WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Customer Research and Trial Update Report
Electric Nation

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Contents

Glossary

Abbreviation	Term
BEV	Battery Electric Vehicles
EV	Electric Vehicle
HV	High Voltage
NIA	Network Innovation Allowance
PIV	Plug-In Vehicle
PHEV	Plug-In Hybrid Electric Vehicle

1 Introduction

This report provides an update on the customer-facing aspects of Electric Nation ("the Project") – both the customer research questionnaires and trials of smart charging. As detailed below the project aims to show the technical feasibility and benefits of smart charging and customer acceptance of the concept.

At the time of writing the Project is nearing the end of the recruitment stage. Over five hundred smart charger installations have been completed, and approximately 320 participants are under routine demand management. The second Baseline survey, investigating participant reaction to the first demand management trial, began being issued by Impact Utilities in mid-January 2018.

Participants receive their first survey (the Recruitment survey) a fortnight after installation and the Baseline survey between two and six weeks later to establish routine charging behaviour. Customer research industry insight, provided by the projects highly experienced customer research contractor Impact Utilities, suggests that the response rates of both surveys (86% and 78%) are very good when compared to industry averages for this type of research. Consequently, the Project has already received a significant amount of data about EV drivers, their attitudes, and their charging habits, highlights of which are included in this report. Data is also being collected from chargers, showing each transaction and meter values (current made available to the charge point and current drawn by the vehicle).

1.1 The Electric Nation Project

Electric Nation is a Western Power Distribution and Network Innovation Allowance funded project. WPD's collaboration partners in the project are EA Technology, DriveElectric, Lucy Electric GridKey and TRL.

Electric Nation, the world's largest electric vehicle (EV) trial, is revolutionising domestic plug-in vehicle charging. By engaging 500-700 plug-in vehicle drivers in trials, the project is answering the challenge that when local electricity networks have 40% - 70% of households with electric vehicles, at least 32% of these networks across Britain will require intervention.

The project is developing and delivering a number of smart charging solutions to support plug-in vehicle uptake on local electricity networks. A key outcome will be a tool that analyses plug-in vehicle related stress issues on networks and identifies the best economic solution. This 'sliding scale' of interventions will range from doing nothing to smart demand control, from taking energy from vehicles and putting it back into the grid, to traditional reinforcement of the local electricity network where there is no viable smart solution.

The development of the project deliverables is being informed by a large-scale trial involving plug-in vehicle drivers that will:

- Expand current understanding of the demand impact of charging at home, on electricity distribution networks, of a diverse range of plug-in electric vehicles - with charge rates of up to 7kW, and a range of battery sizes from 6kWh to 80kWh+.
- Build a better understanding of how vehicle usage affects charging behaviour.
- Evaluate the reliability and acceptability to EV owners of smart charging systems and the influence these have on charging behaviour. This will help to answer such questions as:
    - Would charging restrictions be acceptable to customers?
    - Can customer preference be incorporated into the system?
    - Is some form of incentive required?
    - Is such a system 'fair'?
    - Can such a system work?

The results of this project will be of interest and will be communicated to the GB energy/utility community, to UK government, to the automotive and plug-in vehicle infrastructure industry and to the general public.

To be eligible to participate in the project Electric Nation participants are required to already have an EV, or to be about to take ownership of an EV. They must live in the WPD licence area (the Midlands, South West and South Wales). In return for taking part in the project the participants receive a smart charger. Trial participants are recruited via a recruitment campaign that has utilised social media, internet presence, traditional PR, attendance at EV events and creating links with EV retailers.

1.2 Purpose and Structure of Report

The purpose of this report is to provide an update on the progress of the trial aspects of Electric Nation, both the smart charging roll-out and customer research. It also sets out the next steps for the project.

The structure of the report and the contents of each section is as follows:

- Section 1: an introduction to the document and its purpose.
- Section 2: the customer research approach, the surveys which customers will complete and data collected by the trial to date.
- Section 3: insight into results of the Recruitment survey to date, showing the demographic data for Electric Nation trial participants.
- Section 4: insight into results of the baseline survey to date, showing participants reported charging behaviour.
- Section 5: the trial design including the process being followed to move customers into demand management.
- Section 6: data on charging behaviour collected to date including the frequency and timing of charging, use of timers and the level of flexibility available.
- Section 7: the next steps for both customer research and the smart charging trial, including early testing of the next smart charging algorithms for both CrowdCharge and GreenFlux.

2 Customer Research and Data Collection

2.1 Customer Research

Customer research is one of the many data sources being gathered by the Electric Nation trial (others include vehicle telematics data, charge point data, data from apps or demand control preference systems and participant enquiries). This research is being undertaken by Impact Utilities. These sources of information will be used to provide an answer to the overall customer objective of the trial:

> To prove which, if any 'Managed EV Charging to Support Local Electricity Networks' regime applied to trial participants is most likely to be satisfactory to all customers.

A condition of taking part in the Electric Nation trial[1] requires participants to complete a number of surveys during the course of the Project to enable the Project to understand participants' attitudes toward charging their EVs and their level of acceptance of varying degrees of managed charging. As the trial progresses and the level of managed charging/systems used to manage charging changes, the customer research will map any alterations in the participants' attitudes towards charging their vehicles and managed charging.

Participants contact details are collected by DriveElectric, the project partner responsible for participant recruitment and associated data protection[2], as part of the enrolment process. DriveElectric clearly explain to trial participants before they enrol in the Electric Nation trial that they are obliged to complete customer research surveys. The graphic overleaf demonstrates the exchange of participant data between DriveElectric and Impact Utilities.

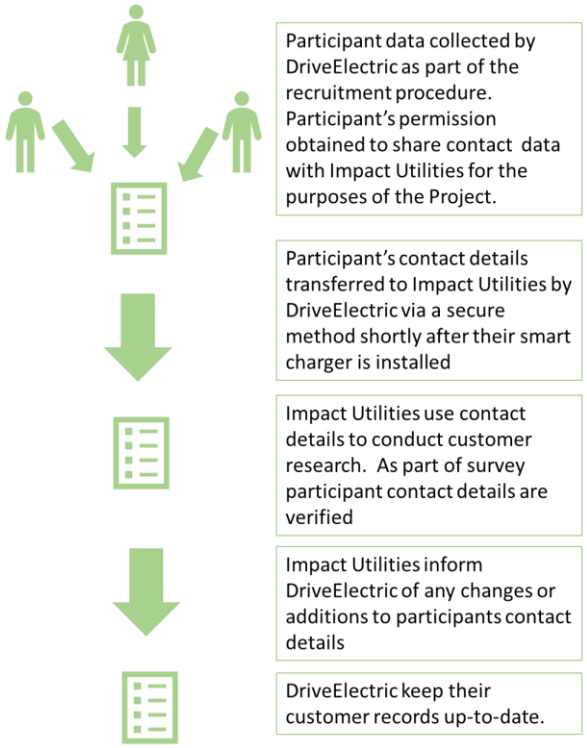
Shortly after the installation of a participant's smart charger they are asked to complete the Recruitment survey (see Appendix 1). This survey concentrates on collecting demographic and socio-economic data, information about the participants, their household, their plug-in vehicle (PIV) and their level of satisfaction with their smart charger installation experience. Participants are later (approximately 6 weeks) asked to complete a Baseline survey (see Appendix 2) to obtain data on their charging behaviour, their satisfaction with this and their attitude towards having their charging managed.

Further surveys will be conducted towards the end of each managed charging cycle, and then a final survey will be conducted at the end of the trial. The first survey to ask participants about their experiences under managed charging has been issued in mid-January 2018. The findings from this survey will be discussed in future Trial Update reports.

[1] This condition is highlighted in project publicity literature, such as the Project website and brochure (which can be accessed via the Project website http://www.electricnation.org.uk

[2] The Projects Data Protection Strategy can be found at: http://www.electricnation.org.uk/wp-content/uploads/2016/11/NIA_WPD_013-CarConnect-Data-Protection-Strategy-FINAL.pdf

Figure 1: Exchange of participant data between DriveElectric and Impact Utilities



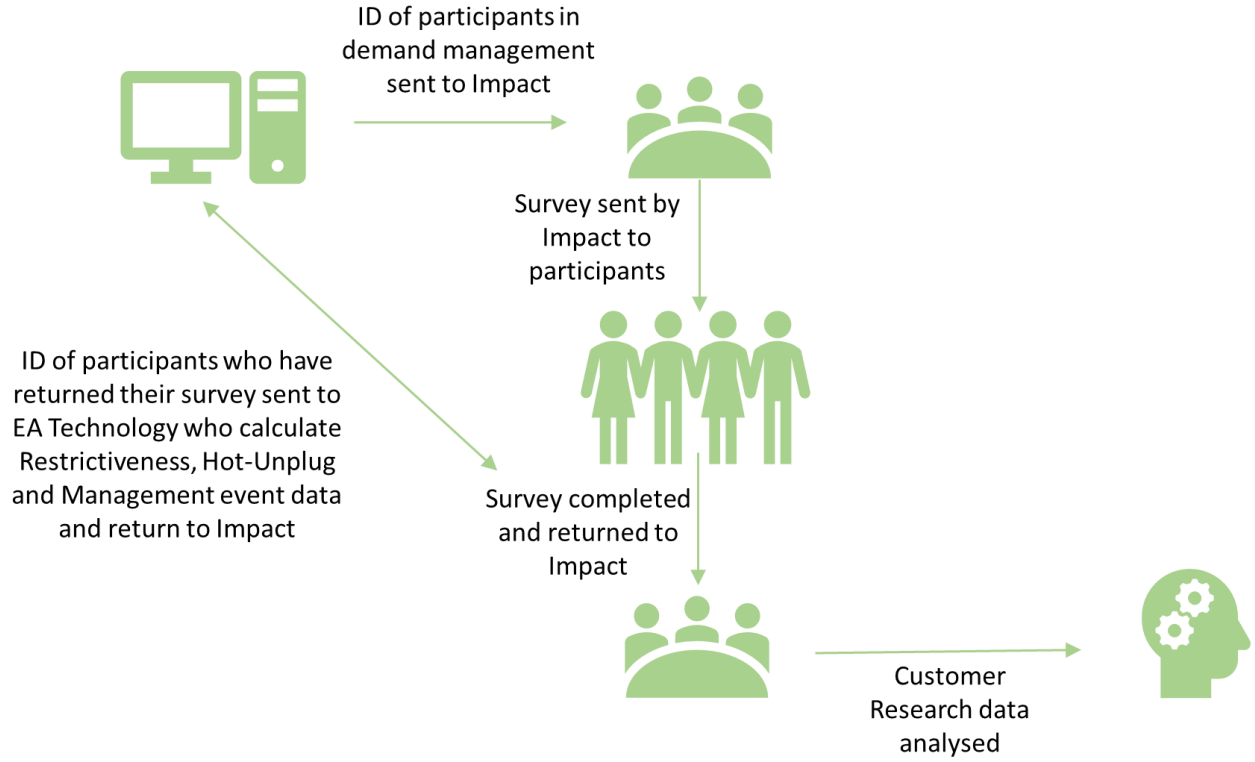
2.2 Surveys investigating attitudes to managed charging trials

A selection of participants has progressed to the demand management trial: GreenFlux 168/309 installed and CrowdCharge 153/224 installed, overall 60% of chargers in demand management at time of writing report. Not all project participants have been part of this demand management trial to date, either because of technical issues with their smart charger, because their smart charger has not been installed for a sufficient length of time (to assess communications reliability) or they have not started using their charger because they are waiting for delivery of their EV.

An important aspect of the Electric Nation trial is to monitor how participants' attitudes to demand management are altered by their experiences of demand management in the project. Therefore, it is important that the survey results are analysed in the context of the individual participants' experience of demand management. It should be noted that some of the trial participants (number will be reported once recruitment is completed) will experience a period of unrestricted home charging (so called "charge at will"), charging data and survey results for these participants will act as a baseline for charging behaviour. These results can then be used for comparison against charging behaviour and attitudes for participants who go quickly into managed charging from the start of their participation in the trial.

The flow of information and precise data that Impact Utilities will require to judge the impact of demand management on participants has been considered by the project team. This data and information flow is illustrated in the diagram below:

Figure 2: Data flow for Baseline 2 survey



Impact Utilities are informed by EA Technology of the ID of participants who have been subject to managed charging for at least four weeks. Impact Utilities then issue survey links to the relevant participants and encourage participants to complete the survey, either online or by telephone according to the participants choice. Impact Utilities will then inform EA Technology when a participant has completed their survey, so data can be generated about the impact of demand management on the participant. The content of this data will be covered in Section 0. Impact Utilities will then use this data to inform their analysis of the survey responses that they receive.

2.3 Data Collection

Recruitment for the Electric Nation trial (and, so, installations of smart chargers into participant's homes) started in January 2017. The final installations are expected to be completed in May 2018. This will be ahead of the schedule.

This report is based on the data collected from the Recruitment surveys of trial participants in the weeks after the installation of their Electric Nation smart charger and data collected from the first Baseline survey. The table below summarises the number of Recruitment surveys completed as of 8th January 2018.

	Surveys Sent	Surveys completed
%	100%	86%
N	515	442

Table 1: Recruitment surveys completed

A smaller number of participants have been in the Project long enough to be asked to complete Baseline survey 1. The table below summarises the number of Baseline surveys completed.

	Surveys Sent	Surveys completed
%	100%	78%
N	486	377

Table 2: Baseline surveys completed

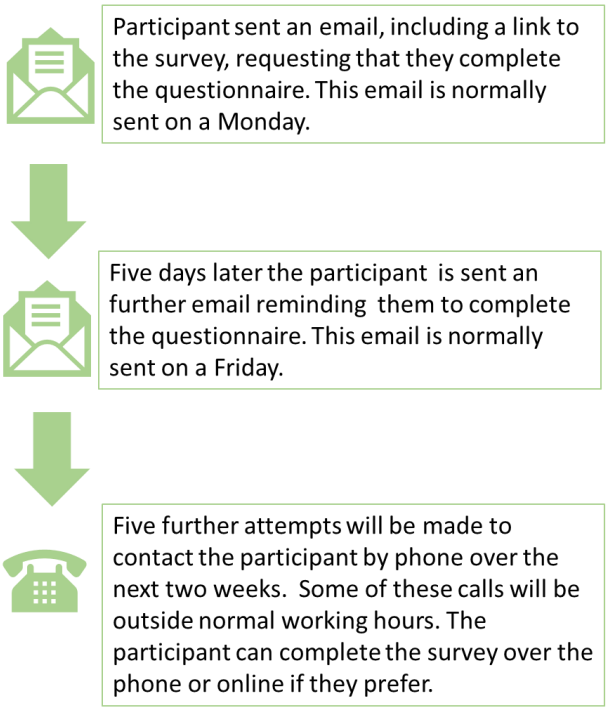
It is too soon at the time of writing this report to provide completion rates for Baseline survey 2 (started 15th January 2018, involving the 300+ trial participants under managed charging for at least 4 weeks at the beginning of January) - this survey investigates participant attitudes to the first managed charging trial.

The tables above represent a snapshot of the number of surveys completed at the time that this report was written. The high level of survey responses can be attributed to a number of factors and process put in place by the project team:

- A newsletter was sent to all participants (December 2017) reminding them of:
  - The importance of the customer research
  - Their obligations as trial participants
  - The details of the customer research contractor (Impact Utilities)
  - The incentive they will receive for completing some surveys
  - Asking them to expect the Baseline 2 survey soon
- Tweets to remind participants to complete the surveys
- DriveElectric reminding participants during the enrolment that under the terms of the trial, in return for the installation of a free “smart” EV charger at their home, they are asked to participate in customer research surveys
- DriveElectric are ensuring that participants are expecting communication from Impact as part of the trial
- DriveElectric are collecting personal email addresses from participants rather than work addresses that are more likely to reject Impact’s emails as Spam. They are also encouraging participants to put Impact’s email address into their contacts list, again to reduce the chance that emails will be rejected as Spam or being blocked by servers which are likely to be more sensitive in their places of work.
- Participants are given the flexibility to take part over the phone or online and with/without the assistance of a professional interviewer
- Impact Utilities proactive attempts to contact participants who have not completed their surveys. This procedure is outlined in the graphic below.

- The high response rates and active communication from participants demonstrate that participants are enthusiastic about participating in the trial and completing the surveys.
- Impact Utilities have designed the surveys so they are not unduly onerous for participants to complete.

Figure 3: Procedure used to encourage participants to complete questionnaires



For all trial surveys, the participant is sent a link to the questionnaire by email (Appendix 3 and 4). If they fail to complete the survey within an allotted period, then the link will be re-sent with a further email reminding them to complete the questionnaire. If the participant still does not complete the survey, then the survey company will attempt to contact the participant by telephone. The participant will be telephoned several times over the following weeks.

Participants will receive vouchers for an online store (Amazon) for completing each of the trial surveys. This excludes the Recruitment survey and Baseline 1 survey. Completion of the Recruitment survey and the Baseline 1 survey are an obligatory condition of trial participation and therefore not rewarded. Participants will not be eligible for the vouchers above if they do not complete the Recruitment and Baseline 1 surveys.

3 Recruitment Survey Results - Participant Demographics

The Recruitment survey provides demographic and socio-economic data about the trial participants. This survey provides the Project with a survey population and frame of reference against which all future survey measurements will be compared. It should be noted that:

- The survey population is representative of the population **who have had their smart charger installed to date.** Project recruitment is nearing completion, and it is expected that the final smart chargers will be installed in May 2018. Final statistics about the Electric Nation trial population will be available a few months thereafter.
- As seen below, the population recruited is skewed towards affluent males, aged 36-55, so is unlikely to be representative of the WPD regional customer base. This will be investigated further when trial recruitment is complete.
- The survey population demographic is also unlikely to be representative of the wider population of car owners, but may be of electric car owners, perhaps more correctly this should be “new car buyers/leasers”, again this will be investigated further when trial recruitment is complete.
- Surveys completed by participants after each demand management trial will be matched demographically to the Baseline survey population, so that the Project is always comparing a like for like population.

These points should be taken into consideration when drawing conclusions from the survey data.

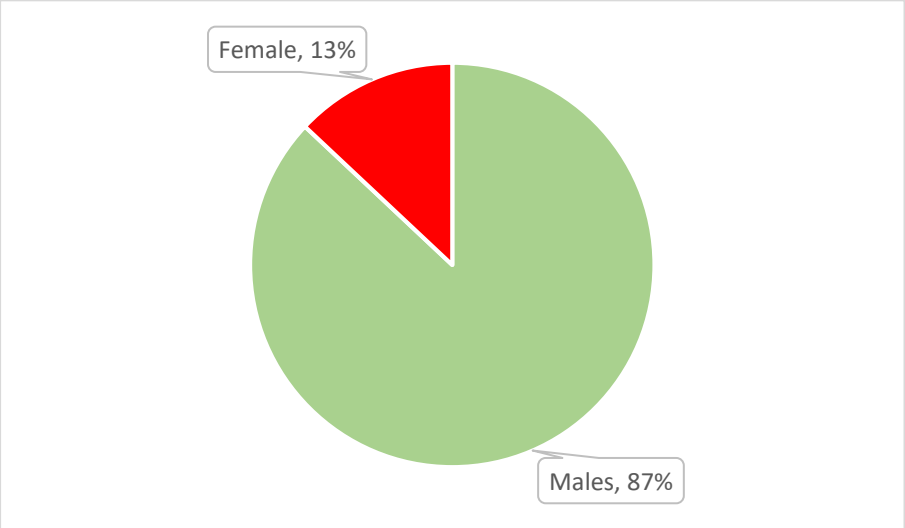
Data provided in this section is for the whole project population who have responded to the Recruitment survey.

Recruitment for the trial is progressing at a very healthy rate. 75% of the expected number of participants have now had their smart chargers installed (526 on Wednesday 10th January out of an upper target of 700). The recruitment data presented here is not however necessarily representative of the final participant population. The charts and graphs below illustrate the demographics of the trial participants who have completed the Recruitment survey to date. Once smart charger installations have been completed the trial population demographics will be compared to the wider WPD customer base. It is expected that the data to complete this comparison may be available in late Spring/ early summer 2018.

3.1 Gender

There is a pronounced gender split amongst participants. Of the 442 participants who have completed the Recruitment survey 87% are male, compared with 13% females.

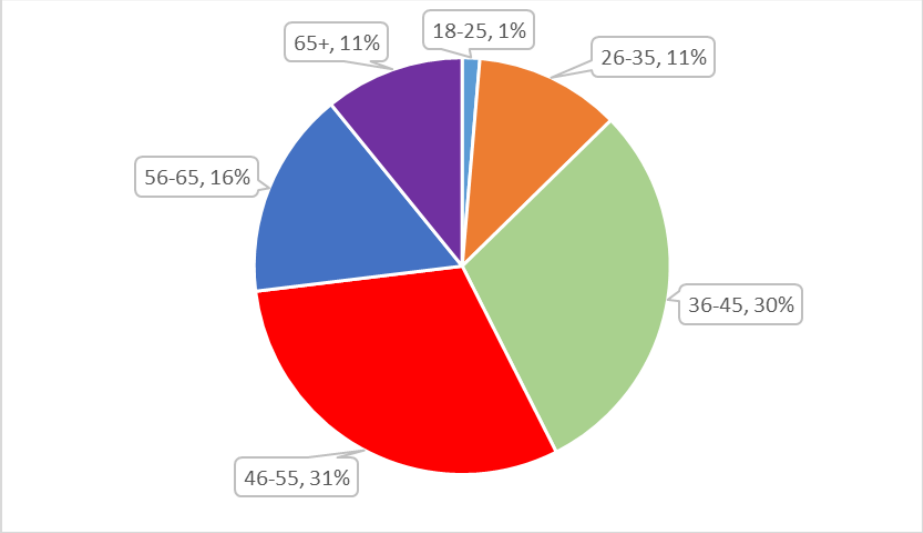
Figure 4: Gender split of participants (based on 442 surveys)



3.2 Age

The chart below demonstrates the age split of participants. The majority of participants are aged between 36 and 55 however the trial does include participants from all age groups eligible to drive a vehicle.

Figure 5: Age split of participants (based on 442 surveys)

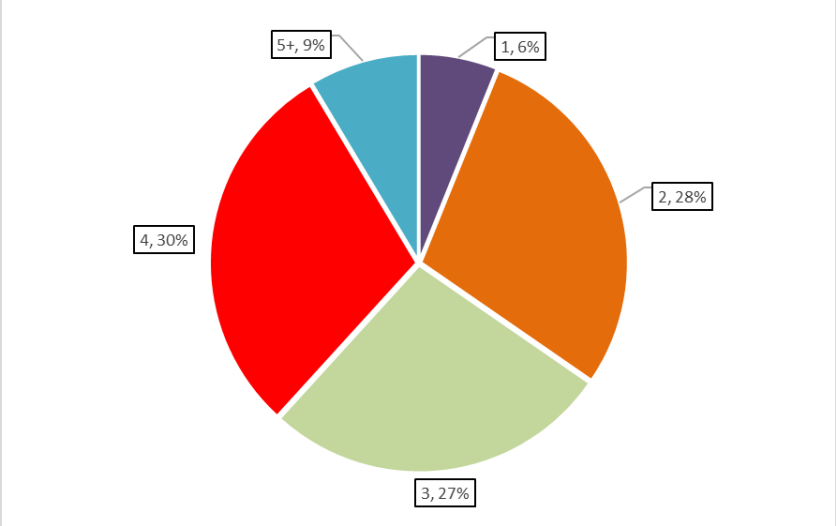


The average age of a participant is 49. The youngest participant is 21 and the oldest is 85.

