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

Jan 2023

Project Reference Number

NIA2_NGESO027

Project Registration

Project Title

Carbon Intensity Modelling

Project Reference Number

NIA2_NGESO027

Project Licensee(s)

National Energy System Operator

Project Start

January 2023

Project Duration

1 year and 0 months

Nominated Project Contact(s)

James Kelloway (ESO)

Project Budget

£205,000.00

Summary

The current methodology for calculating carbon intensity from fossil plants is based upon a simplistic calculation which does not capture variability between different generators of the same type, or within individual generators over time. National Grid ESO's ability to improve the carbon intensity calculation is hampered by lack of available data on the fuel consumption of individual generators, which is considered commercially sensitive by the data owners.

Using available data and relevant knowledge from scientific literature, this project will research and develop a refined model that will improve the accuracy of carbon intensity for power generation. This data is important in tracking the progress towards de-carbonising the electricity system, and in future could also be used to optimise the dispatch of power based on carbon intensity.

Preceding Projects

10026595 - Virtual Energy System

Third Party Collaborators

UKRI (Hartree Centre)

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

The current methodology for calculating carbon intensity from plants that emit carbon at the point of generation, is based upon a simplistic calculation which does not capture the variability between different generators of the same type, or within individual generators over time. When carbon emitting plant is running at non-peak efficiency, during partial load, ramping and unfavourable ambient conditions, the existing method underestimates the carbon impact of using the plant by around a third. There is a need to align our understanding of real-world emissions of all plants that emit carbon at the point of generation and enhance the accuracy of carbon intensity reporting to support the delivery a of zero carbon electricity system.

Method(s)

This project consists of three work packages, running sequentially with a mid-term review to reassess the viability of the project and continued alignment with project objectives.

Work Package 1 – Creation of the model for gas plant performance

Initial models for the performance of power plant carbon intensity (CCGT/OCGT/Biomass/Coal) will be created based on the values in the literature. These models will be compared against the known values for energy produced by month and input usage by month (subject to data available from BEIS) to test their performance against the current single values used for plant carbon intensity. The model will then be refined by using the physical understanding of power plant operation and an estimation technique such as a Kalman filter to use the available data to refine the estimates of the latent variables in the system. The resulting models will be benchmarked against the previous ones and a measure of their uncertainty provided.

It is expected that the data available for biomass/coal will be much less than those for gas plants due to commercial sensitivities around the BEIS data due to the small numbers of energy plants. This means it is expected the models produced will be weaker for biomass/coal than for Open Cycle Gas Turbine (OCGT)/Combined Cycle Gas Turbine (CCGT). The uncertainty around the models for all plants will inform the feasibility of WP2.

Work Package 2 – Carbon Intensity Optimiser

A proof-of-concept tool will be created to optimise dispatch by considering current constraints (system requirements) and the models created in WP1. The problem of interest will be considered as a stochastic optimal control problem. Reinforcement learning algorithms will be employed to create a tool that will not only consider the current system requirements but also the carbon intensity of those decisions.

Work Package 3 – Project Report

A report will be produced to provide an overview of the work completed, potential impact and limitations identified. This will include recommendations for follow on projects to further develop and operationalise outcomes of the project, identifying additional data that would allow development of a more accurate model or optimiser.

In line with the ENA's ENIP document, the risk rating is scored Low.
TRL Steps = 1 (2 TRL steps)
Cost = 1 (£205k)
Suppliers = 1 (1 supplier)
Data Assumptions = 2
Total = 5 (Low)

Scope

This project for carbon intensity modelling will:

- Explore how to accurately model carbon output of carbon plant in different operational modes
- Use a combination of traditional statistical techniques and cutting-edge machine learning methods to increase accuracy beyond current peak efficiency assumption
- Build upon internal capability with external domain experts.
- If successful, provide recommendations for future development of carbon intensity tool into Carbon Intensity of Balancing Actions and Virtual Energy Systems (VES).

Objective(s)

- Identify key missing data items that will have the most impact on our understanding of the carbon intensity of gas/coal/biomass generation.
- Improve the carbon intensity modelling of CCGT/OCGT/Coal/Biomass plants in different states by creating models for when they are operating outside of peak efficiency, and by better understanding the relative efficiencies of BMUs where data is available.

