WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

ELECTRIC NATION (CarConnect)

WPD_NIA_013

NIA MAJOR PROJECT PROGRESS REPORT

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31/10/2018	1.0	Final

Contents

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1 Executive Summary

Electric Nation (the customer facing brand of CarConnect) is funded through Ofgem's Network Innovation Allowance (NIA). Electric Nation was registered in April 2016 and is expected to be complete by October 2019.

Electric Nation aims to enable DNOs to identify which parts of their networks are likely to be affected by Plug-in Vehicle (PIV) uptake and domestic charging, and whether PIV domestic charging demand management services are a cost effective solution to avoiding or deferring reinforcement on vulnerable parts of their networks, using three methods:

Method 1: Modelling

This project will provide DNOs with an assessment tool to predict where PIV market penetration may cause network problems through increased demand for domestic PIV charging. This tool will, firstly, enable assessment of all (non-meshed) LV networks in a DNO's licence area to identify those most likely to be affected by increased penetration of domestic PIV charging. Secondly, the tool will enable more detailed assessment of those LV networks to identify the level of domestic PIV charging penetration that would present a problem and trigger reinforcement and enable assessment of domestic PIV charging demand control, and potentially Vehicle to Grid (V2G), as solutions to avoid or defer reinforcement.

Method 2: Monitoring

This project will develop an algorithm deployable on an existing substation monitoring facility that will enable the effect of charging PIVs on a LV network to be retrospectively analysed and allow the measurable impact to be compared against the modelling tool output.

Method 3: Mitigation

This project will adapt existing smart charger technology, potentially including V2G chargers, if state of technology development is sufficiently advanced during the project timeframe, and existing commercial charger management services to deploy these in a mass-market customer trial. The aim of the trial is to prove the technical/economic viability of domestic PIV charging demand control and V2G services, to avoid or defer network reinforcement and to prove that such systems are acceptable to customers. The customer trial will include a wide range of PIVs, with a range of battery sizes and charging rates to assess to what extent such systems can be deployed in a future with a diverse PIV market.

This report details progress of the project, focusing on the period April 2018 to September 2018.

1.1 Business Case

As groups of neighbours acquire PIVs, localised clustering of demand is likely to cause problems for electricity networks, as demonstrated through the (Low Carbon Networks Fund) My Electric Avenue (MEA) project. MEA showed that approximately 30% of GB low voltage networks will need reinforcement by 2050, if adoption of PIVs (and domestic charging) is widespread (i.e. meeting DECC's High EV Market Growth Forecast). This represents a present day cost of £2.2bn to UK customers – Transform Model® analysis, based on UK Government forecasts of nearly 40 million PIVs on UK roads by that time. The UK Government is committed to the electrification of transport – as illustrated by its recent investment into ultra-low emission vehicles (ULEV) such as its extension of grants for PIV chargers, PIV car subsidies and the Go Ultra Low Cities Scheme.

Which parts of distribution networks will be affected by PIV market growth is not understood – the MEA analysis used idealised network types. There is no tool available for assessing real LV networks to identify those at risk from high penetration of domestic PIV charging, and to identify the technical efficacy and economic viability of smart solutions (domestic charging demand control and V2G) against traditional network reinforcement. Through this project, a tool will be developed that will allow the assessment of real LV networks for the susceptibility to excessive demand from domestic PIV charging.

In recent years, "smart" chargers have been developed for domestic and public charging use, which are controllable for access and billing purposes. Alongside these smart chargers, control services have been developed and deployed to carry out this access control and billing services. These smart chargers also give the option to modulate the power taken by PIVs, giving a more refined set of demand control options than trialled in MEA. It is thought that these technologies could be adapted for domestic charger control to provide demand control services to DNOs across LV areas (rather than just single feeders). However, it is not known whether the application of these technologies, for charging PIVs at home, is technically viable and acceptable to customers. The technical challenges include: ensuring secure and reliable communications between the charger and control services; providing customers with information about the charging of their PIV; allowing the customer to state preference as to when they are charged (ensuring the control is as "fair" as possible to all); and investigating what, if any, compensation or incentives customers require to participate in PIV demand control. Also, the PIV market has and will continue to diversify with a range of battery sizes fitted to PIVs and nominal charge rates growing (from 3kW to 7kW+), making possible peak loads higher and adding complexity to the challenge of PIV demand control. Therefore, this project will investigate to what extent it might be possible to utilise domestic PIV charging demand control to defer or avoid some of the £2.2bn cost to UK customers, calculated in the MEA project.

In addition, vehicle to grid (V2G) services and associated technologies are being developed in the UK and abroad. The impact of mass V2G services on LV networks needs to be understood, especially as some V2G services (such as transmission frequency services) may adversely affect distribution network operations, in a similar way to solar PV generation. V2G could be a solution as much as a problem for LV network congestion, in that export mode could be used to address peak PIV demands - but as V2G has not been developed sufficiently at this time this is a poorly understood option. Furthermore, adapting the domestic PIV charging demand control services to utilise V2G export mode to address PIV charging induced peak loads has not been proven. This project aims to explore the technical readiness of V2G technology for domestic use and assess its potential economic feasibility.

1.2 Project Progress

This report covers project progress for the period April 2018 to September 2018.

Project activities in this period have focussed on completing recruitment of customers into the trial (achieved June 2018), demand management events on customer charger points with a winter profile moving to a spring profile over the summer period, continued effort in resolving charger communication issues, the delivery of a second V2G charger for the V2G trial and further development of the Network Assessment Tool.

EA Technology:

- Attendance and presentation at a number of relevant industry events to raise the profile of the Electric Nation project and to share early learning arising from the customer trial;
- Activity on development of the Network Assessment Tool (NAT) focussed on improving bulk data import and processing, development of the substation level user interface and development of a method for distributing EV uptake forecasts to the customer level;
- Customer research through questionnaires at: baseline, post installation, and during the trial;
- Manual testing of V2G chargers on the Capenhurst test system;
- Implementing GreenFlux and CrowdCharge Apps into the customer trial, data gathering and customer research;
- Testing the 2nd generation GreenFlux and CrowdCharge Apps in preparation for the next phase of the project;
- Assisting DriveElectric in resolving charge point communication and back-office integration issues and faults, and tracking the communications performance over time; and
- Moving customers into demand management, scheduling demand management events and monitoring the impact on customers.

DriveElectric:

- DriveElectric has achieved the target of recruiting 700 participants;
- Due to delays of the delivery of new electric vehicles across the UK, project partners agreed the final installation figure could be below 700 – the agreed figure was 673 approved surveys;
- DriveElectric has completed installation of these 673 chargers, with 328 via CrowdCharge and 345 via GreenFlux;
- Recruitment activities have ceased due to recruitment target being reached;
- Fixes for charge point communication issues continue to be monitored, analysed and developed on both PIVDCS systems; and
- Continued documentation of all faults received, including hardware and behavioural, and the fixes used via the CRM system for project learning.

Lucy Electric GridKey:

- Completion of GridKey Project Report: "Electric Nation Functional Requirements Document and Close Down Report; and
- Completion of inputs to the project.

TRL:

- Continued monitoring of project against Key Outputs, Milestones, Actions, Risks and Issues;
- Provision of regular (monthly, quarterly and six-monthly) reports to WPD describing project progress; and
- Providing technical and project management oversight of project delivery and work being carried out by the delivery team.

1.3 Project Delivery Structure

1.3.1 Project Review Group

The Electric Nation Project Review Group meets on a bi-annual basis. The role of the Project Review Group is to:

- Ensure the project is aligned with organisational strategy;
- Ensure the project makes good use of assets;
- Assist with resolving strategic level issues and risks;
- Approve or reject changes to the project with a high impact on timelines and budget;
- Assess project progress and report on project to senior management and higher authorities;
- Provide advice and guidance on business issues facing the project;

- Use influence and authority to assist the project in achieving its outcomes;
- Review and approve final project deliverables; and
- Perform reviews at agreed stage boundaries.

The last Project Review Group meeting was held on 17th January 2018 and the next is being held on the 15th November 2018.

1.3.2 Project Resource

Western Power Distribution (WPD)

Project Manager: Ricky Duke

Project Support: Emily Green

Marketing and Data Provision support as required.

EA Technology (EATL)

EA Technology's primary roles in the project are:

- Project management – delivery of project;
- Management of project supporting activities, such as marketing and, PR for customer recruitment, and customer research;
- Development of the Network Assessment Tool;
- Development of the customer trial programme;
- Management of the PIVDCS suppliers and their input to the trial;
- Development of the PIVDCS algorithm(s);
- Management of V2G trial; and
- Production and dissemination of the project deliverables, reports and learning outcomes.

DriveElectric (DE)

DriveElectric's primary roles in the project are:

- Recruitment of customer trial volunteers;
- All practical aspects of operating the customer trial;
- Customer relationship management (including data protection);
- Supply of PIVs to some of the customers volunteering for the trial (not funded by this project);
- Supply and installation of "smart" chargers, through sub-contractor organisations;
- Customer communications and retention in the trial;
- Supply of vehicle related trial data; and
- Supply of V2G chargers.

TRL

TRL's primary roles in the project are:

- Overarching project overseeing role for all three methods, providing WPD deeper insight into how the project is performing from both a Project Management and Technical perspective;
- Provision of feedback, expert advice, technical review and reporting of project approach and milestones;
- Maintaining the project RAID log, Action Log and Key Outputs and Milestones log, alongside EATL and DE;
- Monthly meeting coordination and reporting;
- Monthly and 6 monthly reporting to WPD;
- Escalation of significant issues to WPD; and
- Independent validation of milestones.

Lucy Electric Gridkey (LEGK) (Now complete)

Lucy Electric Gridkey's primary roles in the project are:

- Supply of monitoring equipment;
- Development of a detection algorithm (TTP supporting LEGK); and
- Production of a functional specification for a detection algorithm to detect EV charging.

1.4 Procurement

Table 1-0 details the current status of procurement for this project.

Table 1: Procurement details

Provider	Services/goods	Area of project applicable to	Anticipated delivery dates
CrowdCharge	PIVDCS services	Test System Pilot Installations Customer Trial	August 2016-December 2018
GreenFlux	PIVDCS services	Test System Pilot Installations Customer Trial	August 2016-December 2018
ICU Charging	Smart Chargers	Test System	Completed July

Solutions		Pilot Installations Customer Trial	2018
APT	Smart Chargers	Test System Pilot Installations Customer Trial	Completed July 2018
The Tech Factory	Systems Integration (smart charger communications) equipment, services and support	Test System Pilot Installations Customer Trial	August 2016-December 2018
NCC	Cyber Security Assessment of PIVDCS systems	Customer Trial & Functional Specification	Summer 2019
EV Charging Solutions Stratford Energy Solutions Actemium UK The Phoenix Works DRSFM	Smart Charger Installation services	Pilot Installations and Customer Trial	Completed July 2018
Impact Utilities	Customer research services	Customer Trial	December 2016 – January 2019
AutomotiveComms	Marketing & PR services	Project	July 2016-October 2019
TTP	Algorithm	Monitoring	End of project

	development for LEGK		
GEOTAB	Vehicle Telematics	Telematics	Completed August 2018

1.5 Project Risks

A proactive approach is taken to ensure effective risk management for the CarConnect | Electric Nation project. A RAID (Risks, Assumptions, Issues, and Dependencies) log is maintained, examined and updated by TRL, EATL, and DE. This activity ensures that risks are frequently reviewed, examining: whether risks still exist, whether new risks have arisen, whether the likelihood and impact of risks have changed, for reporting of significant changes that will affect risk priorities, and to deliver assurance of the effectiveness of control.

Risks are reported to WPD within each monthly report. At each monthly meeting, the RAID log is reviewed and updated by the project delivery team, TRL and WPD. TRL provides a critical overseeing role within the meeting to ensure that all risks are being effectively captured and managed.

Contained within Section 7.1 of this report, are the current top risks associated with successfully delivering Electric Nation as captured in the RAID log. Section 7 provides an update on the most prominent risks identified at the project bid phase.

1.6 Project Learning and Dissemination

A Project Learning Log is maintained. Project lessons learned and what worked well are captured throughout the project lifecycle. These are captured through a series of on-going reviews with stakeholders and project team members, and will be shared in lessons learned workshops at the end of the project. These are reported in Section 5 of this report.

Project Dissemination Activities during this period

The team has attended a number of relevant industry events to raise the profile of the Electric Nation project and to share early learning arising from the customer trial:

- EA Technology highlighted the Electric Nation project as part of a presentation delivered at the North Wales and Mersey Dee Energy Summit on 12th April 2018.
- WPD presented the project at the Utility Week Future Networks Conference on 18th April 2018, to share the latest on domestic smart charging and the trial to industry and interested stakeholders.

- DriveElectric presented the project at the Utility Week Live Conference on 22nd May 2018, to share the latest on recruitment to industry and interested stakeholders.
- EA Technology presented the project at the REA Electric Vehicle Experience Conference on 7th June 2018.
- The project attended Cenex LCV 2018, 12th - 13th September at Millbrook Proving Ground, and EA Technology presented on project progress.

2 Project Manager's Report

2.1 Project Background

Electric Nation aims to enable DNOs to identify which parts of their network are likely to be affected by Plug-in Vehicle (PIV) uptake and domestic charging, and whether PIV domestic charging demand management services are a cost effective solution to avoiding or deferring reinforcement on vulnerable parts of their networks, using three methods.

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2.2 Project Progress

2.2.1 Method 1: Modelling

In this period EA Technology work on development of the NAT has focussed on:

- Bulk data import and processing;
- Development of the substation level user interface; and
- EV uptake forecast distribution methodology and implementation.

Bulk data import and processing

Following on from the work described in the previous report to take the initial development of the network mapping and assessment heuristics and algorithms (based on the Plymouth area), to further sample areas in each of the other WPD license areas: In the early part of this reporting period these methods were implemented across the whole of WPD's four license areas based on data provided by WPD. This included development of bulk data import routines and optimisation of processing to produce network maps, capturing errors when required, and then bulk network assessment using the Debut engine.

This work was technically successful, further improvements in processing efficiency will be pursued if time allows towards the end of the project.

However, the bulk import and processing operation identified significant numbers of substations with missing customer data (predominantly in the West and East Midlands). This missing data is not a development issue at this time, but is being pursued with WPD in order that a full data set can be imported at some time to provide a complete mapping exercise.

The bulk data mapping and assessment exercise also resulted in new and known mapping failure modes, these will be counted, assessed and triaged for further mapping heuristic improvements as time in the development work allows.

Development of the substation level user interface

An interface for users to review substation level mapping and network assessment (including with forecast EV uptake) is required.

The developed solution is illustrated overleaf (using mock data, not actual feeder assessments) and consists of a side bar to right and zoomed in view of the LV substation and its associated customers (coloured by "dumb" feeder number, ex Crown) and the NAT-mapped cable segments (coloured by NAT heuristics to match with customers by dumb feeder identifier).