3.3 Household sizes

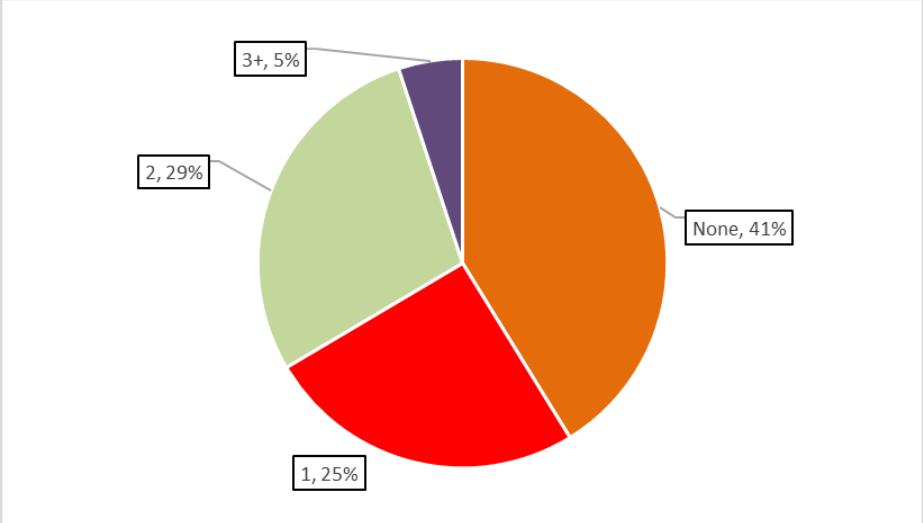
Electric Nation participants represent a range of different household sizes (including adults and children). This is demonstrated in the chart below:

Figure 6:Participant household size (based on 442 surveys)



The number of children in participant households is illustrated below:

Figure 7:Number of children in participant households (based on 442 surveys)

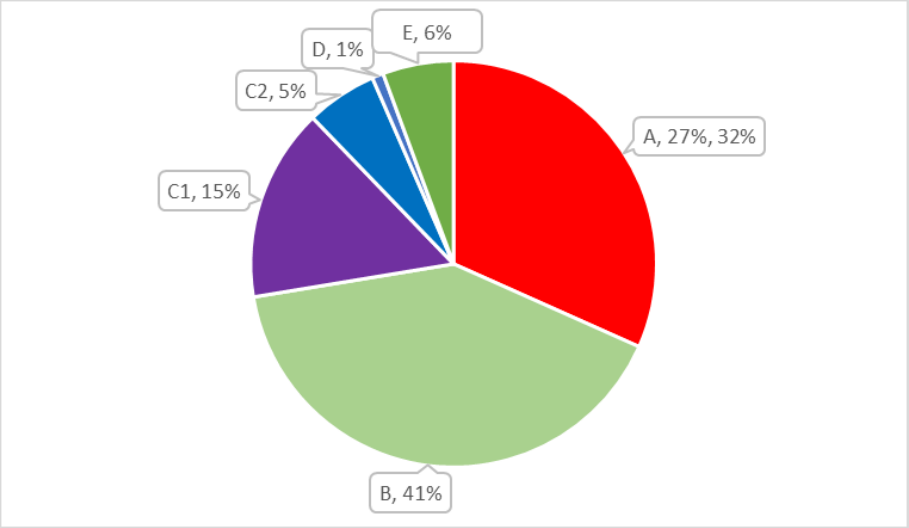


These charts demonstrate that the project has a spread of participants representing different household sizes, including smaller households with no dependent children and households with multiple children.

3.4 Socio-economic and employment data

The chart below shows the professional background of participants.

Figure 8: Socio -professional category of participants (based on 442 surveys)



The table below provides a breakdown of the socio professional segmentations of the categories above.

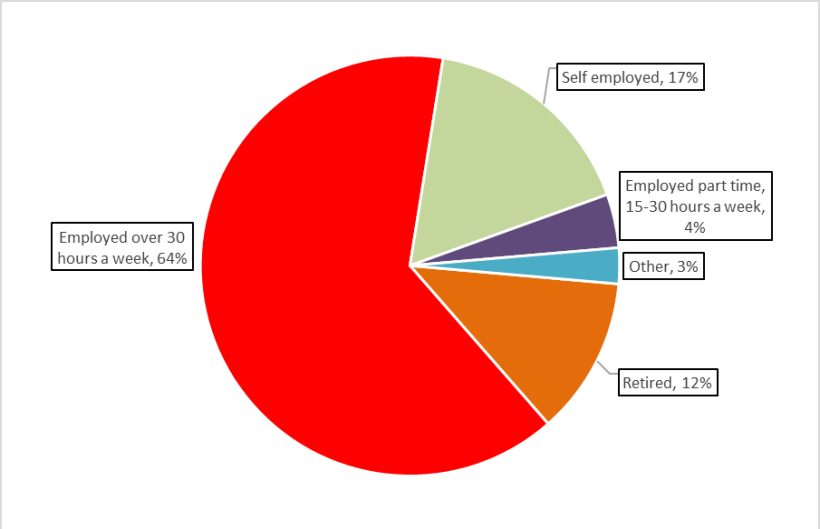
Category	Definition
A	Higher Managerial, administrative, and professional
B	Intermediate Managerial, administrative, and professional
C1	Supervisory, clerical and junior managerial, administrative and professional
C2	Skilled manual workers
D	Semi-skilled and unskilled manual workers
E	State pensioners, casual and lowest grade workers, unemployed with state benefits only

Table 3: Socio-professional categories

Most trial participants are engaged in Higher or Intermediate professions however trial participants have been recruited from all socio-economic categories.

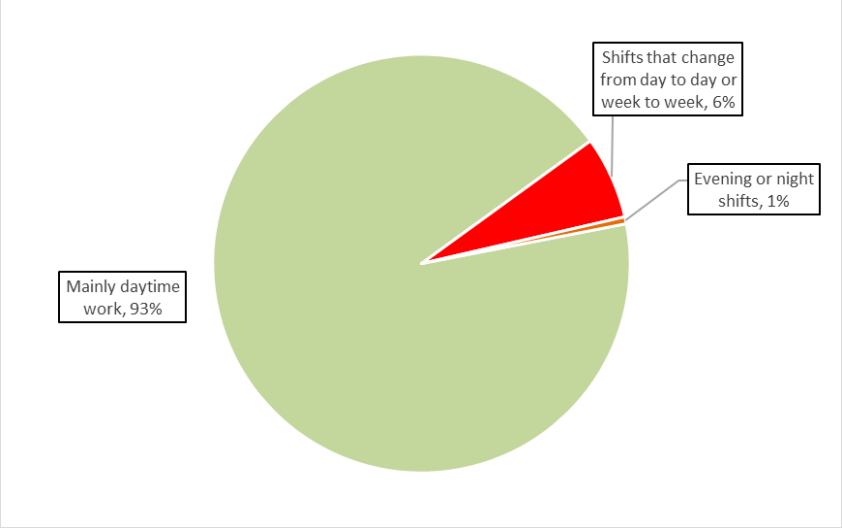
The chart below demonstrates the employment characteristics of participants. Most participants work full time however the trial has over 10% of participants who are retired. The number or self-employed participants is similar to the national rate[3].

Figure 9: Participant employment characteristics (based on 442 participants)



The chart below illustrates the working pattern of those participants who are in employment.

Figure 10: Working time characteristics of participants in employment (376 participants)



This demonstrates that most participants who work do so during the daytime. It may suggest that these participants may have little flexibility about when they charge their vehicles, if they charge them at home, because they are not at home during the daytime. They may be more likely to charge their vehicle during the evening, or overnight.

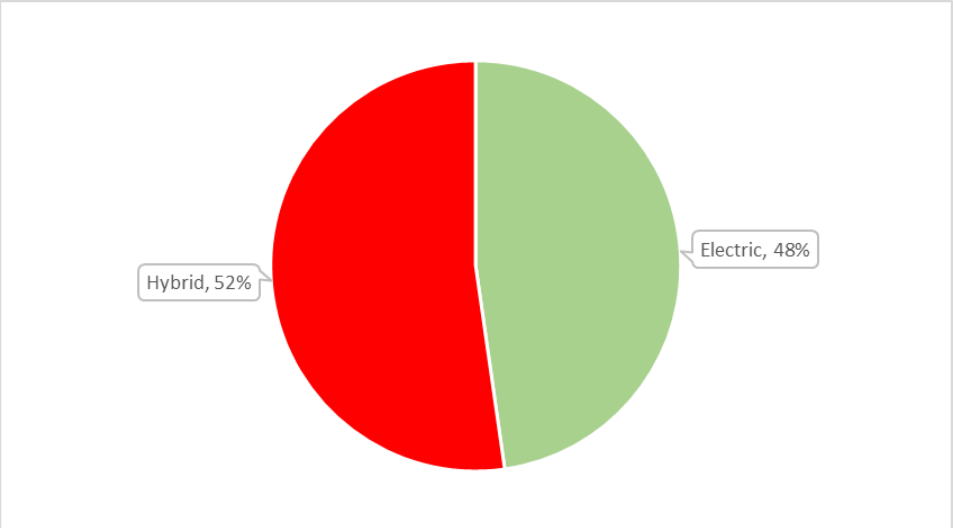
[3] According to the Office of National Statistics approximately 14.9% of people in employment were self-employed in 2016 https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/trendsinselfemploymentintheuk/2001to2015

See section 4.2 for insight on where trial participants charge their cars.

3.5 Car type

The chart below shows a near equal split among participants who own Battery Electric Vehicles (BEVs) and Plug-In Hybrid Electric Vehicles (PHEVs).

Figure 11: Vehicle type split amongst participants (based on 442 surveys)

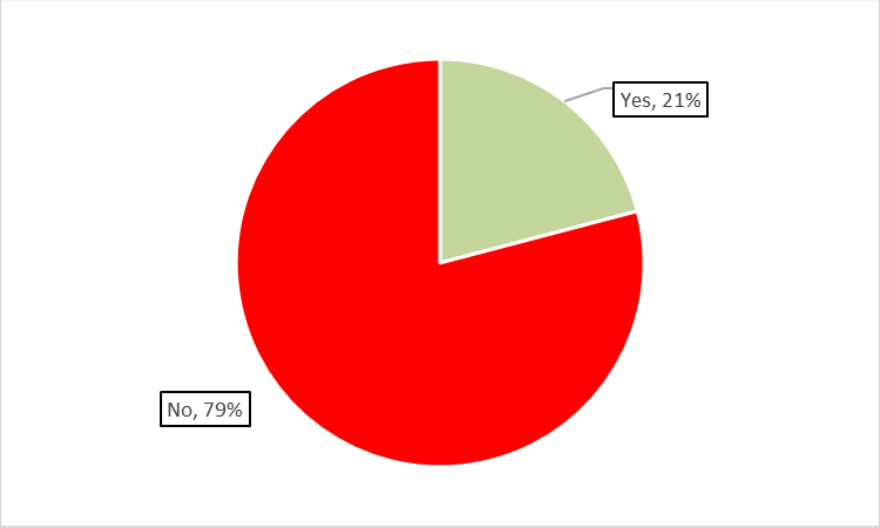


Participants with a PHEV can drive their vehicle despite the battery being empty. These participants may therefore be less concerned about completing a charge and therefore having their charge managed. This will be explored later in the report.

3.6 Ownership of solar PV panels

Over one fifth of participants have solar PV panels fitted to their properties.

Figure 12: Trial participants with solar panels (based on 442 surveys)

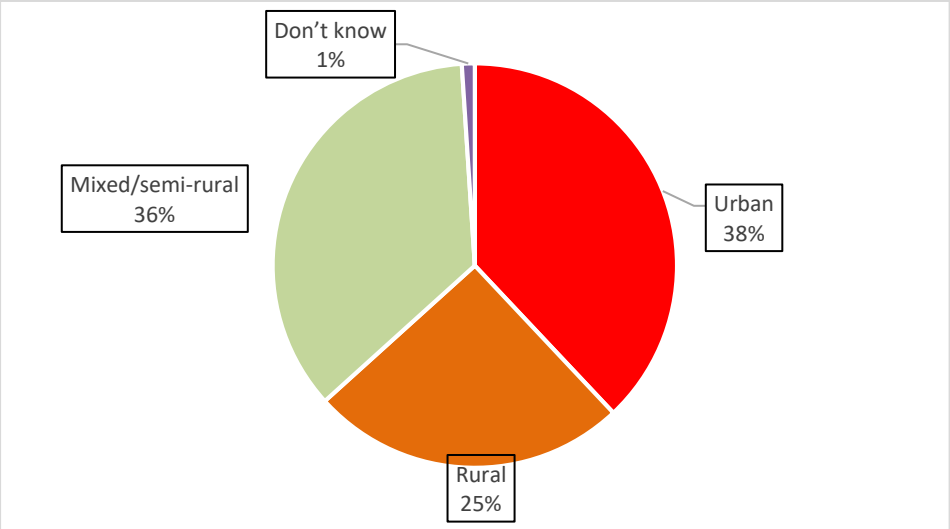


This is a larger proportion than the general population[4]. It **may** suggest that Electric Nation participants, as a whole, are more environmentally minded than the general population, have the financial means to invest in solar PV panels or have seen them as a good investment opportunity. The general shift towards renewable energy generation where households installing small scale generation sources such as PV could also suggest that the project participants are representative of a future customer base where these technologies are more prevalent.

3.7 Do you live in rural, suburban or urban area?

Trial participants were asked to classify whether they live in an urban, suburban or rural area.

Figure 13: Do you live in an urban, suburban or rural area? (387 respondents)



Respondents are most likely to state that they live in an urban area, however a quarter say that they live in a rural area. This data will be crosschecked at a later stage in the project using available postcode data on whether a participants' Local Authority is classified as rural or urban to nullify any bias in understanding of these terms. These data suggest however that participants represent a cross-section of residential categories.

The recruitment survey results so far suggest that the trial population is skewed towards affluent males aged 36 to 55 in higher or intermediate professions. A proportion of the group are environmentally minded. Participants cover a cross section of other attributes such as vehicle type, household size, number of children and rurality. This may change as more participants are recruited into the project. Given project timescales to recruit and complete the trial, and the current demographics of EV ownership, it will not be possible to remove the influence any recruitment bias completely via targeted enrolment.

[4] There were 886,000 households in England, Scotland & Wales with MCS certified Solar PV FIT installations by May 2017 (ONS). There are roughly 26.3 million households in the UK (ONS 2016). So, approximately 3% of households in England, Scotland & Wales have solar panels.

4 Baseline 1 Survey Results

The Baseline 1 survey is conducted approximately six weeks after a participant has had their smart charger installed – the purpose of the survey is to capture an understanding of participants' charging behaviour, once they have been driving their plug-in vehicle for sufficient time to get used to it and overcome any immediate range anxiety issues they may have suffered as a new plug-in vehicle driver.

The survey questions will also be used to identify any changes in the participants' charging habits once they experience demand management. It will also be used to reference the acceptability of demand management as opposed to unrestrained charging.

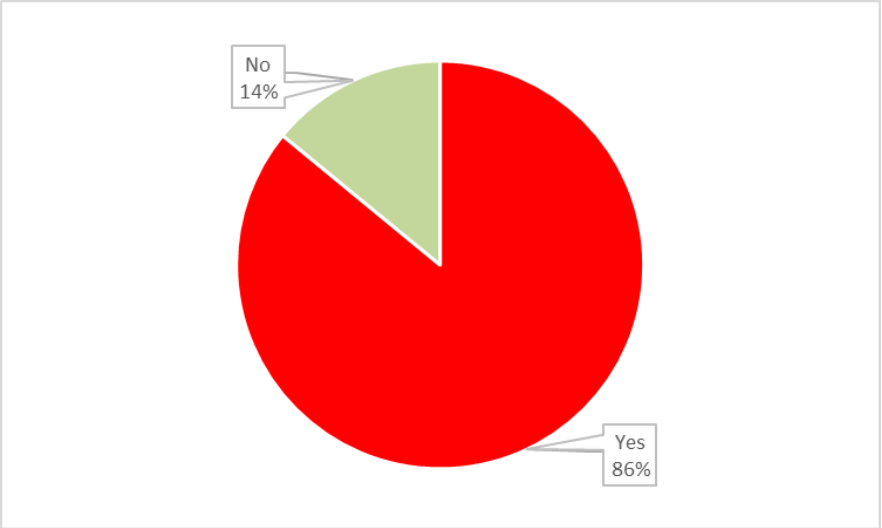
Participants are split between a 'charge at will' group (at least 90 days period where their charger will not be managed) and 'straight into demand management' group (see Section 0 for further details). The baseline survey results of these populations can be compared to show any difference in initial satisfaction between those who are allowed a period of unrestricted charging vs. those who are very quickly put under demand management. Comparison of participants who have experienced these two pathways at the analysis stage will help to reduce the effect of anomalies such as experience or knowledge levels and reduce the impact of Hawthorne effects (the alteration of behaviour by the subjects of a study due to their awareness of being observed).

This section of the report is designed to provide an insight into the interim survey results at the point of writing. These data do not distinguish between the "charge at will" and "straight into demand management" groups at this time - A full analysis, including distinguishing differences between these two groups and levels of statistical confidence of the survey results, will be provided later in the trial.

4.1 Do you have access to another vehicle?

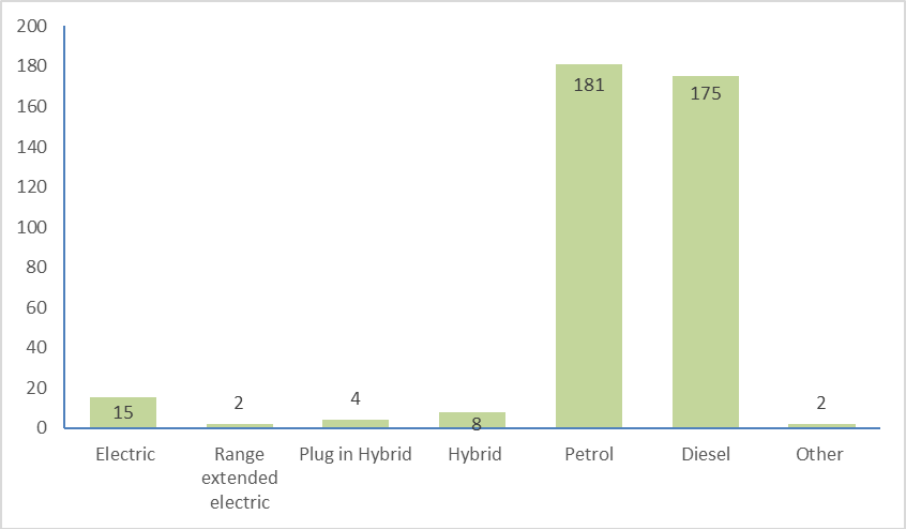
Participants were asked if their household has access to another vehicle(s).

Figure 14: Do you have access to another vehicle? (377 responses)



The participants with access to another vehicle were then asked how the other vehicles(s) were powered (please note that some households have access to multiple other vehicles).

Figure 15: What type of alternative car does your household have access to (377 participants asked, 324 of whom have access to another vehicle, total of 387 vehicles)

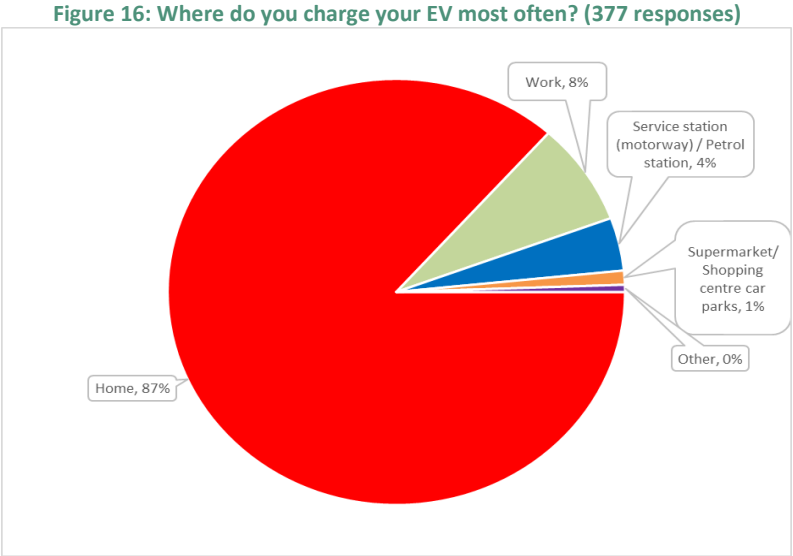


At time of writing, 21 participant households have two plug-in vehicles.

4.2 Where do participants usually charge their EV?

Participants were asked where they charge their EV most often. Most participants usually charge their EV at home.

Figure 16: Where do you charge your EV most often? (377 responses)

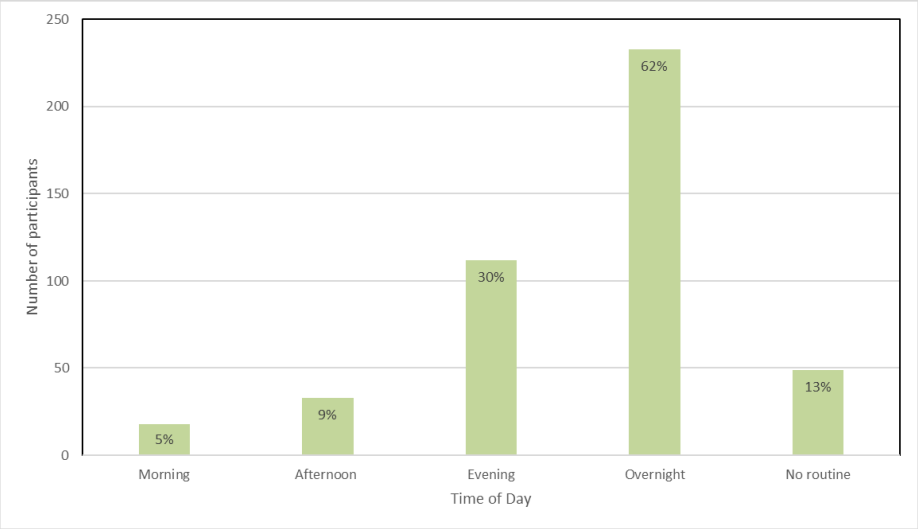


Five participants (1%) stated that they do not charge their vehicle at home – however, there is still value in gathering their attitudes to charging data as where they do charge may be useful to understand why people do not charge (or do so infrequently) when a charger is available to them. Two of these participants use Tesla superchargers at motorway service stations, two charge their vehicle at work and one uses the free charger at a Nissan dealership.

4.3 When do you usually charge your EV?

Participants were asked what time of day they usually charged their EV, when they charge it at home. Participants were given the option to choose more than one answer.

Figure 17: When do you usually charge your EV when you charge at home? (377 participants)

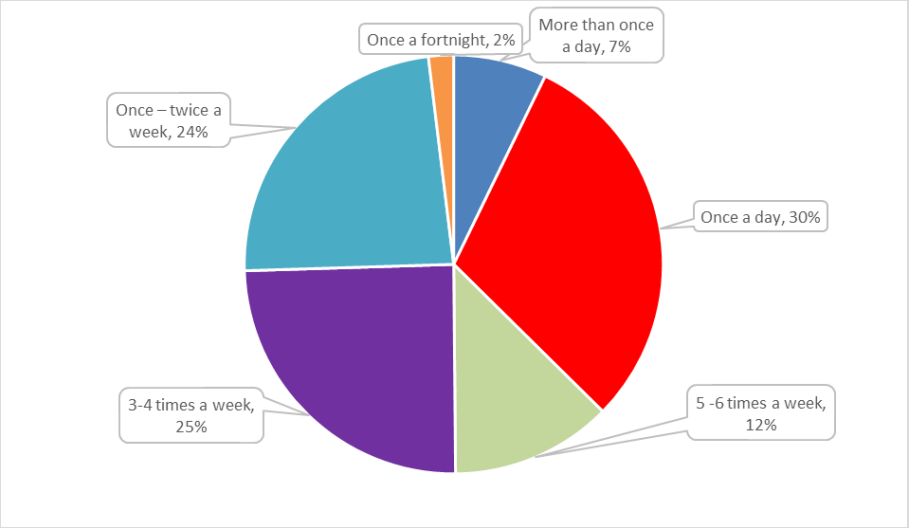


Most participants stated that they charge their EV either in the evening or overnight. These data will be compared to data gathered from smart chargers at a later point in the trial.

4.4 How frequently do you charge your EV?

Participants were asked to indicate how frequently they charged their EV.

Figure 18: How frequently do you charge your EV? (377 participants)

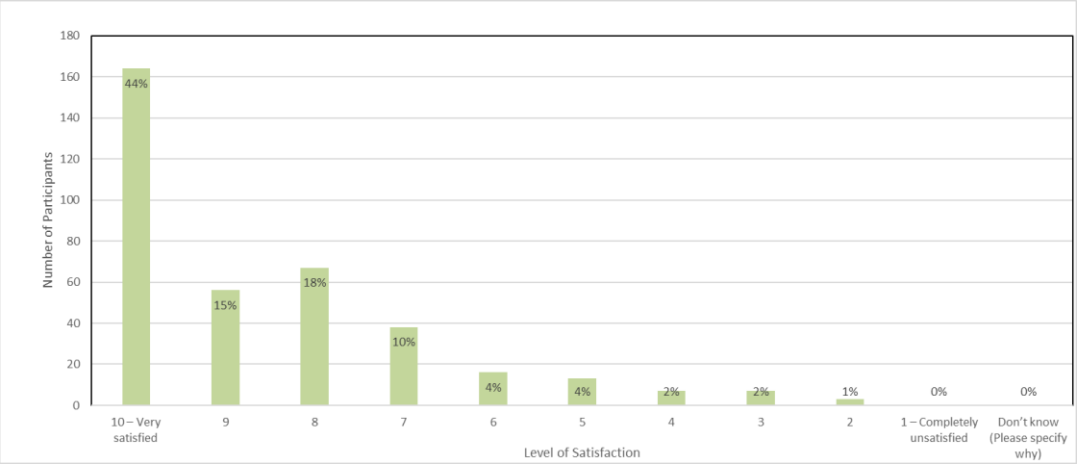


Over a third of participants charge their EV at least every day. These data will be compared to charging transaction data gathered by the project in due course.

