WESTERN POWER DISTRIBUTION

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NEXT GENERATION NETWORKS

Customer Research and Trial Update Report
Electric Nation

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Contents

Glossary

Abbreviation	Term
BEV	Battery Electric Vehicle
EV	Electric Vehicle
HV	High Voltage
NIA	Network Innovation Allowance
PIV	Plug-In Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
REX	Range Extender 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 six hundred smart charger installations have been completed, and approximately 450 participants are under routine demand management. The second demand management algorithm is being rolled out to GreenFlux participants at the time of writing.

The report authors would like to thank Impact Utilities, who are providing customer research expertise to the Electric Nation project, for their input and insight into Sections 2, 3, 4 and 5 of this report and for providing many of the graphics in these sections.

Participants receive their first survey (the Recruitment survey) a fortnight after installation of their charge point, 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 participant response rates to surveys (93% and 90% for the first two surveys respectively) are very good when compared to industry averages for this type of research. This is likely due to respondents being highly engaged with the project overall, and after the baseline and recruitment surveys, respondents receive a £10 Amazon voucher for each survey completed. However, they are only eligible for the incentive if the recruitment and baseline surveys have been completed. 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.

This report also contains information on recruitment of trial participants into the trial and on into demand management. 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). This data is used to determine trial participants charging behaviour under both charge at will and demand management regimes and the frequency and duration of demand management events and the impact of demand management events on individual customers and groups of customers defined by the type of vehicle they drive (BEV/PHEV/REX) or the size of their battery.

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 domestic smart charging 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: results from the survey of customers who have experienced the first demand management algorithm
- Section 6: reports on progress with moving customers into routine management and the effect of this management at both a group and individual charger level.
- Section 7: describes the next algorithms which will be deployed into the trial, results of testing and progress with rolling the GreenFlux app out to customers.
- Section 8: the next steps for both customer research and the smart charging trial.

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 (between 2 and 6 weeks after having their charger installed or after receiving their EV, whichever is later) 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.

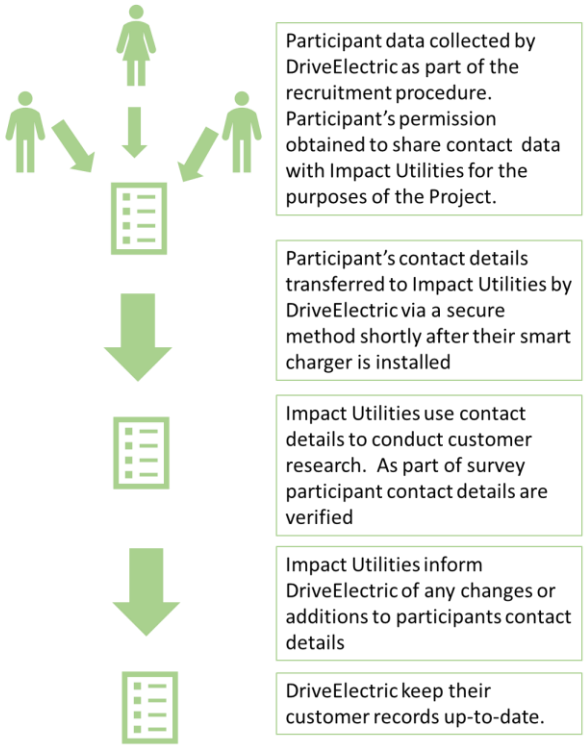
Further surveys will be conducted towards the end of each managed charging cycle, and then a final survey will be conducted at the end of the trial. The first survey to ask participants about their experiences under managed charging was issued in mid-January

[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 -this is in the process of being updated to be compliant with GDPR.

2018. The findings from this survey will be discussed in future Trial Update reports. The content of this survey is very similar to the Baseline survey in Appendix 2 to allow direct comparison.

