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.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

NIA Project Close Down Report Document

Date of Submission

Jun 2022

Project Reference

NIA_WPD_055

Project Progress

Project Title

Dynamic Charging of Vehicles

Project Reference

NIA_WPD_055

Funding Licensee(s)

WPD - Western Power Distribution (East Midlands) Plc

Project Start Date

December 2020

Project Duration

1 year and 3 months

Nominated Project Contact(s)

Ricky Duke

Scope

This project is a tabletop feasibility study and research project to understand the electrical and physical impact of DWPT technology within the UK. Over the 11-month project, we will carry out modelling and simulations of a case study in Coventry to provide DNO's with the specification for connecting this to the distribution network.

Objectives

- Assess the electrical impact of DWPT technology on the distribution network
- Examine issues such as earthing and having multiple connection points
- Model DWPT on a selected case study within Coventry
- Review current DWPT technologies already available worldwide
- Deliver a set of Electrical values which can be adopted into WPD modeling as business as usual
- Report on the feasibility of DWPT in the UK
- Forecast DWPT uptake within the UK
- Evaluate the business case and feasibility for DWPT in the UK

Success Criteria

- Assess the viability of DWPT rollout within WPD's license areas, both electrically and physically

- Review of current DWPT or continuous charging systems available worldwide
- Development of model to accurately assess impact on the distribution network
- Delivery of a set of Electrical values for WPD to incorporate into in-house planning tools for BaU
- Dissemination of the results to other UK DNO's and stakeholders

Performance Compared to the Original Project Aims, Objectives and Success Criteria

This Project completed all of its aims, objectives, and success criteria.

Objectives

- Assess the electrical impact of DWPT technology on the distribution network – Complete

o Based on desktop study required for real-life data on electrical impact. The WP3 report contains an assessment of electrical impact including demand on network and power quality.

- Examine issues such as earthing and having multiple connection points – Complete

o The ElectReon system requires the DNO's earth to be supplied to the management unit (MU), where an additional earth electrode is connected to the same earthing system. The coil segments are earthed via the MU. The Network connection architecture is discussed in the WP3 report.

- Model DWPT on a selected case study within Coventry - Complete

o The WP3 report describes two scenarios, Public Service Vehicles and mixed-fleet. Simulation results are provided for both scenarios and detailed within the projects reports.

- Review current DWPT technologies already available worldwide – Complete

o The WP2 literature review contained a summary of DWPT solutions and existing deployments (past, current and planned) worldwide. DWPT is at an early stage of demonstration and deployment, with only a few current and proposed projects identified around the world. ElectReon is the only active provider in the market, with other companies having been acquired or focusing their technologies on non-DWPT scenarios.

- Deliver a set of Electrical values which can be adopted into WPD modelling as business as usual – Complete

o The WP4 report contains an indication (for the ElectReon technology) of the power rating of DWPT Management Units for different trials. For the DWPT demonstrator at the case study location, the Management Unit rating is 173kVA. The WP4 report also provides a load profile for the two scenarios providing peak demand and times of day, unsurprisingly the peak demand coincides with peak traffic flow from commuter traffic.

- Report on the feasibility of DWPT in the UK – Complete

o It was established that it is physically feasible to create a DWPT demonstration project on Kenilworth Road in Coventry. Investigations have shown that there are no existing underground utility apparatus present at the proposed locations that would prevent an installation. Furthermore, it was established that a network connection of 160kVA is available without the need for upstream network reinforcement at this location.

- Forecast DWPT uptake within the UK - Complete

o While there may be incentives to introduce an electrification enabler such as DWPT, other potential solutions (such as hydrogen, better batteries and ultra-rapid charge points) will compete for attention and funding. Other considerations such as the complexities of infrastructure development and supply chain development may also affect the opportunity to gain traction for DWPT. A number of uptake scenarios were defined in the WP4 report.

- Evaluate the business case and feasibility for DWPT in the UK – Complete

o The business case for different DWPT uptake scenarios were assessed in WP4. From the scenarios explored in the modelling, only one (HGVs on the motorway network) comes close to cost parity with conductive charging on a marginal cost basis. Applying DWPT for buses and coaches on urban 'A' roads is the least economic scenario.