4.5 How satisfied are you with the current arrangements?

Participants were requested to indicate how satisfied they were with the current charging arrangements. Nearly half were very satisfied.

Figure 19: Participant satisfaction with current charging arrangements (based on 377 responses)



Over 75% of survey respondents were satisfied (Satisfaction rating of 8-10) with the current arrangements, 20% were neutral (rating 7-4) and 3% were dissatisfied (rating 3 or below). 44% of respondents gave a 10/10 satisfaction rating indicating that they are very satisfied.

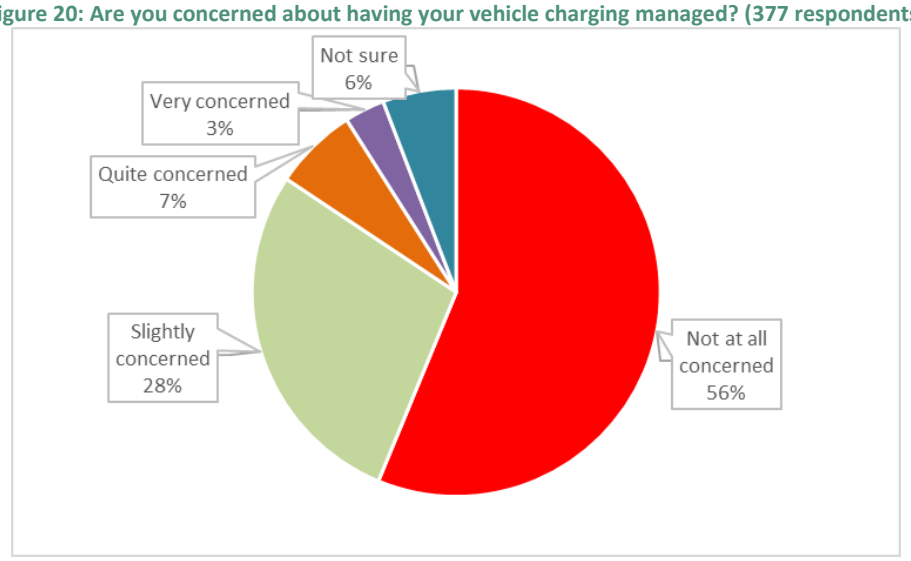
The publicly available charging infrastructure was cited as a reason for frustration in some cases rather than dissatisfaction with the facility to charge their EV at home.

4.6 Are you concerned about having your charging managed?

Respondents were asked about their level of concern about the upcoming charge management trials (at the time they receive this survey most will not have experienced demand management; some may have just entered demand management – timing of survey returns will be compared with date of entering demand management later in the trial).

Trial participants are made aware that the Electric Nation project will be trialling managed charging and that as trial participants' their EV charging will be subject to demand management in a broad sense, however they have not been given precise information about the nature of the trial.

Figure 20: Are you concerned about having your vehicle charging managed? (377 respondents)



Over 80% of respondents were not at all or only slightly concerned about the upcoming trial. These results were then analysed according to the type of vehicle (BEV or PHEV) that the respondent owned to see if either category of participant were more concerned. Figure 21 below shows the level of concerned of the BEV drivers.

Figure 21: Are you concerned about having your vehicles charging managed (180 BEV respondents)

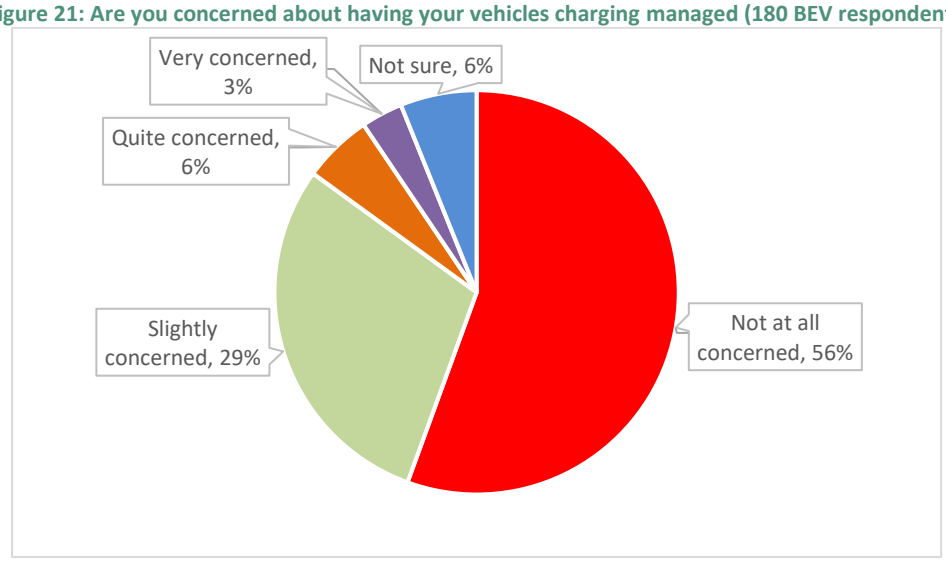
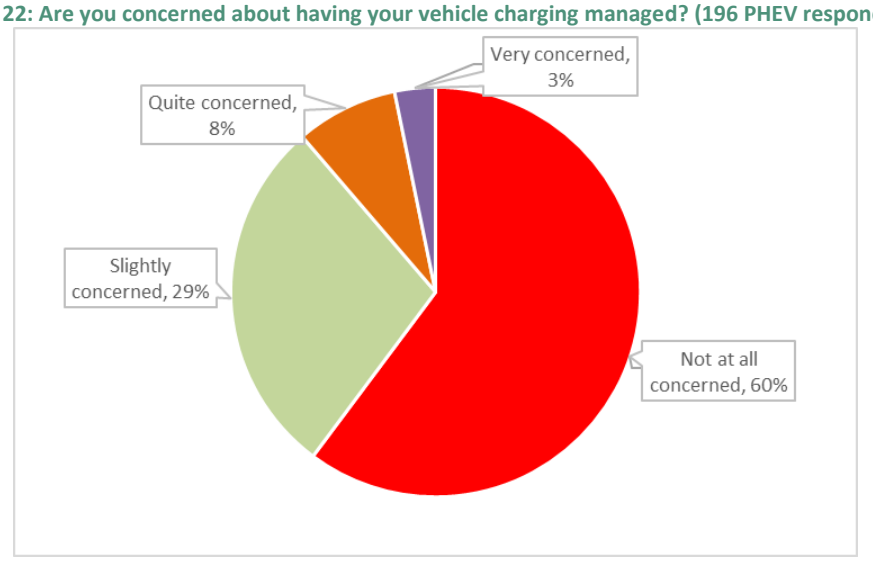


Figure 22 shows the level of concern of the PHEV drivers.

Figure 22: Are you concerned about having your vehicle charging managed? (196 PHEV respondents)



The PHEV drivers were slightly less likely to be concerned about having their charging managed while the BEV drivers were slightly more likely to be unsure about the upcoming trial, however this difference is very small and unlikely to be significant.

To conclude, the Baseline survey suggests that most trial participants who have completed this survey usually charge their EV at home, either in the evening or overnight. More than half of participants do not use their charger every day. Most are satisfied with the current, uncontrolled charging experience. This is significant because all future measurements of satisfaction will be compared to this level of acceptability. Most are not concerned about the upcoming charge management trial. Many have access to another vehicle other than their EV. It is work noting that even at this early stage of EV ownership there are some households with multiple plug-in vehicles.

These are preliminary results based on data that is subject to change as more participants complete the Baseline survey. Further analysis and statistical testing of this data will be carried out as the Electric Nation trial progresses.

5 Trial Design and Update on Demand Management Roll-Out

5.1 Introduction

A core part of the Electric Nation project is a large trial of smart charging (demand management) which will encompass all project participants (approximately 700). The aim of this trial is to evaluate the reliability and acceptability to EV owners of a smart charging system and the influence this has on charging behaviour.

This section describes the trial design in more detail, building on the information included in the Algorithm Development and Testing Report, and the previous trial update report (published in November 2017). It also reports on the progressing with moving all the trial participants into routine demand management.

5.2 Electric Nation Cohorts – GreenFlux and CrowdCharge

Two demand management providers are being used within Electric Nation, GreenFlux[5] and CrowdCharge[6]. Trial participants are allocated to each group during the recruitment process. Each company uses different algorithms to allocate current to individual chargers and the testing of these algorithms was reported in the 'Algorithm Development and Testing' Report[7]. The amount of data they have available (e.g. car state of charge) and the way the participant interacts with their system will also differ between the two providers in later stages of the trial, and in some cases between participant groups for the same provider (e.g. telematics data for CrowdCharge). The two cohorts are being managed to ensure a consistent mix of vehicle type and battery sizes. The current balance of the two cohorts is shown in Figure 23 and Figure 24, based on all chargers installed up to 5th January 2018.

These indicate that the two groups are well balanced. The tables below allow a comparison to be made between the Electric Nation cohort and the UK market for plug-in vehicles.

Table 4: New Registrations of PIVs in the UK 2015 - 2017[8]

	2015	2016	2017	Electric Nation (all participants)
Plug-in Hybrid New Registrations	18,737 (65%)	28,923 (74%)	18,337 (68%)	280 (53%)
Battery Electric Vehicle New Registrations (including range extender)	9,936 (35%)	10,246 (26%)	8,591 (32%)	252 (47%)

[5] https://www.greenflux.nl/en/
[6] http://crowd-charge.com/
[7] https://www.westernpower.co.uk/docs/Innovation/Current-projects/CarConnect/CarConnect-Algorithm-Development-and-Testing.aspx
[8] Data from: http://www.eafo.eu/content/united-kingdom Data taken 5th January 2018

Table 5: Sales of PHEVs and BEVs in the UK (2017)[8]

PHEV Type	Sales in 2017
Others	7,188*
Mitsubishi Outlander	4,296
BMW 330e	2,984
Mercedes C350e	1,734
BMW i3 Range Extender	1,140
Volvo XC90 PHEV	995

BEV Type	Sales in 2017
Nissan Leaf	4,113
Tesla Model S	1,297
Tesla Model X	1,205
Renault Zoe	700
BMW i3	699
Others	577

* No other detail available

In the table above, the Tesla Models S and X and Renault Zoe fall into the '35kWh+' category, accounting for 3,202 of 26,928 PIV sales in 2017. A proportion of the 'Other' BEV vehicles may also fall into this category (e.g. the e-Golf with a battery capacity of 35.8kWh). Depending on the composition of the 'other' BEV group the % of 2017 sales which fall into the 35kWh+ category is between 12 and 14% (between 3,202 and 3,779 vehicles). This compares to 19% of the Electric Nation cohort. This indicates that the Electric Nation trial is more heavily weighted towards BEVs with larger battery sizes when compared to the current UK vehicle sales. However, these vehicles are anticipated to dominate in the future, as the cost of EVs decreases and battery capacities increase to allow vehicles to have a longer range.

Figure 23: Composition of Cohorts (Plug-in Vehicle Type)

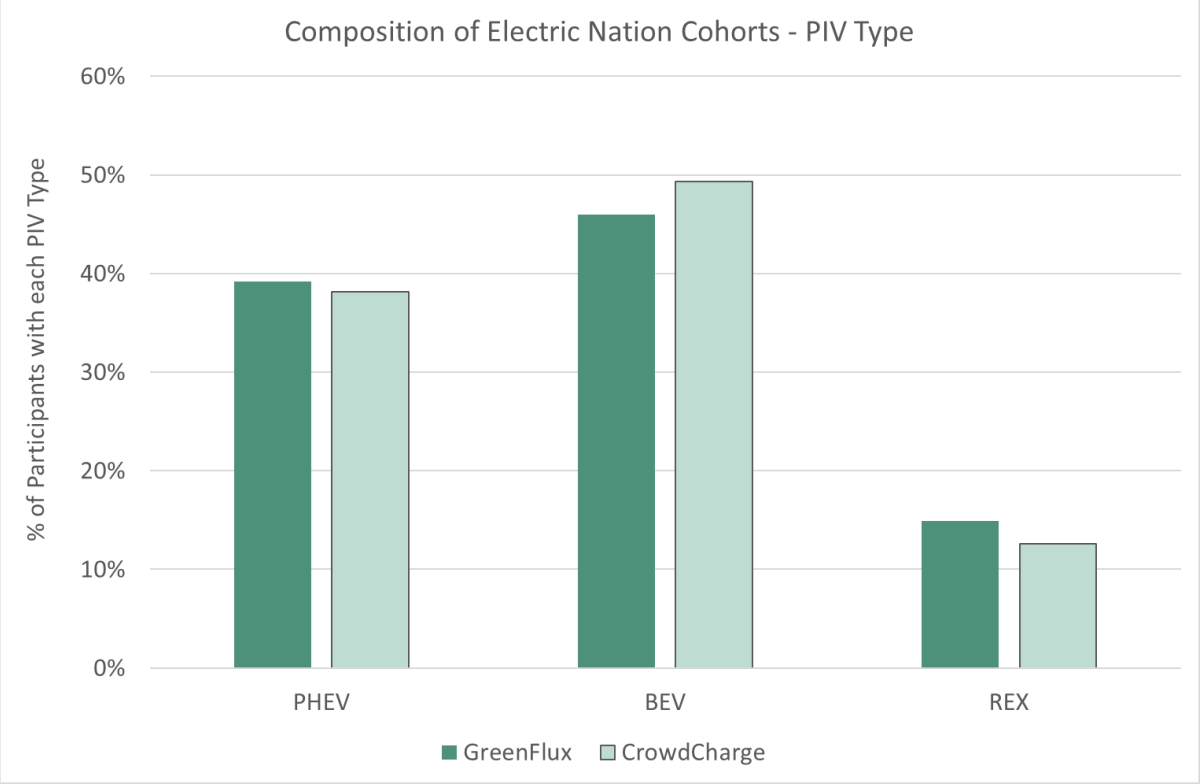
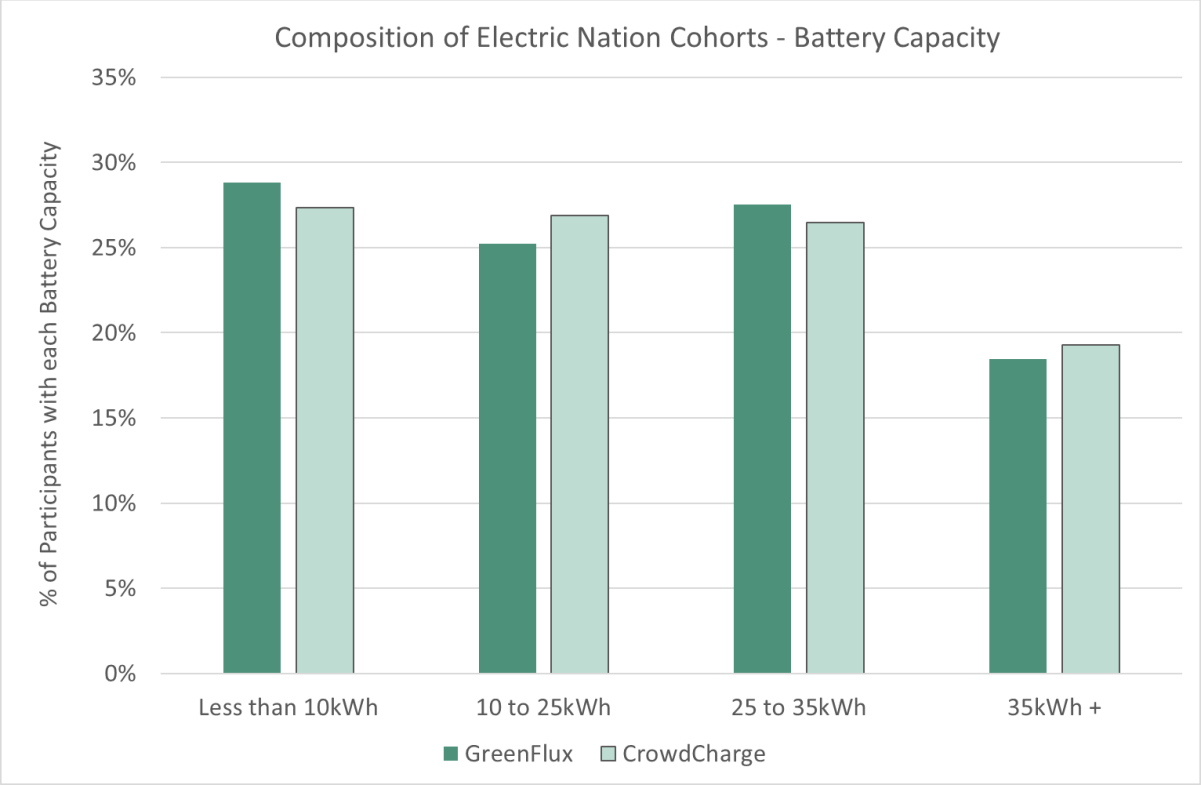


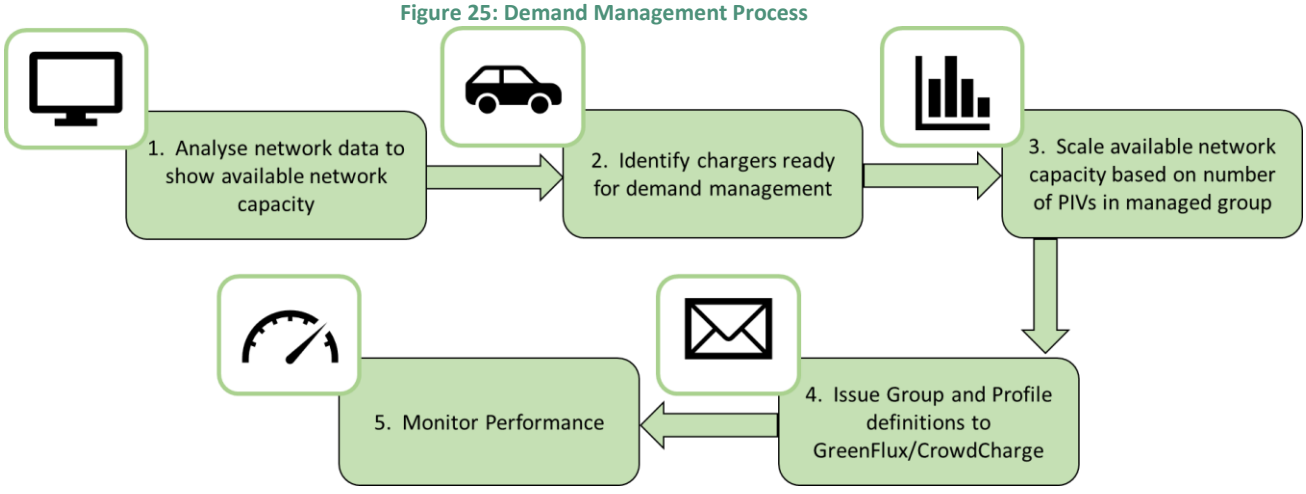
Figure 24: Composition of Cohorts (Battery Capacity)



5.3 Demand Management Process Update

From July 2017 onwards, participants are being moved into demand management through a series of group expansions, following the process illustrated below.

Figure 25: Demand Management Process



Further details of each of these stages were given in the previous trial update report[9]. This text is reproduced in Appendix 5 of this report, with the bullets below summarising developments in the period between the end of October 2017 and the time of writing.

[9] https://www.westernpower.co.uk/docs/Innovation/Current-projects/CarConnect/Electric-Nation-Customer-Research-and-Trial-Update.aspx Accessed 05/01/2018

- **Analysis of network data to show available network capacity:** a 'winter' profile was implemented for both groups in mid-November. This is the most restrictive profile to date, due to higher levels of background loading (i.e. less 'spare' capacity for EV charging). This has led to regular curtailment of customers in the peak periods. Further details are given in Section 0.
- **Identify chargers ready for demand management:** the process set out in the October 2017 version of the report has continued to be followed. A further 173 participants are now in routine management. Further details of this are provided in Section 5.4 below.
- **Scale available network capacity based on number of PIVs in the managed group:** the scaling process was adjusted in November 2017 to account for the reliability of communications in the managed group. The network capacity for EV charging is calculated based on the number of chargers in the group. However, when a proportion of these chargers are not communicating with the demand management system then the likelihood of reaching the capacity limit decreases. To account for this a reliability factor is now applied, so for example, in a group of 100 participants, with communications reliability of 90% a network capacity profile (demand limit) is produced for 90 participants.
- **Issue group and profile definitions to GreenFlux/CrowdCharge:** no change to the process.
- **Monitor Performance:** The level to which demand management has occurred, and the impact of this on participants is under review and this is discussed in more detail in Section 0.

5.4 Progress with the roll-out of Demand Management to Participants

For participants to enter routine management they must pass a number of tests. At any of these stages it is possible for an issue to occur which could delay a charger entering management. This section outlines the detailed process by which chargers pass through these stages for both GreenFlux and CrowdCharge and the progress made to date with moving participants into routine management. In the text below, two groups are discussed, 'Charge at Will' and 'Straight into Management':

- Charge at Will: Approximately 100 participants in each cohort (GreenFlux and CrowdCharge) are allowed unrestricted charging for approximately 90 days before demand management is imposed.
- Straight into Management: once the charger is in use approximately two weeks is permitted to prove the reliability of the communications from the charger, then the charger enters the managed group.

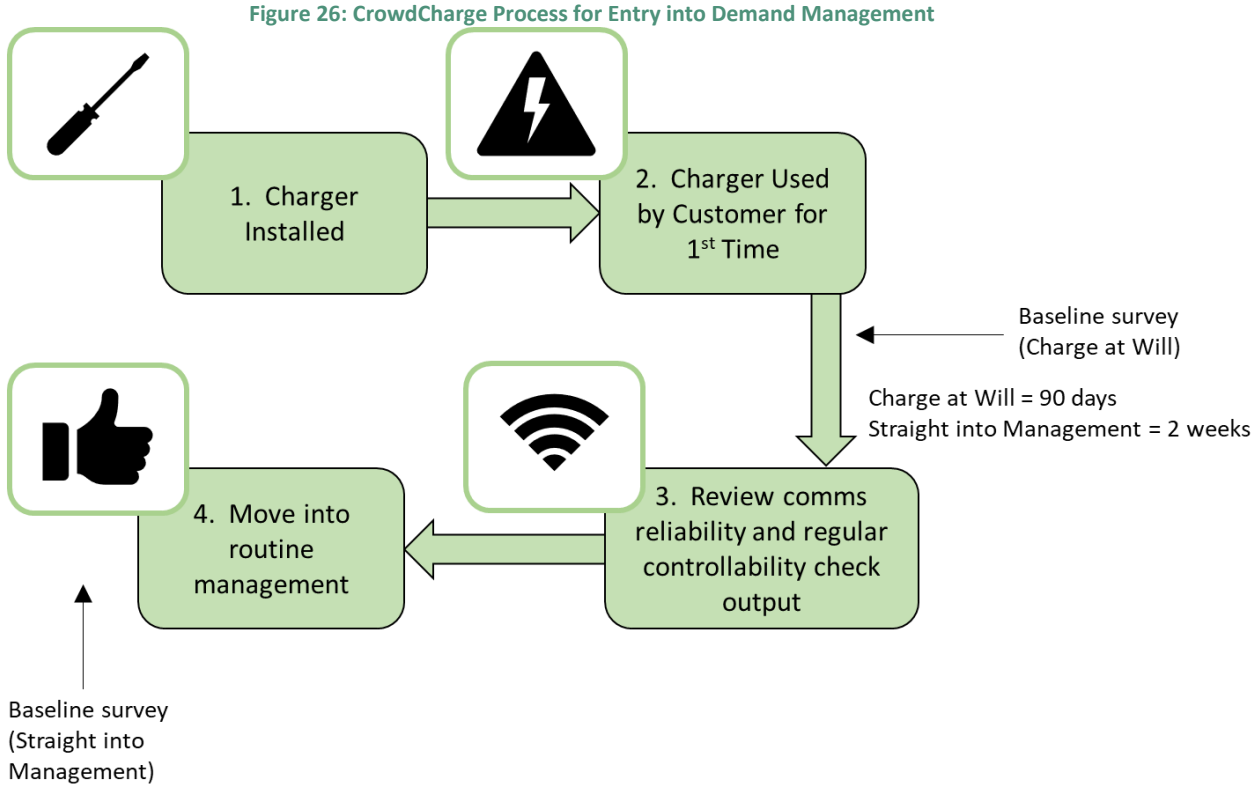
By using these routes, it should be possible to show whether there is any difference in the acceptability of demand management depending on whether participants have prior experience of unrestricted charging. The results of the 'baseline' surveys between the two populations can also be compared to show whether participants have different satisfaction levels with their charging at this stage, or whether their charging behaviour changes once they enter routine management (if they are aware of this), or once they have experienced

some curtailment. This analysis will be completed later in the trial and the results shown above (Section 4) include participants from both populations.