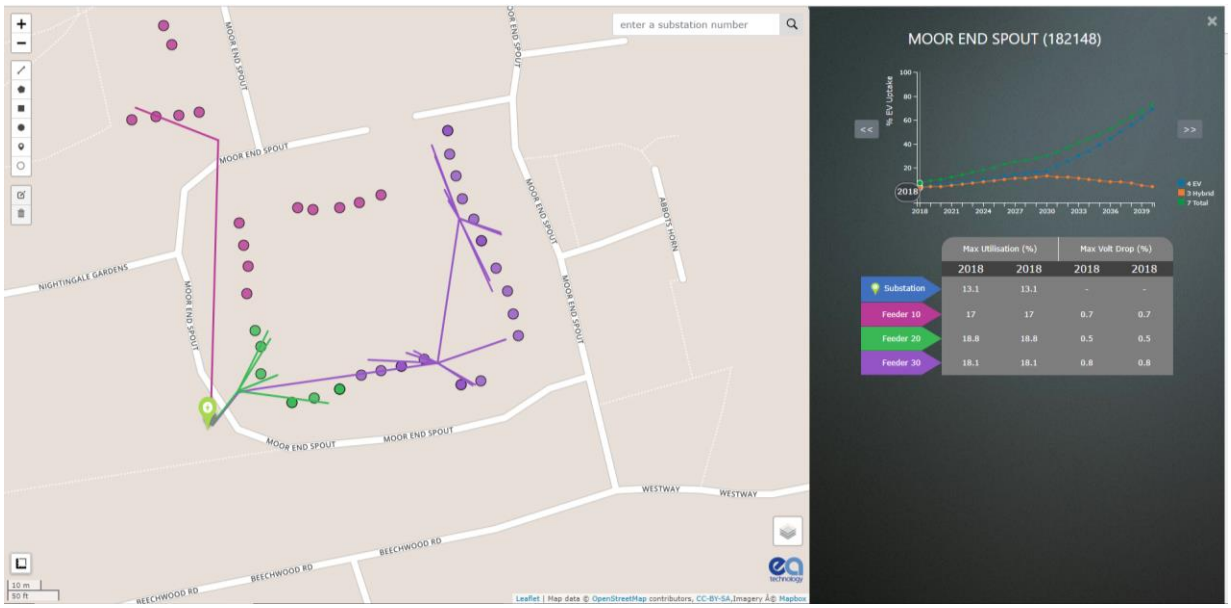


Figure 1: Example of mapped Low Voltage network

The side bar provides:

- A graphical representation of the forecast EV uptake for the substation
  - User can pick which year to view
- A tabular representation of the Debut assessment for the network as mapped
  - Substation utilisation
  - For each feeder mapped: worst cable segment utilisation and highest percentage voltage drop

For a substation where EV penetration has adverse effects the user is given information on both parts of the display, as below (using mock data, not actual feeder assessments):

- On the map
  - Substations are coloured red if their associated networks have red issues (or amber if network issues are amber)
  - Over utilised cable segments are highlighted in red
  - Feeder cable nodes over 5% voltage drop are identified
- On the side bar table
  - Near or over utilised substations are coloured amber or red
  - Where a mapped feeder has one or more near or over utilised cable segments it is coloured amber or red
  - Where a mapped feeder has voltage drops more than 4% they are coloured amber and 5% or more red

Figure 2: Example of mapped low voltage network with over-utilised substation and feeders with two near-maximum voltage drop and one over-maximum drop

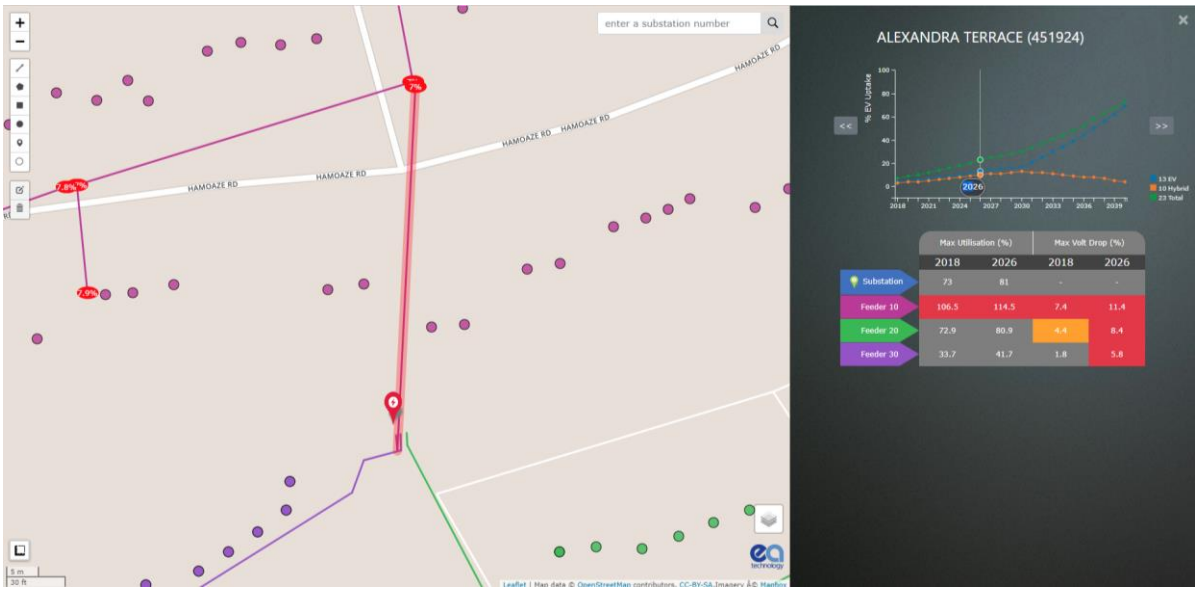


Figure 3: Example of mapped low voltage network showing over utilised cable segment highlighted

As mentioned above, in these examples, mock data has been used to illustrate the functionality.

Further improvements to the side bar and functionality are planned:

- Correct EV forecast data needs to be incorporated into NAT and Debut Assessments run on these (see next section)
- User can set EV penetration level (percentage or number) and run Debut assessment to view results (effectively over-riding the EV uptake forecast and pre-populated assessments)

- LV substation details will be displayed below the results table (currently viewed on pop-up box when substation selected, which obscures view, though can be collapsed) Figure 4:

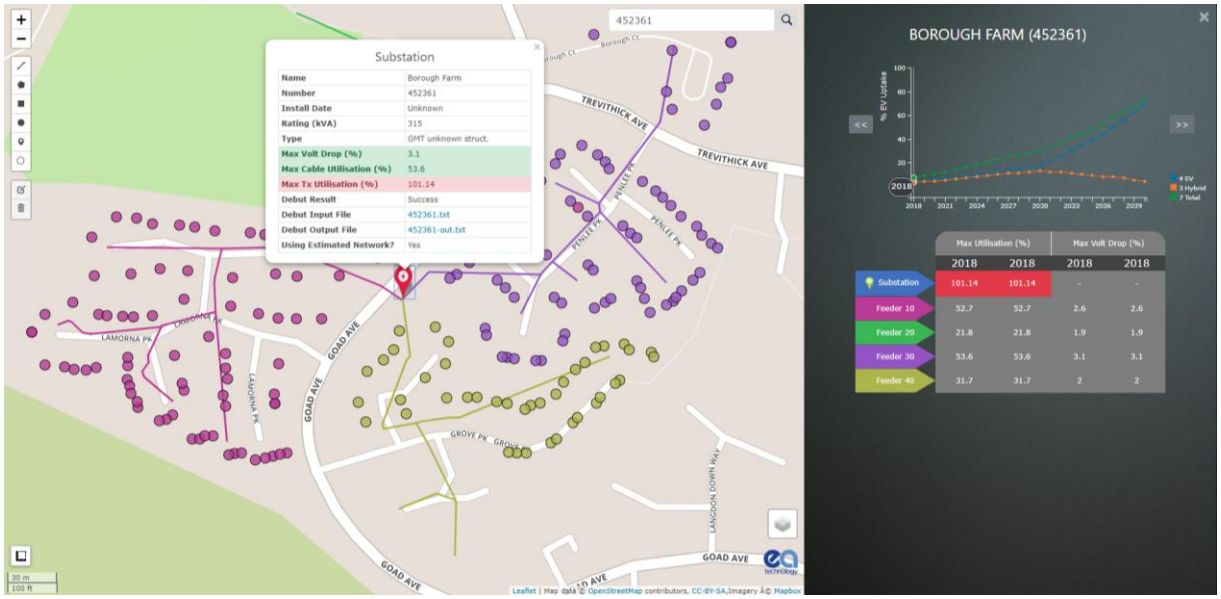


Figure 4: substation details pop-up

- Map functions to view cables segment and customer details need improving

EV uptake forecast distribution methodology and implementation

WPD have provided EV uptake forecasts for all four of their license areas, supplied by Regen developed in previous projects for WPD.

These forecasts are based on Energy Supply Areas (ESA), (low voltage networks supplied from a primary substation or bulk supply point – defined by WPD) and cover the period 2018-2030.

EA Technology have developed a method to take these ESA forecasts and allocate the forecast EV numbers to low voltage substations within each ESA.

This method uses Census 2011 data related to:

- Housing types – with a view that people living in terraced houses and flats will be much less likely to purchase EVs in the next decade
- Household income (after housing costs) – with a view that the higher the household income the more likely a household is to purchase EVs in the next decade
- Car/van ownership – with a view that households with no access to a personal vehicle are unlikely to purchase an EV and those with more than one personal vehicles are more likely to purchase an EV in the next decade

- Rural/Urban setting – with a view that households in sparsely populated areas will be further away from EV charging infrastructure developed in the next decade and so less likely to purchase EVs.

These factors were combined into an EV uptake factor for census areas (Middle Layer Super Output Areas – MSOA) with minimum population of 5,000 and mean of 7,200 (covering, on average, 3,000 households). This is the smallest household level area for which census data can be accessed easily.

Unsurprisingly, MSOA boundaries do not fit to ESA boundaries, so the number of customers in each MSOA overlap area within an ESA and the EV uptake factor for each MSOA is used to apportion EV uptake forecast, for each year, to the MSOA area within each ESA boundary.

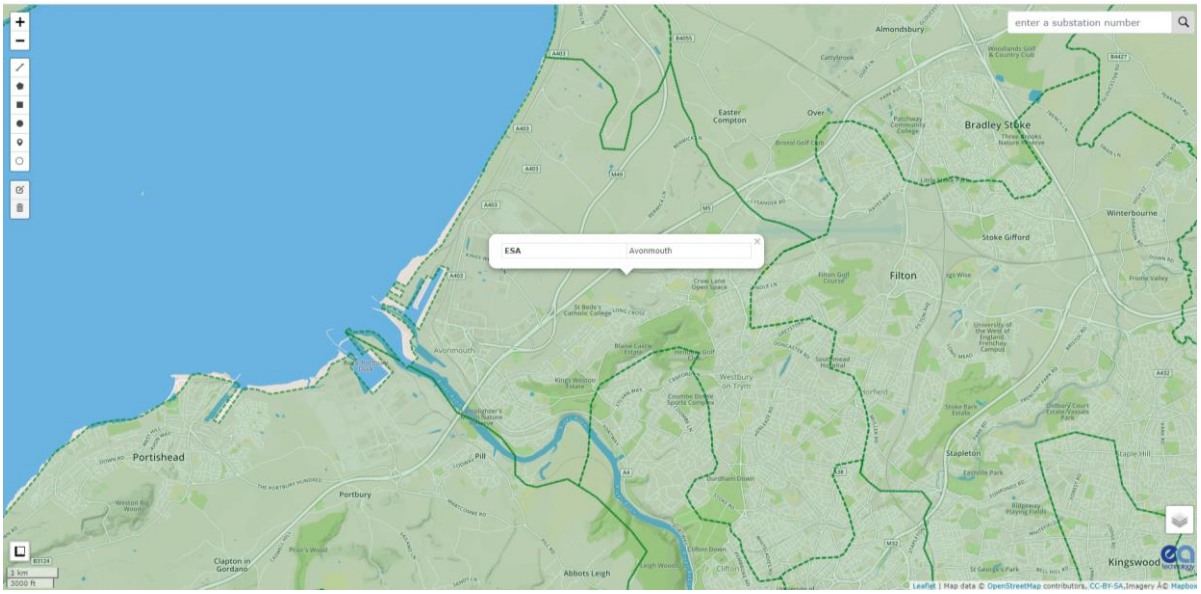


Figure 5: Map view showing ESA boundary (Green)

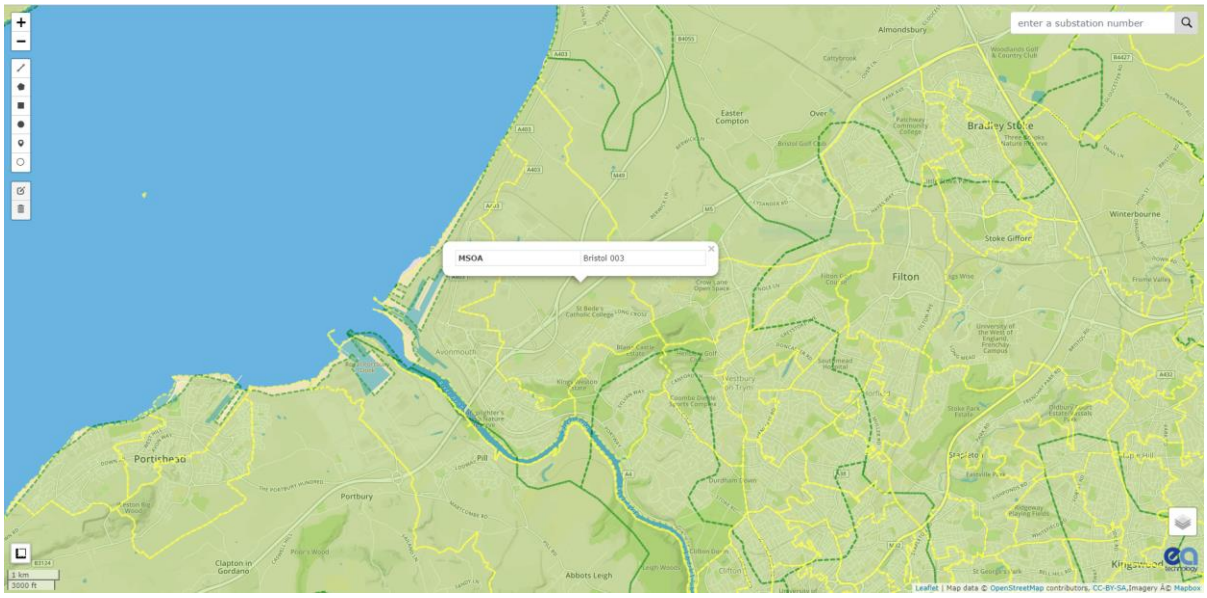


Figure 6: Map View with MSOA boundaries (yellow), illustrating how boundaries do not match

The result is a split of the ESA EV forecast (for each year) to all LV substations within the MSOA area within the ESA boundary.

This EV forecast then needs to be apportioned to each LV substation which is achieved by firstly identifying all existing EV charger locations (by substation), taking this away from the forecast and then apportioning the remainder to each substation based on the number of customers connected to the substation.

Finally, for each substation the EVs are distributed to customers, firstly acknowledging existing charger installations, the remainder allocated using a pseudo-randomised method: The “three bucket” method, as illustrated below in an idealised network model with two existing EV chargers and three additional chargers required to be allocated to make up the forecast for a particular year.