Success Criteria

- Assess the viability of DWPT rollout within WPD's license areas, both electrically and physically – Complete

o It was established that it is physically feasible to create a DWPT demonstration project on Kenilworth Road in Coventry. The overall peak demand at the distribution substation chosen was unlikely to cause any problems with available capacity or network reinforcements, but there may be peak demand issues on the feeding primary substation. There is still uncertainty around power quality effects from the varying voltages and frequencies that can be present in this technology.

- Review of current DWPT or continuous charging systems available worldwide – Complete

o The WP2 literature review contained a summary of DWPT solutions and existing deployments (past, current and planned) worldwide. Only ElectReon are present in the market with a DWPT product, other systems such as catenary are also looked at within the report.

- Development of model to accurately assess impact on the distribution network – Complete

o The WP3 modelling work simulated energy demand for different use cases. The modelling looked at various factors that looked at wide scale deployment and utilisation of DWPT, types of roads, traffic flow information, traffic speeds etc. this allowed us to model electrical demand based on these factors and create various scenarios based on usage.

- Delivery of a set of Electrical values for WPD to incorporate into in-house planning tools for BaU - Complete

o The electrical values formed part of WP4 report, which detailed peak demand per km and peak demand of this technology is to be utilised across the network. It also provided peak demand per management unit which supplies each 100m section of DWPT coils. Also provided was a load profile based traffic flows, speed of vehicles and lengths of coils to determine the demand at specific times of day

- Dissemination of the results to other UK DNO's and stakeholders – Complete

o All project deliverables and reports have been published on our website and the hyperlinks to these reports are below, along with the monthly NIA reports, annual ENA reports and a closedown report. A webinar took place at the Future Roads and Infrastructure conference on Tuesday 16th November 2021, and a link to the presentation where other DNO's and stakeholders were present is found here: https://vimeo.com/640129022/d952645b32. The project team were also present at the Society of Motor Manufacturers and Traders (SMMT) in July 2021

Required Modifications to the Planned Approach During the Course of the Project

In March 2021, Toyota Tsusho UK chose to withdraw from the project. ElectReon, a DWPT provider, agreed to become a partner and was able to fulfil the role in the project that had originally been envisaged for Toyota Tsusho UK which was to provide information on the supply chain of this equipment. ElectReon made valuable contributions at partner meetings and in reviewing project deliverables and provided real-world experience of DWPT installations.

There was a minor reporting change in the project; the business case, which was originally part of WP3, was moved to the WP4 report. It was agreed that t the business case fitted better in the WP4 reporting. This was because the business case could not come before the modelling work carried out in WP3, once the modelling work around the utilisation and deployment of DWPT the business case was able to be derived from that data and suited the WP4 report better.

Lessons Learnt for Future Projects

- DWPT operates at frequencies between 10 and 100 kHz, often centred on 85 kHz, and requires AC/DC and DC/AC converters to increase the frequency of power supplied, this could have an impact on power quality depending on the efficiencies and how the technology is being utilised.
- Variations in air gap, lateral alignment and longitudinal alignment, mean that DWPT systems must be designed to give acceptable power transfer efficiency when misaligned.
- DWPT deployments should adopt a modular design to allow for scalability and reduce distribution network impacts. All DWPT solutions consist of a Management Unit (MU), Ground Assembly (GA) and Vehicle Assembly (VA) for which the MU and GA is controlled by the installer of the coils.
- The take up of this technology will depend heavily on vehicle manufacturers adopting this technology and installing VA (Vehicle Assembly) or receiver units on their vehicles.
- A total of eight DWPT demonstrations or deployments have been identified around the world with most projects focusing on supplying power to heavy vehicles such as trucks or buses. This is significant as at this stage of the technology lifecycle, it is not deemed feasible for privately owned passenger cars.
- ElectReon is the only active participant in the DWPT market at present.
- Early learning has determined that the lack of comprehensive standards across all the elements of technology, installation and use of DWPT is currently a risk for future deployment. To avoid problems of interoperability, tailored standards on the type and placement of receiver coils, compliance with roadway construction and safety regulation to standards of service, information sharing, data collection and payment will be required.
- Power Quality – DWPT systems are made up of various electronics that will have an impact on the power quality at the point of connection to the network. Impacts such as harmonics are discussed within the report but can only truly be detailed using a live trial.
- The cost to install DWPT is at a best case scenario three times more expensive than traditional conductive charging. This is taking into account the most likely scenarios and comparing with traditional methods. This is a significant barrier to wide scale rollout and for DWPT to be realised in the UK either the costs of purchasing and installation will need to be reduced or the costs per kWh will increase significantly to outweigh any potential savings through reduced battery sizes.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

