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 2016

Project Reference Number

NIA_SPT_1507

Project Registration

Project Title

Modelling of Static and Dynamic Loads

Project Reference Number

NIA_SPT_1507

Project Licensee(s)

SP Energy Networks Transmission

Project Start

January 2015

Project Duration

3 years and 0 months

Nominated Project Contact(s)

James Yu (Future Networks Manager)

Project Budget

£75,000.00

Summary

The ultimate goal of this project is to improve the understanding of behaviour of load centres and evaluate the existing load models used in the system studies performed by Scottish Power EN (SPEN). It is expected that by achieving this, the accuracy/effectiveness of network planning and operation tools will be improved by:

- gaining a better understanding of load behaviour

- improving understanding of existing load models

- creating new methods for the estimation of load model parameters

- demonstrating a methodology for estimation of load model parameters using different load models

- assessing the interaction between different load types and the main grid.

This project proposal is the first stage in achieving a more detailed understanding of the load behaviour within SPEN. It is envisaged that this stage will be followed by another project stage, which will focus on experimental research. This experimental research will involve using a larger number of sensors (e.g. Phasor Measurement Units) to monitor different load centres in SPEN and then performing a centralized assessment of these measurements to identify the real-time variations in the characteristics of the system load, based on the concept created in the first stage of the project.

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

The load model is one of the most important elements of the models used for network planning studies and system operation. As it is known, the load behaviour is highly dependent on voltage and frequency, i.e. the active and reactive power consumed by the load can be described as a function of system voltage and frequency. This relationship is rather complex and is commonly described using nonlinear load models that are dependent on voltage and frequency. However, a load model cannot be used to properly describe the load characteristics without the proper model parameter values. It is these parameter values that allow a generic load model to represent the specific characteristics of a load centre. For example, different load centres can be represented using the same load model, as they present the same general behaviour, but different model parameter values to distinguish between their specific natures. However, a challenge in determining these load parameter values is that the composition of the load and consequently the suitable parameter values, or even the most suitable model, will vary throughout the day, seasonally and over the years as the customer demand changes (e.g. the advent of consumer electronics in the past decades or the anticipated adoption of the heat pump for domestic heating). This means that the validity of a load model will decay over time and this is why load characteristics should be permanently monitored. Developing detailed knowledge of the individual bus loads in an electric distribution system could prove remarkably beneficial for both planning activities and system operation. The difficulty lies in the fact that the load consists of a multitude of disparate components with widely differing characteristics, which, nevertheless, must be represented by a single aggregated model.

Method(s)

Load models are necessary during system planning and operation studies because it is not feasible to include an individual model for each individual component of load in the system. The concept of aggregated loads is the best option for the study of load behaviour and its effect on the power system. This aggregated model balances the loss of accuracy that is inevitable during aggregation against the necessity of developing practical load models for system studies. Aggregated load models represent groups of loads, which together respond in a way that can be modelled by general equations. In this context, the existing load models can be classified into two major groups:

a) Static load models

b) Dynamic load models

Scope

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- improving understanding of existing load models
- creating new methods for the estimation of load model parameters
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Objective(s)

The key objectives are to:

1. Maximise Economic and Effective Utilisation of Network Assets
2. Maximise Operating Efficiency
3. Understand the Impact of Emerging Technologies on Future Networks
4. Supporting SPEN Decision Making

In support of the above the following will be undertaken:

1. Literature review of the existing aggregated static and dynamic load models

2. Review of estimation methods used for the estimation of unknown load model parameters.

3. Creation of computer suite for assessing behaviour of different load models and understanding the interaction between different load models and the supplying grid.

4. Development of a robust estimation method for the estimation of unknown load model parameters.

5. Validation of new robust estimation methods using detailed static/dynamic load models through extensive computer simulation.

6. Validation of load models using data recorded under laboratory conditions.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

1. Introduce accurate and realistic static and dynamic load models for power system simulations used for network planning and operation studies
2. Maximising capacity of existing assets and thereby potentially deferring network reinforcement.
3. Influence on fundamental network design principles
4. Improved prediction of load behaviour after voltage and/or frequency changes.
5. Wide understanding of new measurement/estimation/optimisation techniques, which can be applied to different applications within utilities
6. Minimize number of customers' outages and reduced probability of blackouts

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This project will evaluate the existing approaches on load dynamic modelling. The main part of the project will be generated from simulation. However, the key innovation part is to compare the novel load dynamic modelling with the system data recorded during the system events.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

SPEN's operational area

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£75,000

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)

An estimate of savings if the problem is solved will be considered as part of any follow-on work arising from this research work.

Please provide a calculation of the expected benefits the Solution

Not applicable at this research stage.

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

The modelling approach (Method) has the potential to be widely rolled out across GB Network Licensees system

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

Not applicable as this research stage of modelling static and dynamic loads

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 learning should help Network Licensees with accuracy/effectiveness of their network planning by gaining a better understanding of load behaviour and an improved understanding of existing load models

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.

n/a

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

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

- [x] Yes