

NIA Project Registration and PEA Document

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Project Reference

NIA_NGGT0154

Project Registration

Project Title

Spatial GB Clean Heat Pathway Model

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NIA_NGGT0154

Project Licensee(s)

National Grid Gas Transmission

Project Start

October 2019

Project Duration

1 year and 4 months

Nominated Project Contact(s)

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Project Budget

£368,140.00

Summary

Development of the GB Heat Decarbonisation Model, an integrated, cross-vector model of the whole heating system within Great Britain.

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Problem Being Solved

Recent efforts by the networks, government and other stakeholders investigating options for decarbonising heat are yielding large amounts of information and useful datasets regarding the performance of these options, but this data has not been integrated in a manner that facilitates cross-comparison and development of a coherent strategy, either at the national or local levels. The lack of clear strategic direction results in difficulties for network companies (as well as the wider energy sector, businesses, energy users, local government, communities and other stakeholders) in planning investments and could lead to investments being delayed or risk of sub-optimal investments resulting in stranded assets.

National pathway optimisation models exist but they are really energy balancing models at GB level. These models generally do not represent the heating sector well and lack the spatial granularity and understanding of consumer behaviour required to model heat pathway choices and explore local differences. Other models are single pathway models that do not adequately represent the competition between pathway choices and cross-vector impacts.

Method(s)

The project is divided into six main tasks as summarised below:

Task 1: Model framework development

- Agree desired format of user interface and model outputs
- Develop and agree detailed approach to each sector
- Workshop with stakeholders to finalise specification

Output:

- Functional specification of the model

Task 2: Data collection

- Collect datasets covering current uptake of technologies in each sector and consumer preferences
- Assess gaps in the literature and develop plan to mitigate impact on model
- Review national and regional policy relevant to each sector
- Interview key stakeholders to inform scenario-driven sectors

Outputs:

- Assessment of data quality and mitigation plan to address any gaps
- Interviews with up to 10 stakeholders

Task 3: Component model development

- Refine and customise existing sector models
- Incorporate the collected data and scenarios defined above into the relevant sector models
- Validate sector-specific models individually prior to system-wide integration

Outputs:

- Sector-specific calculation modules ready for integration in the GB Heat Model
- Descriptions of each module including assumptions, inputs, and validation of outputs

Task 4: Model validation scenarios

- Develop a set of scenarios to be used for model validation, representing a range of different outcomes
- Document input variables for each scenario to support consistent Model testing and validation
- Incorporate validation procedures into the user manual

Outputs:

- Specification of scenarios and sensitivities to be used for model validation
- Expected outputs for each validation scenario

Task 5: Spatial GB Clean Heat Model integration

- Integrate component models into the framework defined in Task 1
- Develop user interface, including facility for model control, user inputs, and model output
- Test and validate the Spatial GB Clean Heat Pathway Model

Output:

- Beta model version for use in Task 6

Task 6: User acceptance testing, peer review and model handover

- Third party peer review process & model revisions
- Model demonstration workshop
- User trial and feedback period
- Revisions to model and documentation
- Produce final project report
- Delivery of final model version

Output:

- Workshop for model users and wider stakeholders
- Spatial GB Clean Heat Pathway model user manual
- Model assumptions and QA log
- Model Peer review and user acceptance testing reports
- Final model version

Scope

The project will test the following hypotheses:

1. That the solutions to heat decarbonisation which deliver the best efficiencies in terms of cost and emissions reduction across the whole energy system, are driven mainly by local factors which cannot be understood by a top-down assessment framework.
2. That we are able to develop a first-of-a-kind spatial demand modelling platform for GB which incorporates all low-carbon heating options to determine plausible local decarbonisation pathways to 2050. Development would focus on the following functional features:
Spatial resolution:

- Address-level analysis of building stock characteristics and associated energy demand
- Low carbon infrastructure deployment (e.g. district heat and H2) modelled at high spatial resolution (LSOA to local authority), enabling area specific modelling of the competition between low carbon infrastructure and building-scale technologies.

Understanding consumers:

- Consumer choice factored into technology uptake forecasts
- Heat decarbonization pathway choices to factor consumer choice into technology uptake forecasts
- Consumer behavior factors included in analysis of energy consumption (e.g. impact of household income) and the impact of energy efficiency / low carbon heating measures (e.g. in-use factors)

Multi-vector:

- A comprehensive range of low carbon heating technologies will be represented in the model, including building level technologies, district heat, hydrogen, and biomethane
- Pathway choices determined based on economic optimization, consumer choice and physical suitability of buildings

Time dependency/Network Impact:

- High temporal resolution profile modelling to assess technology operation and impacts on existing networks.
- Multi-year pathway evolution (to 2050), including supply / build-rate constraints, cost curves, technology improvement

3. That this platform can subsequently be extended beyond heat to include other demand sectors like industrial demand, home appliances, transport demand, and demand side response across all vectors.

- The initial version of the model will be focussed on heat demand and supply. However, the model design choices will prioritise building a platform that can be easily extended to offer additional functionality in the future including the decarbonisation of other sectors, for example adoption of low carbon transport technologies, in a consistent spatially resolved format.