Existing EV charger installations are black, feeders identified by colour, bucket boundaries are set by dividing the number of customers by three (remainders being allocated to or taken away from closest to substation bucket):

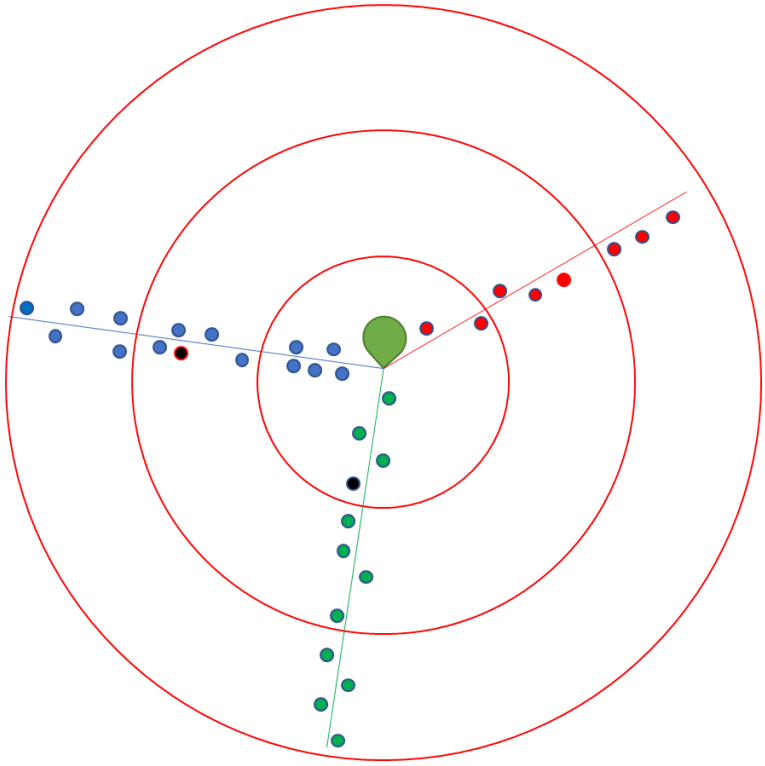


Figure 7: Network as-is with three bucket boundaries (circles)

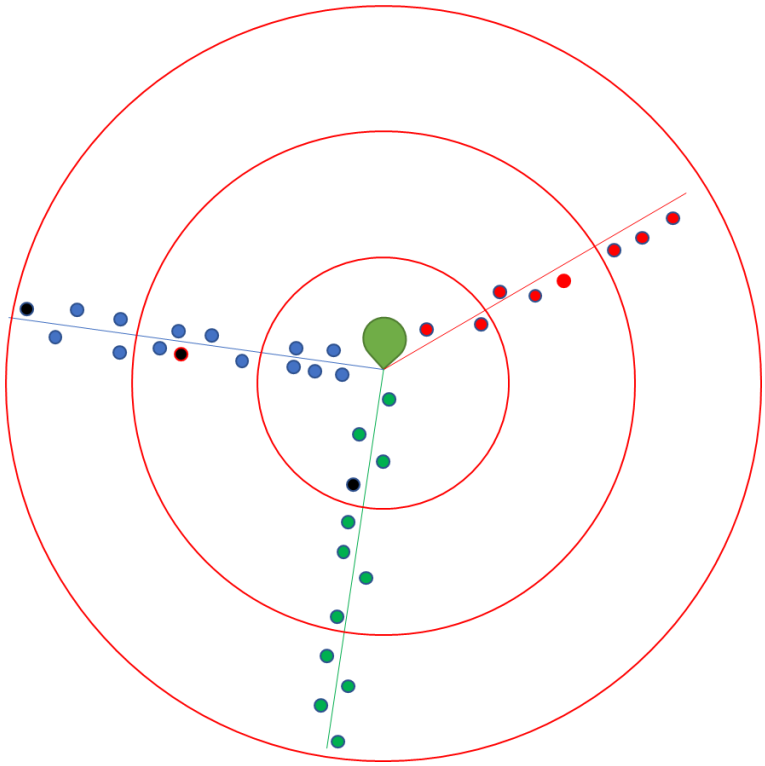


Figure 8: The first additional charger allocated to customer furthest away from substation (blue feeder) – in "furthest bucket"

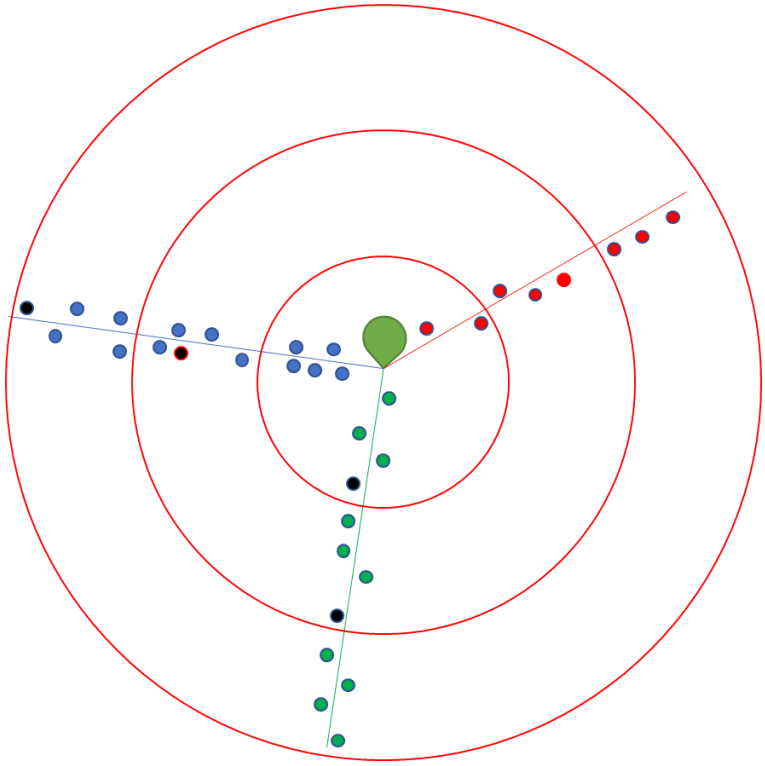


Figure 9: Second additional charger allocated to customer furthest away from substation in "middle bucket" – this time on green feeder

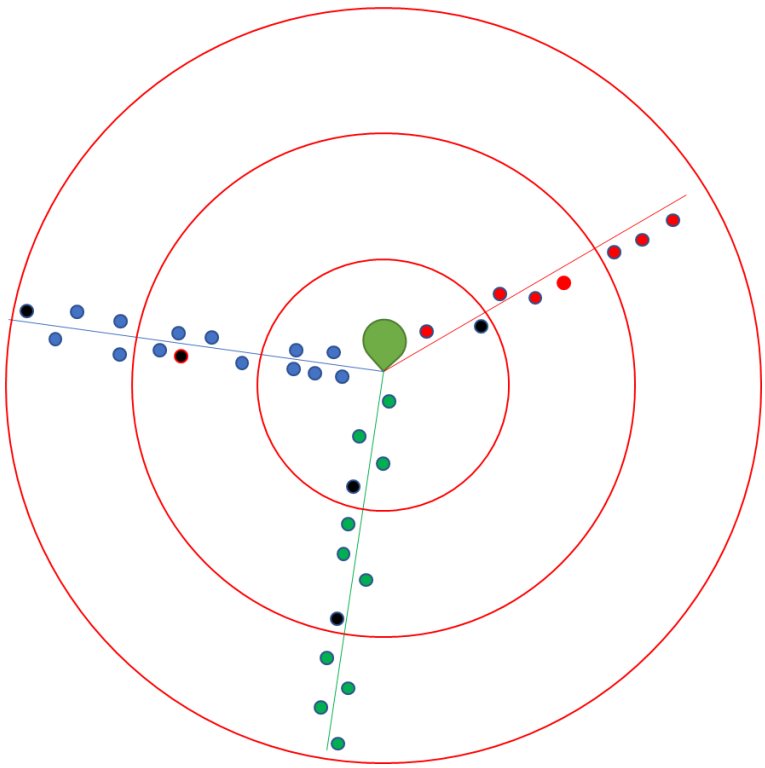


Figure 10: The third additional charger allocated to customer furthest from substation in "closest bucket" – this time on the red feeder

The method repeats the exercise for additional chargers, skipping where a customer already has a charger. If all customers on a feeder have a charger then a second charger is allocated to the customer.

If and when the EV forecast increases for a particular substation, the previous allocations are remembered and new EVs allocated to the substation as per the method, where new charger installations are confirmed the method adapts as required.

At time of writing this report this approach to EV forecast uptake allocations has been developed and proven on one ESA and is being applied to all four WPD license areas.

This will then allow for recalculation of EV impact assessment across all mapped low voltage networks.

Next Steps:

1. Complete EV uptake forecast allocation methodology
2. Refine substation level user interface and functionality
3. Improve Debut assessment routine by ignoring customers with no mapped feeder (commonly caused by erroneous “dumb” feeder assignments in Crown database, e.g. four “dumb” feeders in Crown, but only three feeders found by NAT, or sometimes customers assigned to wrong substation) – this will improve feeder level Debut assessment success rate
4. Implement Estimated Line Segment and feeder routine, where NAT mapping has failed to provide an estimated view of substation/network EV readiness – Debut Assessments for EV uptake forecasts can then be carried out.
5. Develop user set EV uptake one-off Debut assessment (allows for EV uptake assessment on a single substation beyond pre-populated results based on EV uptake forecasts)
6. Work with WPD to fill in data gaps from Crown
7. Development plan for strategic user interface
8. Development plan for Smart Charging solution assessment at substation and strategic level.

2.2.2 Method 2: Monitoring

Progress within this reporting period

The development of the EV detection algorithm by TTP and Lucy Electric GridKey has been completed in the last reporting period and the Project closedown report has been produced and accepted by WPD within the reporting period.

2.2.3 Method 3: Mitigation

Progress within this reporting period

Marketing and PR

EA Technology has continued to lead project marketing and dissemination activities in this period.

EA Technology has developed a positive relationship with the Office for Low Emission Vehicles, which is supportive of Electric Nation, with smart charging being on the UK Government policy's agenda under the Automated and Electric Vehicle Bill[1].

- Following a meeting with OLEV in January, EA Technology received a copy of OLEV's Electric Vehicle Home Charge Scheme charging data, under an MOU to be signed by WPD. This data has been compared with WPD's charge point installation data supplied for the development of the Network Assessment Tool (NAT) in an attempt to identify clusters of EVs on WPDs networks. Unfortunately, the OLEV location data is postcode only, whereas WPD locations are based on MPANs, this leads to some error in matching the two data sources, in addition there are gaps in WPDs data (correlating to gaps in customer data identified in the NAT development work). EA Technology are in the process of requesting MPAN based data from OLEV and identifying the gaps in WPD data for WPD to resolve.
- As a result of EA Technology's engagement with OLEV, the project was used as a smart charging case study in OLEV's 'Road to Zero' EV strategy published in July 2018.

<u>Social media</u>

Twitter

To date, the Electric Nation Twitter account has more than 1,990 followers; the account has delivered 1,000+ tweets, and achieves a good level of retweet activity, including regular retweets by WPD, the Office for Low Emission Vehicles, and project partners and suppliers.

[1] The Automated and Electric Vehicle Bill is expected to complete progress through the Parliamentary process this year and includes provisions for managed EV charging.

LinkedIn

Managed by EA Technology, Electric Nation has a LinkedIn Group that currently has 43 members from across automotive/energy/DNO stakeholder groups. It is used on a relatively infrequent basis to deliver news items and event details at which the project and its partners will be appearing. The Group will become more active once the project starts to deliver trial results and learning.

Facebook

Electric Nation has a Facebook page that is customer-facing and is therefore managed by DriveElectric, albeit its set up was supported by AutomotiveComms to ensure branding and message were in line with strategy.

Project Website

In this reporting period EA Technology has ensured the website is kept up to date, with revised and new FAQs and produced 8 News items for the project website, covering project news:

- 17/04/2018: What Has Been Learnt So Far From Electric Nation Surveys?
- 10/04/2018: Come And Meet Electric Nation At Robert Llewellyn's Fully Charged Live Event
- 12/06/2018: Electric Nation At Robert Llewellyn's Fully Charged Live, Silverstone, 9-10 June 2018
- 04/07/2018: Western Power Distribution Smart Charging Video
- 19/07/2018: Final EV Smart Charger Is Installed For The Fully-Recruited Electric Nation Project
- 6/09/18: Smart Charging App – Early Indications Of EV Driver Usage
- 6/09/2018: Come And Visit Electric Nation At Lcv2018
- 18/09/2018: Electric Nation At The Cenex Low Carbon Vehicle 2018 Event

The WPD-produced animation "Smart Charging Explained" was published on the project website in July 2018.

A press release celebrating the project's final smart charger installation was produced and released in July.

Project newsletters

Two project stakeholder newsletters were produced by EA Technology in this period (Published May & August – the latter in co-ordination with the LCV event) which were

distributed to the project contacts' list (comprising 400 stakeholders across automotive, utilities, academia and Government).

EA Technology, in partnership with DriveElectric, also produced a newsletter for the trial participants in May.

Recruitment of Trial Participants

The DriveElectric team has completed recruitment and installation of 673 chargers. The final charge point was installed during July 2018. The below table details the split between the two PIVDCS systems and the split by vehicle type (BEV, PHEV and REX).

Table 2: Split between vehicle type on Crowd Charge and GreenFlux system

Row Labels	Crowd Charge (CC)	GreenFlux (GF)	Grand Total
Electric only (BEV)	157	158	315
Plug in Hybrid Electric Vehicle (PHEV)	135	138	273
Range extender (REX)	36	49	85
Grand Total	**328**	**345**	**673**

The below table shows the highest volume lead sources since the recruitment stage began, compared against installations thus giving a representation of conversion rates for each lead. Unsurprisingly, Google provide the largest number of leads with one of the highest conversions rates at 73%. As DriveElectric has reported in monthly progress reports, car dealer and installer leads are the most valuable as these provide a strong conversion.

Interestingly, friend's recommendation leads produced 8.8% of the total installations which showcases the impact word of mouth marketing can have during a recruitment phase. This also produced a high conversion rate of 75.6% therefore should be capitalised on in future WPD innovation projects.

Table 3: highest number of leads received compared to number of installation on EN.

Lead sources	Total leads received	Installations	Conversion rate (%)
Stratford Energy	**19**	**19**	**100.0**
Tesla Bristol	**22**	**19**	**86.4**
Twitter	**17**	**14**	**82.4**
Facebook	**24**	**19**	**79.2**
Work Colleague	**27**	**21**	**77.8**
Friend's Recommendation	**78**	**59**	**75.6**
Google	**252**	**184**	**73.0**

Fully Charged	**40**	**29**	**72.5**
SpeakEV	**29**	**21**	**72.4**
WPD	**16**	**11**	**68.8**
Facebook Tesla Owners Club	**25**	**17**	**68.0**
Tesla	**27**	**18**	**66.7**
Tesla Solihull	**31**	**19**	**61.3**
Facebook BMWI3	**18**	**11**	**61.1**
EN Web lead	**87**	**47**	**54.0**

Chargepoint Installations

Stratford Energy, The Phoenix Works, DRSFM and EV Charging Solutions have continued to provide excellent customer service both during the order process and if a charger fault requires their assistance. Since April 2018, DriveElectric has received six instances of positive feedback; five of these are related to the installer's service with the final praising the smooth order process from qualification to installation.

With installations now complete, the table below shows the split of installations per installer. EV Charging Solutions and Stratford Energy have completed the highest number of installations with 41.5% and 30.9%, respectively. DRSFM and Actemium have completed the lowest number with 4.8% and 7.1%; the reason for this is due to their geographical coverage in the south west where leads were occasional.