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



2.2 Surveys investigating attitudes to managed charging trials

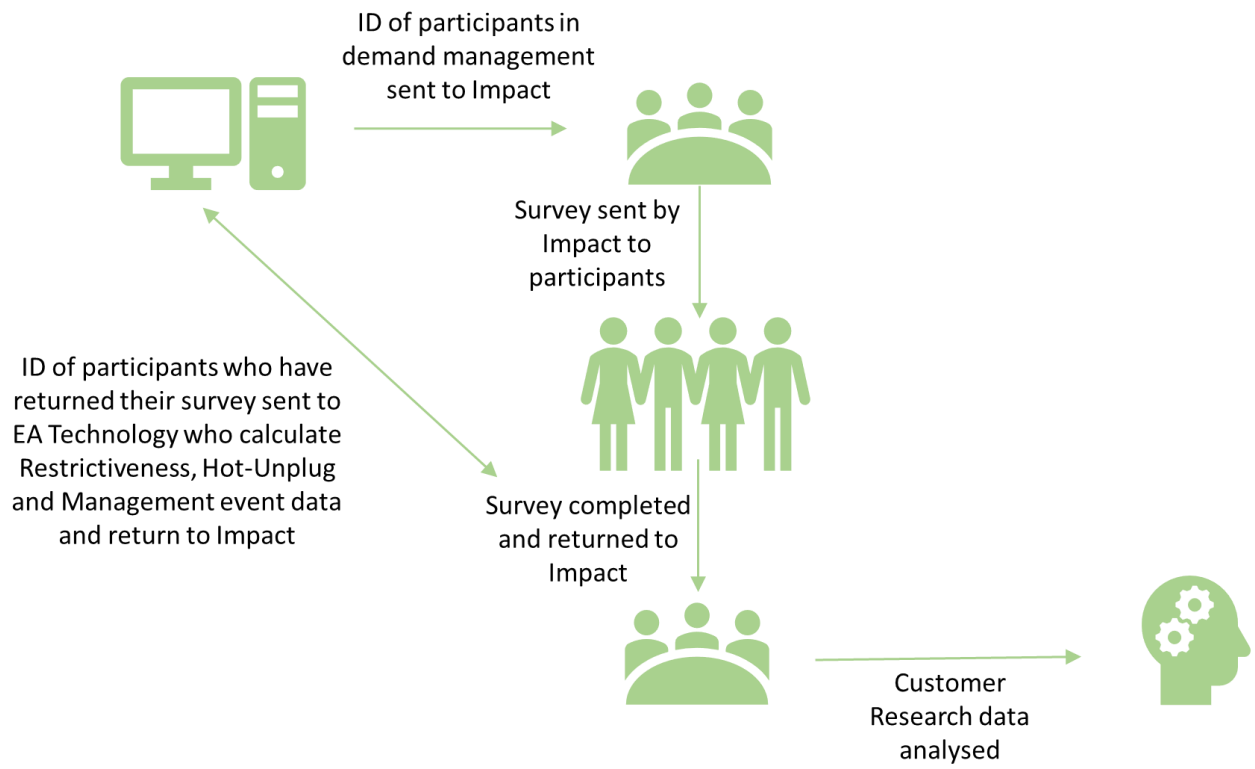
A selection of participants have progressed to the demand management trial: GreenFlux 249/332 installed and CrowdCharge 206/296 installed, overall 72% of chargers are in demand management at time of writing this report. Not all project participants have been part of this demand management trial to date, either because of technical issues with their smart charger (mainly communications not working or configuration issues which cannot be resolved remotely – in most cases this does not prevent the customer charging, but would prevent demand management), because their smart charger has not been installed for a sufficient length of time (approx. two/three weeks to assess communications reliability) or they have not started using their charger because they are waiting for delivery of their EV. Further details of this process are given in Section 6.

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. Over 200 participants were moved into demand management after they had experienced approximately 90 days of unrestrained charging. For comparison, other participants were moved straight into demand management after it had been ascertained that their charger was working correctly. This group would not have had the opportunity to experience and become accustomed to unrestrained charging. After a participant had been subject to demand management for around four weeks they were issued a survey by Impact Utilities. This survey is nearly identical to the Baseline survey issued to participants when they had completed 90 days of unconstrained charging.

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 trial 1 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 for them to be included in a second baseline survey (for comparison against the first baseline survey). Impact Utilities then issue survey links to the relevant participants and encourage them to complete the survey, either online or by telephone according to the participant's their 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. 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 June 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 6th April 2018.

	Surveys Sent	Surveys completed
%	100%	93%
N	562	522

Table 1: Recruitment surveys completed

The table below summarises the number of Baseline surveys completed.

	Surveys Sent	Surveys completed
%	100%	90%
N	529	476

Table 2: Baseline surveys completed

Trial survey 1 investigates participant attitudes to the first managed charging trial. This survey started 15th January 2018 and has involved over 300 trial participants who have been under managed charging for at least 4 weeks. Response rates to this survey are summarised in the table below.

