NIA Project Registration and PEA Document

Date of Submission

Feb 2014

Project Reference Number

NIA_NGET0097

Project Registration

Project Title

Development of Dynamic Demand Models in DIgSILENT PowerFactory

Project Reference Number

NIA_NGET0097

Project Licensee(s)

National Energy System Operator

Project Start

May 2014

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Nikola Gargov

Project Budget

£267,869.00

Summary

Dynamic demand models will be developed in PowerFactory and be used to represent the sizeable industrial dynamic demand service (hundreds of MW and beyond for primary and secondary frequency response) provided to the GB system. These dynamic demand models consists of a set of various dynamic demand technologies (from small-scale to large-scale with various operational characteristics), and will be integrated with the GB dynamic power system model in National Grid. The feasibility, reliability and predictability of the dynamic demand service to the GB power system will then be investigated, based on the integrated dynamic demand model and the GB dynamic power system model.

Third Party Collaborators

Cardiff University

Nominated Contact Email Address(es)

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Problem Being Solved

The UK is working towards de-carbonization of its electrical power system (by encouraging renewable power generation) and electrification of its heating and transport sectors. It is anticipated that a large proportion of renewable power will come from wind turbines. There could be up to 30 GW of wind generation within a total generation capacity of some 100 GW serving a load of around 60 GW by 2020.

The uncertainties brought by the intermittence of renewable energy generation introduce inevitable concerns over the operation of the power system. A high penetration of renewable energy especially wind energy will increase the difficulty of frequency regulation. In addition, the largest in-feed loss of GB power system will increase from current 1,320 MW to 1,800 MW in 2014 requiring more reserve to support the system frequency.

National Grid provides services for balancing demand and supply across the GB transmission system, conventionally mainly based on large central synchronous generators. National Grid paid around £192.6 million for frequency response services and around £92.94 million for fast reserve services in 2011/12. Finding cost-effective ways to maintain the future system balance is a priorty for enabling the integration of non-synchronous power generators.

A number of studies have been carried out to investigate system balancing with a high renewable energy penetration, mainly by using the flexible capabilities of generators. However demand is also capable of supporting system operation. Dynamic demand technologies, first introduced by Fred Schweppe in 1980, use loads which are not time-critical to help balance demand and supply in a power system.

Research results have shown that dynamic demand technologies are able to halt a drop of frequency by a rapid reduction in demand. However, previous research has also raised the potential problems that the use of dynamic demand technologies may cause the synchronization of appliances after for instance a sustained low frequency incident. The loss of diversity in loads may cause a further frequency reduction when a large number of loads are re-connected simultaneously leading to demand disconnection. Therefore there is a clear need to investigate the technical feasibility and key technologies of applying dynamic demand technologies in delivering balancing services, and to quantify their impact on the system operation. This will allow the System Operator to draft an appropriate operational control strategy to better manage dynamic demand in particular under severe system stress conditions.

Method(s)

Research and Development

The research will build upon the preliminary success of the collaborative effort between National Grid and existing demand management providers. The unique frequency response service provided to National Grid is in its infancy with a several MWs already available. National Grid is working closely with existing providers in rolling out the service into tens and possibly hundreds of MW in the longer term. It is therefore important to make sure the service will be of value to the power system rather than having a negative impact on system performance. The rolling out of these services will be based upon testing, modeling and monitoring to allow the System Operator to gain confidence in the service not only during normal system operation but at times of system stress.

The key success factor is to better understand the inherent behavior of the service elements (e.g. thermal cycle of fridge/freezers, dynamic behavior of water pumps, etc) and be able to predict the effect of the demand controller on them during small and large system frequency disturbances. Developing accurate dynamic demand models which have been validated by test results will be critical in achieving the above objective.

The focus of demand management providers will be to continue to apply their technology to a wide range of demands and Cardiff University, in collaboration with providers and National Grid, will continue to support the dynamic demand model development in PowerFactory to ensure suitability, predictability and diversity criteria are met.

- Given the above needs, the method to be adopted for the proposed project is summarized below: Appropriate dynamic demand models will be developed in PowerFactory by Cardiff based on the dynamic demand technologies, and validated by their providers using their on-site injection test data.

- These models will be integrated with the dynamic model of the GB power system through the collaboration of Cardiff and National Grid. Research staff from Cardiff University will spend three months in National Grid to work on the model integration and the integrated model will be validated by National Grid.

- The impact analysis of dynamic demand on balancing the GB power system will be carried out through close collaboration between National Grid, demand management providers and Cardiff University.

Scope

Dynamic demand models will be developed in PowerFactory and be used to represent the sizeable industrial dynamic demand service (hundreds of MW and beyond for primary and secondary frequency response) provided to the GB system. These dynamic demand models consists of a set of various dynamic demand technologies (from small-scale to large-scale with various operational characteristics), and will be integrated with the GB dynamic power system model in National Grid. The feasibility, reliability and predictability of the dynamic demand service to the GB power system will then be investigated, based on the integrated dynamic demand model and the GB dynamic power system model.

Objective(s)

The key objective of this project is to develop validated dynamic demand models in PowerFactory and integrate it with the Master GB dynamic power system model in National Grid, which will provide a means for National Grid to quantify the impact of various dynamic demand technologies and gain confidence in the service provision from dynamic demand.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success criteria for this project will include:-

- An integrated dynamic demand model and GB dynamic power system model (in the Master GB model in PowerFactory) is developed and validated.
- Results from the impact analysis of dynamic demand on balancing the GB power system are provided.
- All models to be documented in a final report.

Project Partners and External Funding

Cardiff University

There is no external funding for this project.

Potential for New Learning

The project will develop key learning by:-

- Developing an understanding of the impact of various dynamic demand technologies on GB system operation.
- Developing the capability of quantifying the impact of various dynamic demand technologies and gaining confidence in the service provision from dynamic demand.

Scale of Project

The project will be laboratory scale and can not be reduced further.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The research will be carried out in Cardiff University (Cardiff), model integration will be carried out in National Grid, and some model validation will be carried out in London.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The total NIA project expenditure is £267,869

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)

With a large penetration of dynamic demand National Grid will be able to reduce the use of conventional fossil fuel generation plant thus reduce the total capital and operational cost and CO_2 emission while facilitating larger integration of intermittent renewables, which will eventually reduce the electricity cost at the customer side and protect environment.

This project will enhance the opportunity for rolling out tens or even hundreds of MW of demand response to displace response from more expensive generators. This is expected to stimulate further innovation on demand response from other service providers. This will facilitate competition in the Frequency Response Market and when it is fully developed, the saving could be up to 5% or £10m pa.

Please provide a calculation of the expected benefits the Solution

Not required for research projects.

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

The output of this project will be a model used by National Grid and a better understanding of impact of dynamic demand on system balancing. This dynamic demand model has the potential to be used by other system planning and operation software to quantify the impact of dynamic demand.

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

The dynamic demand models developed could be applied across the GB network without additional cost implications.

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 impact of dynamic demand technologies on balancing the GB power system will be quantified which will facilitate National Grid to make technical preparation and commercial arrangement in order to consider and accelerate the use of dynamic demand in the system operation.

As DNO's become more active in managing the electricity distribution networks this learning could be of value to them as well as the GB System Operator.

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.

Currently there is no suitable dynamic demand model available and no other similar NIA project in progress.

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

☑ Yes