Table 4: Split of number of installations per installer.

Installers	Number of installations	Percentage of total installations
EV Charging Solutions	279	41.5
Stratford Energy Solutions	208	30.9
The Phoenix Works	106	15.8
Actemium	48	7.1
DRSFM	32	4.8
Grand Total	**673**	**100.0**

DriveElectric continue to record all faults via the EN support line and assigned to the participant's installer as appropriate to resolve the issue. Installers continue to cooperate with the EN support team during this ongoing process.

Customer Relationship Management (CRM) System

DriveElectric's CRM system has been continuously updated to reflective lessons learned. The objective of this is to simultaneously streamline processes for the EN team and to

improve the participants overall experience with the order process. As the recruitment and qualification was completed during June 2018 the volume of learning has reduced compared to the initial recruitment start phase.

DriveElectric continued to hold bi-weekly internal meetings with all members of the EN team until the qualification stage was completed. These meetings contributed to improving processes and ultimately the participants' experience.

Customer Support System

The customer support system tracks reported faults and enquires, which are stored within DriveElectric's CRM database. The EN support team are then able to categorise them accordingly, as shown in the table below. The table below shows all faults recorded to date; the main faults on the project are communications related and configuration issues.

The configuration figure on the GreenFlux system is extremely high due to 4 mass configuration errors that affected most of their chargers. Most of these configuration issues were resolved within a short time frame of 24-48 hours. Despite these errors, positively only a handful of customers experienced some inconvenience to charging which was handled accordingly by the EN support team.

The communications error is much higher on Crowd Charges system as 10-15 chargers require resetting each week by the participant which reinstates the connection.

Table 5: All faults record on EN to 28/09/18 split by PIVDCs

Fault Categories	Crowd Charge	GreenFlux	Grand Total	Crowd Charge (%)	GreenFlux (%)	Total (%)
Charger Lead	1		1	100.0	0.0	0.0
GreenFlux		1	1	0.0	100.0	0.0
Other	2	1	3	66.7	33.3	0.1
APT Charger	4		4	100.0	0.0	0.2
ICU Charger		5	5	0.0	100.0	0.2
Vehicle	4	1	5	80.0	20.0	0.2
Communication system	4	4	8	50.0	50.0	0.3
Admin	25	10	35	71.4	28.6	1.4
Enquiries	23	15	38	60.5	39.5	1.6
App	20	25	45	44.4	55.6	1.9
Electrical	33	44	77	42.9	57.1	3.2
Behavioural	53	51	104	51.0	49.0	4.3
Hardware	86	91	177	48.6	51.4	7.3
Configuration	42	744	786	5.3	94.7	32.5
Comms	791	335	1126	70.2	29.8	46.6
Grand Total	**1088**	**1327**	**2415**	**45.1**	**54.9**	**100.0**

Vehicle Telematics

Obtaining participants permission to use vehicle telematics information has continued to be a challenging task over the past 6 months. This is because providing telematics data was not a project requirement. There has been little change in figures for telematics over this period.

Telematics from Tesla vehicles is obtained directly using an API supplied by Tesla through agreement with DriveElectric. For other vehicles, a third party OBD-II port dongle - supplied by GeoTab - is used. The below table (Table 6) shows the breakdown between vehicle manufacture, and the telematics status. 89 participants did not respond to DriveElectric's initial request; 20 participants declined, and 25 participants initially agreed consent on the invitation call but did not return the required authorisation form. Telematics recruitment ceased as agreed by all project partners during August monthly progress meeting.

Table 6: Telematics update as of 28/09/18

Telematics status	Electric only (BEV)	Plug in Hybrid Electric Vehicle (PHEV)	Range extender (REX)	Grand Total
1.b) Not using - customer declined	4	15	1	**20**
1.c) Not using - form(s) not returned	8	15	2	**25**
1.d) Not using - Installed Inactive		1	1	**2**
1.d) Not using - no response to enquiry email	28	39	22	**89**
1.e) Not using - Geotab vehicle model issue	1		1	**2**
1.f) Not using - Nissan old model	33			**33**
2.a) On hold - no solution for vehicle		1	1	**2**
4.b) Consent form received	3			**3**
5.a) Install requested		1		**1**
5.b) Install booked	6			**6**
5.c) Install cancelled		2		**2**
6. Data flow to be verified	3			**3**
7.a) Installed - Device Operating			1	**1**
7.b) Installed - incomplete data	4			**4**
7.c) Installed - Fully Operating on CC	16	19	3	**38**
(blank)	51	42	4	**97**
Grand Total	**157**	**135**	**36**	**328**

Customer Communication

DriveElectric are the primary point of contact for all participants. All participants were updated on their application on a bi-weekly basis via a charger update email during the charger order process. These proved useful to communicate to the participant if any information of their application was missing.

Out of 946 home surveys that were sent, this meaning they passed to the installer to manage, only 1.5% of these applicants filed a formal complaint against the installer; this is an exceptionally low figure considering the vigorous survey order process.

EA Technology has supported DriveElectric's engagement with trial participants, on a technical level, through provision of draft email communications. In this reporting period this has included:

- GreenFlux app roll out email and user instructions;
- Crowd Charge app roll out email.

Dissemination

EA Technology, WPD and other project delivery partners have attended relevant industry events to raise the profile of the Electric Nation project and to share early learning arising from Algorithm Development and Testing Report.

- EA Technology highlighted the Electric Nation project as part of a presentation delivered at the North Wales and Mersey Dee Energy Summit on 12th April 2018.
- WPD presented the project at the Utility Week Future Networks Conference on 18th April 2018, to share the latest on domestic smart charging and the trial to industry and interested stakeholders.
- DriveElectric presented the project at the Utility Week Live Conference on 22nd May 2018, to share the latest on recruitment to industry and interested stakeholders.
- EA Technology presented the project at the REA Electric Vehicle Experience Conference on 7th June 2018.
- The project attended Cenex LCV 2018, 12th -13th September at Millbrook Proving Ground, and EA Technology presented on project progress.

Customer research

The customer research activities of the project aim to provide qualitative evidence of customer driving and PIV charging behaviours, and acceptance of PIV charging demand management during the customer trial. This will be measured through a series of questionnaires that customers involved in the trial will be asked to complete (electronically, over the phone and in some cases, face to face).

The following types of questionnaires are included:

- Baseline questionnaire – post-recruitment, pre-installation of smart charger – developed and deployed to customers as they are recruited into the trail. This is aimed at gathering recruit socio-economic data and vehicle usage data.
- Post installation questionnaire. This is aimed at gathering data on attitudes to charging their PIV after a few months, in most cases before they experience demand management, but in some cases where demand management is imposed on their charger shortly after they join the trial. Whether trial participants experience demand management before receiving this questionnaire depends on whether they have a PIV already; if the trial participant has to wait for delivery of a new PIV this can be several months after they have had their charger installed. In addition, whether the trial participant has experienced demand management before they receive this questionnaire proved to be highly dependent on charger communications – where reliable charger communications have been difficult to establish participants' experience an extended period of being able to charge at will before demand management is imposed. This is all useful data.

- Trial questionnaire. This is aimed at gathering data on attitudes to charging their PIV during the trial, having had their charger under demand management for at least four weeks.
- Trial 2 Questionnaire. This is aimed at gathering data on attitudes to charging their PIV during the trial, having had their charger under demand management for at least four weeks and access to an app that gives trial participants the opportunity to interact with the demand management system managing their charger.

Both the recruitment and post installation questionnaires are now complete, as the recruitment and installation process is completed. Customer response rates to these surveys have been very good and are set out below.

Table 6: Customer response rates to the recruitment and post installation questionnaires

Recruitment		Baseline	
N sent	N returns & % complete	N sent	N returns & % complete
670	623 / 93%	529	508 / 96%

The Trial questionnaires follow up the post installation questionnaire to investigate whether customers in the trial have changed their charging behaviours and attitudes to charging, driving and journeys, having experienced charging demand management and access to the apps. The questionnaires were launched in mid-January 2018 (Trial) and July 2018 (Trial 2). To date response rates to these questionnaires are:

Table 7: Customer response rates to the trial questionnaires

Trial (ongoing)		Trial 2 (ongoing)	
N sent to date	N returns & % complete to date	N Sent to date	N Returns & % complete to date
310	279 / 90%	280	196 / 70%

Thorough analysis and comparison with the Recruitment survey responses was undertaken in early April, addressing questions, such as:

- Have a significant number of trial participants changed their charging behaviours or attitudes to charging, satisfaction with the charging arrangements while being subjected to charger demand management?

- Is there any significant difference in charging behaviours, attitudes, satisfaction between PHEV, BEV and REX-EV drivers?
- Is there any significant difference in charging behaviours, attitudes, satisfaction between drivers with vehicles with different battery sizes? – PHEVs tend to have smaller ~10kWh batteries, BEV battery sizes range from 25 kWh up to 90/100kWh.
- Is there any significant difference in charging behaviours, attitudes, satisfaction between PIV drivers subjected to the different demand management systems: GreenFlux and CrowdCharge? Although the two systems achieve the same result, capping of total PIV charging power to a defined limit by time of day, the impact on PIV charging and so drivers is different.

These analyses were compared with the amount of charger demand management customers had experienced (number of events their PIV had been involved in and the quality of charging interruption they have experienced, based on a derived value of charge-delay).

The results of this interim analysis can be found in project milestone reports for April and July 2018.

The overall outcome being that customer satisfaction with their home charging arrangements (which included regular EV charging demand management over the winter/spring 2018) had not changed significantly in comparison with baseline responses (when customers were able to charge at will with no EV charge demand management).

This led to the conclusion that there was no need to split the trial cohorts into sub-sections to address particular issues with customer satisfaction, EV type, battery size or demand management system performance, for the next phase of the customer trial, where Apps are to be tested, giving the customers some form of interaction with the charging demand management systems**.**

Test System

The test system has been used throughout this period to:

- Troubleshoot communications issues identified in customer trial installations, testing improvements to systems and software/firmware updates before they are issued to customer trial systems;
- Test the GreenFlux and CrowdCharge Apps in preparation for the next phase of the project;
- Test the second generation GreenFlux app in preparation for Trial phase 3 (use of time of use tariffs as an incentive to customers to accept EV charge management); and
- Test 2 prototype V2G chargers.

PIVDCS Configuration Testing and Improvement (Algorithm Development)

Systems integration

The project utilises two different providers of back-office systems and charge point manufacturer:

- GreenFlux/ICU (Alfen);
- CrowdCharge/eVolt (APT).

The communications performance of charge points on both GreenFlux and CrowdCharge systems is tracked. This information is used as part of the process to judge whether a participant can move into demand management and also to identify where action is needed to rectify communication systems issues, such as where Wi-Fi bridge replacements are required or customer visits are required by The Tech Factory.

<u>GreenFlux/ICU (Alfen)</u>

EA Technology continues to track the 'overall communications reliability'. Figure 11 below shows the performance from Week 20 2017 (15 May 2017) onwards. This indicates that overall communications reliability on GreenFlux dipped but then improved over the past 6 months, reaching 80% in the past few weeks.

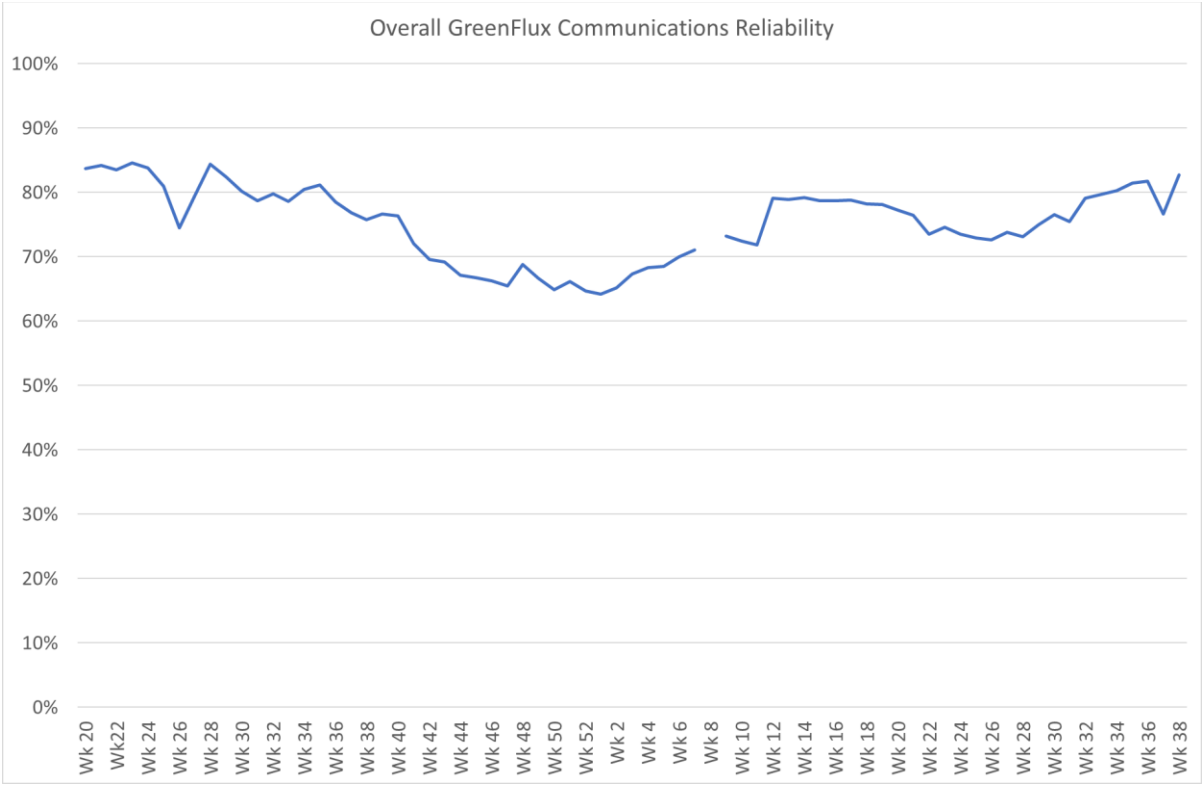


Figure 11: Overall Communications Reliability - GreenFlux

Figure 11 shows percentage uptime across all GreenFlux/ICU (Alfen) units. This shows the effect of a manufacturing error at ICU (Alfen), where 101 chargers were released from their factory (serial numbers 216 – 317) with the wrong firmware version, owing to a quality assurance error. The effect of not having the correct firmware in these chargers was that communications 'auto-detect' was disabled, meaning that where Ethernet communications failed the charger would not automatically fail-over to mobile phone data (SIM) communications. This issue was identified on chargers installed during the last quarter of 2017 as communications on newly installed chargers fell from the historical 70+% online after installation figures. The communications reliability of these chargers is considerably worse than the rest of the GreenFlux/ICU (Alfen) units. Chargers installed from December onwards could be rectified remotely by ICU (Alfen) as part of the installation process, and units with serial numbers of greater than 317 are unaffected, and these being installed in 2018. The remaining units, already installed before the issue was diagnosed, required a site visit to reconfigure the charger's firmware. This was achieved over the summer by Alfen (and their contractor Siemens) resulting in 90% of the faulty chargers being fixed (the remainder could not be fixed because of uncooperative customers).