	Surveys Sent	Surveys completed
%	100%	85%
N	307	260

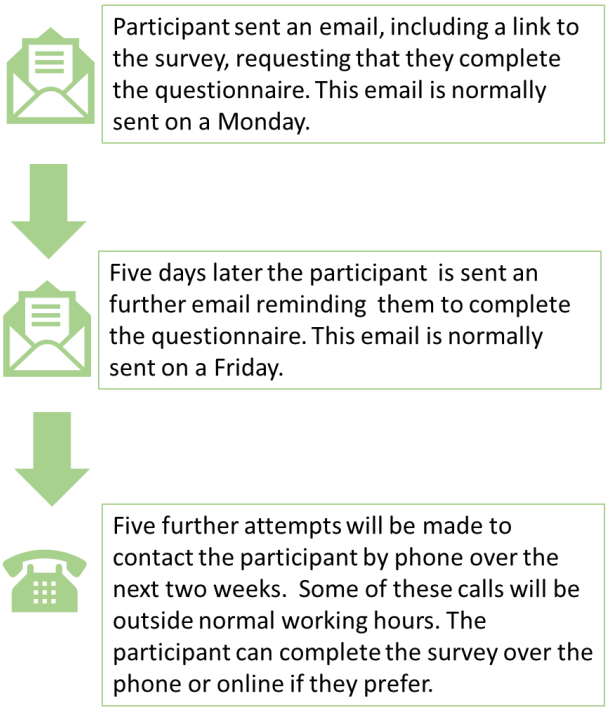
Table 3: Trial 1 surveys completed

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:

- Newsletters was sent to all participants 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 Trial 1 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 (trial participants can, of course, withdraw from the trial at any time or just not participate in a survey)
- 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 Utilities emails as Spam. They are also encouraging participants to put Impact Utilities 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. If this is unsuccessful, then Impact Utilities and/or DriveElectric send a personalised email to ensure communication has been received and check participant has been given ample opportunity to participant in the research
- 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.
- Surveys are kept succinct to prevent survey fatigue and to encourage future participation (surveys should take roughly 10 minutes or less to complete), response rates tend to follow an asymptotic curve with 80% of respondents replying within two weeks of a survey being sent to them, the remainder taking up to 6 weeks to respond with reminders. This pattern can be disrupted by holiday seasons.
- It should be noted that surveys do not highlight the charging algorithm, or provide too much information about being managed, which is to avoid biasing the results as we are testing consumer behaviour and acceptance (which includes what changes are noticed/unnoticed by EV owners)

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 a £10 voucher for an online store (Amazon) for completing each of the trial surveys. This excludes the Recruitment survey and Baseline survey. Completion of the Recruitment survey and the Baseline 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 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 June 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.

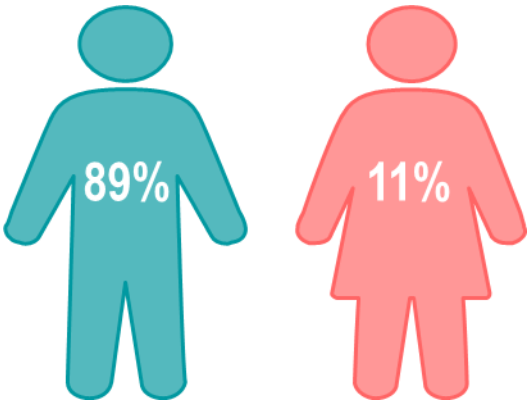
Data provided in this section is for the whole project population who have responded to the Recruitment survey.

Recruitment for the trial is nearly complete. 90% of the expected number of participants have now had their smart chargers installed (628 in w/c 23rd April compared against 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 516 participants who have completed the Recruitment survey 89% are male, compared with 11% females.

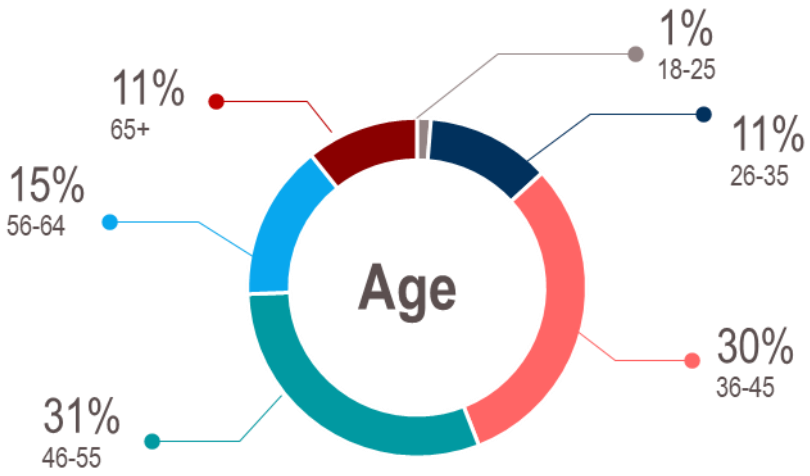
Figure 4: Gender split of participants (based on 516 surveys)