Work package two found that there were eight other projects which have demonstrated this technology, but only one supplier worldwide. It also found that there would be work needed for it to comply with all the existing standards which surround things on highways, electromagnetic emissions, and cyber security.

The third work package was a modelling task based on a case study location. This found indicative demands for a vehicle passing over a DWPT system, and then combined this with the traffic modelled in the area, the expected state of charge, and how that would vary throughout the day. This found that for various scenarios, it would add to the demand at the evening peak as most people are travelling home from work with a car that would be at lower charge than in the morning. This means it will not help us as a DNO with our flexibility aims, in a way that conductive charging could.

The fourth work package looked at the business case from the charge point operators' point of view, to determine if a DNO should expect to see these on the network soon. This found that the best business case was marginal at best, which is to fit the vehicle receiver coils to Heavy Goods Vehicles, and lay DWPT on motorways. This is because HGVs spend a lot of time on motorways and fitting DWPT there would amplify the effects of the installation. The case from the DNOs point of view for this technology was that it

would allow us to provide charge to HGVs in a more distributed manner, and allow us to install DWPT in areas which currently have spare capacity and avoid the need for expensive reinforcement. However, there are numerous technological and regulatory barriers to its uptake in the UK, and as a result, we are not expecting to receive connection requests for these in the near future.
A Draft paper was submitted for peer review, titled Determining the social, economic, political and technical factors critical to the success of dynamic wireless charging systems through stakeholder engagement
https://www.mdpi.com/journal/energies/special_issues/Wireless_Transfer

Data Access

To request access to project data, please visit: www.westernpower.co.uk/Innovation/Contact-us-and-more/Project-Data.aspx
9. Foreground IPR

Foreground IPR

All reports are available upon request.

Report: Literature Review Dynamic Wireless Power Transfer
Ownership: WPD / Cenex Report:

Report: Modelling and Simulation of DWPT technology and Case Study
Ownership: WPD / Coventry University

Report: Deployment Analysis and business case for DWPT
Ownership:WPD / Cenex / Coventry City Council / Coventry University and Hubject

Report: DynaCoV Summary and Feasibility Report
Ownership: WPD / Cenex

Planned Implementation

This feasibility project looked to determine if DWPT is a viable option of dynamically charging of vehicles, which would involve installing equipment under the road surface, retrofitting equipment onto electric vehicles and having a network connection suitable for its demand.
From a network operator's perspective, the increase demand on the network is predictable due to the nature of the management unit controlling the power draw. However, peak demand from this technology coincides with the existing morning and early evening peak demands on the network, so is unlikely to help with our flexibility aims, unlike how conductive charging could (as investigated in Electric Nation and Electric Nation: Powered up). The benefit from the DNO's point of view is that it can disperse the load spatially in a way that conductive charging would struggle to do. For example, we could charge HGVs over a whole length of motorway rather than it being concentrated in a depot. This means we could utilise areas which have spare capacity to fit DWPT to avoid reinforcement.
There are still unknowns surrounding key electrical properties like power quality and fault level, so more would have to be done before a trial which connects to our network. There are also numerous technological and regulatory barriers and currently the technology is prohibitively expensive, as found in the Work Package four, so we are not expecting to be receiving connection requests for these in the near future.

Other Comments

None

Standards Documents

Not Applicable