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

Oct 2023

Project Reference Number

NIA2_NGET0051

Project Registration

Project Title

Interaction of Megawatt e-Trucks with Transmission System (I-MeTTS)

Project Reference Number

NIA2_NGET0051

Project Licensee(s)

National Grid Electricity Transmission

Project Start

November 2023

Project Duration

2 years and 5 months

Nominated Project Contact(s)

Muhammad Shaban

Project Budget

£652,380.00

Summary

There are sectors of the transport system, such as buses and heavy goods vehicles, which have proven challenging to electrify due to their high energy demands. The expected adoption of EVs is a challenge to networks across the globe as they expect to plan network to facilitate the demand growth followed by the transport electrification. Megawatt charging system of eTrucks has the potential to help plan the charging of eTrucks. This proposal aligns with the focus areas of our Innovation strategy. This project will investigate charging infrastructure and its impact on our network. The project will produce models that will accurately assess the impact of a roll out of EV Trucks across our license areas. The key deliverables will be shared with all RIIO licensed UK DNOs for their own use.

Nominated Contact Email Address(es)

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Problem Being Solved

The next decade will see rapid progress and investment in zero emission technology options for electric vehicles (EV), including light-goods (LGV) and heavy-goods vehicles (HGV) alongside deployment of supporting infrastructure and increasing demand from businesses. The government's ambition is to phase out polluting cars and vans (light commercial vehicles) weighing from 3.5 to 26 tonnes in 2035 and intends to phase out the sale of new diesel and petrol HGVs weighing more than 26 tonnes in 2040. This is following the UK Government commitment to end the sale of new petrol and diesel cars by 2030 and for all new cars to be fully zero emission at the exhaust by 2035.

National Grid Electricity Transmission (NGET) identified a requirement for "other modes of road transport to have access to rapid charging / refuelling facilities along the motorways and major A&B roads in England" (NG Supporting the growth of clean transport, Decarbonising Heavy Goods Vehicles on the Strategic Road Network, May 2022). To satisfy the market demand of the truck industry and charge electric heavy-good vehicles (eTruck) within a reasonable time, a new solution for high-power charging is developing. It is expected that the bulk of eTrucks recharging or refuelling will take place at a depot or end location, but the market needs enroute provision too. This will require the development of Megawatt Charging System (MCS), or/and DC Fast Charging with a typical power

output of 50kW - 350kW. The Megawatt Charging System is designed for a charging voltage of up to 1,250 Volts and a current of 3,000 Amperes, theoretically equivalent to a charging power of up to 3.75 megawatts.

The characteristics of Megawatt Charging System electricity demand have a significant impact on the grid due to their relative inflexibility, high power requirements and spatial concentration. This is an emerging topic because despite their significant impact, the operational impacts of MCS on the power grid have not been fully studied in the literature unlike charging for passenger cars.

Method(s)

This study is broken down into the following work packages and deliverables:

Work package 1:
This WP reviews the state-of-the-art of charging technologies, codes, standards, charging options, and road freight activity.

Work package 2:
This WP reviews etrucks Electric Fleet Charging Load Profiles. This will identify the interconnection capacity need / grid reinforcement for different future scenarios.

Work Package 3:
WP3 investigates grid requirements for eTrucks charging and their impact on the grid pprojections for levels of EV adoption continue to be revised, which makes studying the impact of this new type of demand on the power system increasingly important, particularly in the context of light-goods and heavy-goods vehicles.

Work Package 4:
WP4 studies mitigation systems for impact on the grid of eTrucks MCS. Simulations will be run by applying various charging strategies which allow to reduce the peak load at the grid connection point.

Work Package 5:
This WP will develop a High-power EV charging emulator. Development of an experimental laboratory platform at the School of Engineering, Cardiff University to emulate charging stations with different power levels. Perform battery measurements at the cell level (e.g., charge at very high currents) providing scalability and flexibility at larger levels.

Scope

This is a research project to understand the electrical impact of EV Trucks within the UK. Over the 30-month project, we will carry out literature review, modelling, simulations, and developments to provide with specifications of connecting Megawatt charging systems. The main work packages of the technical concept study are:

WP1.1 – Scoping and Review of codes and standards for high power charging.
For example, charging system components, energy service interface, architecture of fast charging stations.

WP1.2 – Review of battery-electric truck wired stationary charging options (public fast, ultra-fast and destination/depot charging).
The eTruck charging technology will be classified presenting the commercially available solutions (e.g. nominal power output) and the industry trend. The range of solutions and data available to support the analysis will be produced.