Objective(s)

Provide a coherent modelling framework for regional energy demand and supply mapping that captures competition between low carbon technologies and the impact that consumers, communities, distribution networks, and regional and national bodies will have on the national heat decarbonization strategy. Improve the evidence base on which National Grid (and gas and electricity distribution network operators) develops investment plans for the forthcoming price control period, reducing the risk of sub-optimal investment decisions or stranded assets.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project would be considered a success if the following criteria are met:

1. The prototype model has been delivered to agreed specifications and on time
2. Model has been validated against historical data and favourably compared against existing approaches to spatial modelling
3. The model has undergone a successful peer review and stress testing by a qualified third party
4. Excellent feedback from intended users of the model on value delivered e.g. DNOs, GDNs, DBEIS, NGESO, NGG, etc

Project Partners and External Funding

Partners

1. National Grid Electricity System Operator (ESO)
2. Element Energy will be undertaking the modelling and analysis work for the project

This project is engaging closely with the following stakeholders who are supporting the project in kind through an industry advisory group

1. Cadent
2. Department for Business, Energy & Industrial Strategy (DBEIS)
3. Electricity North West
4. Northern Gas Networks
5. Northern Powergrid
6. Scotia Gas Networks
7. Scottish and Southern Electricity Networks (SSE)
8. SP Energy Networks (SPEN)
9. UK Power Networks
10. Wales and West Utilities
11. Western Power Distribution

No external funding

Potential for New Learning

While there are many potential pathway choices for decarbonising heat, no clear consensus has emerged regarding the most appropriate approach to heat decarbonisation at the regional or national scale. A number of demonstration projects have been successfully realised but significant uncertainty remains around the scalability, cost, appeal to consumers, and the infrastructure implications of the candidate options. Furthermore, differing solutions may be adopted in individual regions, depending on geographic and economic characteristics, regional policy goals, and existing infrastructure. The heat decarbonization pathway chosen will have implications for a wide-range of stakeholders, including consumers, gas and electricity network companies (at transmission and distribution levels), energy producers, government and regulators, among others. The model developed as part of this project would aid understanding of the potential decarbonisation routes, their likelihood, and the impact on the networks.

The modelling platform will provide an open-source, virtual laboratory for testing hypothesis and assumptions around how to achieve optimum network investment outcomes at local levels in response to low-carbon energy transitions.

The project would help enhance engagement across the energy industry by providing a regional focus that gives distribution networks more opportunity to contribute to the development of GB future energy scenarios and promote a sense of shared vision that policy makers can readily support and help achieve.

Scale of Project

The project is focused on developing a prototype bottom-up model for forecasting decarbonised heat demand and supply across domestic and non-domestic buildings in GB to 2050. The prototype model would provide the following:

- Reflect regional differences: The model will capture regional differences in geography, building stock characteristics and policy at the appropriate scales and assess how these will impact technology uptake regionally and nationally
- Produce spatially resolved outputs: The spatial granularity of the modelling will be appropriate to capture the key drivers of uptake. Outputs will be provided at the spatial level at which the modelling is performed, but also aggregated to higher geographic levels as required to support various reporting requirements
- Account for consumer behaviour: Model consumer behaviour to determine realistic uptake rates of low carbon heating technologies
- Provide a consistent cross-vector evaluation framework: Allow evaluation of all low carbon heating technologies within a consistent framework, including cross-vector interactions (including electricity, gas, hydrogen and district heat networks)
- Enable uncertainties to be explored: Allow multiple scenarios and relevant sensitivities to be modelled to explore the impact of a wide range of assumptions and future scenario conditions on the heat decarbonization pathways modelled.
- A platform for further extension to other demand sectors

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project covers all of GB gas and electricity transmission and distribution licence areas

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£355,640 – NGGT

£20,000 – NG ESO

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 this project flow from the development of a first-of-a-kind platform that will set an industry standard for modelling long term low-carbon energy demand transition at high spatial resolution. This project will generate savings to customers and consumers as the decarbonisation options are better understood.

Please provide a calculation of the expected benefits the Solution

1. Accelerate the convergence on optimal solutions for heat decarbonisation across GB by defining the suitability of technology options for building archetypes by geographic location which would help
 - a. consumers make the best possible purchasing choices for their low-carbon heating. Initial calculations show large savings on appliance costs and energy bills through appropriate tailoring of solutions. Further, outputs from the project would contribute to the creation of market structures and regulatory regimes to ensure choices at each stage of decision making are optimised;
 - b. policy makers identify the type and level of support required by vulnerable consumers and help inform the design of intervention programmes to empower them decarbonise their heating
2. Improve demand modelling capability and efficiency: the prototype version of the proposed modelling platform would focus on the heating sector and would initially serve as a prove of concept. The full benefits of the model are however realised by extending the prototype version to include other demand sectors such as industrial demand, transport demand, home and office appliances demand, and Demand-Side-Response. Benefits accrue from both the higher quality of model outputs and from the overall efficiency savings by consolidating several modelling capabilities into a single platform with a central database for modelling technology uptake, multi-vector fuel demands, carbon emissions, costs, network impacts, with multiple scenario simulation capability and at high spatial resolution.
3. Improve network investment planning: Output from this model in the form of daily and hourly energy demand profiles as well as peak demand by vector will form primary inputs into transmission and distribution network development planning. The proposed spatial approach to modelling, capturing local drivers of demand trends, will help network owners and operators optimise their network design outcomes through better quantification of uncertainties e.g. scale and timing of rollout of heat pumps by network region; size, type, and location of Steam Methane Reforming plants and associated CCS infrastructure; local requirements for hydrogen transmission and distribution; extent of district heat rollout by region, spatial distribution of biomethane production etc.