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 516 surveys)

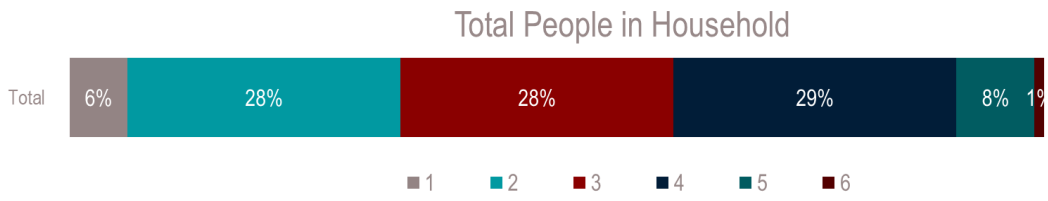


The average age of a participant is 48. The youngest participant is 21 and the oldest is over 80.

3.3 Household sizes

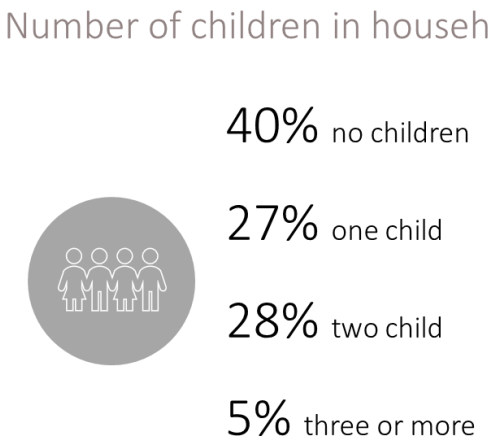
Electric Nation participants represent a range of different household sizes (including adults and children). This is demonstrated in the chart below:

Figure 6:Participant household size (based on 516 surveys)



The number of children in participant households is illustrated below:

Figure 7:Number of children in participant households (based on 487 surveys)



These figures 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 516 surveys)

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

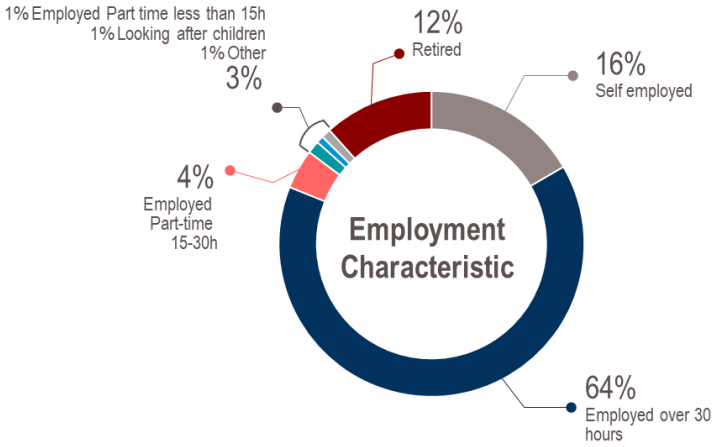
Category	Definition
A	Higher Managerial, administrative, and professional
B	Intermediate Managerial, administrative, and professional
C1	Supervisory, clerical and junior managerial, administrative and professional
C2	Skilled manual workers
D	Semi-skilled and unskilled manual workers
E	State pensioners,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

Table 4: Socio-professional categories

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

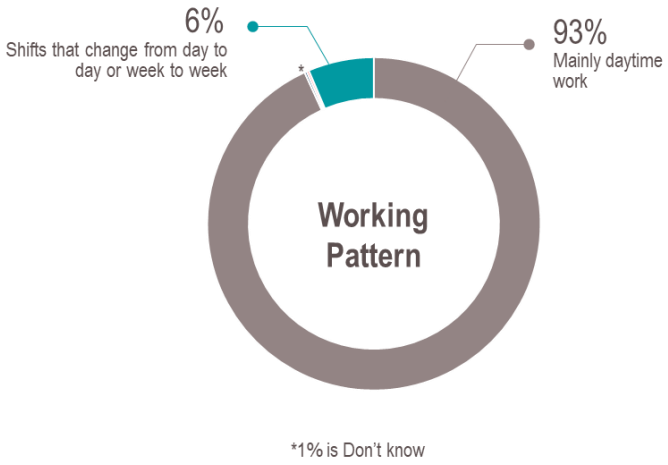
The chart below demonstrates the employment characteristics of participants. Most participants work full time however the trial has over 12% of participants who are retired. The number or self-employed participants is similar to the national rate[3].