The decline in performance of units installed in February 2018 was also of concern, deemed to be unrelated to the Alfen configuration issue. Upon investigation it was found that a number of chargers were suffering from an unreliable broadband internet service, causing the charger to flip-flop between broadband internet and mobile data (SIM) communications. Where the mobile data field strength was adequate a simple solution has been implemented – to configure the charger to communicate using mobile data only. This has contributed to the recent communications performance improvement.

A further firmware issue with the Wi-Fi bridges used to connect the charger Ethernet port to the participant's home broadband router, where, a manufacturer's firmware fault can lead to the Wi-Fi bridge not connecting and so disabling Ethernet communications, has largely been resolved. This fault could only be rectified by installing a replacement Wi-Fi bridge. Again, uncooperative customers mean that some chargers continue with no/poor communications.

CrowdCharge/eVolt

Communications performance since the end of July 2017 for CrowdCharge/eVolt system is shown in Figure 12 below. Compared with the previous six monthly performance report, the overall communications performance of the CrowdCharge/eVolt system has been better in the most recent six months (since January 2018) and has now reached 80%.

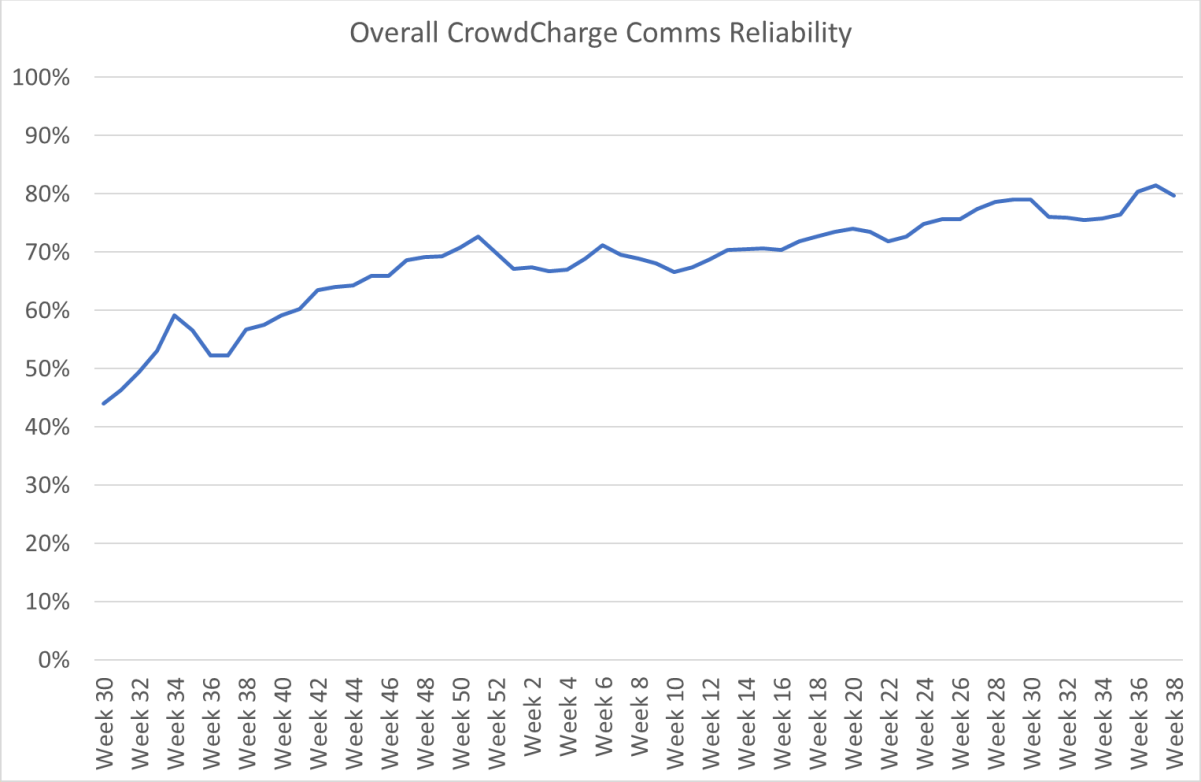


Figure 12: Overall Communications Reliability - CrowdCharge

This has been attained in spite of relatively poor performance at the installation stage, as shown in Figure 13 which shows the percentage uptime since installation across all CrowdCharge/eVolt units.

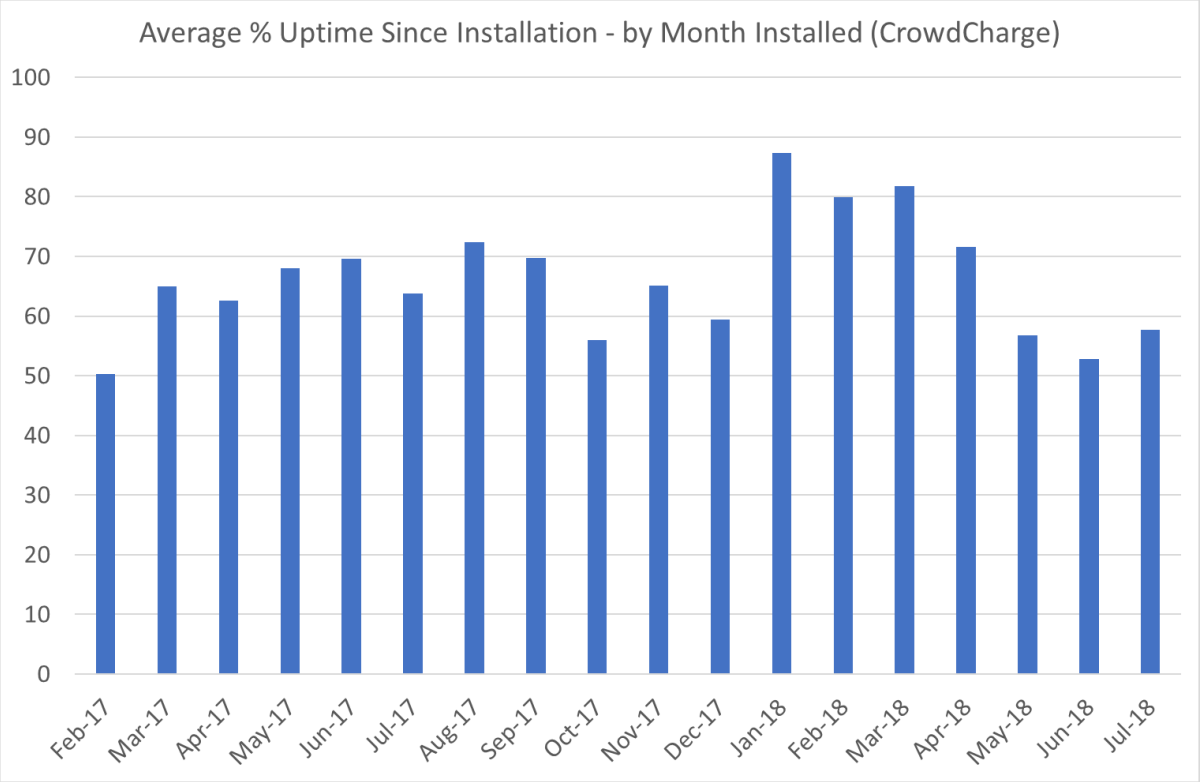


Figure 13: Average % uptime since installation - CrowdCharge

CrowdCharge and the Tech Factory are responsible for identifying and resolving communications issues in this group. The actions taken have been a mixture of customer actions (charger resets, swapping Wi-Fi units) and visits by the Tech Factory to rectify CrowdCharge controller issues that cannot be rectified remotely owing to the secure communications processes built into the CrowdCharge system.

In addition, back office coordination between servers continues to be a problem affecting communications performance: Hubeleon, an asset management server and the CrowdCharge charger management server – where a charger can appear online on the former but not on the latter, resulting in inability to control the charger. Re-coordination of these mismatches is required periodically.

CrowdCharge also have 15-20 chargers a week going offline, most of which merely require a broadband internet router and system reboot to recover – this is about 5% of their installed and online fleet. CrowdCharge have to continue to support these faults to maintain their communications performance.

All of these actions have led to the improvement in communications performance and number of chargers involved in EV charger demand management over the period.

CrowdCharge produces a weekly summary showing which chargers require different actions alongside monitoring the total number of communications faults, recurring issues and new offline units.

For the remainder of the customer trial all involved parties, in both CrowdCharge and GreenFlux systems, are now focussed on maintaining current levels of communications performance. Non-communicating and very poor performing chargers will be withdrawn from the trial over the next couple of months, as these are likely to be more problematic than those with good performance.

Customer Trial

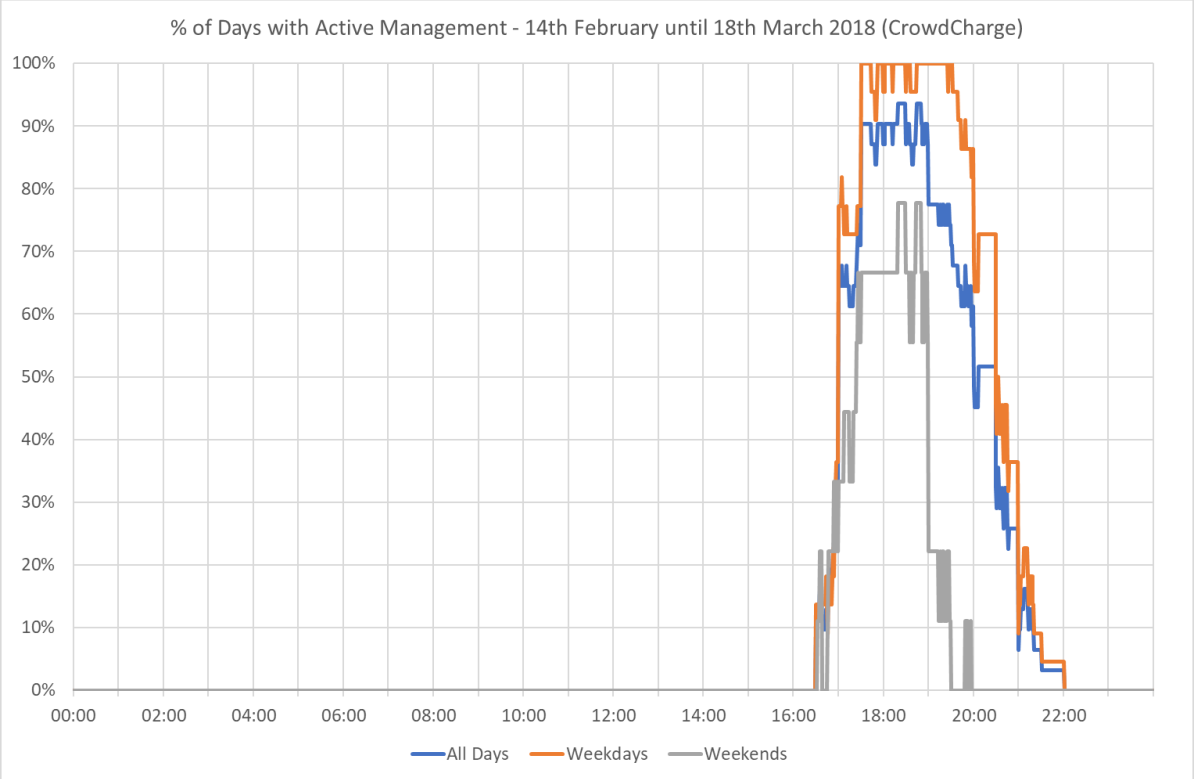
There are two 'routes' by which customers can enter demand management:

- Charge at will – customer has approximately 3 months of unrestricted charging from when they start using their charger
- Straight into demand management – as soon as the customer has started charging and reliable communications are proved the customer enters demand management.

Installations which took place before mid-July 2017 took the first route. Installations occurring after this point should go straight into management. However, some participants have experienced communication issues resulting in a more extended period of time before management can begin.

Customers entering demand management were originally exposed to an autumn demand limit profile and then, from early November 2017 to date, were exposed to a winter profile (the most restrictive within the trial). A decision was made to transfer participants to a spring profile on the 8th of April 2018 (adapted to create a profile that will ensure management continues to occur on some days).

Figure 14 illustrates the frequency with which demand management events have taken place in the CrowdCharge group using winter and then spring demand limit profiles.



