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 2018

Project Reference Number

NIA_NGSO0014

Project Registration

Project Title

System Planning Methods, Tools, and Analytics

Project Reference Number

NIA_NGSO0014

Project Licensee(s)

National Energy System Operator

Project Start

March 2018

Project Duration

1 year and 4 months

Nominated Project Contact(s)

Jason Valsamis-Fagas

Project Budget

£110,000.00

Summary

The scope of this project set focuses on researching and developing theoretical models, methods and prototype tools for supporting transmission planning and system protection as systems start to accommodate high levels of renewable, inverter-based resources such as wind, solar PV, and battery energy storage, some of which are located on the distribution network system. Transmission planners and protection engineers need validated models of these new technologies and system planning/protection guidelines for using these models, to ensure the system is developed in a way that can be reliably operated with increasing penetrations of these resources. This project set includes research to provide the understanding needed to develop these new models, tools and methods. The validation efforts in 2018 will use measured disturbance data of complex wind and PV power plants in order to validate the generic wind and solar PV plant controller models.

Third Party Collaborators

Electric Power Research Institute

Nominated Contact Email Address(es)

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Problem Being Solved

The GB electricity system is changing rapidly with the level of installed wind and solar photovoltaic (PV) generation increasing substantially without validated, publicly available computer-generated models that represent the behavior of many of these

technologies.
The integration of renewable energy resources into power systems introduces an impact on system protection, resulting from the complex fault response characteristics of these devices which are interfaced with the grid through power electronics based converters and do not behave like conventional synchronous or asynchronous machines.
Electricity network transmission planners and protection engineers need validated models and system planning/ protection guidelines for using these models to help operate the system. The current state of modelling used for network access planning within the GB System Operator is as below:

- There is minimal simulation of distribution level models and no capability to model these according to their specific characteristics.
- Current models are based on traditional sources of generation.
- Equivalent modelling to simulate new renewable energy resources are not fit for purpose.

Method(s)

Research projects run by the Electric Power Research Institute (EPRI) typically span multiple years. The research work planned in 2018 for this EPRI project work stream PS173A will build on efforts in previous years and will follow the approach outlined below:

- Identify new theoretical model development and validation needs through working with EPRI members and industry groups as well as continuing generic wind and solar PV model validation efforts. Coordination efforts will include groups such as WECC's Renewable Energy Modeling Task Force, the IEC working group on wind generation, the IEEE working group on dynamic performance of renewable energy systems, NERC's Modeling Working Group and Load Modeling Task Force and other stakeholders such as equipment and software vendors.
- Using input from these groups, EPRI will develop new model specifications and validation approaches that will then be communicated with commercial software vendors, ensuring these new models are able to be properly implemented into commercial tool libraries.
- The proposed screening tool will be developed and demonstrated using suitable case studies to show how it could be used to assist planners in determining impacts of Distributed Energy Resources (DERs).

Based on the above methodology for EPRI project's activities in 2018, National Grid as the GB System Operator intends to use the learnings from these proposed activities to inform how the new model theorem for DER and New Transmission Resources could be integrated into the existing PowerFactory model used by network access planning teams. The case studies and validation approaches will be used by the System Operator to inform and drive the strategy for its future of network access planning tools.

Scope

This project work stream PS173A under the EPRI program 173 consists of two sub-projects:

- P173.003: Model Development and Validation of Renewable Energy Technologies
- P173.009: Impact of Renewables on System Protection

The scope of this project set focuses on researching and developing theoretical models, methods and prototype tools for supporting transmission planning and system protection as systems start to accommodate high levels of renewable, inverter-based resources such as wind, solar PV, and battery energy storage, some of which are located on the distribution network system.
Transmission planners and protection engineers need validated models of these new technologies and system planning/protection guidelines for using these models, to ensure the system is developed in a way that can be reliably operated with increasing penetrations of these resources. This project set includes research to provide the understanding needed to develop these new models, tools and methods. The validation efforts in 2018 will use measured disturbance data of complex wind and PV power plants in order to validate the generic wind and solar PV plant controller models.

Objective(s)

The R&D efforts in this EPRI research project work stream PS173A aim to achieve the following objectives under its two sub-projects as outlined below. These are expected to enhance National Grid's knowledge of these research areas to aid with improving its transmission planning and system operation capabilities
P173.003: Model Development and Validation of Renewable Energy Technologies:

- In prior work, the limitations of positive sequence models in comparison with three-phase models were investigated and demonstrated. Models in positive sequence planning tools (both generic and vendor specific) are known to be inappropriate for use in certain studies, such as wind/solar interconnection in weak systems. In 2018 the work will focus on quantifying these limitations through case studies on actual systems in collaboration with EPRI members. Through its membership of this research group, National Grid as the GB System Operator will look into participation in the proposed case studies.
- Modeling of Distributed Energy Resources (DER) for Stability Studies: This task builds on the work undertaken in 2017. The research under this task will be closely coordinated with the research on load modeling performed in another (related) EPRI research programme, which considered the further development of modular composite load models, and the relationship between the load model and the DER model.
- Development of a generic model for wind inertia modeling: Adding a feature to the 2nd generation generic renewable energy system models, for modeling so-called "synthetic inertia" or "emulated inertia" for wind turbine generators.
- Continued generic wind and solar plant model validation efforts: In 2018 the work will continue on pursuing measured disturbance data of complex wind and PV power plants that will be used to validate the generic complex plant controller model. This work will be

subject to data availability.