Figure 9: Participant employment characteristics (based on 516 participants)



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

Figure 10: Working time characteristics of participants in employment (454 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. See section 4.2 for insight on where trial participants charge their cars.

[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

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).

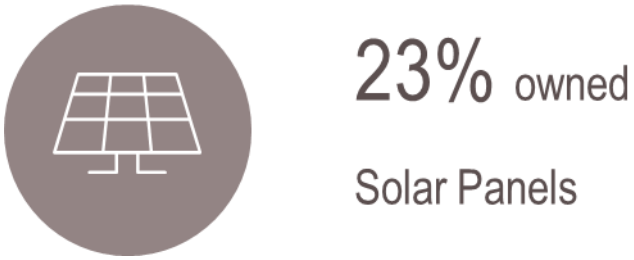
Figure 11: Vehicle type split amongst participants (based on 516 surveys)

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 516 surveys)



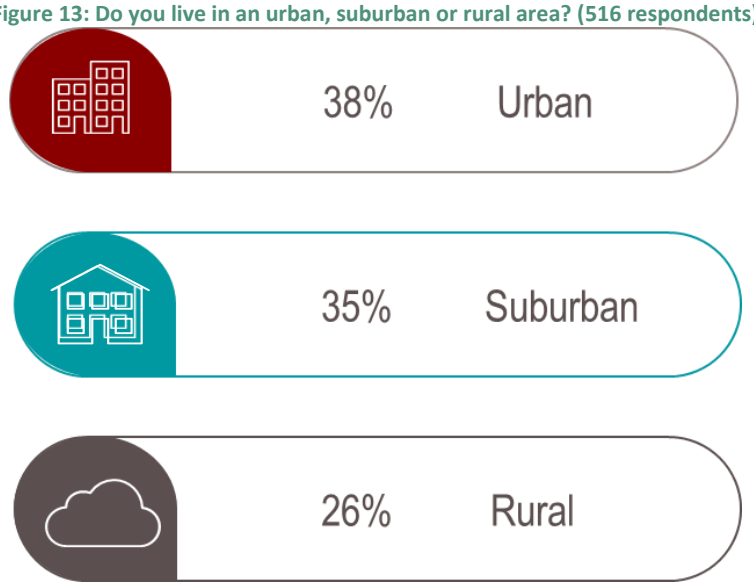
This is a larger proportion than the general population[4]. It **may** suggest that Electric Nation participants, as a whole, are more environmentally minded than the general population, have the financial means to invest in solar PV panels or have seen them as a good investment opportunity. The general 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.

[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.

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? (516 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 Baseline Survey Results

The Baseline survey was conducted approximately two to 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.

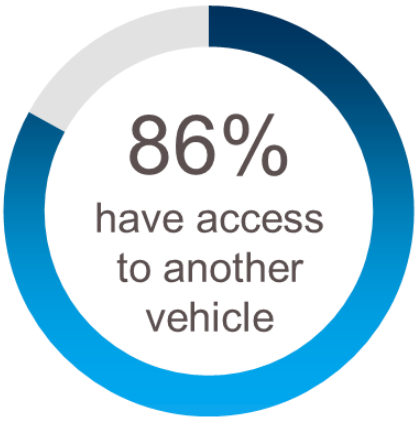
Participants are split between a 'charge at will' group (at least 90 days period where their charger will not be managed) and 'straight into demand management' group (see Section 6 for further details). The baseline survey results of these populations can be compared to show any difference in initial 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. The data does 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?

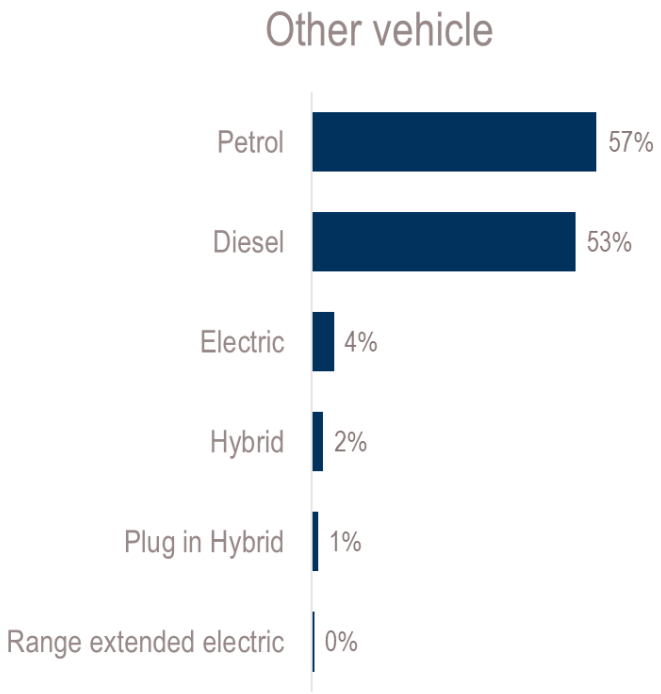
Participants were asked if their household has access to another vehicle(s).