5.4.1 CrowdCharge

The diagram below shows the stages by which CrowdCharge participants enter demand management:

Figure 26: CrowdCharge Process for Entry into Demand Management



This process has been modified since the previous trial update report, as the communication reliability and controllability check has been integrated into a single step.

The number of chargers at each stage is shown in the following table.

Stage	Number Passed Stage	Notes
1. Charger installed	224 (based on information until end w/c 8th January)	Chargers are nominally allocated to 'straight into management' and 'charge at will' based on the installation date. 98 chargers, installed before the end of June are 'charge at will'. It was intended that all subsequent installations would be 'straight into management'. However, delays in moving chargers into management (mainly due to communications reliability) will result in some chargers being re-classified using the date of the first transaction and the date when the charger moved into routine management. To create a statistically significant cohort between 75 and 100

		chargers will need to follow the 'straight into management' route. The splits between 'charge at will' and 'straight into management' given below are based on the nominal classification.
2. Charger used by participant for 1st time	201 of 224 (last reviewed 15th January) = 98 Charge at Will + 103 Straight into Management*	A transaction record is not currently available for the remaining 24 chargers (all straight into management). There are a variety of potential possible causes for this: • Communications reliability – if chargers are not communicating with the back office then no transaction records will be available. • Charger not yet in use – e.g. car not yet delivered, this applies to four of the 'unused' chargers, as they have a communications reliability approaching 100%.
3. Review communications reliability and controllability – Charge at Will	78 (of 98 Charge at Will)	96 of the 98 charge at will participants have been charging for long enough to be eligible for routine management. 78 of these have passed a review of the communications reliability. Of the remaining 18: • Seven are not communicating with any part of the CrowdCharge system. • Five are only communicating with part of the CrowdCharge system. This prevents a controllability check taking place. • Six have unreliable communications with CrowdCharge.
3. Review communications reliability and controllability – Straight into Management	75 (of 126 Straight into Management)	In total 100 of the 126 'Straight into Management' chargers have reached this stage. The remaining three 'used' chargers have been in use for less than two weeks. 25 chargers have not yet passed an assessment of communications reliability and controllability. • 16 are not communicating with any part of the CrowdCharge system. • Four are only communicating with part of the CrowdCharge system, preventing a controllability check taking place. • Five have unreliable communications with CrowdCharge.
5. Move into routine management	153 (78 charge at will, 75 straight into management).	153 chargers have moved into routine management, and this will continue to expand as other charge points moved through the preceding stages. Section 0 provides more detail on the results of this demand management.

*a proportion of these nominally 'straight into management' will be reclassified as charge at will.

As shown above there are two main reasons preventing chargers progressing into demand management:

- No transaction records: potential causes for this issue include poor communications, a delay in the start of charging (e.g. delay in vehicle delivery), a configuration error or the installation of equipment at an incorrect location (owing to installer error a mis-matched charger-controller pair have been installed at a few participants' homes). Where a configuration error is the cause, then transaction records are available from an alternative source[10], but are not currently being supplied to the project database. An audit has been completed to identify units which may be subject to either a configuration error, or installation at an incorrect location. Many of these issues have been resolved in last quarter, with further work underway on the remaining sites.

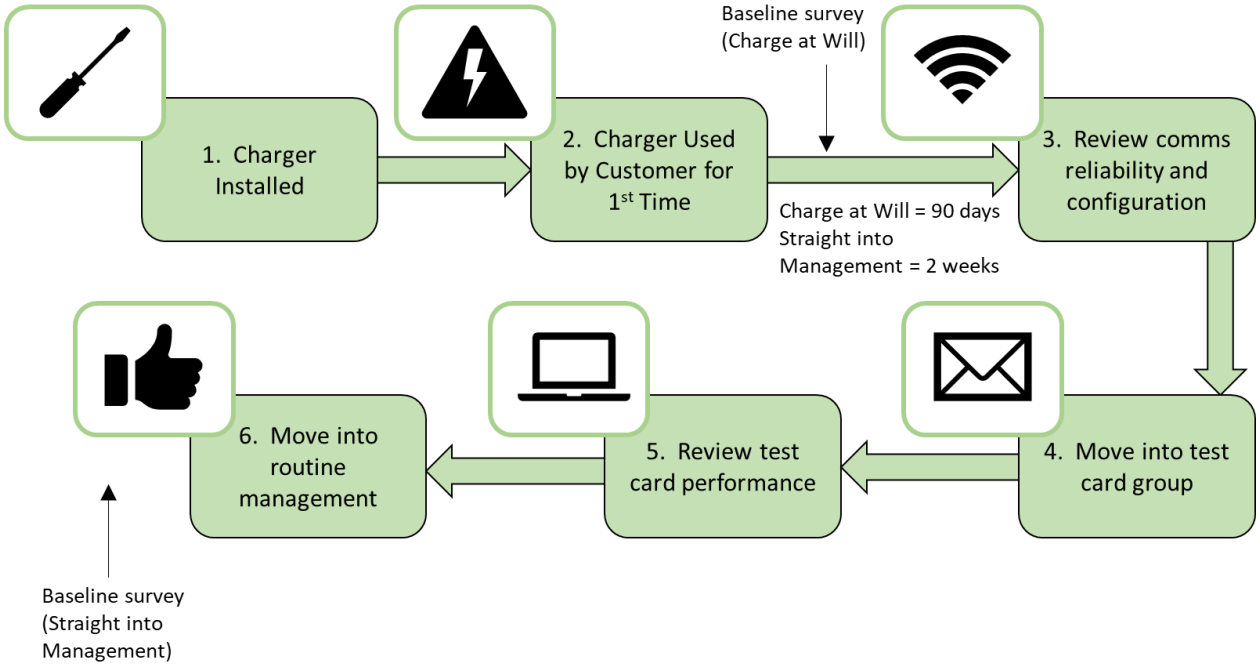
- Communications reliability to all parts of the CrowdCharge system: this continues to be an area of focus for the CrowdCharge team. The following actions are being taken:
    - Ongoing monitoring of communications performance by CrowdCharge and EA Technology, issues raised with the Tech Factory (responsible for systems integration) as they arise.
    - Contact with participants: this is the first stage diagnosis, co-ordinated by CrowdCharge/Drive Electric and resolves issues such as equipment being switched off.
    - Issuing of new wi-fi units: this may resolve some communications issues and is being attempted before a site visit is instructed.
    - Site visits: The Tech Factory are carrying out site visits where necessary to restore communications and recording the findings of these visits in order to identify the root cause of the issues experienced and modify procedures to address these.
    - Ongoing communications system development: this is focused on identifying additional measures that can be taken in relation to the system hardware, software, or project processes which could improve communications reliability (e.g. reducing the likelihood of equipment being incorrectly paired or installed in the wrong location). A process is in place to ensure these changes are tested prior to deployment in the trial group.

5.4.2 GreenFlux

The diagram below shows the stages by which GreenFlux participants enter demand management.

[10] Without divulging confidential information regarding the CrowdCharge system configuration: transaction records, namely energy consumed (kWh) during a charging event, can be retrieved from a part of the system, when periodic meter values during a charging event are not available.

Figure 27: GreenFlux Process for Entry into Demand Management



The number of chargers at each stage is shown in the following table.

Stage	Number Passed Stage	Notes
1. Charger installed	309 (based on information until end w/c 8th January)	Chargers will be reclassified based on the actual time between being used and entering routine management, as outlined in the CrowdCharge section above. 138 chargers are nominally 'charge at will' and 171 are 'straight into management'.
2. Charger used by participant for 1st time	275 of 309 (last reviewed 16th January). 134 charge at will, 141 straight into management.	Of the 34 chargers without a transaction record, only four are online, suggesting that the main cause of the lack of transaction records is communications. Once communications are restored these records will be sent to the back office. However, these records may indicate that the participant has been charging for an extended period of time, leading to a requirement to reclassify chargers from 'straight into management' to 'charge at will'.
3. Review communications reliability and configuration – Charge at Will	120 (of 134 Charge at Will which have been used)	120 chargers have been transferred into the test card phase following a review of their configuration and communications reliability. Difficulties in establishing reliable communications accounts for 10 of the remaining 14 participants. Of the remaining four, two chargers are currently running an experimental firmware version to resolve a comms issue. This firmware does not include smart charging capability at the time of writing. One participant in this group has not yet used their charger, and the other has left the project.

3. Review communications reliability and configuration – Straight into Management	85 (of 141 Straight into Management which have been used)	85 have been transferred into the test card phase. Of the remaining 56 units: • 3 have not been installed for long enough to reach this stage (i.e. only one week of comms data) • 48 have unreliable communications. Of these, 36 were affected by a configuration error in the Alfen factory leading to lower resilience of the communications system. Efforts are underway to restore comms to these units and correct the configuration error. • 2 are running the experimental firmware described above. • 3 have a configuration error (different to the one described above).
4. Move into test card	205 (both routes) = 120 'charge at will' and 85 'straight into management'.	205 chargers will have entered the test card phase since early July.
5. Review test card performance	Charge at Will: 120 reviewed, 110 passed Straight into Management: 79 reviewed, 58 passed.	6 chargers entered the test card phase in w/c 17th January and have therefore not yet been reviewed. The causes for failure or a delay at the test card phase are: • Lack of transactions in test card phase (16 of 31): successful transactions are required to pass this phase. Where a participant uses their charger infrequently the test card phase may last longer. If this delay is substantial, then customers are contacted by Drive Electric to ascertain the reason why the charger is not being used. • Experimental firmware due to previous comms issues (5 of 31): as described above, this firmware appears to resolve the communications issue, but does not allow for smart charging, so these customers have temporarily left the test card phase whilst smart charging functionality is added to the firmware. • Unusual behaviour in test card phase (5 of 31): these cases are referred to GreenFlux and/or Alfen for investigation before customers move into routine management. • Charger offline (3 of 31): this prevents meter values being sent to the online portal, therefore the test card performance cannot be evaluated. New Wi-Fi

		units are being sent to these customers in order to restore communications. • Prior use of a timer (1 of 31): earlier in the trial the GreenFlux algorithm required an adaptation to allow maximum current to be allocated to vehicles which have used a timer. Whilst this algorithm was in development some participants were removed from smart charging. The majority of these have now consented to return to the test card phase and have passed through to routine management. One customer remains. • Dropped out of the trial (1 of 31): this participant no longer owns an EV.
6. Move into routine management	168 chargers	168 chargers (110 charge at will, 58 nominally straight into management) have moved into routine management, and this will continue to expand as other charge points move through the preceding stages. Section 0 provides more detail on the results of this demand management.

As summarised in the table above the main reason preventing chargers moving through all stages of the demand management initialisation process is a lack of reliable communications. A total of 95 chargers are delayed at various stages due to a communications problem. A further nine are running an experimental version of the firmware to resolve communications problems. A substantial proportion of these are due to a configuration error in the Alfen factory, which led to the chargers only communicating over ethernet (no SIM card). The following actions are being taken to address this:

- Issue of new Wi-Fi units to participants with offline chargers: some Wi-Fi units contain a firmware error, which results in the connection being lost following a power cycle, unless power is restored in a specific order. This can be resolved with an updated pair of Wi-Fi units. Initially these are being dispatched for participants to install. If this is not successful, then a visit by the Tech Factory will be arranged.
- Over the phone troubleshooting of hard-wired connections: some chargers with a hard-wired ethernet connection are currently offline. A trouble-shooting process has been followed via a phone call between the participant and Drive Electric. Where this is not successful a visit is arranged by the Tech Factory.
- Week by week monitoring of reliability: this is reported as part of monthly project management reports. It allows offline chargers to be identified for either of the two actions described above.

Once communications have been restored to the chargers affected by the configuration error at the Alfen factory a firmware update can be applied. This allows the internal setting (wired/auto-detect) to be amended so the SIM card is activated, providing greater resilience against ethernet failures in the future.

5.5 Results of Demand Management to Date

The first 'routinely managed' groups were established in July, and these have been expanded multiple times over the summer, autumn and winter, as shown below.

Group Number	CrowdCharge		GreenFlux	
	Total Number of Participants in Group	Date Enacted	Total Number of Participants in Group	Date Enacted
0001	10 (10 (CAW)/0 (SIM))*	04/07/2017 = Summer	16 (16/0)	11/07/2017 = Summer
0002	21 (15/6)	15/08/2017 = Summer	31 (31/0)	10/08/2017 = Summer
0003	33 (25/8)	11/09/2017 = Summer	44 (44/0)	31/08/2017 = Summer
0004	45 (24/11)	17/09/2017 = Autumn	63 (56/7)	18/09/2017 = Autumn
0005	57 (42/15)	09/10/2017 = Autumn	92 (75/17)	11/10/2017 = Autumn
0006	76 (48/28)	30/10/2017 = Autumn	131 (97/34)	15/11/2017 = Winter
0007	86 (51/35)	20/11/2017 = Winter	142 (102/40)	18/12/2017 = Winter
0008	102 (58/44)	29/11/2017 = Winter	148 (106/42)	04/01/2018 = Winter
0009	112 (65/47)	06/12/2017 = Winter	168 (110/58)	w/c 15th January = Winter
0010	124 (70/54)	13/12/2017 = Winter		
0011	149 (77/72)	10/01/2018 = Winter		
0012	153 (78/75)	w/c 22nd January		

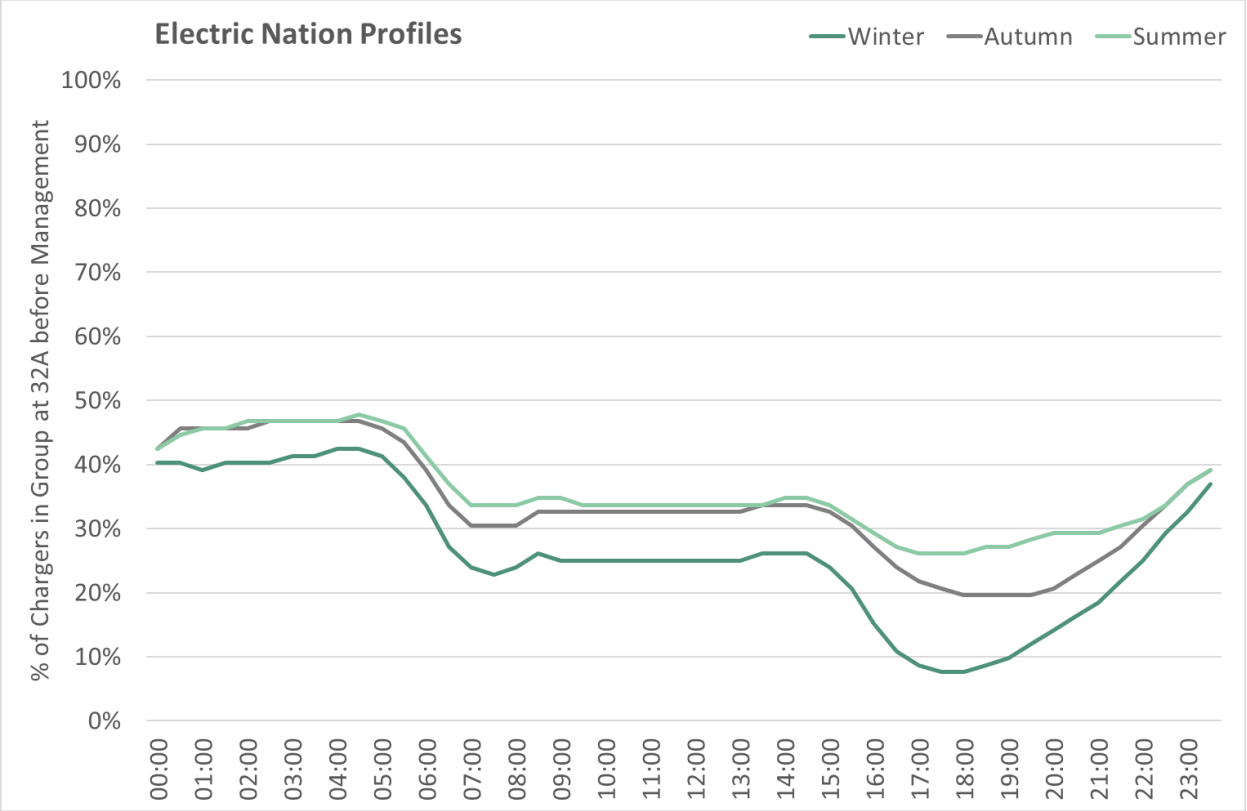
* Split between Charge at Will (CAW) and Straight into Management (SIM)

As described above a new 'demand limit' is provided to CrowdCharge/GreenFlux each time the routinely managed group expands. The profile will also be adjusted throughout the year to reflect varying levels of 'spare' network capacity across seasons. Summer profiles were used until mid-September, before all participants were transferred into Autumn from mid-September, and winter from mid-November. A spring profile will be applied in early March.

The level of demand management which occurs is a function of the demand limit profile and the charging diversity of the managed group. As increasing numbers of participants in the group plug-in at the same time then it becomes more likely that demand management

will occur. Management (curtailment of available current from chargers) also becomes increasingly likely as the seasons change, as the 'spare' network capacity available for EV charging decreases due to increases in other loads. This is illustrated for summer, winter and autumn profiles in Figure 28 below.

Figure 28: Differences in Summer, Autumn and Winter Weekday Profiles



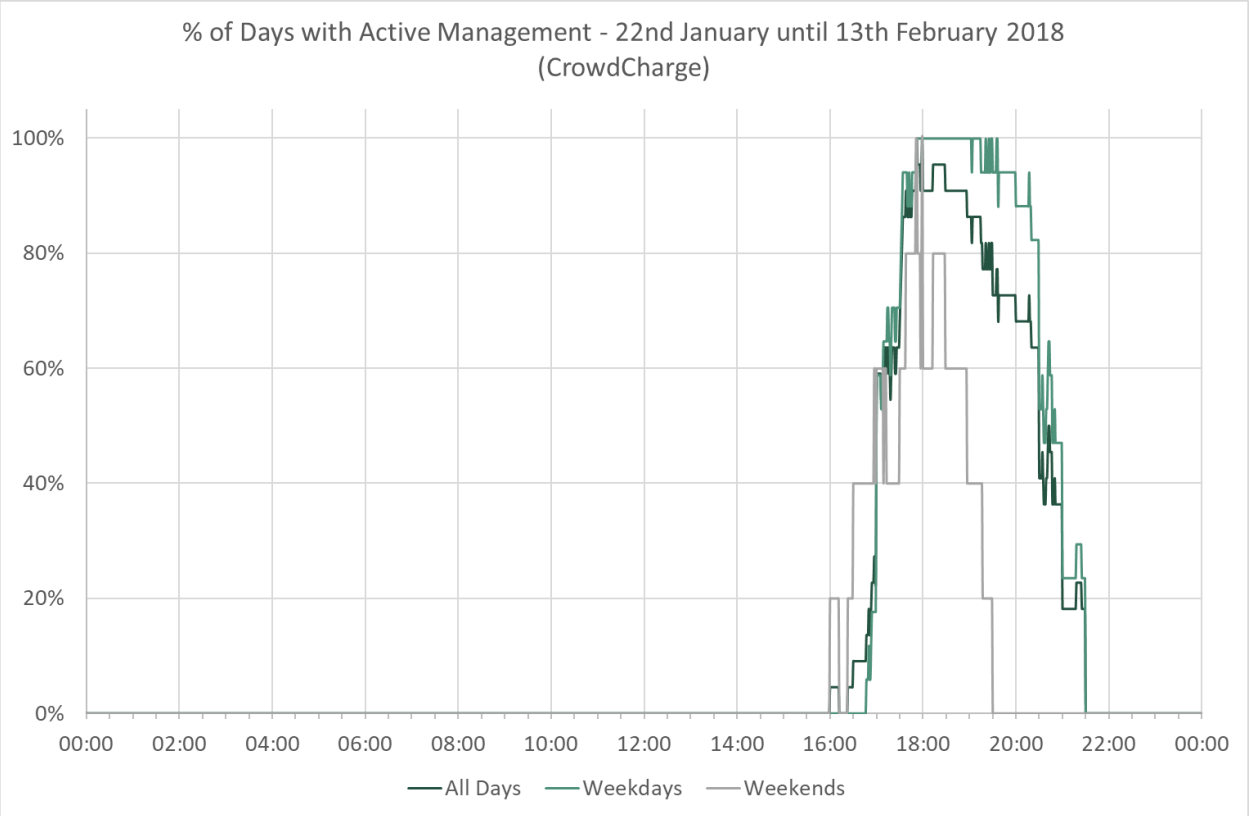
In the autumn example above, on each weekday 19% of the 92 stations in the group can charge at 32A at 19:00. Therefore, if on a given weekday only 15 chargers were being used at this time then no management would occur. Graphs such as the above provide an indication of how restrictive a given profile is but cannot predict whether management will occur on any given day, as this depends on the charging behaviour of each participant.

The degree of management which occurs can only be inferred after the event based on the information received from the demand management providers – current allocated and current drawn. Data is presented below on the use of demand management in the period from 22nd January to 13th February, for the CrowdCharge group[11]. The GreenFlux group are likely to follow a similar trend in terms of the frequency with which demand management occurs, as the group composition and profile generation process is similar between the two groups.

[11] Data from GreenFlux, and the calculation method to be used is still under development at the time of writing, and further details will be provided in the next trial update report.

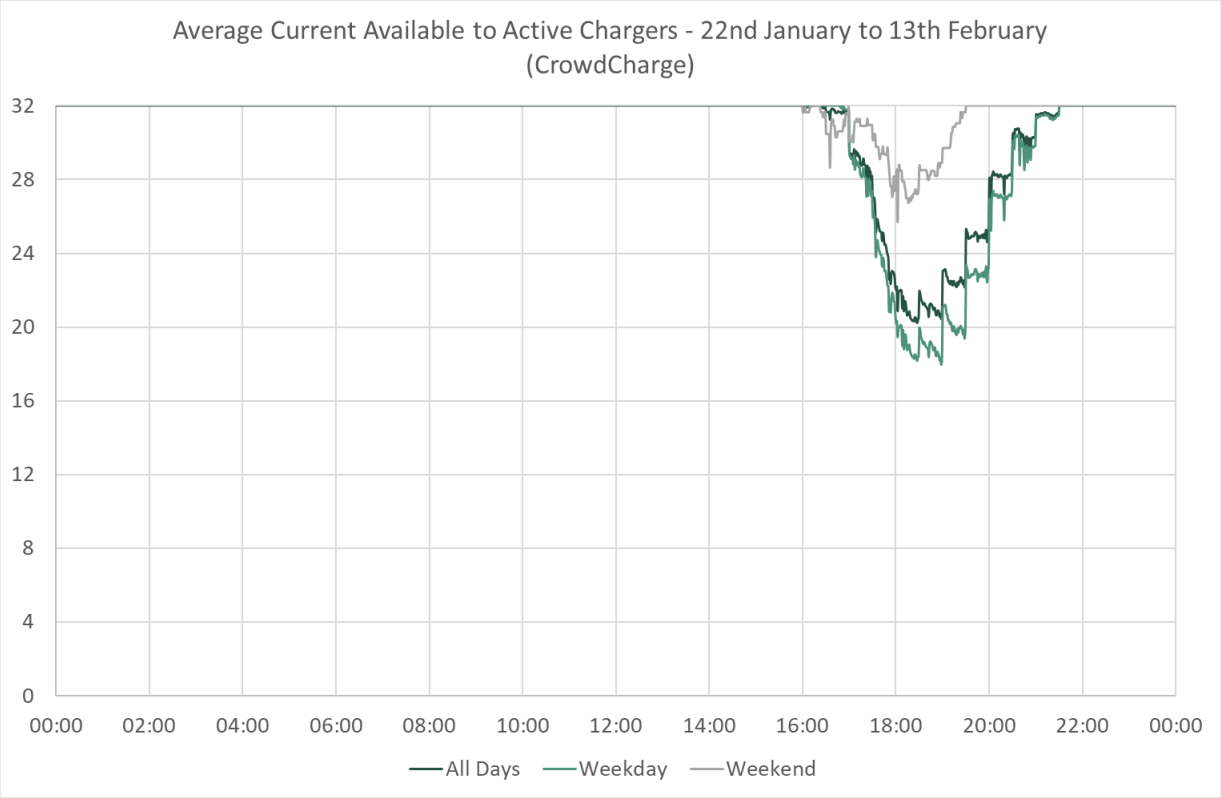
The graph below is based on a comparison of the total number of days (all, weekday and weekend) in the period from 22nd January to 13th February inclusive and the number of days on which management occurred, on a minute-by-minute basis.