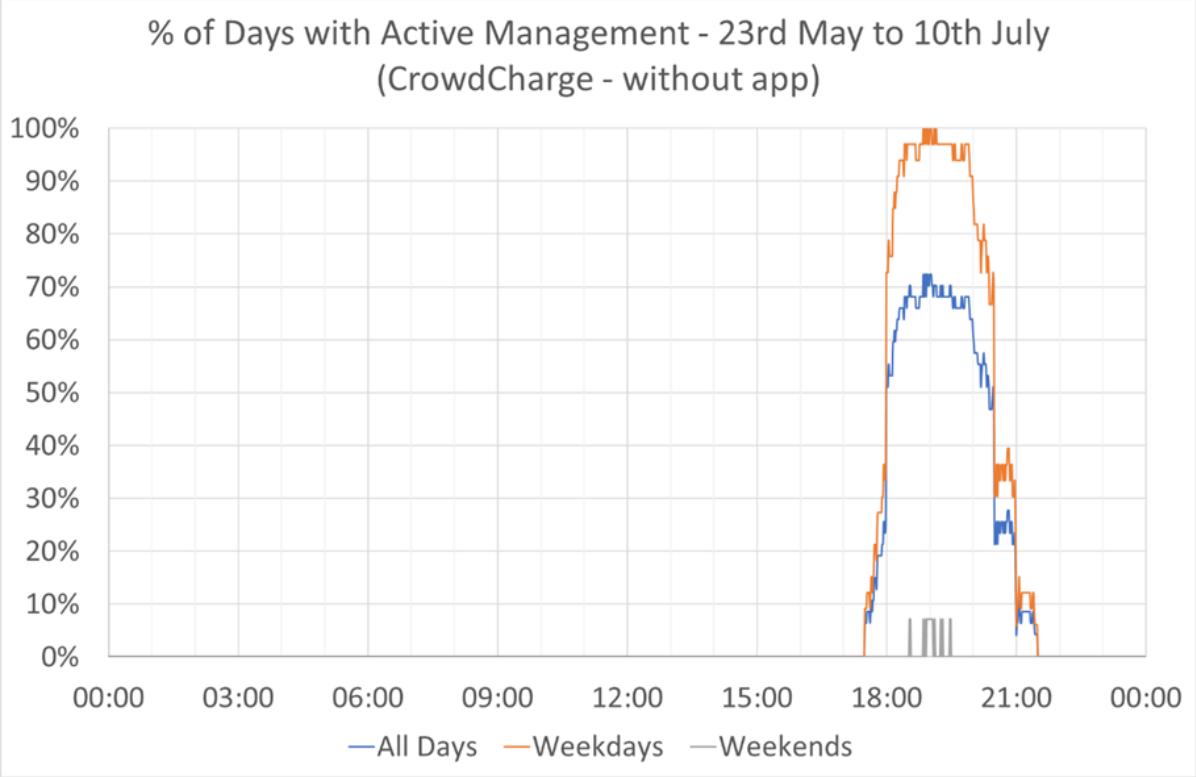


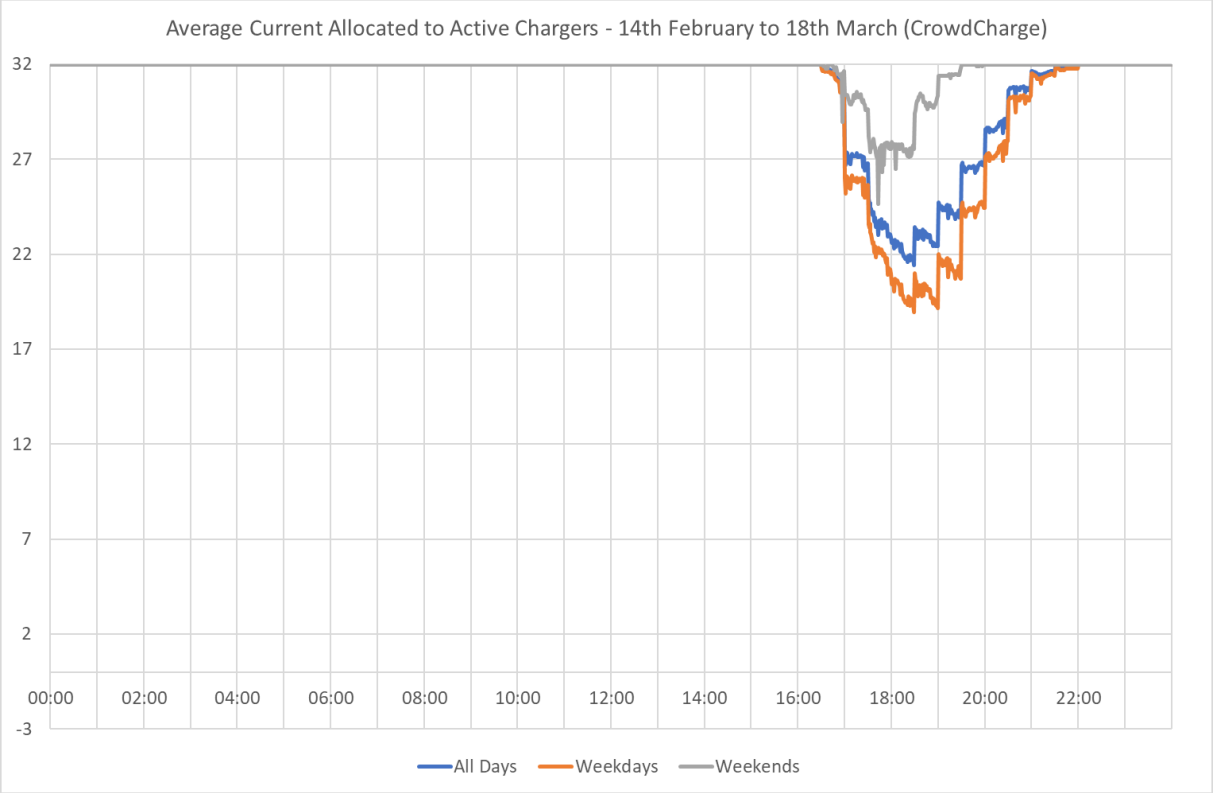
Figure 14: Percentage of days with active demand management (CrowdCharge): Upper winter profile, lower spring profile

This shows that, with the most restrictive winter profile, management continues to be active at some point on all weekdays and most weekend days. Management at the

weekend tends to be active for a shorter period of time. However, it can be seen that, with the less restrictive spring profile, on weekdays demand management occurs over a shorter time-span and only for a very short period on all days and rarely happened on weekends.

If management is never active then the average (and minimum and maximum) current will be 32A. If management is occasionally active but not particularly restrictive, then the average will be close to 32A. This is shown for all days, weekdays and weekends in Figure 15.

This shows the inverse trend to Figure 14 above, showing much more restrictive management during the week compared to weekends in winter and spring.



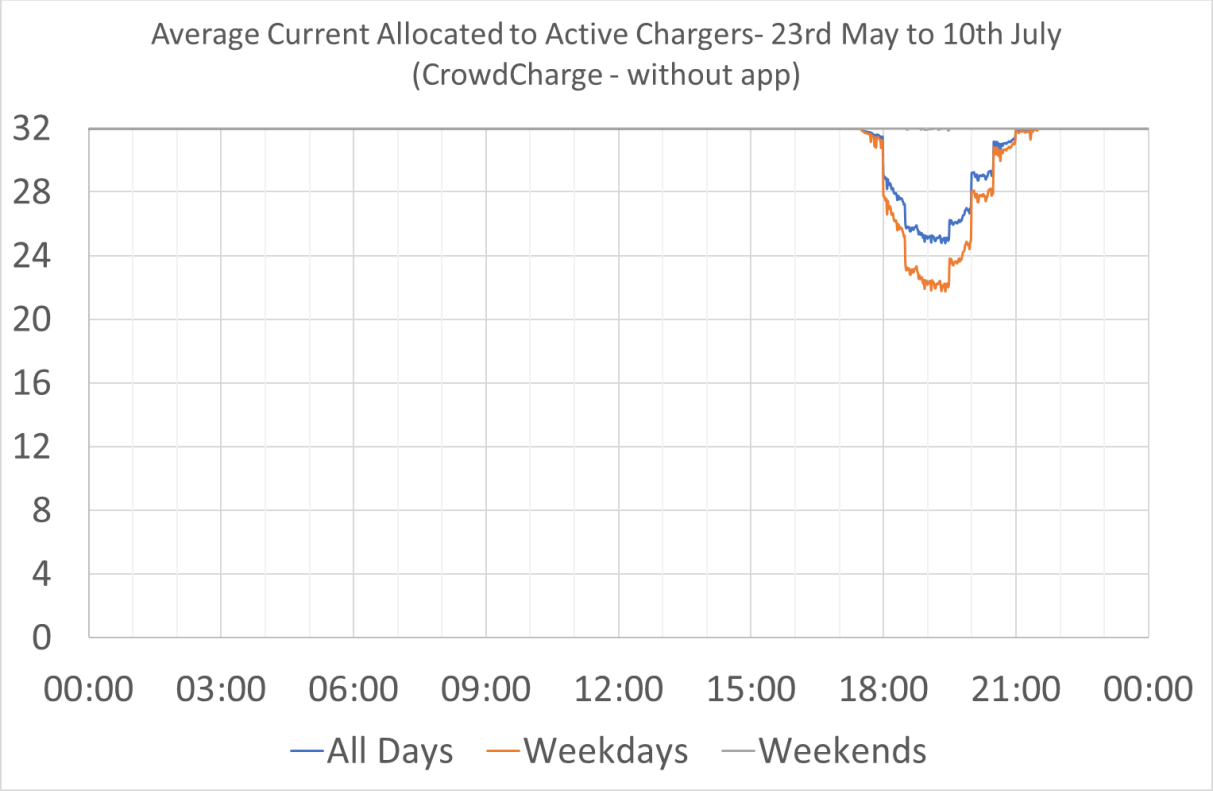
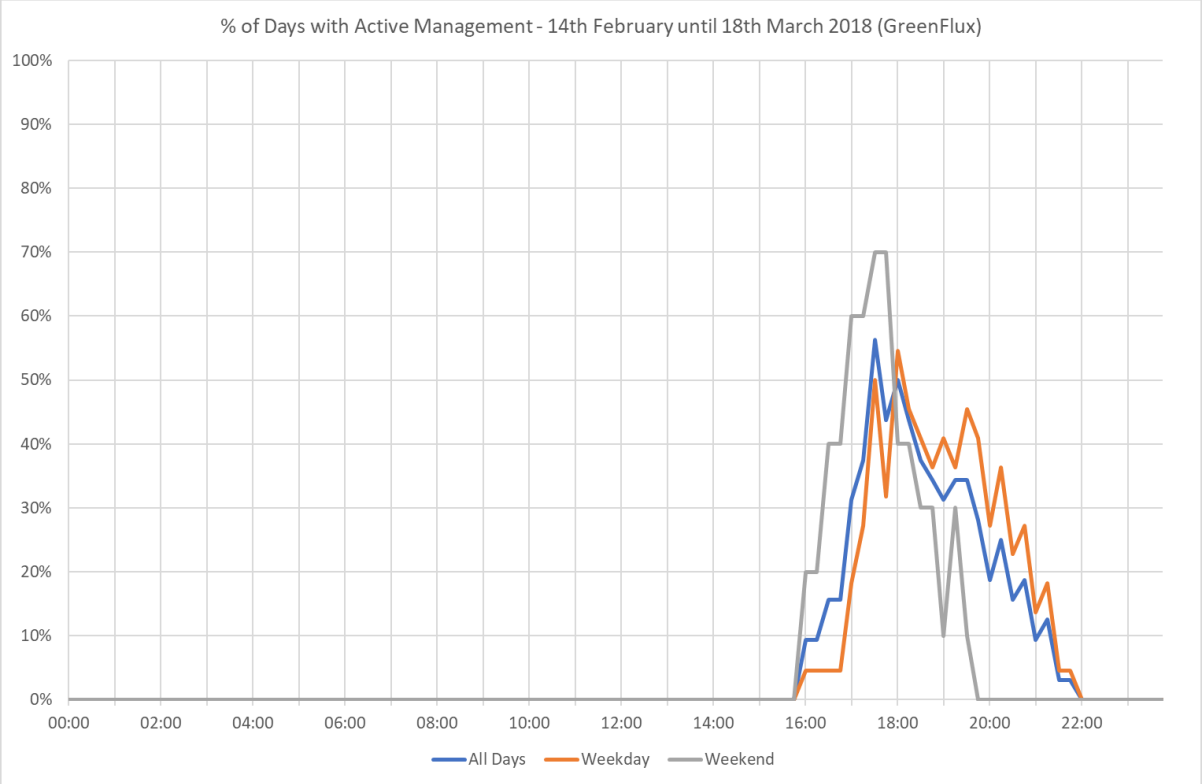


Figure 15: Average current during allocated to chargers 23rd May – 10th July 2018 (CrowdCharge)

For GreenFlux, Figure 16 shows a lower occurrence of demand management relative to the CrowdCharge group, and a higher probability of management occurring at a weekend compared to a weekday. Management will occur less in the GreenFlux group owing to the method used to allocate charge. Within the GreenFlux system a nominally 16A vehicle is only ever allocated 16A, rather than 32A. This allows the same total limit to be spread over a greater number of chargers before curtailment is required (assuming some nominally 16A vehicles are active).



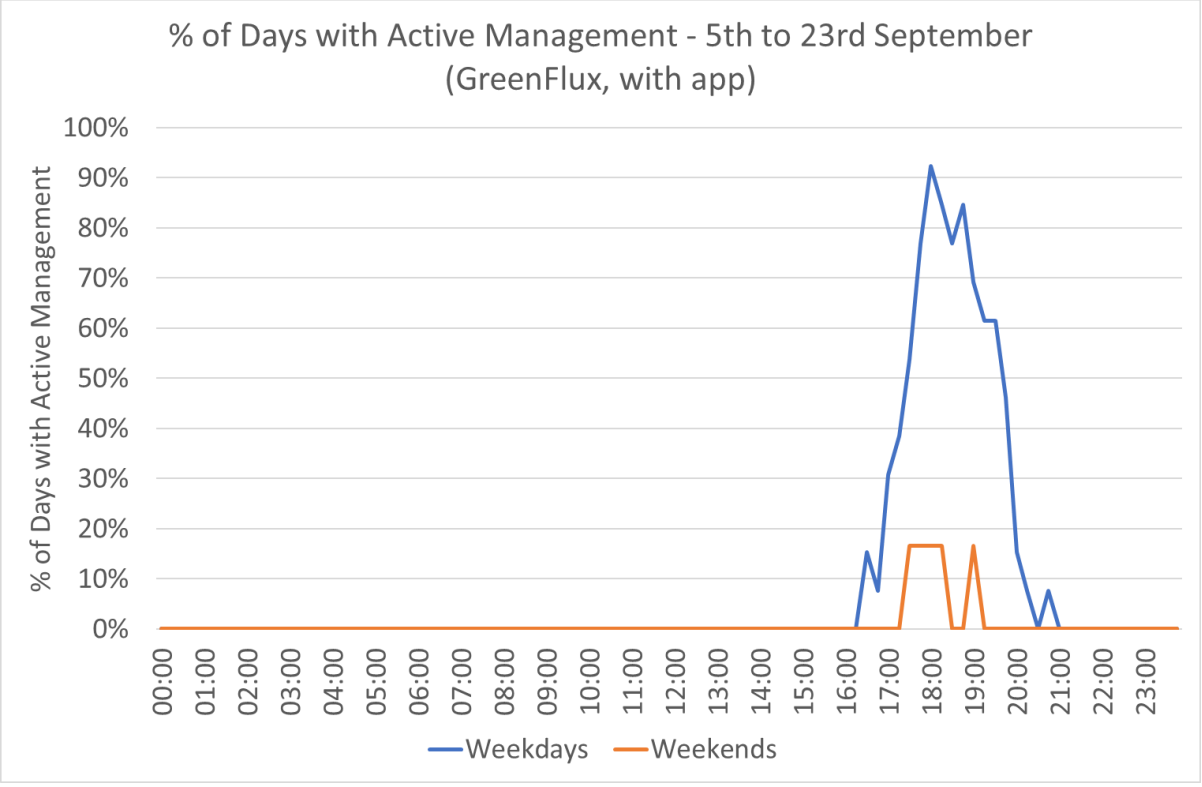


Figure 16: Percentage of days with active demand management (GreenFlux): Upper winter profile, lower spring profile

Implementation of Demand Management

GreenFlux

The roll-out of demand management continues. 114 participants who entered the trial via the "Charge at Will" route have now entered demand management, along with 165 participants who were straight into demand management, making a total of 279 trial participants under demand management.

A small number of customers have had to be removed from demand management. The majority of these are owners of the BMW 330e, which has a known issue with smart charging where a pause in charging is employed. In this situation the car does not start charging again after the pause and so the only acceptable solution for these participants is removal from the smart charging group.

GreenFlux has developed an app which allows participants to request 'high priority' for their current charge session, decreasing the participant's chances of experiencing curtailment as a result of demand management. This has been offered to trial participants (Trial phase 2) since May 2018.

Preliminary results of the customer survey for Trial 2 (results from around 150 participants). The main findings from this are:

- 86% of participants rate the acceptability of their charging arrangements as 7 or higher (on a scale of 1 – 10)
- Awareness of the app is high – 92% of respondents were aware they could access an app
- 70% of participants who were aware of the app had used it
- The respondents who hadn't used the app cited the following reasons (categorised based on free text responses), a follow-up will be arranged for those citing problems with accessing the app or other technical issues:
    - Wouldn't make a difference to their charging regime/not relevant to me (49% of respondents who hadn't used the app)
    - Technical problem (10%)
    - Issue with invite or setup (12%)
    - No smartphone access (10%)
    - Other (20%)
- Awareness of the app functionality was high – 90% were aware that the app allowed them to request high priority
- Reasons for using the app were as follows (categorised based on free text responses):
    - Journey requirements (57% of those who had used the app)
    - Testing the app out (36%)
    - Other (4%)
    - Didn't want to wait for charging to complete (2%)
    - To use PV (1%) (N.B. this functionality is not included in the app)

- The app appears to have alleviated some participants' concerns regarding smart charging:
    - 39% of participants were unconcerned by smart charging regardless of the app
    - 20% had concerns and the app alleviates some of them
    - 20% are not sure if the app has alleviated their concerns (over half of these respondents had not used the app)
    - 14% had concerns and the app alleviates most of them
    - 7% had concerns and the app alleviates all of them

Further data is being collected from the remaining trial 2 participants.