Figure 14: Do you have access to another vehicle? (470 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).

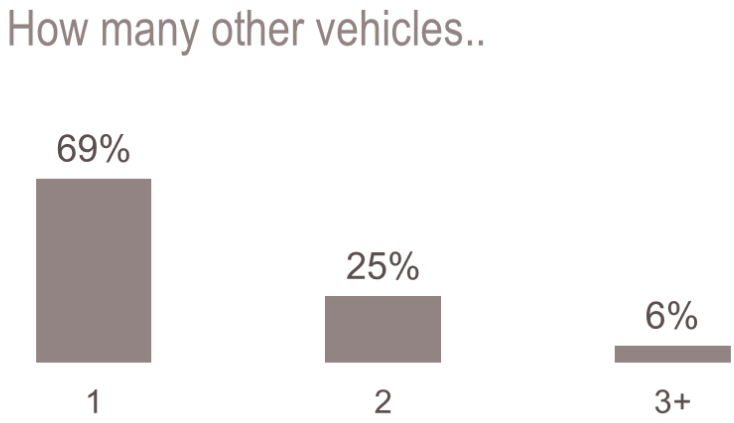
Figure 15: What type of alternative car does your household have access to (402 participants have access to another vehicle)



At time of writing, over 20 participant households have more than one plug-in vehicles.

Those households who have another vehicle, many have more than one vehicle as is demonstrated in the figure below.

Figure 16: How many other vehicles in participant household (402 responses)



4.2 How do you use your vehicle?

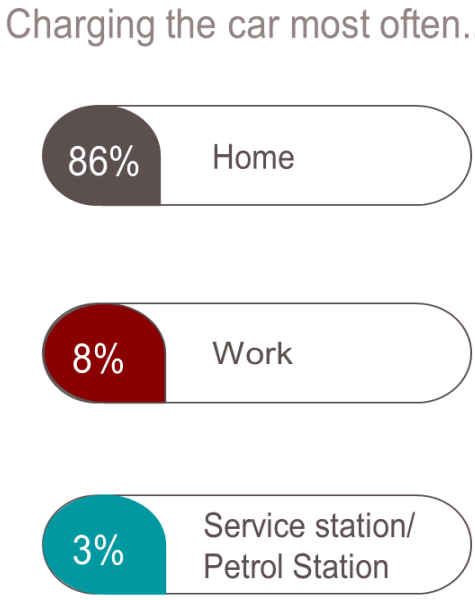
Participants were asked how they used their EV.

Figure 17: How do you use your EV? (470 responses)

4.3 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 18: Where do you charge your EV most often? (470 responses)

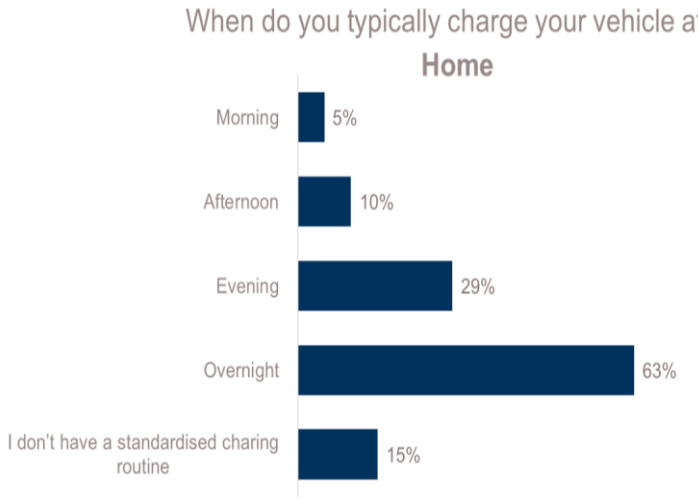


Five participants (1%) stated that they do not charge their vehicle at home – however, there is still value in gathering their attitudes to charging data because it may be useful to understand why people do not charge (or do so infrequently) at home where a charger is available to them. Two of these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

4.4 When do you usually charge your EV at home?

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.