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

Model scope covers the whole of GB and therefore model highly replicable across GB.

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

The model will cover the whole of the GB.

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)

Forecasting of supply and demand

- Will generate new insights into how hybrids, storage, smart appliance controls, and time of use tariffs (TOUTs) could affect demand side flexibility on gas and electricity grids

Whole energy system

- Will develop a GB view of future of heat that are regionally optimised across all vectors
- Will produce new insights on the growth of hybrid heating systems that may require new cross-vector financing models

New types of gas

- Will help identify local constraints on biomethane injection into the gas grid
- Would help local requirements for hydrogen transmission and distribution systems

Future markets

- Will provide a tool for analysing network impacts of consumer behaviour on uptake and use of low-carbon heating in homes and businesses

- 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 comprehensive survey of existing projects has been undertaken and none has the explicit aim of developing an open source modelling tool for high resolution mapping of energy demand transition and their impact of network planning. The risk of duplication is therefore negligible. However, there are projects currently ongoing or being proposed which could potentially feed data and insights into this project to help with model benchmarking. For example,

1. Wales & West Utilities has recently engaged Regen to deliver an NIA funded project [Ref NIA_WWU_054] to produce regionalised, locally distributed and scenario-based forecasts out to 2035, for WWU South West and Wales licence areas.
2. SP Energy Networks is undertaking an NIA funded project [Ref NIA_SPEN_0045] which aims to develop and apply methods to explore optimal decarbonisation pathways to determine likely future residential heating technology mixes against a backdrop of policy, cost and demand uncertainties.
3. Cadent, in partnership with University of Birmingham, is proposing a Future Gas Demand Forecasting study to help deliver more accurate gas forecasting that captures the dynamics of changes to gas demands due to changes to heating technologies, embedded generation and storage (including behind the meter installations) and increased quantities of low carbon supplies at distributed level out to 2030. The Cadent project will deliver a set of sub-hourly demand datasets for one LDZ with future extension to a second LDZ

Additionally, the project will ensure model development is carried out in accordance with best industry practice and standards by periodic review of progress through a project advisory group with broad representation from the energy industry.

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 project involves developing a prototype modelling platform to explore how the combination of choice editing, consumer demographics, geographic location and public policy drive low-carbon demand transition on a highly spatially resolved map of GB. As a proof of concept, the prototype will be applied to evaluation of decarbonisation pathways for heat in residential and commercial buildings to 2050 that capture detailed local building characteristics, consumer characteristics, and competition between building-level technologies and low-carbon infrastructure at local levels (i.e. the balance between reusing of existing infrastructure and building new ones). This would help bridge the gap between top-down modelling approaches and a genuinely bottom-up approach to pathway analysis. No model of this scope and sophistication exists today. The proposed model is a single solution to several problems. It will address the current reliance on consensus-based approaches to spatial mapping of low-carbon energy demand transition to a data-driven approach and effect a step improvement in the quality and precision of information used for network investment planning. The model will help address the lack of strategic direction on heat decarbonisation by initiating a shift of focus away from generic national decarbonisation scenarios to more specific regional pathways and help steer stakeholders towards convergence on cost-optimal, tailored solutions; it will demonstrate how the burdens of decarbonisation are distributed between individual consumers, the networks and the three tiers of administrative bodies (local, regional, and national), ensuring responsibilities are clearly understood and vulnerable consumers are adequately protected.

Relevant Foreground IPR

n/a

Data Access Details

n/a

Please identify why the Network Licensees will not fund the project as part of it's business and usual activities

The project is very speculative research project and involves testing hypothesis to help understanding of the fundamentals drivers of energy transition in highly distributed demand categories like heat. Hence the need to bring in other distribution networks as partners in order to create a truly open and collaborative environment. Moreover, the project would only develop a prototype platform which would require further development before it is suitable for incorporation in to business as usual processes.

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 comes with considerable risk of failure that other funding streams would be unable to accommodate such as: 1 - The

tractability of incorporating all features at the proposed level of resolution and delivery of a solution that is practical in terms of model run-times [Resolution as in segmentation of the building stock (domestic and non-domestic), consumer archetypes, and the number of competing technology choices to be modelled in a single framework] 2 - The complexity involved in modelling the large number of decision points and interactions between choices is very significant and large amounts of input data will be required

This project has been approved by a senior member of staff

Yes