WP1.3 – Review of road freight activity based on existing studies and statistics.
This task will assess requirements and assumptions for the modelling studies. EU Regulation on driving times and rest periods is still applied in the UK and, according to these rules, the maximum daily driving period is 9 hours (10 hours in exceptional cases), and the minimum rest periods is (at least) 9 hours. Mandatory breaks of 45 minutes every four and half hours are legally required, which can be split into two breaks of 30 and 15 minutes. These will be used for assessing the charging patterns based on road freight activity.

WP2.1 – Generating load profiles for eTruck charging (depot, long-haul stops and enroute charging) including slow and fast charging.
Because fleet operational data is highly variable and uncertain, the analysis will use, for example, a Monte Carlo simulation to evaluate probabilistic distributions of fleet schedules to develop reasonable boundaries of potential charging profiles.

WP2.2 – Evaluation of charging demand for eTrucks using NGET charging scenarios (as presented in Supporting the growth of clean transport, Decarbonising Heavy Goods Vehicles on the Strategic Road Network, May 2022).
Several study cases will be identified (e.g., operating centres/depots, long haul stops and enroute charging) and realistic charging load profiles from WP2.1 will be used considering vehicle traffic flow.

WP2.3 – Forecast power demand and peak-demand from MCS of eTrucks (e.g., maximum charge rate is capped at 350kW based on the Megawatt Charging System standard). This could identify the interconnection capacity need / grid reinforcement for different future scenarios. Assess if the extreme scenario with a maximum charge rate of 350kW, based on the Megawatt Charging System standard, is introducing a new grid peak.

WP3.1 – Impact of high-power and megawatt charging on the transmission networks.
The charging infrastructure demand for eTrucks (including both light and heavy trucks) is diverse depending on trip distance. Charging options are classified as: public high-power and megawatt charging, semi-public and overnight charging (at the place of commercially loading/unloading of freight), public during resting periods, private at the depot (destination) and home (for LGVs).
The project will build a simulation environment to study the impact of high-power and megawatt charging on the grid due to the movement of eTrucks and the associated density value. Transmission networks incorporating public high-power and megawatt charging will be modelled in detail. Each modelled high-power charging station will be connected to the transmission system (e.g., Tesla Supercharger network). The individual charger demand profiles are summed at each station to create a station-level demand to be served by the power grid.

WP3.2 – Future scenarios Extrapolate the supercharger network to 2030, 2035 and 2040 scenarios (e.g., using DfT's predictions). The power flow analysis will be performed, assessing the spatial-temporal impacts of additional pulsating load demand from public fast and ultra-fast charging.

WP4.1 – Charging scenarios and their power requirements illustrating the broad range of charging options with an input from WP1.3. Assumptions on the specific energy consumption and resulting charging energy needs will be evaluated for the following charging options:
High-power and megawatt public charging along the motorway long-haul traffic (highly frequented charging stations). Public charging during resting periods (slower charging).
Remote semi-public and overnight charging (at the place of commercially loading/unloading of freight) and at the depot (destination).
Commercial logistics hubs combining long-haul and short-haul trucks.
The methodology will consider analysis of highway traffic flow along with truck mobility patterns, stochastic simulation of truck arrivals (variation of the station density), charging infrastructure requirements, required grid connection power. Extreme scenarios of high traffic volume and low traffic volume will be considered.
Real data of Heavy-Duty Electric Fleet Depot Charging Load Profiles (15-min. average demand) from NREL will be used for this study.

WP4.2 – Charging management, assess the 9-hours rest period (including overnight) charging management options, giving priority to fast charging and ultra-fast charging. The impact on the grid depends on the maximum number of eTrucks which are charging simultaneously. So, a charging management in combination with their respective rest period could mitigate this impact. We will use different traffic flow patterns and eTrucks fleet composition as case studies.
For the highway charging use case, where eTrucks typically connect for shorter periods of time and drivers seek to charge as fast as possible within that window, charging management offers limited value so the impact on the grid will be higher.

WP4.3 – Charging scenarios in combination with local stationary storage. Assess the minimum battery energy storage systems (BESS) required for reducing the charging peak power demand by considering the charging scenarios from WP4.1. This will use individual demand profiles of the previously analysed scenarios. Assessing savings in grid connection costs.

WP4.4 – Charging scenarios in combination with local renewable generation. Scenarios will consider renewable generation installation at the site or depot charging in proximity with renewable generation (e.g., wind farms in rural area) to smooth the charging demand.