Figure 29: % of Days When Management Has Occurred (CrowdCharge data)



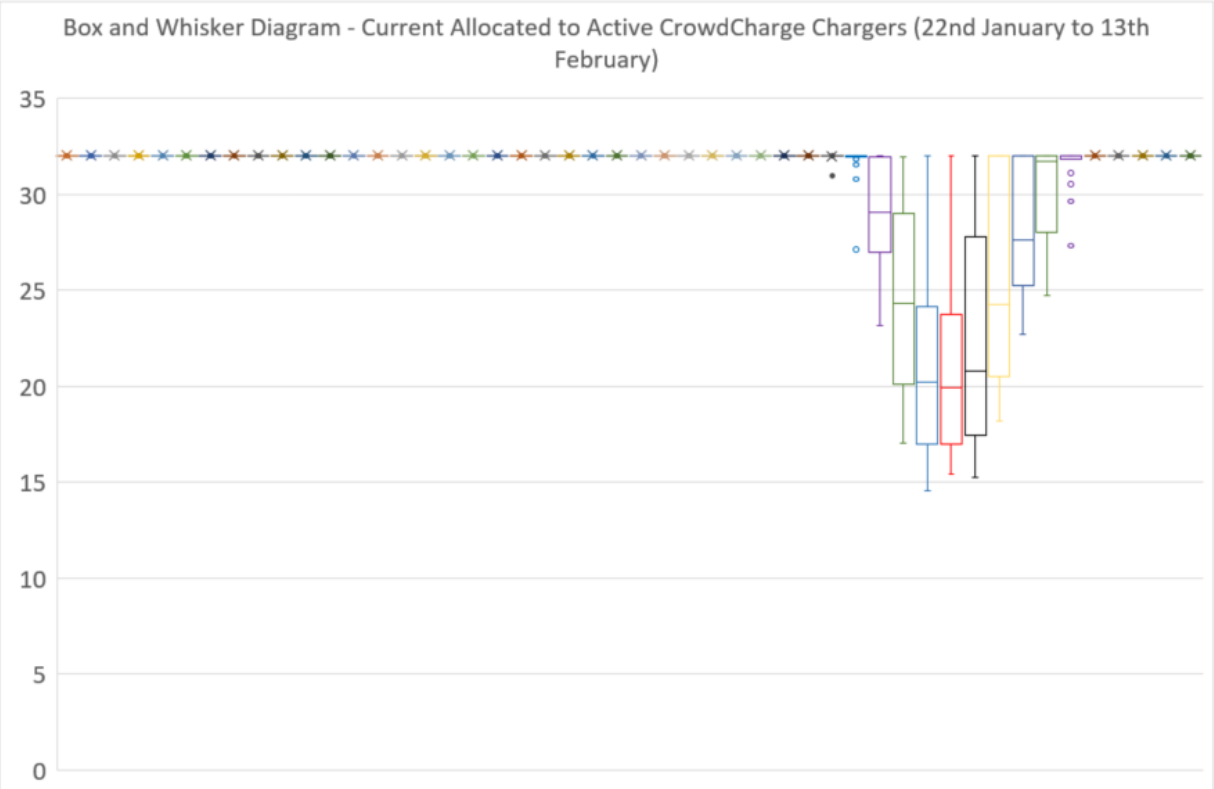
As expected, due to the restrictive nature of winter profiles, management is occurring for at least part of the day on all days. Management at the weekend tends to start earlier, but last for a shorter period. The impact on customers of these events depends on the severity of the management – i.e. how much they were curtailed by. This can be analysed using the average current available from charge points.

Figure 30: Average Current Available to Active Chargers (22nd January to 13th February - CrowdCharge only)



The level of restriction which occurs at the weekend tends to be much lower than weekdays. Indeed, for cars which only draw 16A (PHEVs and some earlier BEVs) these events may not have resulted in any curtailment, as 16A was still available. Figure 30 shows the average current available on a minute-by-minute basis. The box plots below show the spread of level of management, based on 48 half-hour averages (i.e. the average current allocated in the 00:00 – 00:29 period, compared across all days in the period 22nd January to 13th February.

Figure 31: Distribution of Available Current per Charger (half hour periods for 22nd January to 13th February)



Box and whisker diagrams show the spread of data, illustrated as follows for HH37 (1st blue box from the left):

- The minimum value is shown by the lower whisker – in this case on the most curtailed day 14.5A was available from charge-points in this half hour.
- The first quartile is the base of the box, so on fewer than 25% of days less than 17A was available in this half hour.
- Median value is the line in the centre of the box – slightly above 20A.
- The upper quartile is the top of the box, so on 75% of days less than 24A was available at this time.
- The maximum value is shown by the upper whisker, so in this case there was at least one day which was not curtailed in HH37.

This plot shows considerable variability in the current available during curtailment periods (the evening peak). A proportion of this variability is likely to have arisen by including all days rather than separating weekdays and weekends – the difference between the two can be seen in Figure 30.

A total of 157 chargers are included in the managed group in the period analysed above. Only 23 (15%) of these chargers don't appear in the charge control log over the period from 22nd January to 13th February. There are a variety of reasons for this:

- Use of timers or other charging behaviour leading to the charger not being active in the managed periods. Further details of charging behaviour are given in Section 6.

- Charger not being used – e.g. if the participant is on holiday or charging elsewhere.
- Lack of communications. Communications reliability in the managed group is typically between 85 and 90% so this could account for a degree of the 'unmanaged' chargers.

Further analysis will be completed to show the level to which individual participants are affected. For example, although 134 chargers are included in the charge control log the curtailment only has the potential to impact the participant if the current made available is less than the car would have been drawing (e.g. a reduction in current available to 28A does not affect a PHEV with a rating of 16A, or a vehicle where the charge cycle was nearly complete and it was only drawing 8A).

The analysis above is based on group level information, and the methodology is under further development at the time of writing, particular in respect of showing the use of management for the GreenFlux cohort and the impact on individual customers.

As set out in the previous trial update report an assessment will be made for each participant of the level of management they have experienced, using a summary of three metrics across all their transactions as described below:

- Overlap between transaction and management event – i.e. was there a group level management event which occurred whilst the vehicle was charging. The methodology for detecting group level events is being refined at the time of writing, with partial results shown for CrowdCharge above.
- Restrictiveness - calculated by dividing the average current drawn over the course of the transaction by the maximum current drawn. The restrictiveness can be used to judge the severity of a management event, but it must be compared with a similar, unmanaged transaction. For this reason, the restrictiveness of all transactions will be calculated, in order to build up a library of values for 'managed' (i.e. transactions which overlap a period where the total group values are close to the profile limit) and unmanaged transactions, for all car types.
- Hot Unplug (Yes or No) - A transaction (charge event) is "hot unplugged" if the participant unplugs the vehicle before the battery is full. This does not necessarily mean that the participant hadn't received all the charge they required – they may only need enough energy for a short journey before plugging in again. A 'hot unplug' can be identified using the meter values received immediately before the end of the transaction. A hot unplug when management has occurred is the situation where the likelihood of a true customer impact is highest. However, it may still be possible that the customer had enough charge, even though the battery hadn't reached 100% State of Charge.

The three measures above can be applied to each transaction, with the options shown below.

Transaction Overlaps a Period where Management is Likely to be Active (Point 1)	Vehicle was Hot Unplugged (Point 3)	Restrictiveness (Point 2)	Conclusion
No	No	A number between 0 and 1	Management was not applied, and the vehicle was fully charged before the customer unplugged. The restrictiveness value provides a baseline for an unmanaged charge event (i.e. for this particular make/model) and energy consumed.
No	Yes	A number between 0 and 1 (more likely to be close to 1 due to absence of 'tail')	Management was not applied but the vehicle was unplugged before fully charged. These transactions will provide a measure of how often the customer does this in the absence of management, which can then be compared to the situation once management is applied.
Yes	No	A number between 0 and 1	Management occurred but the battery was still fully charged before the customer unplugged. This does not necessarily mean the customer was not inconvenienced (e.g. they may have used another car or delayed their departure). The restrictiveness value can be compared with a similar unmanaged transaction and can be used to show the degree of management applied.
Yes	Yes	A number between 0 and 1	Management occurred and the battery was not fully charged when the customer unplugged (but unknown to what level). This is the situation with the highest potential impact on the customer. It is possible that the customer would have 'hot unplugged' in the absence of demand management, therefore for each customer an assessment will be made of the change in frequency of hot unplugging (with and without management) and using the restrictiveness to judge the severity of management events.

These measures will be summarised at a participant level and provided to Impact Utilities to allow them to combine this information with the results of customer research surveys.

6 Early Data on Charging Behaviour

Electric Nation is believed to be the world's largest EV domestic smart charging trial, and incorporates many different makes and models of plug-in vehicles. The smart chargers installed for the project generate substantial quantities of data, at two different levels of detail:

- Transaction records: showing the time at which the vehicle was plugged and unplugged, and the amount of energy transferred in the charge session.
- Meter values: a record of the amount of current (amps) made available from the charge point and drawn by the vehicle, either for each minute, or every three minutes (CrowdCharge, GreenFlux respectively). This allows more detailed analysis, for example showing the time at which charging began (as distinct from when the vehicle was connected, showing participants using timers) and when charging was complete. Meter values are crucial to showing the impact of demand management, as they show both the restrictiveness of a transaction and whether a vehicle was 'hot unplugged' (had the charge session finished before the vehicle was unplugged?).

In addition to using these data to show the incidence of demand management, it can also be used to increase understanding of typical charging behaviour and so the load which may be created because of increasing EV uptake. The length of the trial, number of participants involved and wide variety of vehicle types will increase the value of this data.

This section presents some early findings based on data received to date. The project will continue to build on this analysis and present further results in future reports. A full dataset will be made available at the conclusion of the project.

6.1 Frequency and Timing of Charging Events

The extent to which smart charging/demand management will be required in this project will depend on the load created by EV charging, relative to the available network capacity in a given location. This is in turn depends on factors such as how often people charge their vehicles, the charge rate (7kW or 3.6kW), the timing of charge events (both start time and duration), and seasonality.

6.1.1 Frequency of Charging

Transaction records received from chargers to date have been analysed to determine the typical frequency with which trial participants charge their vehicle. This is shown below, based on the number of transaction records (where greater than 0.5kWh of energy was transferred) received from each charger since the date it was first used by the customer. Records for chargers with less than 50% communications reliability are excluded as this can lead to a falsely low charging frequency due to missing records. This methodology will be refined further in the latter stages of the project to make use of data received from chargers once communications are restored.

Figure 32: Charging Frequency - by Vehicle Type

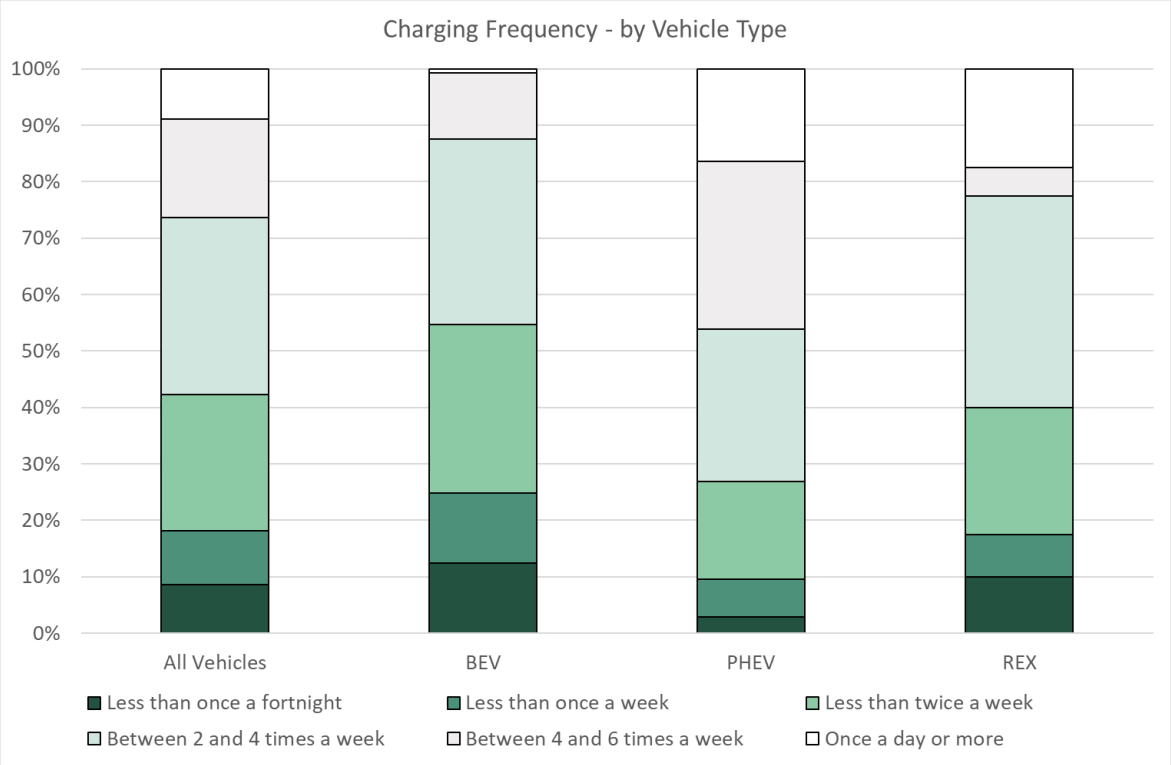
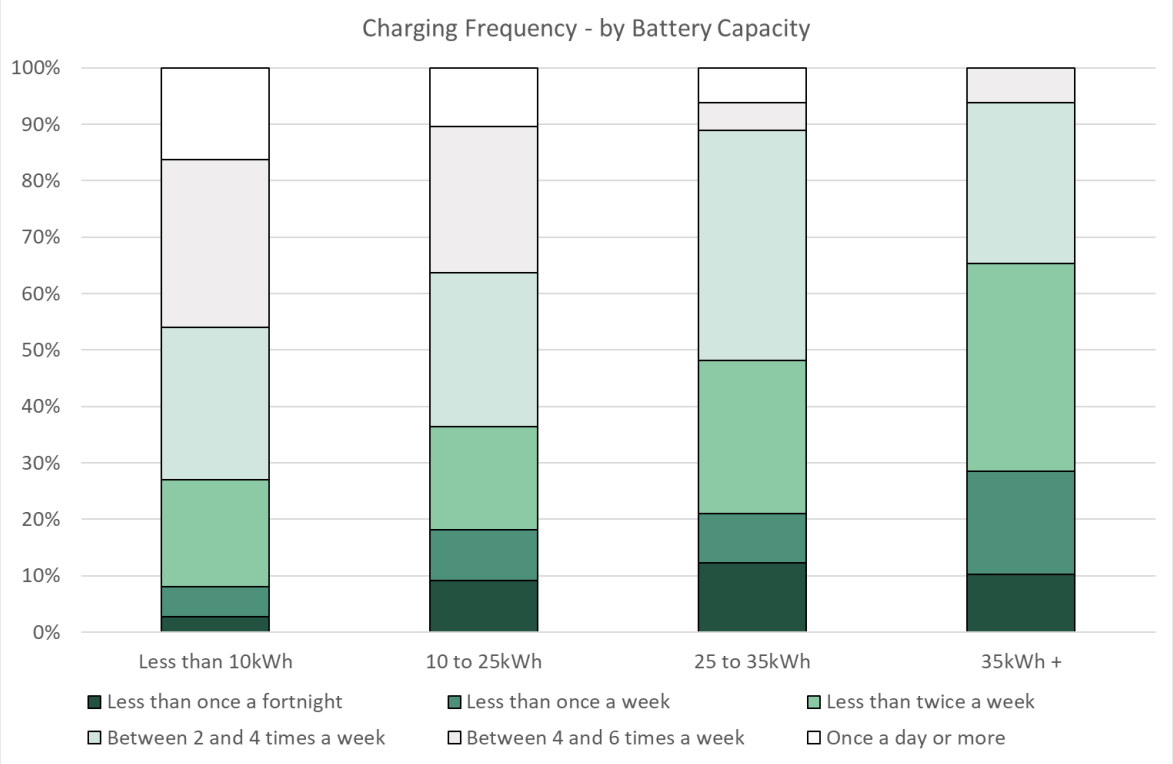


Figure 33: Charging Frequency - by Vehicle Type

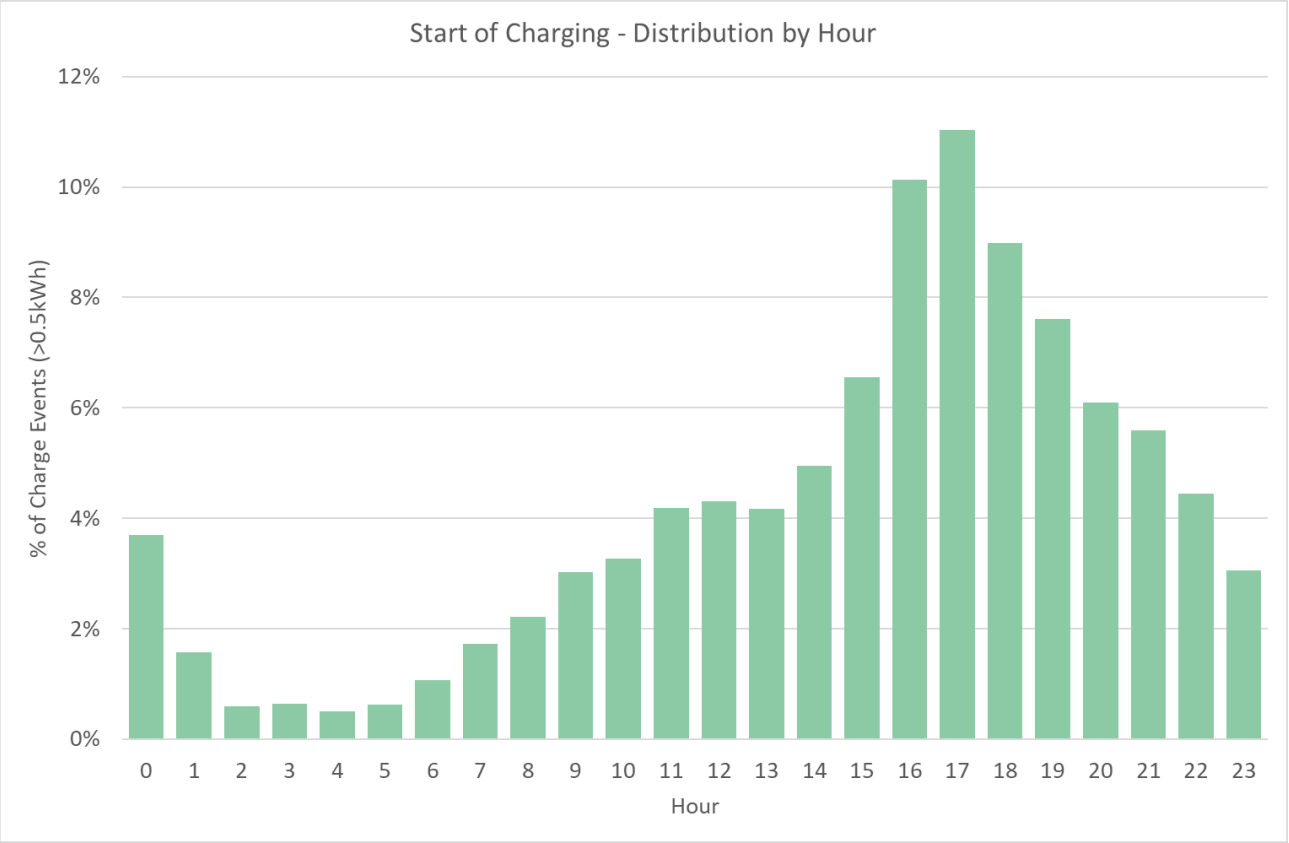


This indicates that the majority of participants charge less than four times a week. As expected, charging every day is more prevalent for participants with smaller batteries and therefore lower ranges (less than 10kWh and 10 to 25kWh).

6.1.2 Time of Charging

The time at which charge events occur is also key to the effect this will have on distribution networks. As shown in Figure 28 the 'spare' network capacity varies significantly through the day. Figure 28 demonstrates the variation for a weekday but the pattern is broadly similar for weekends. A simple distribution of the start of EV charging is shown below, for all transactions where more than 0.5kWh was consumed. The start of charge is based on the meter values received from the charge point (where available), or the plug-in time.

Figure 34: Start of Charging - Distribution by Hour



This shows a similar to trend to previous EV studies, with a pronounced peak in charge events beginning during the evening peak times. These charge events are the most likely to be affected by demand management as spare network capacity is at its lowest at this time. The charge events which begin in the early hours of the morning are typically as a result of drivers using timers. For example, 1,035 transaction records exist for events beginning between 00:00 and 00:59. Of these, 976 have a 'start charging' time (as distinct from purely the time the vehicle was plugged in, allowing the use of timers to be observed) – for 852 of these events there was at least a 10-minute gap between the vehicle plugging in and charging beginning. 10 minutes was chosen as a relatively arbitrary value which indicates a delay between plugging in and current being drawn which is very unlikely to occur in the absence of a timer. Varying this gap does not significantly alter the results presented below. A similar trend is observed for charge events starting between 01:00 and 01:59 (406 of 426 events where 'start charge' is available). This is explored in more detail below.

The additional load on distribution networks created by PIVs will depend on both the time which charging begins and its duration. For example, the additional load at 18:00 will include both those vehicles which plug-in at 18:00, along with a proportion of those which began charging in the preceding hours and have not yet completed their cycle – i.e. all active charging sessions: where an PIV started charging, was charging or completed charging in a specific half hour period. The data collected by the project in the period between May and October 2017 has been analysed and is shown for each half hour period below.

Figure 35: Percentage of EV Population Charging in 1/2 Periods over a Day (Week and Weekend)

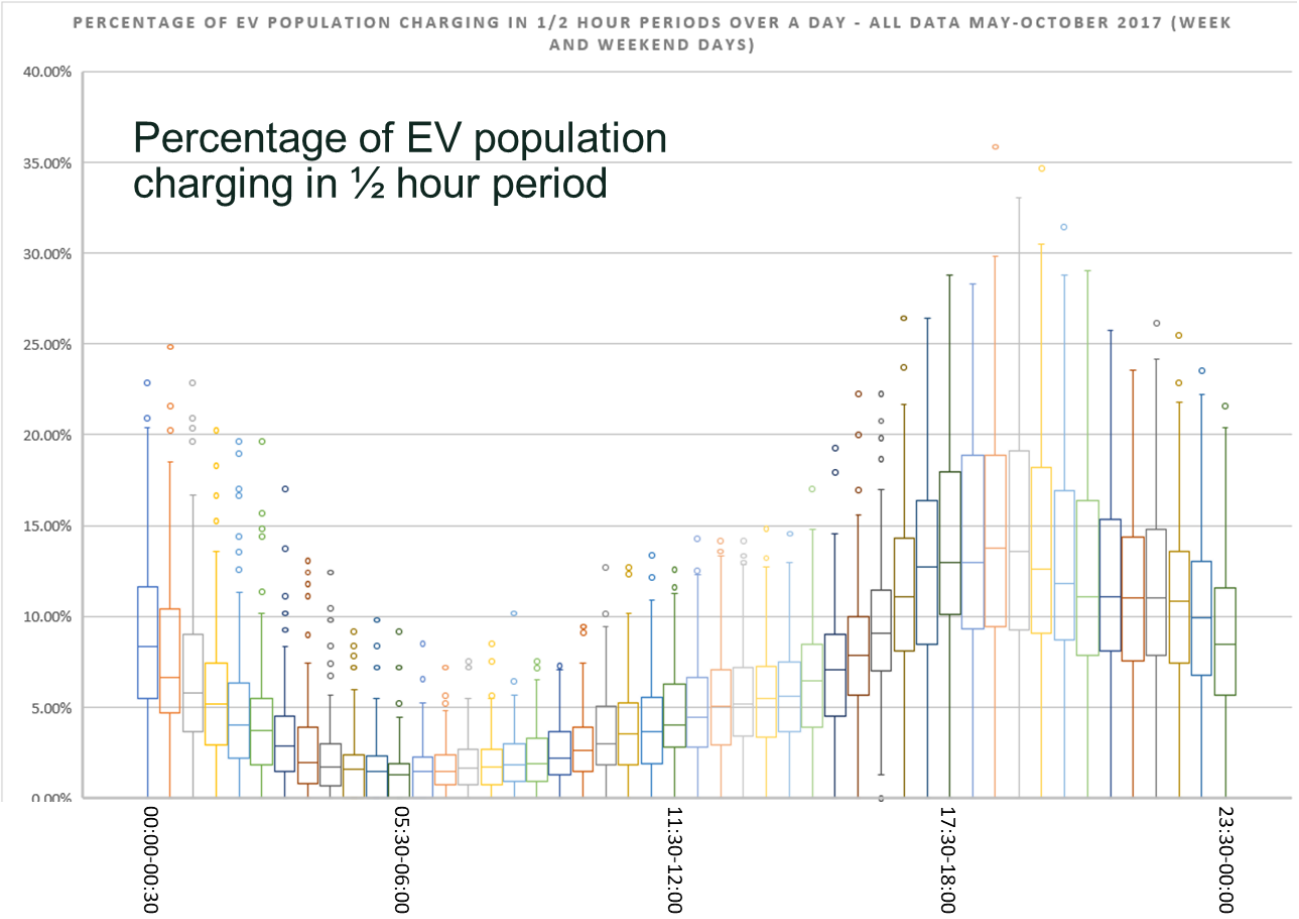


Figure 35 uses 'box and whisker' plots for each ½ hour period. A box and whisker plot allows the spread of the data to be represented. The lower whisker to the lower edge of each box represents the spread (range) of data points in the first quartile, the lower portion of the box represents the second quartile, the line in the middle represents the median value, the upper portion of the box represents the 3rd quartile range and the upper whisker represents the 4th quartile range. Circles outside of the 'whiskers' are outliers (values are considered outliers only if they lie further than 1.5 times the length of the box (known as the interquartile range) from either end of the box).