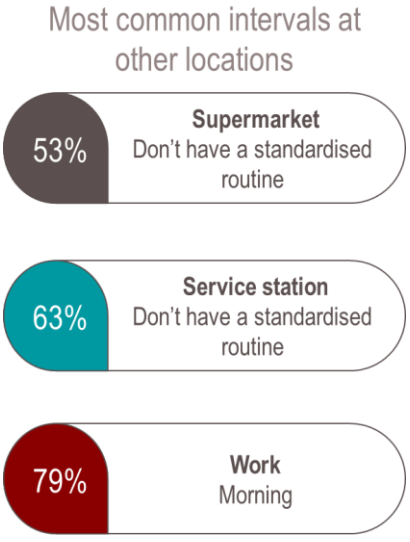
Figure 19: When do you usually charge your EV when you charge at home? (465 participants)



Most participants stated that they charge their EV either in the evening or overnight. This data will be compared to data gathered from smart chargers at a later point in the trial. The chart below provides insight into how frequently participants charge their EVs at other locations and when they are likely to use these chargers.

Participants were also asked about their charging behaviour when they used charge points at other locations.

Figure 20: Frequency that participants charge their EVs at locations other than home (All (470), Supermarket (112), Work (114), Service (137))

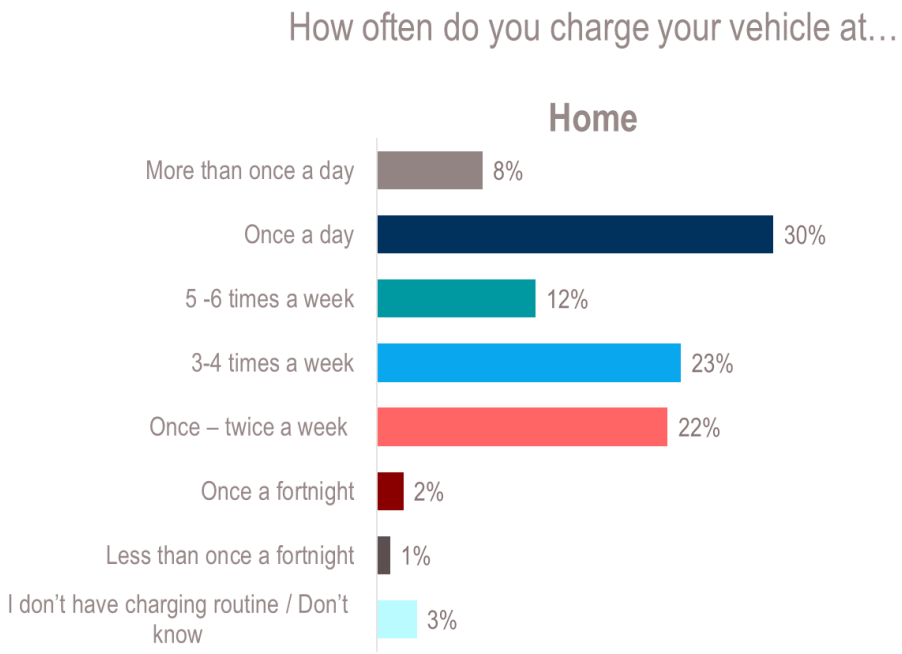


Participants who charge their EV's at other locations are less likely to have a standardised routine, except those who regularly charge their vehicles at work. This may indicate that there could be the risk of a 'morning charging peak' in business districts as EV ownership becomes more prevalent.

4.5 How frequently do you charge your EV?

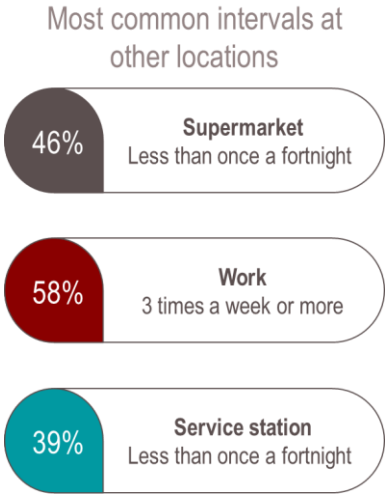
Participants were asked to indicate how frequently they charged their EV at home.

Figure 21: How frequently do you charge your EV? (470 participants)



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

Figure 22: Most common charging frequency at other locations (All (470), Supermarket (112), Work (114), Service (137))



Participants are more likely to use other charge point locations less frequently.

