant risks which warrant further investigation and development of this innovation topic, prior to its use within the business. The main risks are:

- No proven business case – While a value case has been defined for this project, it is contingent on obtaining an as yet unknown level of technical knowledge. No matter what the outcomes of this project are, these will be valuable to consumers, but in a more qualitative manner. However, the foreseen benefits are not sufficient for the business to justify the project's budget.
- Technical challenges – As this research is investigating the fundamental behaviour of untested network investment concepts there may be technical challenges which are unsurmountable. However, these can only be identified through research and attempting to evaluate these new technologies. This results in further research being required to technically understand PEETs in sufficient detail to extract clear value. These risks make it hard to justify when the business would obtain returns for consumers. Without the NIA funding these risks would never be mitigated, and the business would justifiably not research this area; resulting in the potential benefits never being obtained or investigated.

This project has been approved by a senior member of staff

Yes