For example, in the 00:00 – 00:30 period:

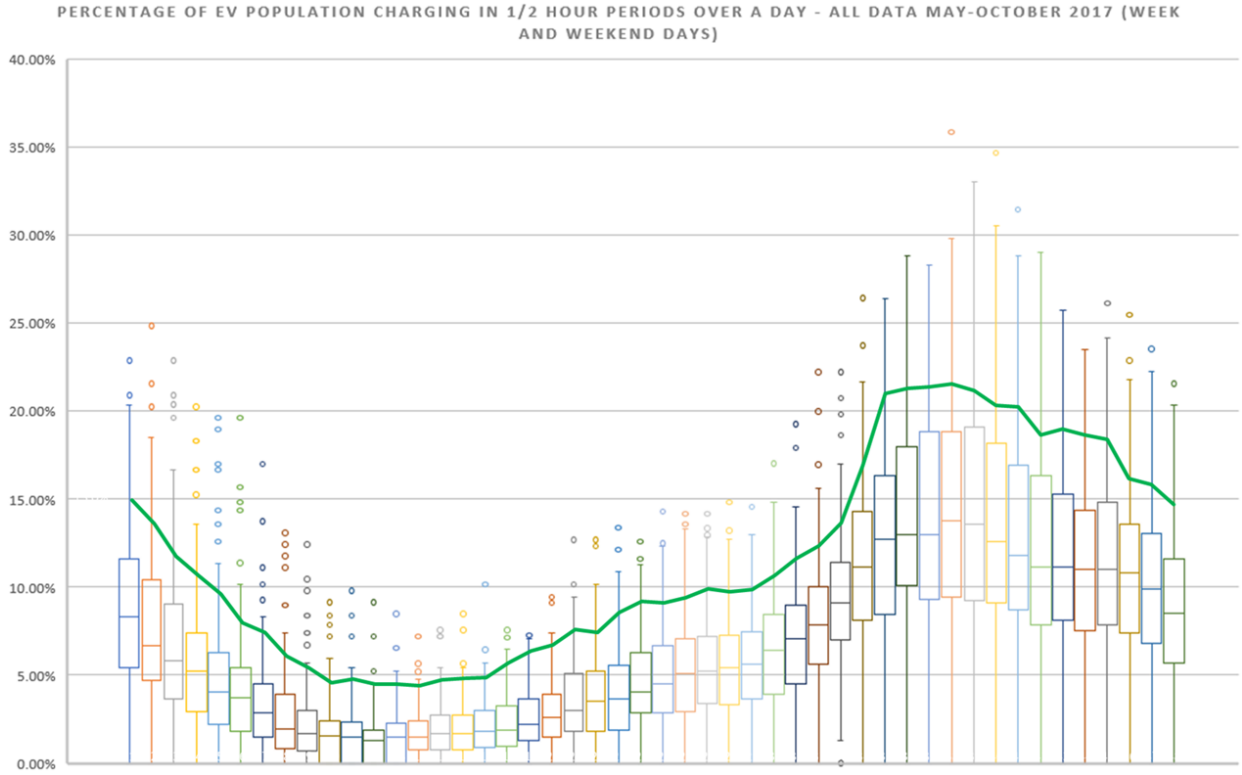
- On 25% of days, less than 5% of chargers are active in this period.

- The median is for ~8% of chargers to be active.
- On 75% of days, less than ~11.5% of chargers are active.

These patterns do appear to vary for weekday and weekends and for PHEV/BEV and may even vary for battery size – further analysis will be undertaken in due course.

The 90th percentile line can also be added as shown in Figure 36. Based on the data received to date it can be assumed, for example, that on 90% of days, less than 15% of EV chargers would be active between 00:00 and 00:30. This allows a prediction to be made of the likely additional network loading which may be created by the uptake of PIVs. It also provides an indication of the likelihood of demand management occurring – for example by comparing with Figure 28.

Figure 36: Percentage of EV Population Charging in Each 1/2 Hour Period - with 90th Percentile



Throughout the trial this data will be further refined to study the effect of various factors including PIV type (plug-in hybrid, battery only), season, weekday/weekend and battery size.

6.1.3 Use of Timers

Many makes and models of PIV include a timer function to control when charging occurs (i.e. delaying it from the plug-in time). In the absence of a timer, and without demand management, an EV will begin charging almost immediately when plugged in and continue to charge until the battery is full, or the vehicle is unplugged. Timers typically function in one of two modes:

- Off-peak timing window (e.g. Mk1 Nissan Leaf): the user pre-programmes times when charging should take place (e.g. 00:00 to 7:00). The vehicle begins to charge at the start of this window.
- Departure time (e.g. BMW i3): the user pre-programmes details of their off-peak tariff, and a time when they intend to unplug the vehicle and begin their next journey. The vehicle evaluates its state of charge and expected charge rate and determines the time to start charging in order to be ready shortly before the departure time.

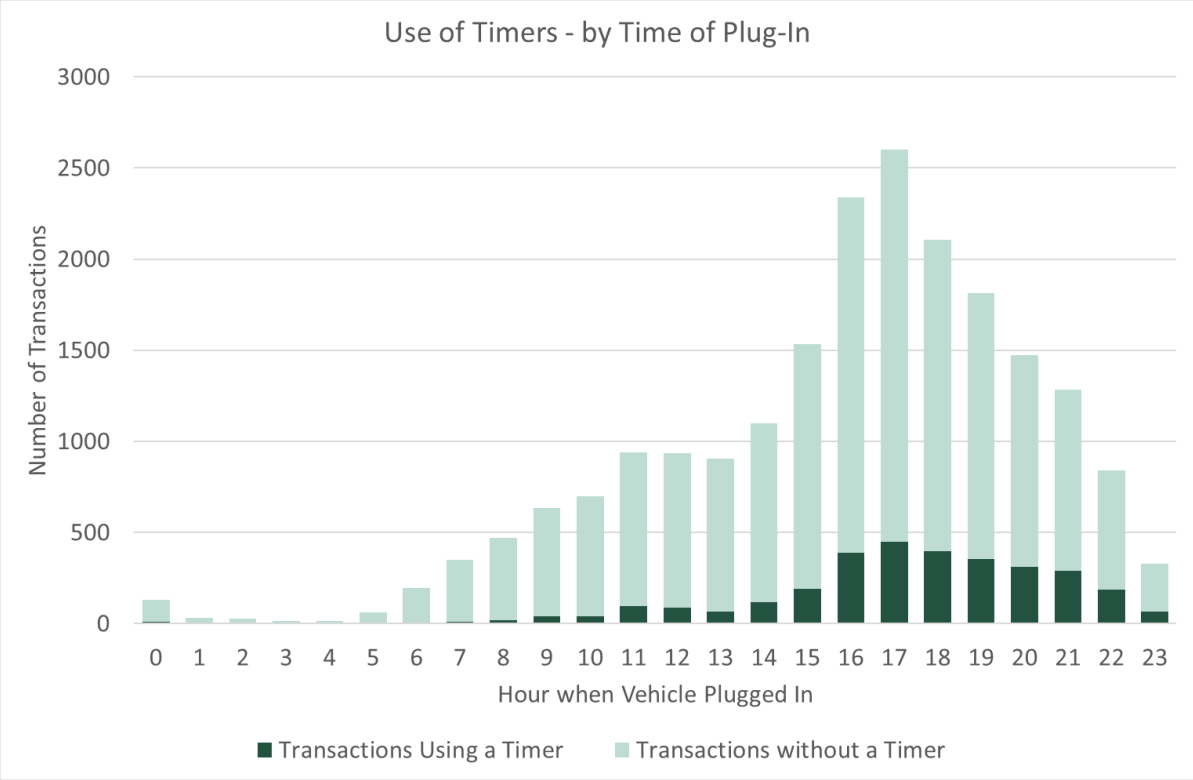
Charge events initiated by a timer are unlikely to overlap with a demand management event (compare the distribution Figure 40 and Figure 29). If this was to occur then a 'departure time' based timer has a greater potential to impact the customer. If a driver wishes to leave at 7 a.m. and charging begins at, for example, 1 a.m. (e.g. the start of an Economy 7 off-peak rate) and occurs at a reduced rate, then it is still likely that the vehicle will be completely recharged by the departure time. However, with a departure time system the vehicle management system is not aware of the potential for charging to be managed, and therefore charging may not begin early enough to fully re-charge the battery if management (curtailment) occurs.

PIV owners may use timers for a variety of reasons including; taking advantage of existing time varying tariffs (e.g. Economy 7), matching their charging with their own electricity generation (midday charging with PV generation) or due to an awareness of network capacity issues and a desire to minimise this (even in the absence of tariff incentives). This sub-section explores the data collected as part of the Electric Nation trial to date, showing the prevalence of the use of timers, and ways in which these are being used.

The analysis below is based on 20,825 transactions for which a 'start of charge' time can be calculated, with consumed energy of >0.5kWh. The start of charge time is calculated using the 'meter value' records, as distinct from the plug-in time supplied in the transaction record (see beginning of Section 6). If a charge event takes place during a communications outage then transaction records are provided once communications are restored. However, meter values are lost, and it is not possible to calculate a 'start of charge' time for these transactions. This data was collected from April to December 2017 (inclusive). This shows that in 15% (3,318 transactions) of cases there was a delay of at least ten minutes between the plug-in event and the vehicle drawing current. Ten minutes was chosen as a relatively arbitrary value which indicates a delay between plugging in and current being drawn which is very unlikely to occur in the absence of a timer. Varying this gap does not significantly alter the results presented below

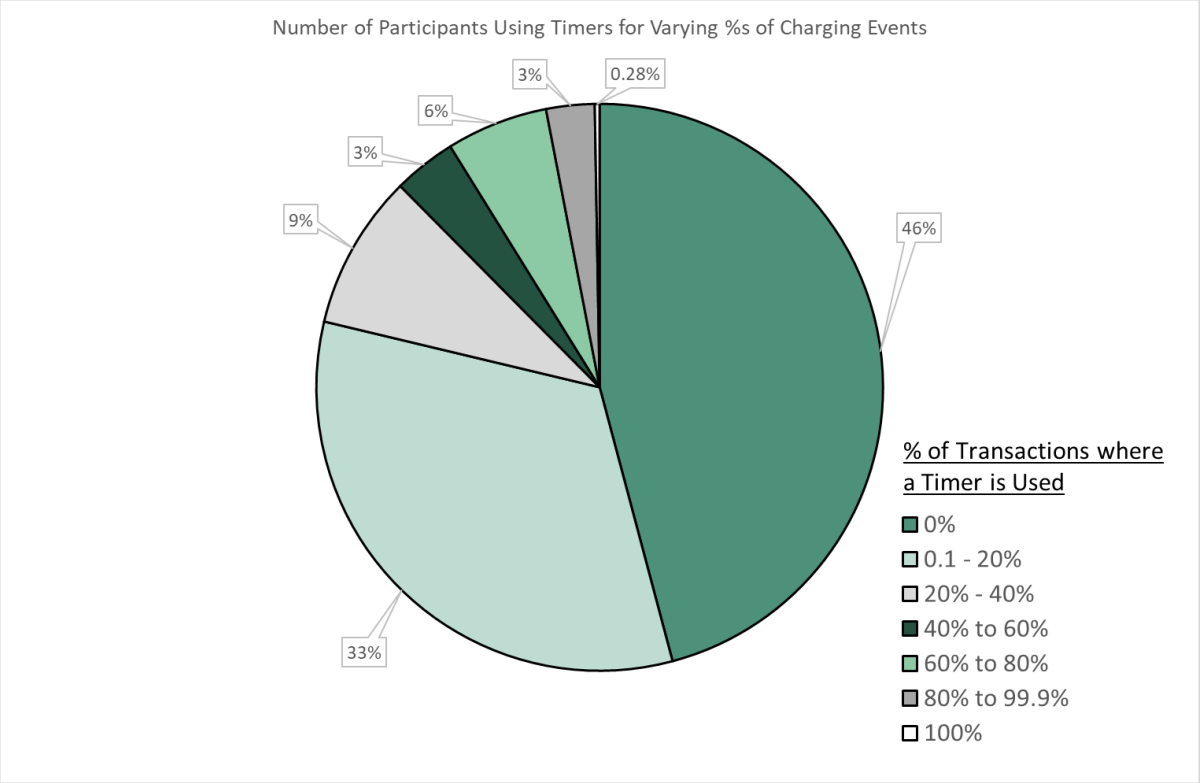
The proportion of plug-in events for which a timer was applied varies throughout the day, as shown below. For example, of the 2,107 plug-in events which have occurred in the 18:00 – 18:59 period, approximately 400 (19%) have used a timer.

Figure 37: Variation in the Use of Timers Throughout the Day



Of the approximately 20,000 charging events where data is available, 15% involve the use of a timer. There are different potential use patterns for drivers, for example, using a timer for all charging sessions, or only occasional use. 362 participants have at least one transaction record where a 'start charge' time is available (i.e. where it is possible to determine if a timer has been used). The percentage of transactions in which each participant uses a timer can be calculated, and this is shown graphically in the pie-chart below.

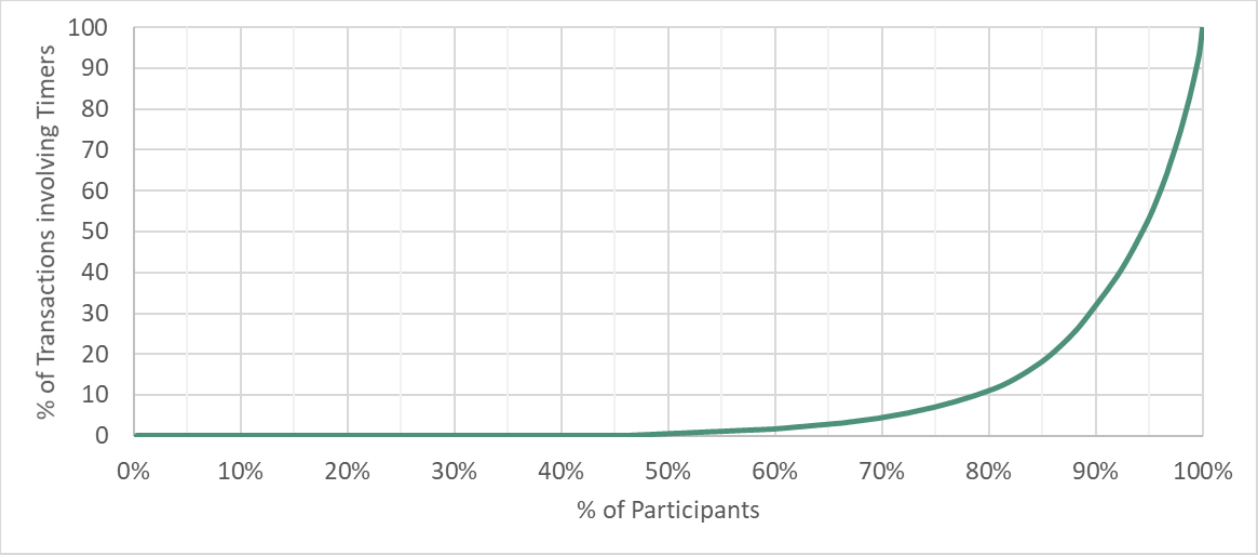
Figure 38: Use of Timers by Electric Nation Participants



For example, 46% of participants have never used a timer, and 33% use one between 0.1 and 20% of charging events.

The graph below shows the contribution of individual participants to the total number of transactions with timers. This indicates that approximately 15% of participants are responsible for 80% of the transactions involving timers.

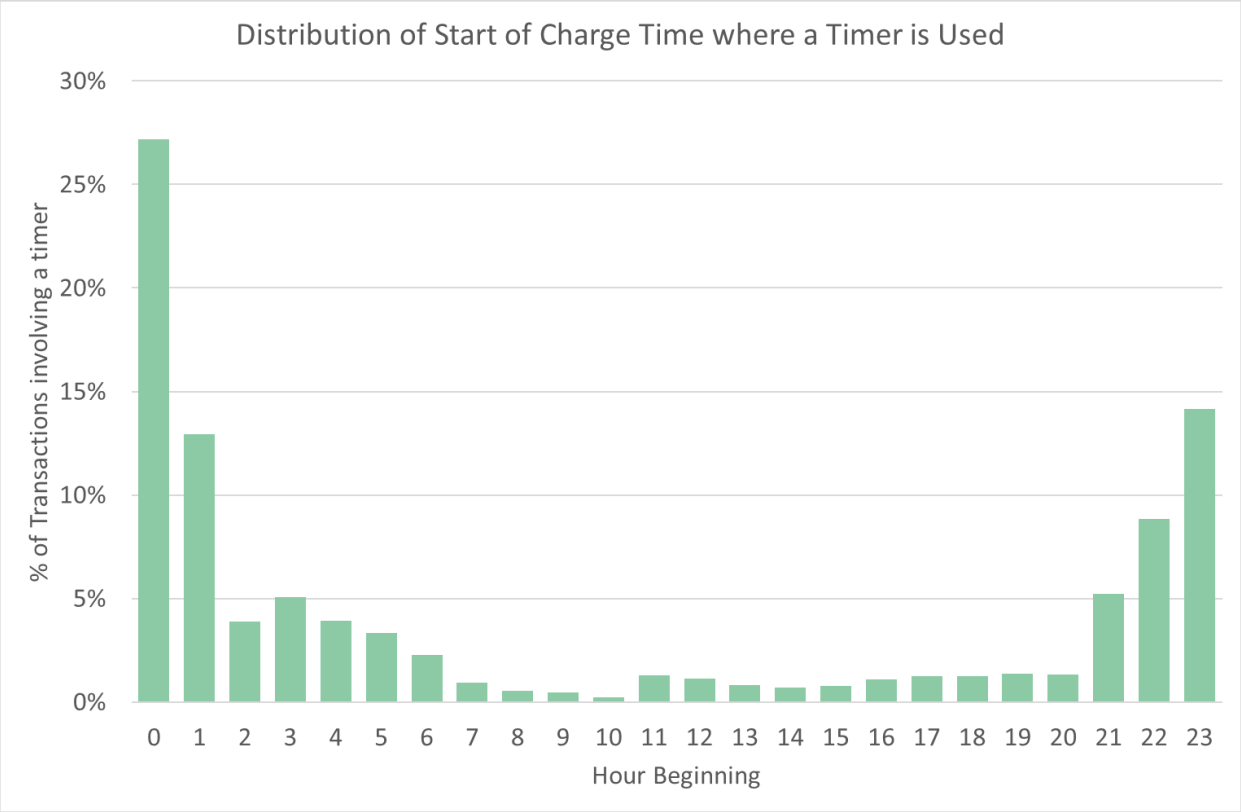
Figure 39: Contribution of Individual Participants to Total of Transactions involving Timers



The time at which charge sessions begin provides an indication of the reason behind timer user – for example, charging due to begin in the middle of the day is likely to be due to a desire to match load to PV generation.

The distribution below shows the most popular period for cars using timers to begin charging is between 23:00 and 01:59, accounting for 54% of transactions. It is likely that the charge events which begin later in the overnight period (e.g. 3 a.m.) are also taking advantage of a cheaper overnight rate, but may be using a departure timer. Further analysis will be completed in the latter stages of the project to compare the participants using timers, with those who are on time of use tariff such as Economy 7.

Figure 40: Distribution of Start of Charge Time where a Timer is Used



The use of timers by participants provides an indication of the willingness of drivers to adapt the time of their charging, e.g. in response to a time of use tariff. This may be explored in future algorithm iterations as part of Electric Nation.

6.2 Flexibility of Energy Requirement

The sub-section above provides an early insight into the additional load which may be created by home PIV charging on distribution networks. Another key part of the Electric Nation project is to understand the degree to which this load may be flexible. A driver will require a certain amount of energy in each charging transaction (either to completely refill the battery, or to have sufficient range to cover their next journeys before another re-charge). In the absence of management or a timer delivery of this energy begins as soon as the vehicle plugs in and may finish some time before the vehicle is unplugged. This gap

between completing charging and unplugging represents flexibility in the time at which the energy required can be delivered, and the potential for smart charging without inconveniencing PIV drivers.

This sub-section presents some early graphical insights into the level of flexibility available in transactions by Electric Nation participants to date.

