nationalgrid

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

May 2018

Project Reference

NIA_NGTO001

Project Registration

Project Title

Electric Road System for Dynamic Charging of Electric Vehicles

Project Reference

NIA_NGTO001

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2018

Project Duration

2 years and 6 months

Nominated Project Contact(s)

Robin Gupta

Project Budget

£308,000.00

Summary

N/A

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

The UK Government announced plans to ban the sale of new diesel and petrol cars by 2040 and electric vehicles are the most promising alternative solution for decarbonisation of the transport sector. A good charging infrastructure is the main factor for electric vehicles uptake. Multiple types of charging points are now installed and according to online database Zap-Map, there are currently approximately 10,800 public connectors in the UK. There are now estimated to be in excess of 70,000 pure electric vehicles on UK roads. That is about six vehicles for every charging point, before adding plug-in hybrids. One of the questions we are faced with today is around the impact this new entrant into the transport system is going to have and how best can the electricity infrastructure support this. If electric vehicles could recharge while driving on a motorway (charge-as-you-drive), it will eliminate the main concerns about the range and lower their cost, making electricity the standard fuel for vehicles. Using these charging technologies, the driver could actually have more energy stored in their battery at the end of the trip than when started the trip.

Limited road trials of the technology needed for dynamic charging of electric vehicles on the UK's major roads are taking place. Some

of these trials are based on the feasibility study commissioned by Highways England into 'dynamic wireless power transfer' technologies.

But installations in roads open to normal traffic are very limited and limited data has been published. Therefore, it is important to review the existing charging solutions and identify the existing standards to find the gaps between the current solutions and the need for new regulations and standards.

Method(s)

There is significant progress in the development of individual charging technologies but the integration of these devices in the road infrastructure is limited to a number of trials worldwide. These trials are mainly focused on buses, and there is limited demonstration work for the infrastructure requirements for dynamic charging of private cars.

The project aims to assess the feasibility of on-road power transfer solutions for dynamic (on the move) charging of electric vehicles. The practicalities of whether an inductive system can be readily integrated will be assessed along with the impact of dynamic charging on the transmission and distribution networks.

Dynamic power transfer is defined by the power which is transferred while vehicles are moving in normal traffic. This solution will require an integration with road infrastructure in order to ensure their optimum functionality.

This project will investigate if the dynamic charging technology is feasible, applicable and electrically safe by using (i) evidence based review of existing knowledge in drivers of change, (ii) qualitative and quantitative analysis of demand patterns for charging, (iii) design power station topologies, completed with (iv) modelling and simulation studies for producing realistic scenarios.

Scope

The main work packages of the technical concept study are:

WP1.1 – Scoping and Review of dynamic charging technologies. The project will identify from available material the existing standards and regulations for the operation of the electric power system, the development of dynamic charging, wireless power transfer, communication requirements and electrical safety regulations.

WP1.2 Review of existing charging solutions in relation to charging type (static inductive charging, semi-dynamic charging, dynamic charging and combined static charging with dynamic charging). Then the electric vehicle inductive charging technology will be classified presenting the commercial available solutions and the industry trend. The range of solutions and data available to support the analysis will be produced.

WP2 Impact of dynamic charging on the transmission/distribution networks. The main aim of this work is to develop a model for simulating the charging demand patterns on a charging lane and build study cases to assess the impact of dynamic charging on the grid. The dynamic (on the move) charging will result in an increase in demand variability due to spatial and time variability caused by charging track layout and traffic. Very few requirements specifically around on-road power transfer solutions are known to date.

WP2.1 Development of a model for dynamic charging. The project will build a simulation environment to study the impact on dynamic wireless charging on the grid due to the movement of electric vehicles and the associated density value. The charging line is split in sections (charging pads) and the dynamic charging based on the detection points associated with the charging pads will be simulated. The power flow analysis will be performed for different grid configurations, assessing the spatial-temporal impacts of additional demand, introduced by charging lanes. The most performant topology will be selected based on the performances analysis.

WP2.2 Evaluation of charging demand. A complete day demand data based on traffic behavior (fast traffic, slow traffic, traffic density) will be generated. Then a number of study cases will be identified based on traffic (e.g. commuting inter-urban patterns, urban patterns, low/medium/high traffic density) and the overall demand on a charging lane due to electric vehicle traffic will be analyzed. The relationship between vehicles traffic flow and power flow/consumption will be assessed.

WP2.3 Integration of solar generation to smooth the charging demand pattern. Solar energy can be used to supply electric vehicle charging stations and smooth the charging demand pattern. In this study the daily balance of EVs charging demand and solar generation for different study cases will be investigated and the power demand reduction due to solar generation will be assessed.

