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

Feb 2014

Project Reference

NIA_NGET0144

Project Registration

Project Title

Integrated electricity and gas transmission network operating model (ICASE Award)

Project Reference

NIA_NGET0144

Project Licensee(s)

National Grid Electricity System Operator

Project Start

October 2012

Project Duration

4 years and 1 month

Nominated Project Contact(s)

David Lenaghan

Project Budget

£200,000.00

Summary

The changing mix of technologies in generation of Great Britian's electrical supplies is motivating the study of the gas and electricity network. There is increasing use of intermittent renewable electrical generation technologies, most notably, wind turbines.

A number of studies have considered the effect, on the electricity network, of the expected increase in the generation capacity due to wind. It is expected that the intermittency in generation due to wind will have an impact on other generation units which will be required to increase and decrease their generation, as the wind generation falls and rises, in order to meet the shortfall between generation and demand. This will lead to a large increase in the volatility of the price of electricity. It is predicted that gas turbines will have a greater role to play in generating electricity. Their ability to ramp up/down quickly compared to other plant suggests they will be more adept at fulfilling the role as the generator to meet variability in demand.

Another reason for the desirability of a combined model for the gas and electricity networks is the changing availability, location and cost of natural gas resources. With the possibility of future restrictions of the availability of natural gas, there is an increasingly likelihood that prearranged curtailment scenarios will become part of the gas power station's contract with the gas Transmission Network Operator. There is little historical precedence for such policy and so little data on its possible effects. The questions of what impact such curtailment would have on the stability and security of the electrical network along with its economic outcomes require the use of a model which combines both the electricity and gas networks.

A model to research the gas and electricity network will allow the study of the gas demand for electrical generation under variations in electrical demand and gas price. It is designed to be extendable to allow the future inclusion of other characteristics. For example,

important questions exist on the cost and reliability of the GB gas and electrical networks under variations in wind, the model allows for the inclusion of change in generation due to meteorological variables.

The operation and development of the future power system will be more and more linked to the evolution of other interconnected energy vector systems, and in particular of the gas network. In conjunction with variations in wind generation and the role of gas turbines in generating electricity as mentioned above, there is also great uncertainty about the development of the heat sector, traditionally mainly covered through gas boilers, with a number of emerging options such as electric heat pumps and cogeneration systems, which could totally change the business cases for both electricity and gas systems. All of these pose new challenges in terms of identifying the optimal operational and planning approaches for the gas transmission and electricity transmission networks, from techno-economic and reliability standpoints. By addressing these challenges there is potential to use that knowledge to develop cutting edge modeling and assessment tools for integrated energy networks under uncertainty.

Nominated Contact Email Address(es)

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Problem Being Solved

The operation and development of a future power system will be more and more linked to the evolution of other interconnected energy vector systems, and in particular of the gas network. Challenges in terms of identifying the optimal operational and planning approaches for the gas transmission and electricity transmission networks, from both techno-economic and reliability standpoints need to be addressed. In researching and understanding these challenges there is also a potential to develop cutting edge modeling and assessment tools that can be used for integrated energy networks that are operating under uncertainty.

Method(s)

Research

The project will interact with a number of existing projects, including the Autonomic Power Systems Grand Challenge, HubNet, and ResNet.

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Assessment of how smart management of both networks could support the development of clean energy scenarios beyond the traditional electricity-only Smart Grid vision. Taking into account day-to-day operation of storage facilities, a successful and realistic modelling of the gas network's current operation, onto which to include an analysis of the electrical network. To enable analysis of sudden changes in the gas demand for electrical generation (e.g. changes in wind or fast changes in electricity demand due to electrification), the model will include an intraday analysis based on hourly or half-hourly demand intervals. Shorter intervals are being considered in a finite difference scheme so that the dynamic aspects of linepack can be considered. Attention is being paid to properly model the gas network dynamic characteristics in its interaction with electricity.