- Assessment of Renewable Generation/DER Hosting Capacity of a Transmission System: This task is continuation of work, begun in 2016 under EPRI's technology innovation (TI) project, on a high-level prototype screening tool. In 2016-2017, the tool framework was developed and implemented using Python/PSSE scripting and bulk system simulation platform. In addition, case studies are being performed using several utility systems to validate and refine the tool. The following objectives are targeted for 2018:

1. Enhancement and further development of tool, implement additional automated screening capabilities.
2. Explore feasibility of including stability analysis (rotor angular stability, transient voltage and small signal stability) and criteria like critical clearing time, speed deviation, transient voltage dip and voltage recovery in the core engine of this tool.

The GB System Operator expects to use the learnings from the above research activities to inform and drive the strategy for the future of network access planning tools, as well as enhancing current modelling capabilities to plan and forecast energy requirements more accurately.

P173.009: Impact of Renewables on System Protection:

- Develop and validate generic short-circuit models of converter interfaced renewable resources including Type 3 and Type 4 wind turbine generators (WTGs)and solar PV generators, suitable for fault analysis, which take into account the complex behavior of the inverter interfaced systems during fault conditions. These models will be shared by EPRI through engagement with commercial software vendors to ensure that they are incorporated into the tools that EPRI members use to conduct protection studies.
- Evaluate the impact of increased renewable penetration on the performance of legacy protection schemes and on conventional methodologies that planning and protection engineers use to conduct relay setting and protection coordination studies. Propose guidelines and recommendations to the engineers when performing protection studies on systems with significant renewables penetration that will ensure the efficiency of the existing protection schemes or suggest new ones.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be successful if National Grid is able to pursue new activities, or modify existing activities, using a robust research evidence base provided by this EPRI project work stream PS173A through the following deliverables anticipated for each of the sub projects:

P173.003: Model Development and Validation of Renewable Energy Technologies:

- Technical Update "Advanced positive sequence models considering weak grid conditions and guidelines for conducting studies using three-phase models" – expected 31/12/2018
- Technical update on DER planning guidelines – expected 31/12/2018
- Macros for automatically creating composite load model and DER representation for planning studies – expected 31/12/2018
- Software (Beta) "Transmission Hosting Capacity Tool - 31/12/2018

P173.009: Impact of Renewables on System Protection:

- Technical Update: "System Protection Guidelines for Systems with High Levels of Renewables" – expected 31/12/2018
- Workshop: "Implementation of EPRI Phasor-Domain Short Circuit Wind/Solar Models in Commercial Platforms and Use Cases" - 31/12/2018

Project Partners and External Funding

Each project facilitated by EPRI is funded through collaborators, including National Grid, that contribute to the development of the project portfolio and then express interest to be involved with a specific project once the portfolio is decided.

The total contribution from all EPRI members for the EPRI Program 173 in 2018 is $3,000,000 and the project work stream PS173A has been allocated a total budget of $300,000 for sub-project P173.003 and $200,000 for sub-project P173.009.

Potential for New Learning

This project will help National Grid by providing new learning in the following areas:

- Improved reliability though improved accuracy of planning studies, particularly for time-domain dynamic studies, have the potential to enhance the capability of the System Operator to investigate potential transient, voltage and frequency stability issues and evaluate potential mitigating options.
- Continued improvement in the methods for validation of dynamic models for wind and PV power plants, including distributed energy resources.
- Potential to achieve improved system reliability and increased grid integration of renewable energy resources through the use of the models from this research in protection studies. The models are expected to better represent the fault response of inverter-based wind and PV generation. This could allow protection and planning engineers to better identify potential system deficiencies and develop mitigating strategies.
- Guidelines for planning and protection engineers to perform protection studies on systems with significant levels of renewables.

- Recommendations for new protection schemes/practices that may be required in systems with high levels of inverter-based renewables.

Scale of Project

This project work-stream PS173A and its associated projects are predominantly laboratory or desk-based research projects.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The research undertaken in EPRI P173 and this project work stream PS173A is predominantly carried out in the US with some activities in the UK. However, the programme carries out reviews of the latest research from across the world and also engages with participating EPRI members globally.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The total indicative NIA expenditure for this project for 2018 is £110,000 .