EA Technology are currently working with GreenFlux to test an updated algorithm and app which will be used for Trial 3. The updated algorithm and app will allow participants to earn a financial reward by moving their charging away from peak periods. Participants will start Trial 3 with a reward balance (e.g. £10). Charging at different times will be at different rates (p/kWh). By changing their charging behaviour participants will either increase or decrease their reward value. There are several ways a participant could achieve this:

- Without using the app, but by changing the time they plug-in their vehicle (but they start charging immediately)
- Without using the app, but use a timer on their vehicle to shift charging away from the peak rate
- Allow the app to manage their charging based on the stated preference of 'minimise cost, optimise time and costs, or optimise time)'.

The three preferences are used to manage when charging can occur, as follows:

- 'Optimise time': vehicle charges immediately, regardless of the cost. It is only paused if this is required due to a network capacity issue
- 'Minimise cost': charging is paused until the off-peak rate begins
- 'Optimise time and cost': charging begins during the 'taper' period which follows the peak period.

Participants will set their preference via the app interface which is saved and applied to all transactions (until the preference is changed). Screenshots of the app interface are shown below:

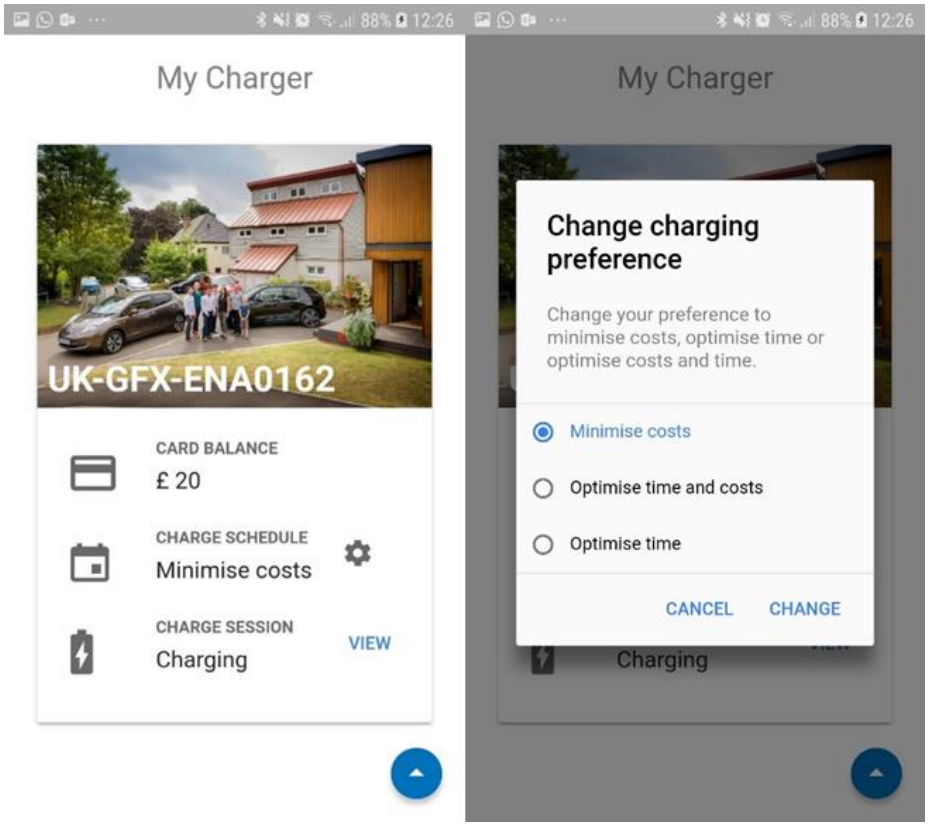


Figure 17: Screenshots of the app interface

Trial 3 will begin early-mid October for the GreenFlux trial participants.

CrowdCharge

The roll-out of demand management continues. 82 participants who entered the trial via the "Charge at Will" route have now entered demand management, along with 182 participants who were straight into demand management, making a total of 264 trial participants under demand management.

CrowdCharge has developed an app which allows participants to influence the demand management system by inputting journey plans (daily, regular and occasional), alongside participants input of their EV's current state of charge (battery charge) or in some cases telematics that provide this data automatically, the CrowdCharge system then plans the EV's charge for its next journey based on the next journey. Depending on the charge required, initial state of charge and plug in time the CrowdCharge system allocates a charge rate that suits the energy required. This is reviewed alongside all other charge plans and the demand limit every time the number of EVs charging changes (and, if the app is used, their charge plans). The overall effect should be that all EVs receive their required charge to make their next journey. Where participants do not use the app, the EV charges at full rate from the moment it is plugged in.

This app has been offered to trial participants (Trial phase 2) since Late July 2018.

The latest status report on invitations to the CrowdCharge app is shown below:

Table 8: The latest status report on invitations to the CrowdCharge app

Status	Total Number of Participants
Declined	2
No response from customer after reminder email	110
Setup and fully operational	126
Total	**238**

This indicates that 53% of participants were sufficiently interested in the app to complete the registration process.

The updated algorithm for Trial 3 was deployed to the test system during the weekend of 15th September. A suggested tariff structure and group limits for testing was provided by EA Technology during w/c 24th September, along with some queries on the functionality of the updated app/algorithm/tariff system. No response has been received from CrowdCharge at the time of writing. The following areas are outstanding which prevent meaningful testing in preparation for Trial 3:

- Detailed description of the functionality of the app/algorithm/tariff combination in order to devise a suitable test plan
- Visibility of the updated app to be used by participants.

It should be possible to limit the number of tests required, and so limit the number of days required. However, this can only be achieved if each test is well designed and appropriate feedback is provided by CrowdCharge in a timely manner, to prevent 'wasted' test days.

Before Trial 3 can begin, testing must be completed, and suitable documentation prepared for participants, which explains the next stage of the trial. EA Technology have not yet received sufficient detail on the updated system to prepare this information or seen any indication that such material has been prepared by CrowdCharge.

Trial 3 needs to be operational for 6 weeks in order to allow participants to get used to the tariff/reward system. The trial must also end (smart charging removed) prior to the Christmas break. There is therefore a risk that unless excellent progress is made in the first half of October it will not be possible to deploy CrowdCharge Trial 3 for enough time to obtain meaningful results.

Vehicle to Grid (V2G) Systems

The project has an aim to bring household scale Vehicle to Grid (V2G) systems into the customer trial, using a single phase, G83/G59 compliant V2G system. This would help to assess whether V2G, alongside smart charging/PIVDCS, can be used to meet the project aims of providing mitigation to PIV charging growth. V2G chargers could be switched to export mode at times of peak electricity demand to support local PIV charging when required, supporting local voltage and reducing LV substation loads.

In the past six months, the previously mentioned unnamed supplier dropped out of the running to supply V2G chargers to the project, another supplier (OVO Energy) entered the frame, but ultimately dropped out again as they cannot supply within the timescales of the project.

This leaves CrowdCharge and their supplier Nichicon, the only credible supplier to the project.

Over the past six months EA Technology have received and installed a modified 2-piece, Vehicle to Home (V2H) charger from Nichicon, via CrowdCharge. While this unit could charge an EV (Nissan Leaf) via its Chademo DC charger it proved incapable of discharging from the EV to export power, nor to work on V2H mode (exporting to a load bank). Eventually, attempts to get this unit to work were abandoned when a second, single-piece V2G charger was delivered to the UK.

This single-piece unit was installed at EA Technology in August and has proved to work in charge and discharge mode satisfactorily, albeit under manual control.

CrowdCharge are waiting for delivery of a communications module for the charger that will interface with a new version of the CrowdCharge Controller that has been developed. CrowdCharge are continuing development of the controller programming that will enable remote control of the V2G charger within the CrowdCharge Smart Charging system (alongside smart chargers) – verbal feedback from CrowdCharge report “good progress”.

Thorough testing of the V2G charger cannot begin until interface with the CrowdCharge system is established.

CrowdCharge have now confirmed their intention to supply five V2G chargers to a limited number of trial participants and have ordered these units from Nichicon for delivery in November 2018.

V2G trial volunteers will be loaned the V2G chargers for a maximum period of six months, after which CrowdCharge will arrange for their removal. During this period the V2G chargers will be managed within a simulated smart charging environment (smart charger transactions will be simulated using existing, historical, trial data charging transactions). EA

Technology will contract Impact Utilities to carry out a discrete customer survey of V2G trial participants towards the end of the trial period.

Actions to be undertaken:

- Nichicon to confirm G59 compliance of these units (there appears to be a slight concern regarding Rate of Change of Frequency trip timing that needs resolving)
- Nichicon/CrowdCharge to confirm delivery date to the UK.

In the mean time

- CrowdCharge to identify up to a dozen potential hosts for the V2G chargers (on the assumption that some will fail to comply with technical requirements along the way)
- CrowdCharge to ask those that are existing Trial participants to confirm their previous Electric Nation pre-installation survey (household electricity supply and distribution details) and to ask new volunteers to fill in the survey
- Installer will then review and rule out those where V2G charger would not be suitable and to identify options for suitable earthing of the installation
- CrowdCharge to then ask WPD to review selected volunteers (by MPAN, to ensure confidentiality) suitability for V2G (important question regarding supply cable capacity/impedance and review earthing options provided by installer)
- CrowdCharge to then make formal request to install V2G chargers in suitable properties, based on WPD feedback.

Next steps

- Introduction of user 2nd generation apps for GreenFlux customers in trial, customer survey starts end November;
- Complete testing of CrowdCharge 2nd generation app, introduce to trail before end October, customer survey starts end November;
- Helping customers to use charging apps;
- Work with Systems Integration provider, charger manufacturers, PIVDCS suppliers and DriveElectric trial support team to maintain communications uptime of chargers in trial to end of trial– ongoing;
- Continue development of trial data database, incorporating data returns from GreenFlux/CrowdCharge/Impact Utilities and developing queries and reports for analysis and project reporting purposes – ongoing;
- Use GreenFlux/CrowdCharge data returns to watch out for potential early issues with PIVDCS App implementation in the customer trial– ongoing;
- Continue management of Customer Research supplier;
- Continue pursuit of V2G trial option with CrowdCharge;

- Prepare for decommissioning of smart charging systems in January 2019 – aim to leave all customers with a functional charger in non-smart charge mode (i.e. dumb);
- Plan for data analysis and reporting in 2019, alongside market research with respect to development of functional specification for smart charging and commercial framework in which it could be delivered to WPD; and
- Continued development of the Network Assessment Tool.

3 Progress against Budget

Table 9: Progress against the budget

Spend Area	Budget (£k)	Expected Spend to Date (£k)	Actual Spend to Date (£k)	Variance to expected (£k)	Variance to expected %
WPD PROJECT MANAGEMENT (LOP)	45,000	45,000	45,000	0	0
TRL CONTRACT	226,802	158,762	158,762	0	0
EATL CONTRACT	3,094,359	2,361,492	2,361,492	0	0
FLEETDRIVE CONTRACT	2,129,375	1,895,173.67	1,843,650	51,523.67	2.7
GRIDKEY CONTRACT	89,680	89,680	156,002	-66,322	-74
GRIDKEY CONTRACT	165,800	165,800	99,480	66,320	40
EQUIPMENT REQUIREMENTS	5,000	2,760	2,760	0	0
DEPOT INSTALLS	10,000	10,000	10,000	0	0
DEPOT INSTALLS	90,000	90,000	90,623	-623	<1
DEPOT WPD INSTALLS	10,363	10,363	10,363	0	0
WPD PROJECT MANAGEMENT 2	51,000	34,782	34,782	0	0
TOTAL	**5,917,379**	**4,812,289**	**4,812,914**	**50,898.67**	**1**

Comments around variance

1. Equipment costs unexpected sub install ancillaries
2. WPD project management weighted heavily at project start
3. Awaiting clearance for recent fleetdrive invoice

4 Progress towards Success Criteria

1. An LV Network Assessment Tool for DNOs (an add-on to the widely used WinDEBUT LV design tool) that:
   a. Analyses and quantifies PIV related stress issues on LV networks (to LV area scale), including:
      a. Heuristics enabling rapid assessment of PIVs on LV networks through "topological" modelling of LV networks
      b. Ability to include known PIV charger installations
      c. Ability to forecast future PIV charger installations based on PIV market growth and forecasts
      d. Flexibility allowing for future charger rating and PIV battery size developments
   b. Identifies best economic PIV solution: Demand Control/V2G/Reinforcement.

   Progress on development of the NAT, bulk data processing for the whole of WPD's license areas is completed. This includes mapping of low voltage networks (combining substation, cable segments to map feeders and customers associated with feeders) and Debut assessments to identify substation and cable segment utilisations and maximum voltage drop on mapped feeders. The bulk data processing has identified some gaps in WPD data (e.g. no customer data for certain substations), which is being addressed and mapping/data errors (e.g. wrongly assigned customers to substation, too many dumb feeder groups for identified feeders) that result in a failed Debut assessment, these are being addressed by modifying the assessment method to produce partial assessments where possible. A user interface for substation level review has been developed, work continues to add functionality. Development of a method for sharing WPD provided EV uptake forecasts at Energy Supply Area level down to substation and customer level has been developed and is being applied across all WPD licence areas.

2. A functional specification for a technique to monitor and understand the effects of electric vehicle charging on LV networks across different levels of penetration (to be delivered by others)

   This aspect of the project is now complete and has been accepted by WPD

3. A functional specification and commercial framework for future procurement and deployment of PIV/V2G Demand/Export Control Services by DNOs to delay or avoid network reinforcement in cases where PIV installation numbers create network stress.

   DriveElectric's recruitment of customers into the trial and installing charging and communication kit in their homes has been excellent; DriveElectric achieved the target

of 700 recruited participants in January 2018, this being 3 months ahead of the project's deadline.

All installations were completed in this reporting period, with the total figure standing at 673; the final Electric Nation charger was installed in July 2018. This lower installation figure of 673 chargers was agreed by WPD and project partners. Installations throughout this period continued to be of a high quality with positive feedback remarks received from participants detailing the installer's professionalism.

Communication issues with the CrowdCharge and GreenFlux PIVDCS systems have continued over this reporting period. With Crowd Charge, the system is required to be reset manually by the participant if it loses comms; on average in 80% of drop of communications the reset fixes the issues with the remaining 20% requiring a piece of hardware or software to be replaced/re-flashed on site. The GreenFlux system has suffered with a 'median delay of communications' error, this meaning the charger appears on line with a heartbeat signal, but the charger cannot be demand manage controlled. Or the charge point is offline due to poor internet/GSM connection. Despite on-going issues on the two systems, it has not affected the participants' ability to charge their vehicle. If an instance occurs where the participant cannot travel with their EV due to lack of charge, DriveElectric reimburses their travel until the charging issue is resolved.

5 Learning Outcomes

The project maintains a comprehensive learning log. The lessons learned during this period have primarily been in the following areas:

- Faults
- App development

- Use of sheltered test environment prior to roll-out to customers
- Recruitment
- Telematics
- EV registrations
- Recruitment
- IOT communications
- NAT Development
- Smart Chargers
- Customer Research
- Marketing

Details of the learning log entries created in the last 6 month period are provided in Table 10 below.