WP4.5 – Charging scenarios in combination with both local BESS and renewable generation. Assessment of their performance in reducing peak demand and the impact on the grid will be explored.

Objective(s)

The main objectives of the project are:

- Detailed review of existing technologies, standards and regulations, commercially available solutions for high-power, megawatt charging.
- Modelling studies of the charging demand patterns for different charge types, generating electric trucks fleet charging load profiles.
- Forecast power demand and peak-demand from MCS of electric trucks.

- Analysis of the impact of high-power and megawatt charging on the grid. Evaluation of the whole system requirements for high-power and megawatt charging.
- Assess the performance of different mitigation systems to reduce the local concentrated peak demand.
- Validation of charger/battery models through laboratory experiments.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project ensures that NGET and the UK energy industry are at the forefront of global developments in enhancing network capacity to meet the increasing demands of customers. With access to the latest research development in the charging systems for eTrucks, NGET will be able to plan effectively and efficiently which could deliver savings. Furthermore, the leveraged funding mechanism ensures that expensive research can be carried out at subsidised rates, thereby ensuring the best value for consumers' money. The project will not restrict benefits delivered to vulnerable consumers based on any vulnerability class.

Success Criteria

This project will be successful if:

- An improved understanding of charging system for electric trucks is achieved.
- An improved understanding of charge demand pattern by means of modelling studies different charge types, generating eTrucks fleet charging load profiles is developed.
- An appraisal and assessment on the analysis of the impact of high-power and megawatt charging on the grid. Evaluation of the whole system requirements for high-power and megawatt charging.
- Assess the performance of different mitigation systems to reduce the local concentrated peak demand.
- Validation of charger/battery models through laboratory experiments.

Our overall objective is to develop an understanding of the Megwatt charging system which can deliver the quality of service required for future electrification of transport.

Project Partners and External Funding

The following project partners will be supporting the project:

- HV laboratories at Cardiff University will make use of existing instrumentation and laboratory general facilities at no extra cost to the project.
- NGET is providing all the funding for the project and is the lead project partner.ESO and NGED are also involved in the project for learnings.

Potential for New Learning

There is very limited amount of work being done in this area. This work will provide the basis of our understanding of the capabilities of this technology and its limitations. The work will be valuable resource for National Grid and will be an asset in developing our strategy.

Scale of Project

Laboratory studies will be undertaken to demonstrate the testing and studies. As such there is no scope to reduce the scale of the project any further.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

Laboratory studies to be performed at Cardiff University.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£587,142

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 project facilitates energy system transition by helping NGET to understand the increasing demand from transport electrification, especially on fast charging behaviours from electric trucks, to facilitate the network planning process to delay or avoid network investment.

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 research project and early TRL.

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

This will be a GB system wide method. The demand forecasting methods expected to be explored here would be applicable to strategic network planning in every GB network. Nonetheless, this maybe more or less applicable depending on data availability.

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

N/A

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

The project will deliver the methodology, prototypes, and specification for business solution to reflect uncertainties around Megawatt charging on forecasting scenarios and network planning. This will then be tailored to National Grid systems and data but will be available to energy partners who face the same challenges and wish to use the project outputs for their purpose.

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.

There is no overlap between this work focusing on the impact on transmission system and technical requirements and work currently under way in different trials.

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

There are currently no NIA/SIF projects looking at Megawatt charging within the UK. There is significant progress in the development of individual charging technologies but the integration of these devices as a megawatt charging system is limited to several trials worldwide. These trials are mainly focuses on buses and there is limited demonstration work for the infrastructure requirements. There is no overlapping between this work focusing on the impact on transmission system and technical requirements and work currently under way in different trials.

Relevant Foreground IPR

The foreground IPR will be the knowledge gained about Megawatt charging system. The learning will be brought together in a decision support tool which will also form part of the foreground IPR.

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:

- 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 already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

The nature of a research programme means it inherently carries a risk that the research may be unsuccessful and/or identify unforeseen barriers to implementation and National Grid is unable to consider research of this scale as business-as-usual. The NIA funding offers the most appropriate route for NGTO to evaluate the how best the electricity infrastructure can support an electrified transportation system. As relatively little is known about the technology and its low TRL level, this justifies the use of NIA.

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 technology is a low TRL level and there is currently little information available without carrying out a proper feasibility study. The work has not been undertaken elsewhere before and the results could have significant impact on business planning. The results will benefit other energy networks making NIA the most appropriate route.

This project has been approved by a senior member of staff

☑ Yes