Scope

The changing mix of technologies in generation of Great Britian’s electrical supplies is motivating the study of the gas and electricity network. There is increasing use of intermittent renewable electrical generation technologies, most notably, wind turbines.

A number of studies have considered the effect, on the electricity network, of the expected increase in the generation capacity due to wind. It is expected that the intermittency in generation due to wind will have an impact on other generation units which will be required to increase and decrease their generation, as the wind generation falls and rises, in order to meet the shortfall between generation and demand. This will lead to a large increase in the volatility of the price of electricity. It is predicted that gas turbines will have a greater role to play in generating electricity. Their ability to ramp up/down quickly compared to other plant suggests they will be more adept at fulfilling the role as the generator to meet variability in demand.

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Objective(s)

This project will extend classical power system models to an integrated network operation model that takes into account the tighter interaction of electricity and gas systems and the impact of such interaction in terms of flexibility, adequacy, reliability, and resilience of the overall energy system under future uncertain scenarios.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The PhD includes three main deliverables:

1. Report with literature review on gas network, electricity network, and integrated electricity and gas network models for operational assessment and optimization.
2. Report with description of a prototype model for integrated gas and electrical network operational assessment and optimization.
3. Report with a description of the developed integrated gas and electrical network model and case study applications with current and future scenarios.

Project Partners and External Funding

Supplier – Manchester University Photon Science Institute (iCASE Awards)

External Funding

- EPSRC £67,000
- National Grid Gas Transmission £35,000

Potential for New Learning

Research and development towards an integrated gas and electricity transmission network operation model. Provide an assessment on the smart management of both gas and electricity transmission networks can support the development of clean energy scenarios beyond the traditional electricity-only Smart Grid vision.

Scale of Project

Research and development of the integrated energy model will include the Gas and Electricity Transmission Systems in Great Britain.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

Work on this project is primarily desktop based and will be caried out in Manchester.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

NGET NIA project expenditure is £81,000.

National Grid Gas Transmission NIA expenditure is £55,000

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)

As the operation and planning of both electricity and gas networks becomes more complex as a result of substantial changes to demand for both fuels and significant changes in electricity generation and gas production and import patterns, optimising the operation of the two systems which are to a large extent interdependant, becomes more challenging. This project is aimed at investigating ways in which the operations of the two networks overlap and identifying areas of operation and network planning where there could be risk of sub-optimal or potentially conflicting operational control schemes. This project will not on its own solve these issues, rather it aims to clearly identify where they might arise so that future projects can be planned which develop options for resolving them. If sub-optimal interaction between gas and elcetricity networks resulted in one constraining action on the electricity network that could have otherwise been avoided, the costs at current prices would be in the order of £10,000 to £1m per day affected.

Please provide a calculation of the expected benefits the Solution

Not required for a research project

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

This project will not develop solutions ready for replication across the network. Rather it aims to clearly identify where they might arise so that future projects can be planned which develop options for resolving them.

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

This project will not develop solutions ready for replication across the network. Rather it aims to clearly identify where they might arise so that future projects can be planned which develop options for resolving them.

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

n/a

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.

A review of research done to date by National Grid and University of Manchester indentified that the CGEN (combined gas and electricity network) model developed at Cardiff (Chaudry, Jenkins, & Strbac, 2008 - Multi-time period combined gas and electricity network optimisation. *Electric Power Systems Research*, 78, 1265–1279), is fundamentally different to the integrated electricity and gas transmission systems model which will be developed for this project.

The two key areas of difference include:

1a CGEN – Cost centric, economic optimization

1b Integrated Model NIA Project – Network modeling focused on operational considerations

2a CGEN – Static flow rate: gas flow assumed to be in a steady state within a given timeframe (e.g. daily/monthly), resulting in misleading results for the current operation of the networks.

2b Integrated Model NIA Project– Volatile flow rate: consideration of sudden changes to the flow rate and the impact of these on network operations.

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