Table 10: Learning Log entries created in part 6 month period

Context What activity does the learning point relate to?	Learning Point What has been learned?
Faults	BMW 330e charging issue - when plugged in the car does not recognise the charger output and does not accept the charger. EA Technology are due to receive DriveElectric's 330e to conduct testing. EA to raise with BMW if testing inconclusive... (will update once more known)
App development	The process for gaining Apple Apps approval takes far longer than it does for Android Apps. The development and testing of the GreenFlux App has utilised the Android format. Once the App functionality was settled the development of an Apple App was relatively simple, but the process of gaining Apple approval was very time consuming. Updates to an app (e.g. wording changes) require the verification process to be passed again. Limiting updates and allowing additional time within the project timeline can address this issue. This should be factored into future projects where mobile phone Apps are to be used.
NAT Development	The quality of network asset data varies considerably across WPD's four license areas. The outcome of NAT data processing and network assessment success therefore varies with the quality of input data. This could be of use to WPD in terms of targeting future asset data quality/mapping improvement work on areas with poor quality data.
NAT Development	Related to above – EA Technology has realised that measuring the NAT performance at "substation level" mapping/assessment failures is distorted where only one feeder map/assessment failure out of all feeders associated with a substation, where the remaining feeders are classed as good. In future NAT will report both substation assessment success (where all feeders are good) and feeder success for an area (where x%

Context What activity does the learning point relate to?	Learning Point What has been learned?
	of feeder assessments are good)
Use of sheltered test environment prior to roll-out to customers	The availability of a test rig has allowed a number of potential issues to be identified with demand management algorithms prior to roll-out to participants. Addressing these issues using this knowledge prior to deployment into the trial has improved the participant experience and the usefulness of the trial results generated. If algorithms were released with issues which could negatively affect the customers' perception of smart charging then the understanding of the acceptability of the solution would be affected and so the trial results would not give a true reflection of the ability of smart charging to mitigate issues associated with EV demand.
Recruitment	POSITIVE - 'Friends Recommendation' to the project was the fourth highest lead source behind search engine 'Google' in first, and EN website and social media second and third respectively. Out of the total approved surveys, 10% were from recommendations to the project which is a large conversion rate. At the start of the recruitment phase the benefit of asking participants to recommend friends and family to the project may have been overlooked. Providing incentives for recommendations could be utilised on future WPD projects to increase the conversion rates further. With other projects which require recruitment of the public, qualification and marketing process should focus on utilising recommendations to boost customer engagement. Recommendations have a high conversion rate which could be due to trusting a friend or family's opinion. Offering discounts if friends/family applies could be a useful tool to increase leads/conversions rates.
Telematics	When qualifying customers, the project only asked if the participant would be willing to provide telematics data once their charger was installed. As a result the telematics recruitment has suffered with less than 30 vehicles agreeing to supply telematics data on state of charge. Learning: In real terms participants are reluctant to provide telematics data once they have received their free charger already. On future projects, providing telematics data needs to be a project requirement. By having the participant sign they agree to provide telematics data to have the free smart charger installed, this could increase the uptake of telematics data on the project. However this

Context What activity does the learning point relate to?	Learning Point What has been learned?
	could hinder the success of the recruitment so it must be thought of carefully before committing to telematics as a project requirement.
EV registrations	An assumption was made at the start of the project's recruitment phase in December 2016 that EV registrations would continue to grow throughout the project's life. Learning: this assumption was correct; the project was able to recruit the 500-700 target. EV registrations have continued to grow thus the demand for home chargers increased simultaneously.
Recruitment	An assumption was made during the initial project planning stage in March 2016 that sufficient PIV drivers will be willing to participate in the trail. Learning: as the project became oversubscribed in the final stages of recruitment, it is proven that there were sufficient PIV drivers willing to join the project. This assumption correlates with the assumption that EV registrations will continue to grow with the life of the project - which they did. As a result of the registrations growing, the PIV drivers grew, thus needing a domestic charger, which the project provided for completion of market research surveys.
IoT communications	Issue with Tele2 (mobile data SIM operator for GreenFlux SIM Communications) and Microsoft Azure disagreeing on data traffic authentication led to a short (2 days) communications outage on a substantial proportion of GreenFlux chargers across Europe (including EN trial chargers). EN has no direct relationship with Tele2 nor Azure - both contracted through GreenFlux. Learning is that future projects with IoT type devices should consider specification of service level agreements with mobile data (and similar) service providers directly or through contracts with suppliers.

Context What activity does the learning point relate to?	Learning Point What has been learned?
NAT Development	Project Assumption: "WPD have sufficient network data to populate the network assessment tool" - Learning: WPD's LV substation data is good enough for NAT requirements; Cable/OHL data varies from adequate to poor, depending on age of data, leading to NAT feeder translation performance issues, customer (MPAN) data appears good though this is difficult to test (especially domestic/commercial customer type) and number of missing data points cannot be tested other than identifying substations and feeders with no customers.
Smart Chargers	Project Assumption: "Suitable smart chargers will be available for the project". Whilst this is true from a project perspective and smart chargers have been procured, tested and deployed into the customer trial there is a lot of learning from the project regarding smart charger control and communications in particular. In summary, the project used available smart chargers developed for commercial charging stations for deployment into domestic situation. Two charger suppliers/models were selected. Briefly learning is: - charger manufacturers will need to concentrate on development of domestic smart charger, test thoroughly and stabilise firmware (repeated firmware updates have proved problematical in project) - use of external controllers with standardised firmware/functionality could be a solution, though adds cost, but again development needs concerted effort to stabilise firmware and functionality - charger communications needs concerted effort on part of developers and communications industry regarding stability of connection, Wi-Fi (or similar) connectivity (for wireless connection to internet) performance and mobile data connectivity performance

6 Intellectual Property Rights

A complete list of all background IPR from all project partners has been compiled. The IP register is reviewed on a quarterly basis.

No additional foreground IP entries have been made to the IPR register in the last six month period.

7 Risk Management

Our risk management objectives are to:

- Ensure that risk management is clearly and consistently integrated into the project management activities and evidenced through the project documentation;
- Comply with WPD's risk management processes and any governance requirements as specified by Ofgem; and
- Anticipate and respond to changing project requirements.

These objectives will be achieved by:

- ✓ Defining the roles, responsibilities and reporting lines within the Project Delivery Team for risk management;
- ✓ Including risk management issues when writing reports and considering decisions;
- ✓ Maintaining a risk register;
- ✓ Communicating risks and ensuring suitable training and supervision is provided;
- ✓ Preparing mitigation action plans;
- ✓ Preparing contingency action plans; and
- ✓ Monitoring and updating of risks and the risk controls.

7.1 Current Risks

The CarConnect | Electric Nation risk register is a live document and is updated regularly. There are currently 25 live project related risks and 9 risks which have been escalated to issue. Mitigation action plans are identified when raising a risk and the appropriate steps then taken to ensure risks do not become issues wherever possible. In Table 11, the details of the project's top five current risks, which have not been escalated to issue, by category, are given. For each of these risks, a mitigation action plan has been identified and the progress of these are tracked and reported.

Table 11: Top five current risks (by rating)

Details of the Risk	Risk Rating	Mitigation Action Plan	Progress
RO57 V2G charger trial deployment may not be possible	Moderate 40	Keep WPD abreast of latest developments with respect to deployment of V2G charger. Identify constraints to trial deployment and produce action plan to mitigate or manage	1. Delivery constraints CrowdCharge are working with Nichicon to resolve issues 2. CrowdCharge control equipment and back office system readiness

Details of the Risk	Risk Rating	Mitigation Action Plan	Progress
		these as far as possible	CrowdCharge development underway 3. G59 Compliance Issues CrowdCharge are working with Nichicon to resolve issues 4. Connection agreement from WPD cannot be resolved until 5 complete 5. Getting volunteers DriveElectric to take action to find suitable volunteers
R046 customers will switch off chargers	Moderate 30	Customers are being instructed to not switch chargers off as part of trial participation instructions. Customers have also been given detailed instructions to allow them to reset their charger system after a loss of communications.	We have educated people and the number of people still doing this has significantly reduced
RO55 Trial participant personal information may be accidentally released or hacked by third party	Moderate 25	Customer surveys will contain and identity verification question that does not disclose name, address, etc. and instead will use a partial phone number (e.g. "please confirm	Measures described have now been put in place

Details of the Risk	Risk Rating	Mitigation Action Plan	Progress
		your phone number ends in ...1234"). No other personal data is relayed back to trial participants in surveys.	
RO58 At the end of the trial some trial participants may be left with chargers that cannot be reconfigured as dumb chargers	Moderate 24	EA Technology is working with GreenFlux and CrowdCharge to develop a decommissioning plan	New risk
R016 EA Technology or DriveElectric's poor delivery may occur	Minor 12	- Selection of experienced sub-contractors, with potential for overlapping scope - Regular update/progress meetings will be conducted to identify issues early - Contract cover will be appropriate for all areas of work	Performance has been high and the project is well underway

Table 12 provides a snapshot of the risk register, detailed graphically, to provide an on-going understanding of the projects' risks.

Table 12: Graphical view of Risk Register

Likelihood = Probability x Proximity						
	Certain/Immi	0	0	0	0	0
	More likel	0	2	1	0	0
	50/50 chan	1	3	0	0	0
	Less likely to	1	0	2	1	0
	Very unlikely	2	4	8	1	1
		1. Insignific	2. Small	3. Delay,	4. Substan	5. Inability
		Impact				

	Minor	Moderate	Major	Severe	
Legend	16	7	4	0	**No of instances**
Total	27				No of live risks

Figure 18 provides an overview of the risks by category, minor, moderate, major and severe. This information is used to understand the complete risk level of the project.

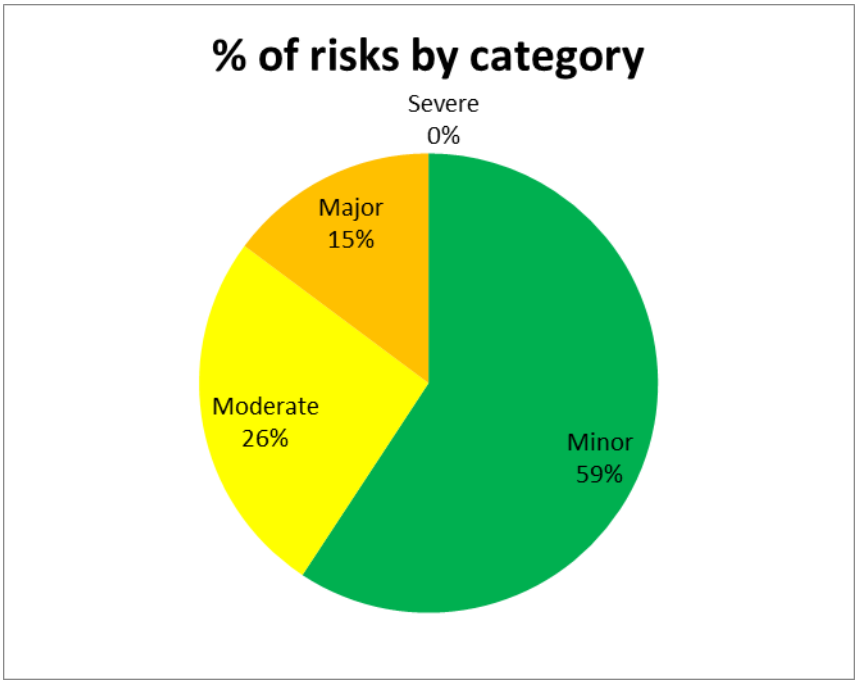


Figure 18: Percentage of Risk by category

7.2 Update for risks previously identified

Six risks have been closed since 31st March 2017, broadly covering the reporting period to which this report relates. The closed risks are:

- Risk 007 "vehicle data capture systems/technology may not be ready in time for vehicle delivery" has been closed
- Risk 044 "…Customer chargers may "trip" off unexpectedly, frequently … has been closed
- Risk 047 "…ICU data SIMs do not initiate or communicate…" has been closed
- RO52 Results from the trial may not be statistically significant has been closed as sufficient numbers have been reached.

Descriptions of the most significant risks identified in the previous six monthly progress report are provided in Table 13 with updates on their current risk status.

Table 13: Risks identified in the previous progress report

Details of the Risk	Previous Risk Rating	Current Risk Rating	Mitigation Action Plan	Progress
R007: The vehicle data capture systems/technology may not be ready in time for vehicle delivery	Major (48)	Closed	Risk Closed	Risk Closed
R046: Customers will switch off chargers	Moderate (30)	Minor 15	Customers are being instructed to not switch chargers off as part of trial participation instructions. Customers have also been given detailed instructions to allow them to reset their	We have educated people and number of people still doing this has significantly reduced

			charger system after a loss of communications (or power failure/charger switched off event). Much work has been done in communicating to customers asking them to leave chargers switched on , reality is some will always do this and this will form part of project results, risk reduced in severity. Plan for App to reduce switching off occurrences.	
R049: Quality issues of ICU charger hardware lead to failures and increased costs form installers	Moderate (27)	Minor (6)	Ongoing fault reporting. DE and EATL regularly communicating with ICU to improve manufacturing process, also feedback on faults will ensure warranty process followed. QA	The situation here is improving with only 10 left to install

			checks in factory increased to 100%.	
R050: Total home load is incorrectly calculated	Moderate (18)	Minor (9)	Increasing numbers of "OWL" meters being installed to gather data to provide more informed guidance. Continue to ensure that all installers are aware of the process for calculating demand and the triggers for asking WPD permissions rather than connect and notify.	All installations now complete
R052: Results from the project may not be statistically robust	Minor (12)	Closed	Risk Closed	Risk Closed

8 Consistency with Project Registration Document

The scale, cost and timeframe of the project has remained consistent with the registration document, a copy of which can be found here:

www.westernpower.co.uk/innovation/projects/electric-nation

9 Accuracy Assurance Statement

This report has been written and compiled by the Project Manager from TRL (David Blythin) and the Project Managers from EA Technology Limited (Nick Storer), and DriveElectric (Adam Langford). This report has been checked by Peter Vermaat of TRL. This report has reviewed and approved by the Future Networks Manager (Roger Hey).

All efforts have been made to ensure that the information contained within this report is accurate. WPD confirms that this report has been produced, reviewed and approved following our quality assurance process for external documents and reports.

Glossary

Term	Definition
BaU	Business as Usual
BEV	Battery Electric Vehicle
CRM	Customer Relationship Management
DE	DriveElectric
DECC	(the former) Department for Energy and Climate Change
DG	Distributed Generation
DNO	Distribution Network Operator
EATL	EA Technology Ltd
EN	Electric Nation
EV	Electric Vehicle
EVRT	European EV Road Tour
GB	Great Britain
HV	High Voltage
IPR	Intellectual Property Register
LCT	Low Carbon Technologies
LowCVP	Low Carbon Vehicle Partnership
LEGK	Lucy Electric GridKey
LCNI	Low Carbon Networks and Innovation
LCV	Low Carbon Vehicles event (2017 event held 6th to 7th September at Millbrook)
LV	Low Voltage
MEA	My Electric Avenue project
MPAN	Meter Point Administration Number
NAT	Network Assessment Tool
NIA	Network Innovation Allowance
OHL	Over-Head Line
PHEV	Plug in Hybrid Electric Vehicle
PIV	Plug in Vehicle
PIVDCS	PIV Demand Control Services (or Demand Management Services)
PR	Public Relations (activities)
REX / REX-EV	Range Extended Electric Vehicle
ULEV	Ultra-Low Emission Vehicle
V2G	Vehicle to Grid
WPD	Western Power Distribution