- Develop a PoC tool to optimise the dispatch of the plants on the grid with respect to the carbon intensity of the energy produced (e.g. by generating a carbon merit order, providing recommendations for dispatch which factor in predicted upcoming BM requirements as well as peak / partial load efficiency of available BMUs, or other methods yet to be determined).

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project has been assessed as having a neutral impact on customers in vulnerable situations because it is a transmission project.

Success Criteria

The project will be deemed a success if:

- It delivers against objectives, timescales and budgets as defined in the proposal.
- WP1 models deliver higher accuracy when compared against actual gas usage (as provided by Major Power Producers (MPP) survey or the Gas System Operator if available) than the current fixed value being used.
- A PoC tool is developed for optimising dispatch based on carbon intensity as well as system requirements.

Project Partners and External Funding

UK Research and Innovation (UKRI)– The Hartree Centre

Potential for New Learning

This project will help the ESO more accurately understand how operating carbon emitting plants in different ways impacts the carbon intensity released, improving the representation of progress to net zero, and enabling future options for carbon optimisation.

Scale of Project

Work will be carried out by UKRI (Hartree Centre) over a 12 month period using data provided by the ESO, available data on plant operation, and knowledge from scientific literature to model more accurate carbon intensity representations across plants that emit carbon at point of generation.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The project will be based upon the GB ESO area of operations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£205,000

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:

The ESO publishes half-hourly information on the carbon intensity of the GB electricity system. This data is important in tracking the progress towards de-carbonising the electricity system.

A greater understanding of how fossil plants emit carbon under different loading scenarios will improve accuracy and transparency of reported carbon intensity, while also providing the knowledge base needed to optimise for the ESO carbon reduction in line with the Net Zero mandate.

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)

N/A

Please provide a calculation of the expected benefits the Solution

Not required as this is a research project.

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

The developed models will be applicable for use across carbon emitting plants in GB.

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

At this stage the costs are unknown for rolling out research learning into further development.

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

☐ 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 will demonstrate a more accurate method for carbon intensity and carbon optimisation. The learnings from the project can also be beneficial for DNOs carbon reporting for their demand side, including the ENA P7 for DNO carbon reporting.

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

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.

This project is an industry first and therefore there is no direct duplication of any existing activities.

The creation of a Virtual Energy System (VES) may require the ability to Carbon Optimise, but in order to do this, all plant behaviours need to be fully understood first. Similarly, the ENA P7 project for DNO carbon reporting for demand side services can utilise outputs from this project in its next iteration

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

This project will utilise enhanced computational hardware and specialist expertise beyond that available within the ESO. It will develop cutting edge modelling of carbon emitting assets to determine optimum dispatch behaviour to minimise carbon intensity and cost, increasing the accuracy of carbon intensity of balancing actions at a half hourly resolution.

A wide range of large data sets will be required to train the model developed to ensure representation of the carbon generation assets with greater accuracy. Where some of this data may be deemed sensitive by data owners and therefore may not be accessible, the model may need to be built by using theoretical scientific knowledge and data.

Relevant Foreground IPR

The following foreground IP will be generated in the course of the project:

- Models for the performance of power plant carbon intensity.
- A PoC tool to optimise the dispatch of the plants on the grid with respect to the carbon intensity of the energy produced.
- A report with an overview work completed, potential impact and limitations identified. This will include recommendations for follow on R&D projects to further develop and operationalise outcomes of the project, identifying additional data that would allow development of a more accurate model or optimiser.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

1. A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at https://www.nationalgrideso.com/future-energy/innovation
3. Via our managed mailbox innovation@nationalgrideso.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at https://www.nationalgrideso.com/document/168191/download.

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

Due to the nature of the project and that it is researching potential modelling of carbon intensity and possibility of carbon optimisation using large sets of data, this does not fall into current business as usual (BAU).

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 TRL of the overall project is relatively low. Therefore, innovation funding is more suitable for exploring the project's potential and increasing the TRL before transferring into subsequent development.
- Conducting this project with NIA funding will ensure that the project findings can be shared more widely with other interested Network Licenses and enable more collaboration and cooperation when accessing required data.
- There are increased risks associated with the availability of required data and a high level of assumptions, which makes this project better suited to NIA.

This project has been approved by a senior member of staff

☑ Yes