Figure 41: Funnel Diagram - April to August 2017

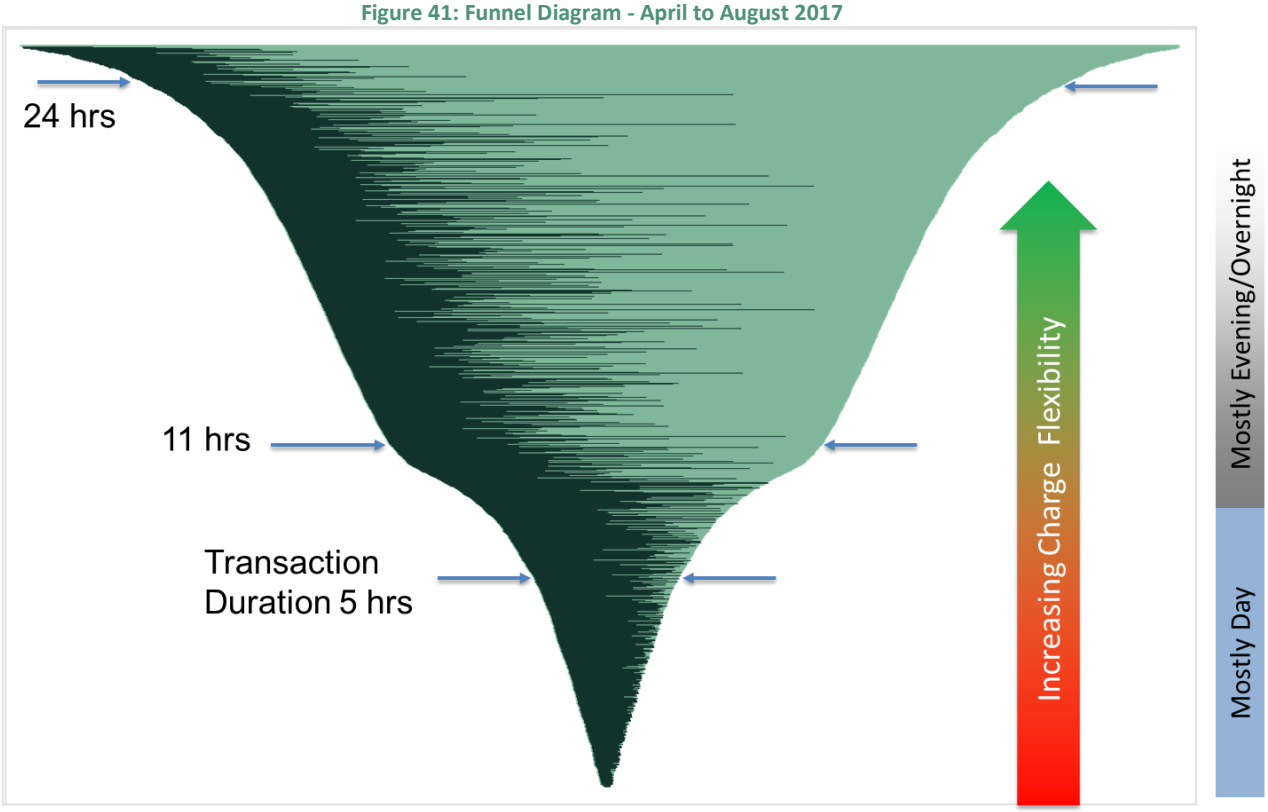
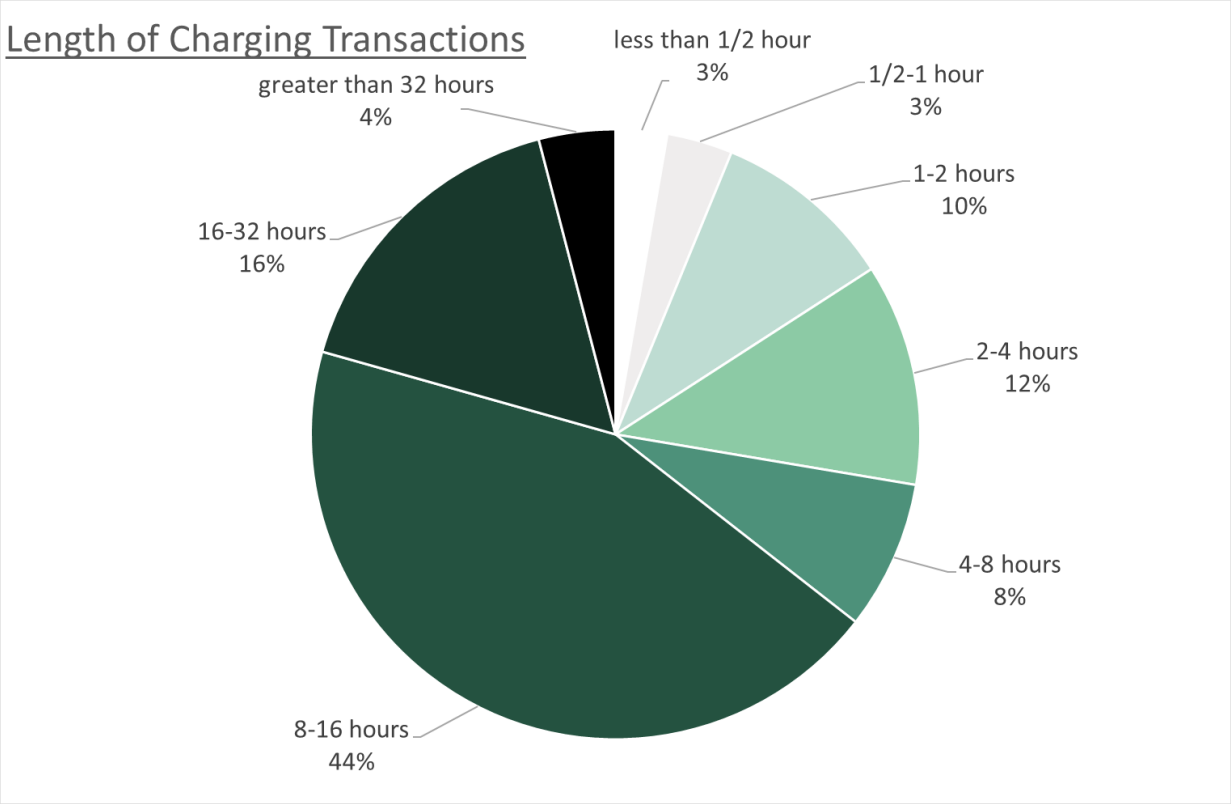


Figure 41 is made up of a large number of thin lines, stacked according to the length of the transaction (time from plug-in to plug-out). The shortest events are at the bottom, and have a duration of less than 5 hours (below the lowest set of arrows), while those at the top are greater than 24 hours long. Each transaction is made up of two coloured sections – dark green where the vehicle is charging, and light green once charging is complete, but the vehicle is still plugged in. There are several noticeable trends from this diagram:

- Shorter transactions have less flexibility – with very little light green visible in transactions less than five hours long.
- Transactions longer than approximately 11 hours have a greater degree of flexibility. This is to be expected, the average energy consumed in a transaction is approximately 11kWh, taking between an hour and a half and three hours to deliver depending on the charge rate. It is therefore unlikely that a vehicle would charge for the full duration of an 11-hour transaction.
- When the time of the charge event is analysed the majority of short transactions occur during the day, whilst long transactions begin in the evening. More flexibility is required in the evening peak due to higher levels of background loading, and this appears to be available from transactions which are occurring in this time period.

The length of a transaction also provides a measure of the degree of flexibility – as the plug-in duration increases it becomes less likely that the vehicle was charging for the whole duration. Early data on the length of transactions for Electric Nation participants in shown in the pie-chart below.

Figure 42: Duration of Transactions (time from plug in to unplug) in Electric Nation



Metrics will be developed to analyse the degree of flexibility available and how this varies with factors such as the PIV type, battery size, time of day and season.

7 Next Steps

7.1 Customer Research

Impact Utilities are continuing to distribute and collect the Recruitment survey and both Baseline surveys. Installation of Smart Chargers will be complete in the Spring. Following the collection of all possible completed surveys, a more complete analysis of participants characteristic and demographics will be undertaken.

Continued collection of the first Baseline survey and comparison with the second Baseline survey as well as use of data provided by EA Technology showing the amount and impact of demand management experienced by each participant will allow Impact Utilities to be able to compare, and calculate with statistical confidence, whether the trial population change their charging or driving habits as a result of experiencing demand management. It will also allow a judgement to be made about the acceptability of particular demand management solutions to the trial population. The learning from comparison of these surveys will help to inform trial design later in the project.

After the end of the project in December 2018 the trial population will be asked to complete a final survey. This survey will seek to establish if trial participants were happy with the trial experience, if they still drive EVs, and also to establish if being part of the Electric Nation trial altered either their driving or charging habits.

7.2 Smart Charging Trials – 2nd Algorithm Configuration

As shown above, the project team are in the process of moving all participants into routine demand management. This will continue until all installations are completed (estimated to be in May 2018), and all issues preventing the roll-out of management are resolved. Alongside this activity participants who are under routine management will experience different levels of demand management as the year progresses.

Further iterations of the smart charging algorithms for both GreenFlux and CrowdCharge will be developed in the second year of the project. The 2nd iteration has been developed by both CrowdCharge and GreenFlux and early testing has begun. This is described for each system in the sub-sections below. These apps will be rolled out to customers in the next quarter.

7.2.1 GreenFlux

A group of participants will be provided with a smart charging app (native to Android and iOS). The app is a simple interface which allows the user to request 'high priority' for the current charge session. Available current is allocated to high priority chargers first, before trickling down to 'normal' and 'low' priorities respectively (low priority occurs at the end of a charge cycle). Therefore, if all active sessions chose to enact the request for high priority, all chargers will have the same priority and will be treated equally.

Photographs of the app interface taken during testing are shown below.

Figure 43: Welcome Screen on 1st Login

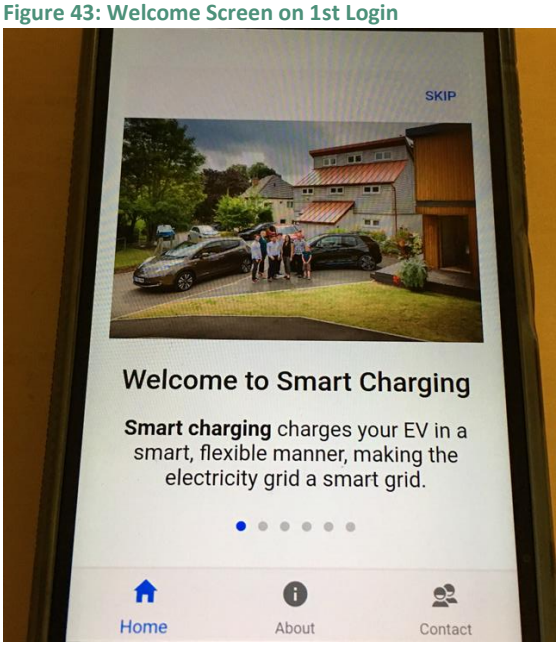


Figure 44: Screen with Active Charge Session

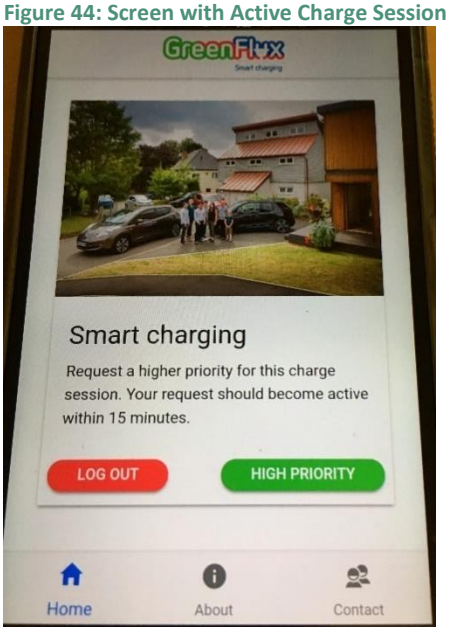
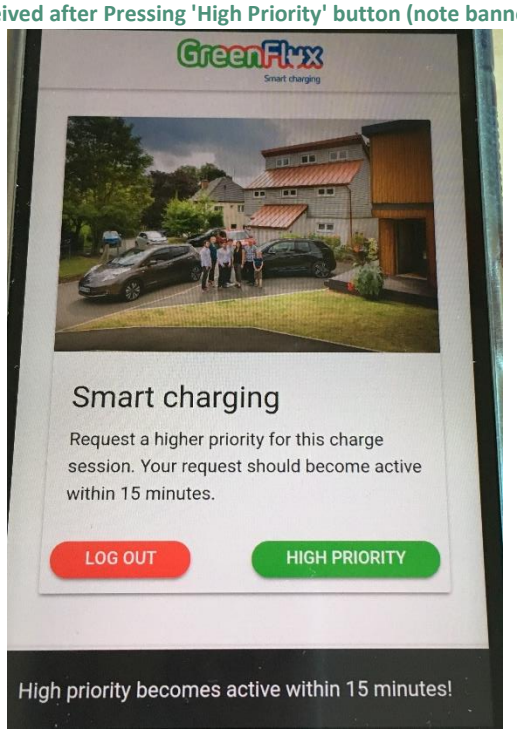
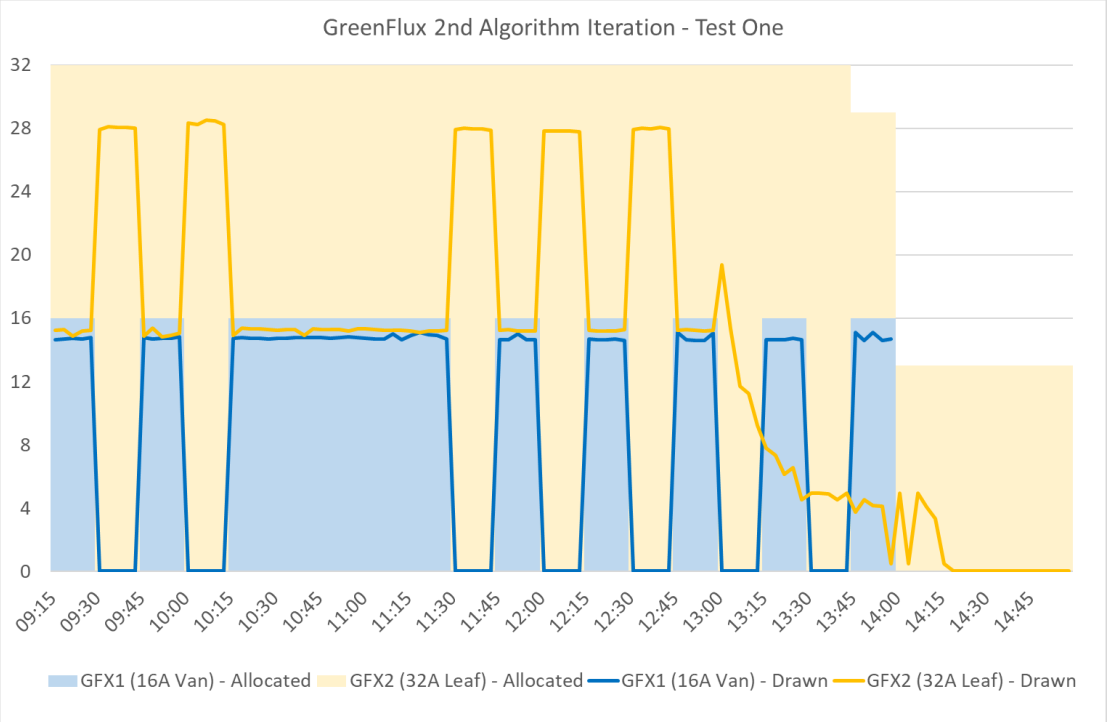


Figure 45: Message Received after Pressing 'High Priority' button (note banner along base of screen)



Two simple tests have been completed using the test system at Capenhurst. The results from one test are shown in Figure 46. In this test a 32A limit was applied to the group of chargers throughout the day. Two vehicles were charging – a 16A rated van on GFX1 and a 32A rated car on GFX2.

Figure 46: GreenFlux 2nd Algorithm Iteration - Test One



The test progressed as follows:

- 9:15 to 10:15 – both vehicles charging and assigned 'normal' priority. 32A was shared equally between the two vehicles, as per the existing algorithm. At 10:05 the 'high priority' button was pressed for GFX1.
- 10:15 to 11:30 – the 'high priority' request for GFX1 was activated, so 16A was allocated throughout this block. At 11:27 'high priority' was requested for GFX2.
- 11:30 to 13:45 – both chargers had equal priority (both high) so were treated equally (i.e. the same as 9:15 to 10:15).
- 13:45 to 14:00 – the current drawn by the 32A Leaf had decreased as it reached the end of its charge cycle. It was therefore allocated 13A.
- 14:00 onwards – the 16A van was unplugged so 13A was allocated to the 32A Leaf, as the charge cycle was nearly complete.

This test was deemed successful and further testing is underway at the time of writing to include:

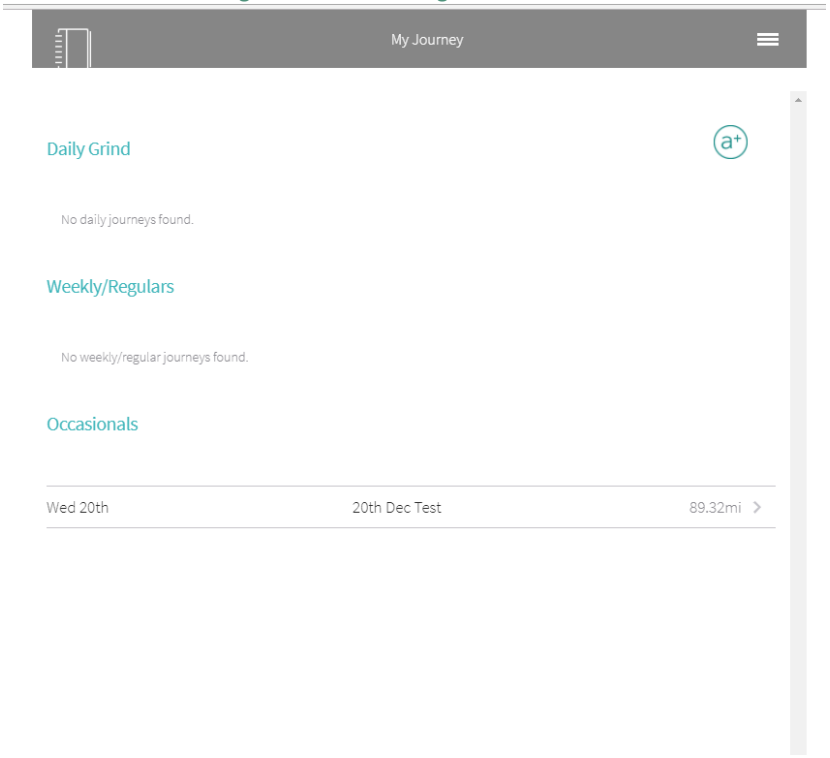
- Increasing the numbers of cars in the test and different combinations of chargers under 'high priority'.
- Time varying profiles
- The effect of communication outages
- Confirming high priority is cancelled if the vehicle is unplugged
- Use of timers
- Tests with all firmware versions currently in the field

7.2.2 CrowdCharge

CrowdCharge have developed a more sophisticated algorithm to allocate current to vehicles based on either knowledge or a prediction of the energy they require. This knowledge could come from the customer, via a web interface or telematics (where available). Alternatively, a prediction can be made based on historical data for the charger.

A screenshot of the web interface is shown below.

Figure 47: CrowdCharge Web Interface



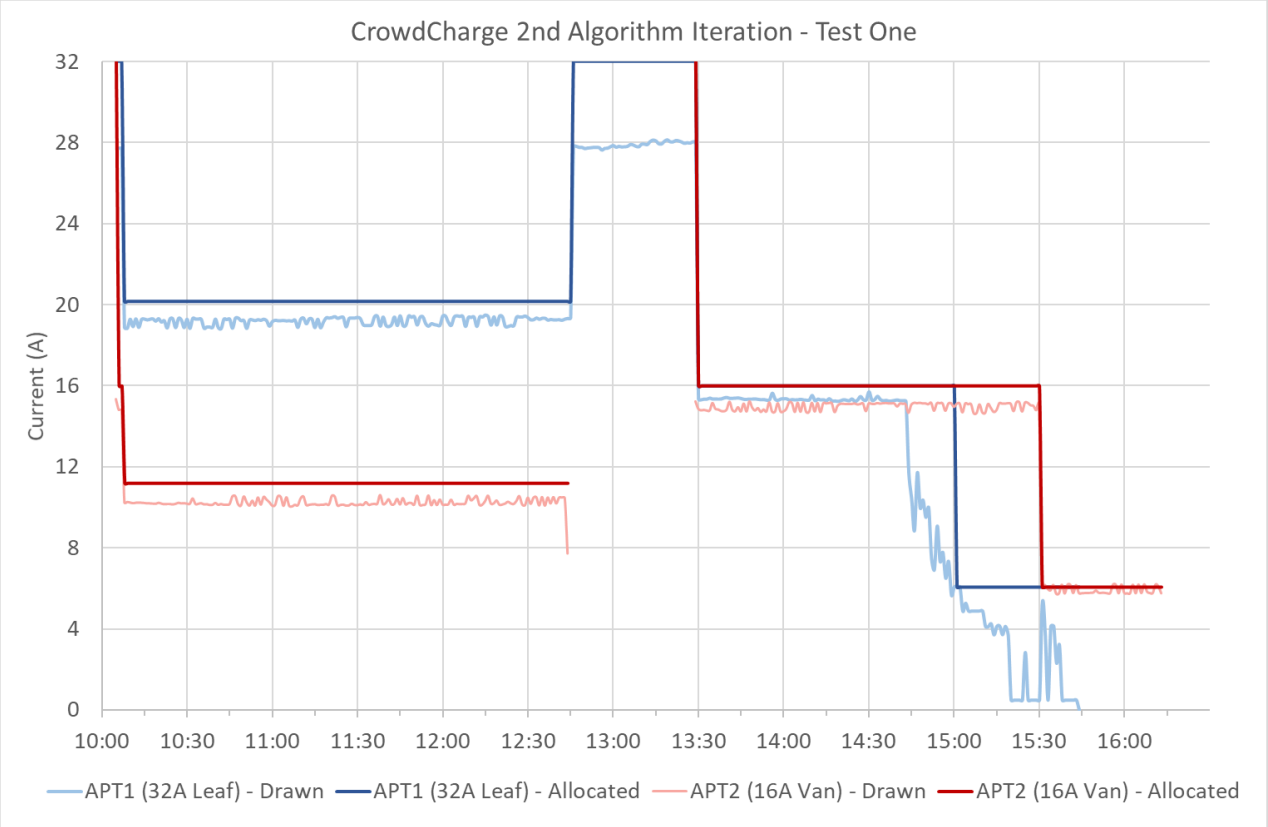
Through the journey planner the user can enter details for regular trips (e.g. daily commute) and occasional journeys (as illustrated above for the 20th December test). A journey plan includes the starting state of charge (%), vehicle to be used (default value is set via the user profile), start and end point (used to calculate mileage) and departure time.

An initial, simple test was completed on 20th December. A 32A limit was applied to a group of two chargers, with journey details as follows:

- APT1: 32A Nissan Leaf, starting at 25% starting range, 90 miles for the next journey, departing at 15:00.
- APT2: 16A Nissan van, starting at 22% starting range, 40 miles for the next journey, departing at 15:30.

Based on the new CrowdCharge algorithm, APT1 should be allocated more of the available current, as it had a higher energy requirement to satisfy the conditions of its next journey. Both vehicles were plugged in shortly after 10:00, with the results shown below.

Figure 48: Results of 1st Test of Second CrowdCharge Algorithm Iteration



- 10:00 to 12:15 – both vehicles plugged in and charging. Less current is allocated to the van (11A compared to 20A) due its lower energy requirement, based on the proprietary CrowdCharge algorithm.
- 12:45 to 13:30 – van unplugged, releasing current to allow the 32A Leaf to be allocated additional current.
- 13:30 to 15:00 – van and car allocated equal amounts of current, due to additional energy made available to the car in the previous period.
- 15:00 to 15:30 – Current allocated to APT1 decreases as it is reaching the end of its charge cycle (current drawn decaying).
- 15:30 to 16:00 – allocation to the van decreases as the pre-programmed departure time has passed.

This test was deemed successful and CrowdCharge are in the process of developing a detailed test schedule to include all the potential scenarios which may arise in the trial (mixture of app inputs being available, telematics data, no data, communications outages, incorrect data etc.).

Appendix 1 – Recruitment Survey

Electric Nation Recruitment Questionnaire

December 2016

568 Electric Nation	ONLINE SCRIPT DRAFT 14/12/16	Susie Smyth, Michael Brainch, Lucy Upshall, Helen Rackstraw

INTRODUCTION TO THE RESEARCH AND ADHERENCE TO MRS CODE OF CONDUCT

CATI ONLY: Hello, may I speak to **NAME FROM SAMPLE** please?

C1. I am calling from Impact Research about the Electric Nation project that you recently agreed to take part in. We recently sent you a survey link by email, can I check whether you received that email?
Yes
No – **CONFIRM EMAIL ADDRESS WITH RESPONDENT MATCHES SAMPLE**

C2. We would be really grateful if you would be able to complete this survey as soon as possible, I can take you through the questions now on the phone, or if you prefer you can complete it online? The survey should take no longer than 10 minutes.
Phone - **CONTINUE**
Online – **CHECK IF NEED LINK RE-SENDING, THANK AND CLOSE.**

Thank you for agreeing to participate in this important project about the future of electric vehicles. This is the first of a number of surveys you will be asked to take part in during the trial and should take no more than 10 minutes to complete, depending on the answers you give us. The purpose of this survey is to check the information we hold about you and gather some background about your household before you start the trials. This information will be used in combination with that from the other trial participants to understand how perceptions might vary by different groups.

This is a genuine market research study and no sales call will result from our contact with you. The interview will be carried out in strict accordance with the Market Research Society's Code of Conduct. Your identity and any information you provide to us will be kept confidential and will not be used for any purposes other than this research. Your details were provided to us

by DriveElectric and only Impact Research and DriveElectric will have access to your personal contact information so that we can keep in touch with you throughout the trials.

SAMPLE CONFIRMATION

We already have some details about you that were passed to us by DriveElectric that we would like to check all are correct before we continue.

S ASK ALL
A1 Can we check your full name is **INSERT FROM SAMPLE** .....
Correct
Wrong – **INSERT NAME HERE**

S ASK ALL
A2 And is this your home address where your charging point is installed? **INSERT FROM SAMPLE** .....
Correct
Wrong – **INSERT CORRECT ADDRESS HERE**

Is your postcode?
INSERT FROM SAMPLE .....
Correct
Wrong – **INSERT CORRECT POST CODE HERE**

QHIDDNO
AUTOCODE DNO FROM POSTCODE LIST:

1) WPD (East Midlands)
2) WPD (South West)
3) WPD (Wales)
4) WPD (West Midlands)
5) Electricity North West
6) Guernsey Electricity
7) Jersey Electricity
8) Manx Electricity Authority
9) Northern Ireland Electricity
10) Northern Powergrid
11) Scottish Hydro
12) Southern Electric
13) SP Distribution
14) SP Manweb
15) UKPN

S ASK ALL

A3 Is this the best telephone number on which we can contact you on for the duration of the trials?