WP3.1 Distribution / transmission network requirements for dynamic charging. The project will identify the requirements for dynamic charging from the power system perspective, based on the following characteristics identified in the modelling study in WP2: maximum expected load, supply voltage, continuous of service for EVs charging (supply is supported by multiple sources e.g. solar generation),

extendibility (e.g. transformers with increased capacity or/and with dynamic loading capabilities), maximum allowed currents for the conductor type, electrical efficiency (loss minimization for transformer and cables), comply with the voltage constraints (maximum voltage drop), power quality, harmonics, fault location and restoration (protection scheme).

WP3.2 Power system requirements for the charging system. The project will consider the following parameters for identifying the requirements for the charging system: primary power transfer unit and voltage level, the size of the substation based on operational conditions identified in the modelling work in WP2, cables type and connection topology, type of road side equipment, converters (DC to AC or vice versa), meters to measure the energy consumed by the EV fast charge point, control devices, protection devices. Electrical safety requirements are extremely important as a near field energy transfer. Trade-off between efficiency (efficiency of such systems deteriorates exponentially with the distance) and safety will be analyzed with a view to identify the best solution.

WP4 Comparative study of magnetic design topologies. Generally all existing high power wireless energy transfer systems use a resonant magnetic induction method as this approach currently provides the highest efficiency over an air gap. The wireless power transfer system consists of the primary circuit, magnetic coupler and the secondary circuit. In dynamic charging, the EV with the embedded excitation coil, is moving on a road and a series of track primary stationary coils are installed under the road. The main aims of this WP is to (i) compare different combinations of primary and secondary pad topologies (parallel flux only, perpendicular flux only, and hybrid flux designs) based on the present options for stationary systems, (ii) build the model for each topology and (iii) evaluate their performances indices for power transfer efficiency and transferred power with respect to design parameters.

Objective(s)

The project will investigate the technical concept of dynamic charging and the main objectives of the project are:

(i) Detailed review of existing technologies, standards and regulations, commercial available solutions and trials worldwide

(ii) Simulation of the charging demand patterns for different case studies

(iii) Analysis of the impact of dynamic charging on the grid

(iv) Evaluation of the distribution / transmission network requirements for dynamic charging

(v) Design of different power station topologies and analysis of their performances

(vi) Modelling studies of dynamic charging technologies and evaluate their performances.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be successful if:

An improved understanding of dynamic inductive charging of electric vehicles is achieved

An improved understanding of whether charge-as-you-drive technology is capable of delivering the quality of service required for future electrification of private transport. This applies equally to private cars, buses and trucks, both in urban and inter-urban areas

An appraisal and assessment of technical technologies required for the transmission and charging system for the implementation of the dynamic charging

Modelling analysis of the dynamic charging of electric vehicles to assess the feasibility of this technology to support the mass movement of electric powered vehicles can be produced

An analysis approach is able to highlight the challenges and associated risks

Follow-up development in this area is identified

Our overall objective is to understand whether charge-as-you-drive technology is capable of delivering the quality of service required for future electrification of private transport.

Project Partners and External Funding

This project will be delivered by Cardiff University.

Potential for New Learning

There is very limited amount of work being done into charge-as-you-go infrastructure requirements. This work will provide the basis for our understanding of the capabilities of this technology and its limitations.

Scale of Project

This project is desk based with perhaps, minimal laboratory testing. As such there is no scope to reduce the scale of the projects any further.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The research undertaken will be carried out in the UK, although the programme also reviews the latest research from across the world.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£308,000

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)

If the problem is solved and the concept of dynamic charging is proved feasible (from technological and impact point of view), this new technology will eliminate the main concerns about the electric vehicles range and lower their cost, making electricity the standard fuel for vehicles. The project will assess the technical concept of dynamic charging and the assessment of the impact of such technology to the transmission system

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

This will be a GB system-wide method

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

This project is focusing on research investigating the technical feasibility of dynamic charging of electric vehicles. The real implementation of this method across GB is outside the scope of the current project.

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)

Service Delivery and Corporate Responsibility

☑ 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.

There is significant progress in the development of individual charging technologies but the integration of these devices in the road infrastructure is limited to a number of trials worldwide. These trials are mainly focuses on buses and there is limited demonstration work for the infrastructure requirements for dynamic charging of passengers' cars. Installations in roads open to normal traffic are very limited and limited data has been published.

At present we are aware of bus demonstration projects in Milton Keynes and Cambridge but no reports or data are currently available. 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.

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

Charge-as-you-go infrastructure requirements are a relatively new area of research for NGTO, driven by the UK Government's recently announced plans to ban the sale of new diesel and petrol cars by 2040. As an industry, there is only a limited amount of work being done to better understand this challenge and this work will provide the basis for our understanding of the capabilities of this technology and its limitations.

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

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 electrifed transportation system.

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 inherent risk of the project is detailed above and the learning from the project will be directly relevant to all Network Licensees. For this reason, NGTO believe this project is appropriately funded through NIA.

This project has been approved by a senior member of staff

☑ Yes