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 objectives, deliverables and tasks proposed within PS173A are expected to generate valuable learning which can improve and maintain the reliability of the GB system operator through benefits and expected savings in the following areas:

- Improved accuracy of network access planning studies, and enhanced capabilities for evaluation of potential mitigating options to respond to voltage and frequency stability issues. The outcomes of the project will benefit the network access planning, control room, energy forecasting and requirements teams within the System Operator.
- The prototype tools and methods delivered from this research project would deliver approaches used to facilitate successful integration of DERs into GB system, which is currently a key challenge, and modelling them for planning and control room operations supported by methods on of how to verify distribution connected resources in bulk system planning models.

An example scenario faced by the GB System Operator where there is lack of clarify of the modelling of embedded systems on the network is described below and how this project can deliver potential savings and efficiencies. This example is based on two areas of the network in the North of Scotland which is managed by the System Operator:

- Based on the current analysis carried out by the network access planning teams for high wing scenarios in Scotland it currently costs in the region of about £7M per day to constrain these two areas in order to successfully operate the system. Within these two areas, approximately 50% of the generation is embedded and it is estimated that 10% of the constraint cost can be saved if we have an advanced modelling strategy for embedded generation through implementing the learnings from this EPRI project.

Please provide a calculation of the expected benefits the Solution

Not required as this is a low TRL research project.

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

It is expected that the framework to accurately model distributed energy resources and evaluate the impact of increased renewable penetration on the performance of legacy protection schemes will be replicable and will also benefit the DNOs' operations and the regional networks they manage. The guidelines and recommendations for protection and planning engineers are also expected to be transferrable.

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

As this project aligns with the strategic innovation areas for the GB System Operator and it aligns with existing activities to tackle the outlined challenges, it is expected that the rollout and adoption of the framework, guidelines and software tools delivered from the

project can be facilitated through early engagement with the National Grid network access planning teams (regional and national), Transmission Operators, and Global Information Systems (Global IS) stakeholders in the project and understand the considerations for using them on the National Grid 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

This project set focuses on developing models, methods and tools for supporting transmission planning andsystem protection, as systems start to accommodate high levels of renewable, inverter-based resources such as wind, solar PV, and battery energy storage, some of which are located on the distribution network system.
This project set includes research to provide these new theoretical models, tools, and methods which would be relevant to National Grid (as the GB System Operator), as well as other network licensees who also have network planners and protection engineers who would benefit from validated models of these new technologies and system planning/protection guidelines.

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 will help address the strategic innovation areas (Developing DSOs & whole system operability, supporting voltage and reactive power, optimising constraint management, understanding long-term behavioral change and enhancing visibility of DER) published in the National Grid System Operator Innovation Strategy document published Feb 2018.

☑ 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.

By participating in collaborative projects through EPRI, National Grid can ensure that unnecessary duplication with other projects under NIA is avoided.

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 GB electricity system is facing rapid changes with the level of installed wind and solar photovoltaic (PV) generation increasing substantially without validated, publicly available computer-generated models that represent the behavior of many of these technologies. Renewable energy resources do not behave like conventional synchronous or asynchronous machines and current models used by the System Operator do not accurately model their characteristics. Such new and unprecedented behaviours on the system are driving the need for electricity network transmission planners and protection engineers to use more advanced and validated embedded generation models, and system planning/ protection guidelines for using these models to help operate the system. The research work in this EPRI project is especially relevant to address this challenge in order to simulate distribution level models, according to their specific characteristics. This is an area of innovation where this EPRI project will deliver new knowledge, methods and guidelines.

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

Participating in this project as a member of the Electric Power Research Institution (EPRI) provides National Grid access to the latest state-of-the-art developments in this research area, access to the EPRI network to discuss, share best practice and positively influence the direction of future research. This arrangement also provides a high level of funding leverage as of the collaborative approach facilitated by EPRI which would benefit the end consumer. The tools, guidelines and methods delivered from the project would allow National Grid (as the GB System Operator) to learn from approaches used by other system operators around the world, who have successfully integrated DERs into their system modelling for planning and control room operations. The potential for using innovative tools, methods and guidelines from this EPRI research project need to be carefully assessed before the System Operator implements any changes to current modelling tools and approaches which can be disruptive to system operation. This EPRI research project provides an opportunity to learn and validate the potential impact of such innovative developments before they can be considered for implementation into business as usual operations.

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

This project and its outcomes would help inform the future network access planning, energy forecasting and control room strategies through addressing modeling and validation of resources connected at the transmission/sub-transmission system. The development and verification of methods to model distribution connected resources in bulk system planning models, which will be delivered from the project, would benefit National Grid as the GB System Operator and the network planning teams of other GB network licensees. NIA funding is the chosen funding route for this project, as this would enable an easy way to participate in this EPRI project and be part of a worldwide network of experts in this field, also benefiting from the learnings of other EPRI members who are System Operators in their respective geographies. By using NIA funding, the System Operator can evaluate (at a relatively low cost and minimal risk) the proposed models, methods and tools from this EPRI project research group, assess early on the risks and implications if the learnings are to be operationalized. It also enables the System Operator to disseminate the learnings to enhance the capability of the GB system and energy sector as well as enabling the transfer of the learnings to other network licensees.

This project has been approved by a senior member of staff

☑ Yes