Correct
Wrong – **INSERT CORRECT NUMBER HERE**

S ASK ALL

A5 And is this your preferred email address?
Correct
Wrong – **INSERT CORRECT EMAIL ADDRESS HERE**

A6 And can I confirm your vehicle is…
FROM SAMPLE:
FULL EV OR HYBRID
CAR MAKE AND MODEL

(ALLOW EDITING FOR ANY FIELDS THAT ARE WRONG)

S ASK ALL
A7 Does your household have regular access to any other vehicles apart from the electric/hybrid vehicle registered for this trial?
Yes **(SPECIFY MAKE AND MODEL)**
No

S ASK IF YES AT A7
A8 How many other vehicles does your household have regular access to?
1
2
3+

S ASK ALL
A9 Which of these best describes how you personally use the electric/hybrid vehicle registered for this trial?
I am the main driver
I drive the car regularly but am not the main driver
I rarely or never drive the vehicle **CONFIRM WITH RESPONDENT, CLOSE, AND CONTACT IMPACT AS ALL DRIVERS SHOULD BE REGULAR DRIVERS OF THE VEHICLE.**

M ASK ALL
A10 Apart from you, who else is likely to drive the electric/hybrid vehicle registered for this trial?
Please select all that apply.

My partner

Another household member
Someone who does not live in the household
Only me EXCLUSIVE

Thank you for confirming that information. We will now ask you some questions about your household.

DEMOGRAPHICS AND HOUSEHOLD INFORMATION

S ASK ALL,
B1 Please record your gender below.

1) Male
2) Female

S ASK ALL
ADD VALIDATION RULE NO YOUNGER THAN 16 AND UP TO 99 YEARS OLD
B2 Please record your age below.
……. Years old

AUTOMATICALLY CODE INTO THE FOLLOWING AGE BREAKS (HIDDEN VARAIBLE]

IF CODE 1 CLOSE

QHIDAGE Please record **age** below

1) Under 18
2) 18-25
3) 26-35
4) 36-45
5) 46-55
6) 56-64
7) 65+

S ASK ALL
B3 Which of the following best describes ***your*** employment?

1) Self employed
2) Employed over 30 hours a week
3) Employed part time, 15-30 hours a week
4) Employed part time, less than 15 hours a week
5) Full time Student
6) Unemployed- seeking work
7) Unemployed- other
8) Looking after the home/children full time

9) Retired
10) Unable to work due to sickness or disability
11) Other (please specify)

S **ASK IF CODE 1, 2, 3, 4 AT B3**
IF CODE 5, 6, 7, 8 SKIP TO B5

B4 Is your work…
1. Mainly daytime work
2. Mainly evening work, from 7pm to 11pm
3. Mainly night work, 11pm to 5am
4. Shifts that change from day to day or week to week

B5 How many people (including children) are there in your household altogether (that is currently living at home with you)?
Please include yourself in the total.
ENTER NUMBER 1-20

IF 2 OR MORE AT B5 ASK B6
B6 How many children live permanently in your household?
ENTER NUMBER 0-20

S ASK ALL
B7 Which ONE of the following categories best describes the employment status of the ***Chief Income Earner*** (CIE) in your household?

1) Semi or unskilled manual *worker (e.g. Caretaker, Park keeper, non-HGV driver, shop assistant etc)*
2) Skilled manual worker *(e.g. Bricklayer, Carpenter, Plumber, Painter, Bus/ Ambulance Driver, HGV driver, pub/bar worker etc)*
3) Supervisory or clerical/ junior managerial/ professional/ administrative *(e.g. Office worker, Student Doctor, Foreman with 25+ employees, salesperson, etc)*
4) Intermediate managerial/ professional/ administrative *(e.g. Newly qualified (under 3 years) doctor, Solicitor, Board director of small organisation, middle manager in large organisation, principle officer in civil service/local government etc)*
5) Higher managerial/ professional/ administrative *(e.g. Doctor, Solicitor, Board Director in a large organisation 200+ employees, top level civil servant/public service employee etc)*
6) Student
7) Casual worker – not in permanent employment
8) Housewife/ Homemaker
9) Retired and living on state pension

10) Retired and not living on state pension
11) Unemployed or not working due to long-term sickness
12) Full-time carer of other household member

S ASK IF CODE 10 AT B7

B8 Which ONE of the following categories best describes the employment status of the Chief Income Earner ***before*** they retired?

SHOW THE SAME LIST AS B7, EXCLUDING CODES 9 AND 10

AUTOMATICALLY CODES OF QUESTIONS B7 AND B8 INTO SOCIAL ECONOMIC GRADE AS FOLLOWS:

CODE 1	**D**
CODE 2	**C2**
CODE 3 OR 6	**C1**
CODE 4	**B**
CODE 5	**A**
CODE 7 OR 8 OR 9 OR 10 OR 11 OR 12	**E**

S GRID ASK ALL

B9 Which of these best represents your **total** household income before tax and other deductions, either per month or per year.

This information will only be used to check that we have surveyed a mixture of different customers.

ONLY ALLOW ONE ANSWER IN ONE COLUMN

	PER MONTH	PER YEAR
1	Up to £539	Up to £6,499
2	£540 - £789	£6,500 - £9,499
3	£790 - £1289	£9,500 - £15,499
4	£1290 - £2079	£15,500 - £24,999
5	£2080 - £3329	£25,000 - £39,999
6	£3330 - £4999	£40,000 - £59,999
7	£5000 - £7499	£60,000 - £89,999
8	£7500 and over	£90,000 and over
98	Don't know	Don't know
99	Prefer not to say	Prefer not to say

S ASK ALL

B10 Which of the following do you have in your main charging address?

Mains electricity only
Mains electricity and mains gas
Mains electricity and another fuel source such as oil

S ASK ALL
B11 Do have solar panels (photovoltaics) at your home address?
Yes
No
Not sure

S GRID ASK ALL
B12 On average, how much is your combined spend, on gas **and** electricity?

ONLY ALLOW ONE ANSWER IN ONE COLUMN

	PER MONTH	PER YEAR
1	Less than £35 per month	Less than £400 per year
2	£35 - £49	£400 - £599
3	£50 - £65	£600 - £799
4	£66 - £85	£800 - £999
5	£86-£100	£1,000 - £1,199
6	£101 - £115	£1,200 - £1,399
7	£116 - £130	£1,400 - £1,599
8	£131-£149	£1,600 - £1,799
9	Over £150 per month	£1,800 or more per year
98	Don't know	Don't know
99	Prefer not to say	Prefer not to say

QHIDFUELPOV:
1 FUEL POOR – IF MORE THAN 10% OF INCOME SPENT ON FUEL BASED ON RESPONSE AT B9 AND B12
2 NON-FUEL POOR – IF LESS THAN 10% OF INCOME SPENT ON FUEL BASED ON RESPONSE AT B9 AND B12

C1 Finally, Have you experienced any technical difficulties while taking the survey?

1. No
2. Yes (Please specify)

Thank you for the information you have provided today. We will be in touch again once you have had your vehicle and been charging it for a few weeks to understand a little more about how you use and charge you vehicle.

If you have any questions in the meantime about the survey you have just done, or future surveys, please contact Impact Research on 01932 226 793 and ask for a member of the Electric Nation team. Our full contact details and those of the Electric Nation project partners such as DriveElectric were provided to you in your welcome pack. Please do not hesitate to get in touch if you have any questions.

Thank you.

Appendix 2 – Baseline Survey

Electric Nation Recruitment Questionnaire

February 2017

568 Electric Nation	ONLINE SCRIPT FV 22/02/17	Susie Smyth, Michael Brainch, Lucy Upshall, Helen Rackstraw

INTRODUCTION TO THE RESEARCH AND ADHERENCE TO MRS CODE OF CONDUCT

CATI ONLY: Hello, may I speak to **NAME FROM SAMPLE** please?
C1. I am calling from Impact Research about the Electric Nation project that you recently agreed to take part in. We recently sent you a survey link by email, can I check whether you received that email?
Yes
No – **CONFIRM EMAIL ADDRESS WITH RESPONDENT MATCHES SAMPLE**

CATI ONLY: C2. We would be really grateful if you would be able to complete this survey as soon as possible, I can take you through the questions now on the phone, or if you prefer you can complete it online? The survey should take no longer than 5 minutes.
Phone - **CONTINUE**
Online – **CHECK IF NEED LINK RE-SENDING, THANK AND CLOSE.**

ASK ALL
Thank you for agreeing to participate in this important project about the future of electric vehicles. This is the second survey that you will be asked to take part in during the trial and should take no more than 5 minutes to complete, depending on the answers you give us. The purpose of this survey is to gauge how you are currently charging your electric vehicle. This information will be used in combination with that from the other trial participants to understand how behaviour might vary by different groups.

This is a genuine market research study and no sales call will result from our contact with you. The interview will be carried out in strict accordance with the Market Research Society's Code of Conduct. Your identity and any information you provide to us will be kept confidential and will not be used for any purposes other than this research. Your details were provided to us

by DriveElectric and only Impact Research and DriveElectric will have access to your personal contact information so that we can keep in touch with you throughout the trials.

USE

We have some details about you we would like to check are correct before we continue.

M ASK ALL

A1 Firstly, what do you use your electric vehicle for? Please select all that apply.

1) Social
2) Business
3) Commuting

S ASK ALL

A2 Does your household have regular access to any other vehicles apart from the electric/hybrid vehicle registered for this trial?

1) Yes
2) No

S ASK IF A2=YES

A2a How many other vehicles does your household have regular access to apart from the electric/hybrid vehicle registered for this trial?

1) ……. **(SPECIFY MAKE AND MODEL FOR EACH)**

M ASK IF A2 = YES PLEASE SHOW ON SAME PAGE AS A2

A3 Is your other vehicle(s)… Please select all that apply.

1) Electric
2) Range extended electric
3) Plug in Hybrid
4) Hybrid
5) Petrol
6) Diesel
7) Other (please specify)

Thank you for confirming this information. We will now ask you some questions about your electric vehicle.

CHARGING BEHAVIOUR

M ASK ALL, ROTATE ALL

B1 To what extent do you agree or disagree with the following statement, where 1 is strongly disagree and 5 is strongly agree.

1) My charging behaviour varies considerably from day to day
2) My charging behaviour has a regular routine
3) Whenever I have access to a charger, I plug in, regardless of the level of charge of the vehicle
4) I will only plug in to charge when the battery is too low to complete my current/next journey

M **ASK ALL, MULTICODE**

B2 Where do you charge your electric vehicle? Please select all that apply.

3) Home
4) Service station (motorway) / Petrol station
5) On street charge point
6) Work
7) Supermarket/Shopping centre car parks
8) Other Car parks (please specify)
9) Friend/relative's house
10) Other (please specify)
11) Don't know

S **ASK ALL, SINGLE CODE**

B3 And, where do you charge your electric vehicle most often?

INSERT ALL SELECTED AT B2

S **ASK ALL, SINGLE CODE BY ROW**

B4 How often do you charge your electric vehicle in the following locations?

	1)	2)	3)	4)	5)	6)	7)	8)
Location	More than once a day	Once a day	5 -6 times a week	3-4 times a week	Once – twice a week	Once a fortnight	Less than once a fortnight	I don't have charging routine / Don't know
INSERT ALL SELECTED AT B2								

M **ASK ALL, MULTICODE**

B5 When do you typically charge your electric vehicle at the following locations? Please select all that apply to each location.

	1)	2)	3)	4)	5)
Location	Morning	Afternoon	Evening	Overnight	I don't have a standardised charging routine
INSERT ALL SELECTED AT B2					

S ASK ALL

B6 Thinking about when you charge your electric vehicle in the following locations, how long do you charge your electric vehicle for on each occasion?

	1)	2)
Location	**PROGRAMMER: NUMERIC BOX** _____ hours	I don't have a charging routine / Don't know
INSERT ALL SELECTED AT B2		

S ASK ALL

B7A How do you tend to judge when to charge your electric vehicle?

1) Number of miles left
2) Percentage of battery left
3) Other (please specify)

S ASK IF B7A = 1

B7B At what point would you feel like you need to charge the battery of your electric vehicle?

1) 10 miles or below
2) 20 miles or below
3) 50 miles or below
4) 100 miles or below
5) 150 miles or below
6) More than 150 miles

7) Other (please specify)

S ASK IF B7A = 2

B7C At what point would you feel like you need to charge the battery of your electric vehicle?

1) Below 75% charge
2) Below 50% charge
3) Below 25% charge
4) Other (please specify)

S ASK ALL

B8 On a scale of 1 – 10, where 1 is completely unacceptable and 10 is completely acceptable, how **acceptable** are your current charging arrangements?

1) 1 – Completely unacceptable
2) 2
3) 3
4) 4
5) 5
6) 6
7) 7
8) 8
9) 9
10) 10 – Completely acceptable
11) Don't know (Please specify why)

S ASK ALL

B9 On a scale of 1 – 10, where 10 is very satisfied and 1 is very dissatisfied, how **satisfied** are you with your current charging arrangements?

1) 1 - Very dissatisfied
2) 2
3) 3
4) 4
5) 5
6) 6
7) 7
8) 8
9) 9
10) 10 – Very satisfied
11) Don't know

S ASK ALL

B10 Which statement best describes your attitude to changing your charging behaviour

1) I am very willing to continue with this current charging arrangement indefinitely
2) I am willing to continue with this current charging arrangement for a limited time only
3) I would prefer alternative charging arrangements
4) I cannot continue with these current charging arrangements

OE **ASK IF CODES 2 – 4 SELECTED AT B10**
B11 Why do you say that?

S **ASK ALL**
B12 How do you feel about having your charging arrangements managed as part of the trial?

1) Not at all concerned
2) Slightly concerned
3) Quite concerned
4) Very concerned
5) Not sure

OE **ASK ALL**
B13 Why do you say that?

INSTALLATION QUESTIONS (DE)

Thinking back to when you had your charge point installed….

G **ASK ALL**
I1 Overall can you tell us what you thought of your experience with DriveElectric in terms of… **ROWS**
a) Contact with DriveElectric
b) Information provided to you about the project
c) Administration of your application for the charger

COLUMNS
1) Very poor
2) Poor
3) Neither poor nor good
4) Good
5) Very good

S **ASK ALL**
I2 How was your experience of the install itself?

1) Very poor
2) Poor
3) Neither poor nor good
4) Good
5) Very good

S **ASK ALL**

I3 Did the installer explain how safety would be managed as part of the installation?

1) Yes
2) No
3) Can't remember

OE **ASK ALL**

I4 Is there anything you feel you need more information on regarding the project?

OPEN ENDED

Thank you for providing that information. I would just like to confirm your contact information is up to date.

CONTACT INFORMATION

S **ASK ALL**

C1 Can I confirm that this is still the best number to contact you on?

1) Yes
2) No

S **ASK IF C1 = 2**

C2 Please provide the best number to contact you on in the future?

_____

C3 Finally, have you experienced any technical difficulties while taking the survey?

1. No
2. Yes (Please specify)

Thank you for the information you have provided today. We will be in touch again once the first trial is underway and you have had few weeks to charge your vehicle.

If you have any questions in the meantime about the survey you have just done, or future surveys, please contact Impact Research on 01932 226 793 and ask for a member of the Electric Nation team. Our full contact details and those of the Electric Nation project partners such as DriveElectric were provided to you in your welcome pack. Please do not hesitate to get in touch if you have any questions.

Thank you.

Appendix 3 – Recruitment Survey Invitation

Dear

You are receiving this survey invitation based upon you signing up to the **Electric Nation** research project. Your details were given to us by our project partner **Drive Electric**.

This initial survey will collect some background information about yourself and your electric vehicle, which will be used throughout the duration of the project. All details collected will be kept confidential and only be used for the purpose of this research as outlined in the welcome back. The information you provide for us is important to help us understand how different electric vehicle users' experiences might vary.

To take part in the survey, please read the following and click on the relevant link below:

<SURVEY LINK>

This survey should take approximately 10 minutes to complete. Please aim to complete the survey within the next seven days, after which time we may be in contact with you to remind you to complete the survey as soon as you can.

As part of this research you will be asked to complete up to seven further surveys throughout the next two years as previously explained.

If you have any queries about the Electric Nation surveys we send you please contact us at Impact Research on 01932 226 793 or electricnation@impactmr.com. If you have any other questions about the research then please refer to your welcome pack for relevant contact details. We look forward to receiving your feedback.

Kind regards,

Impact Utilities

Appendix 4 – Baseline Survey Invitation

Email subject: Electric Nation Survey 2

Dear

Thank you for completing the first survey as part of the **Electric Nation** research. **Now you have had your charger for a few weeks** we would like to ask you about your experience so far.

This survey is to understand your initial charging habits before the demand management trial begins. All details collected will be kept confidential and will only be used for the purpose of this research, as outlined in the Welcome Pack. The information you provide for us is important to help us understand how different electric vehicle users' experiences might vary.

To take part in the survey, please read the following and click on the relevant link below:

<SURVEY LINK>

This survey should take approximately 5 minutes to complete. Please aim to complete the survey within the next seven days, after which time we may contact you to remind you to complete the survey as soon as you can.

As part of the Electric Nation project you will be asked to complete up to six further surveys throughout the next two years, as previously explained.

If you have any queries about the Electric Nation surveys we send you, please contact us at Impact Research on 01932 226 793 or electricnation@impactmr.com. If you have any other questions about the Electric nation project then please refer to your Welcome Pack for relevant contact details. We look forward to receiving your feedback.

Kind regards,

Impact Utilities

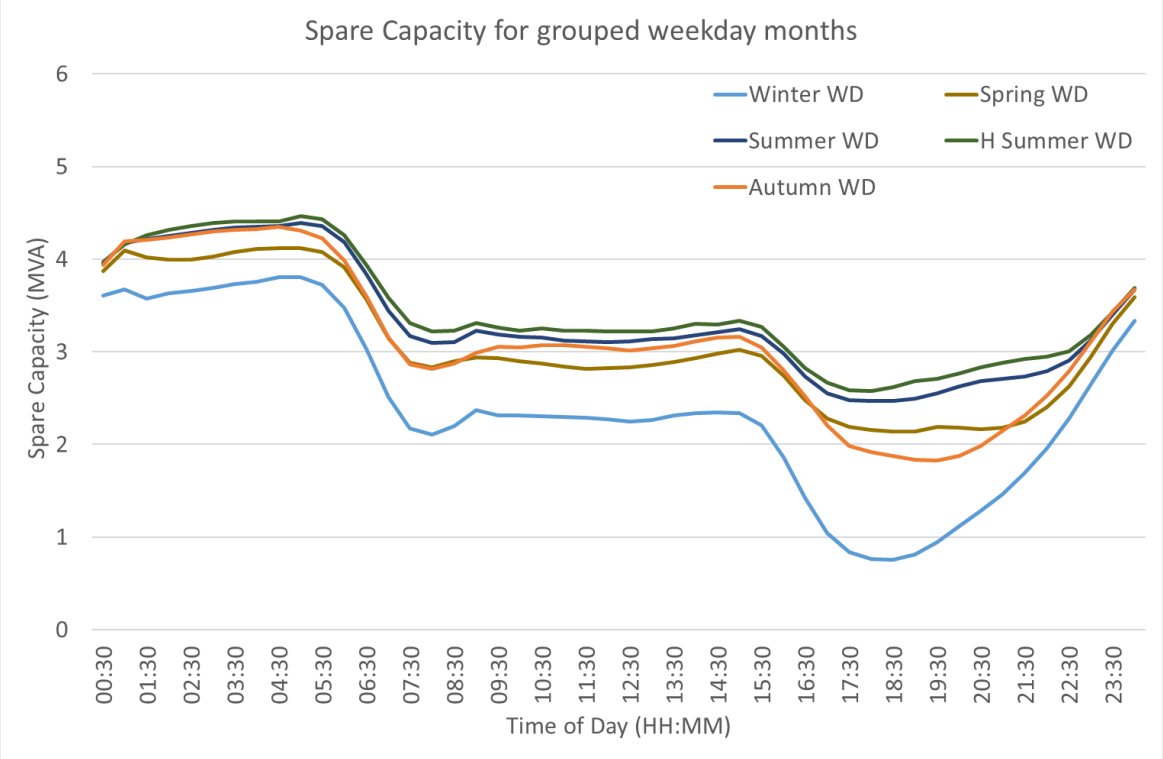
Appendix 5 – Smart Charging Roll-Out Process

Analysis of Network Data to Show Available Network Capacity

Electric Nation is trialling the use of demand management (smart charging) to avoid or defer network reinforcement. To achieve this the additional load from EV charging must be accommodated within 'spare' network capacity. This available spare capacity will vary depending on the network in question and by time of year, weekend/weekday and time of day.

In the first year of the Electric Nation trial 'spare capacity' profiles have been generated for a high voltage (HV) feeder in the East Midlands, for five seasons, for weekdays and weekends. The resulting profile is shown below.

Figure 49: Spare Capacity Profile



In the later stages of the trial alternative profiles may be investigated – e.g. managing based on Low Voltage (LV) network capacity, or for different networks.

This spare network capacity is equivalent to the amount of power which could be drawn by EV charging (or other load growth) on the network without exceeding the networks design limits. However, it requires scaling to be used within the trials – for example, the winter profile above has a minimum spare capacity of 0.75MW in winter at 18:30. This is equivalent to 107 chargers drawing 7kW (or slightly less than a third of each cohort when all participants are under demand management). The project is therefore scaling the capacity profiles so that participants experience a similar amount of demand management as the number of participants under management grows.

Identify Chargers Ready for Demand Management

As set out above, there are two routes in demand management:

- Charge at Will: Approximately 100 participants in each cohort (GreenFlux and CrowdCharge) who will be allowed unrestricted charging for approximately 90 days before demand management is imposed.
- Straight into Management: once the charger is in use approximately two weeks is permitted to prove the reliability of the communications from the charger, then the charger enters the managed group.

By using these routes, it should be possible to show whether there is any difference in the acceptability of demand management depending on whether participants have prior experience of unrestricted charging. The results of the 'baseline' surveys between the two populations can also be compared to show whether participants have different satisfaction levels with their charging at this stage, or whether their charging behaviour changes once they enter routine management (if they are aware of this), or once they have experienced some curtailment. This analysis will be completed later in the trial and the results shown above include participants from both populations.

Regardless of the route to management, chargers must satisfy a number of conditions before they entered the 'managed' group. Prior to this they provide data to the trial which will inform the project's understanding of charging behaviour for different types of PIVs. These criteria are set out below:

- Confirm the charger is in use: the date on which the first significant transaction occurs is recorded for each charger (i.e. excluding small transactions which occur during testing when the charger is installed). There can be delay between charger installation and the first use of the charger, for example if there is a delay in the delivery of the vehicle. For the charge at will group approximately 90 days is required between the date of first transaction and their entry into demand management. This measure is purely based on the time since they start charging, and does not include the number of transactions. However, it is a sufficient period of time for drivers to develop a charging routine.
- Charger configuration is ready for demand management: this is undertaken in conjunction with GreenFlux/CrowdCharge as appropriate and any issues are remedied as necessary.
- Ensure reliable communications: poor communications between the charger and demand control provider could negatively affect the participant's experience of smart charging, or make smart charging impossible (in the case of no communications). If a participant is more harshly affected by demand management due to a communications failure this could be reflected in their acceptability of the concept of smart charging, when it does not represent a realistic scenario. For this reason, participants are only being transferred into demand management after two to three weeks of good (85%+ reliability) performance.

- Test of controllability: this stage confirms that each individual charger is controllable before it is placed in a group. For CrowdCharge participants this is routinely carried out during each transaction and involves a very short reduction in the current available (no participant impact). GreenFlux participants pass through a 'test card' phase in which the charger behaves as it will during management, but full capacity is available at all times. Performance in the test card phase is then evaluated and recorded before the charger passes to routine management.

Batches of chargers which are ready to enter demand management are being identified approximately fortnightly, made up of a mix of participants who have been through the 'charge at will' and 'straight to management' routes. The output from this stage is a list of charger IDs which will form the managed group and the total number of chargers involved. An update on the number of participants which have passed this stage is provided in Section 5.4 below.

Scale Available Network Capacity Based on Number of PIVs in the Managed Group

The profiles of spare capacity (current limit) set out above are scaled based on the number of EVs in the managed group. This scaling factor is applied so that the participants experience a similar level of demand management to that which would apply when 30% of vehicles in the area are electric. This 30% figure was selected based on the findings of My Electric Avenue, and to be representative of a "2030 scenario". The proportion chosen could be altered in one of the later stages of the trial. The level of management that participants experience should stay consistent as the group is expanded (within the same season) as the current limit profile (demand limit) is re-scaled with each expansion.

Issue Group and Profile Definitions to GreenFlux/CrowdCharge

A data format has been agreed between EA Technology and both DCS providers to show the participants who make up a managed group and the weekday/weekend profile they should be managed to. This is issued by EA Technology and then implemented. Participants are not informed when the switch is made into demand management, to avoid prejudicing their survey responses. Impact Utilities are also notified of the date when each participant enters demand management to allow their survey to be issued at the appropriate time.

Monitor Performance

Throughout the trial (both before and after the implementation of demand management) all chargers should supply transaction records and meter values (current drawn and current allocated). These are being supplied to EA Technology by both demand management providers. Analysis of the effect of the demand management applied to date is given in Section 0.