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. 6% of the participants who completed the survey were quite concerned and 2% were very concerned.

4.7 Summary

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 worth 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 Acceptability of the first demand management trial

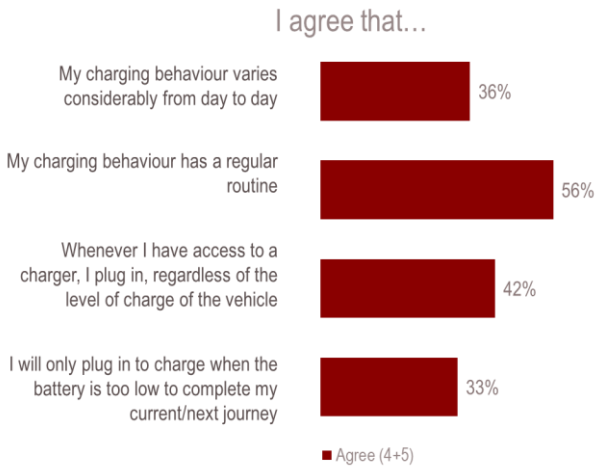
The first managed charging trial started in December 2017. The trial is fully explained in Section 6. Over two hundred participants were moved into demand management after they had experienced approximately 90 days of unrestrained charging. For comparison, other participants were moved straight into demand management after it had been ascertained that their charger was working correctly. This group would not have had the opportunity to experience and become accustomed to unrestrained charging. After a participant had been subject to demand management for around four weeks they were issued a survey by Impact Utilities. This survey is nearly identical to the Baseline survey issued to participants when they had completed 90 days of unconstrained charging. If a participant had completed the Recruitment and Baseline survey they are eligible for a £10 online vouched for completing this survey.

As with previous section of the report, this section 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.

5.1 Reported change in charging behaviour

Participants were asked about their charging behaviour. Comparison of their responses to the baseline data suggests that it has stayed relatively similar. The chart below shows a breakdown of the responses across the whole cohort and by vehicle type.

Figure 23: Reported charging behaviour by whole cohort and type of vehicle (260 survey responses)

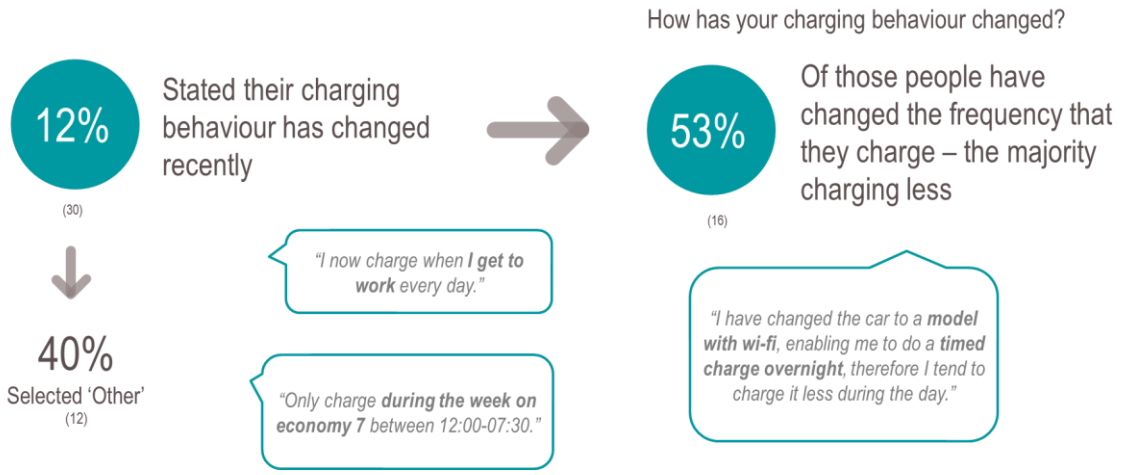


	Fuel Type		
	REX (37)	PHEV (96)	BEV (127)
My charging behaviour varies considerably from day to day	30%	29%	43%
My charging behaviour has a regular routine	51%	69%	47%
Whenever I have access to a charger, I plug in, regardless of the level of charge of the vehicle	43%	54%	31%
I will only plug in to charge when the battery is too low to complete my current/next journey	27%	31%	36%

The only noticeable change in behaviour is that 5% more participants report that they plug in their vehicle to charge regardless of its level of charge, increasing this answer to 42% of participants. The statistical significance of this change will be investigated when all trial 1 responses have been gathered.

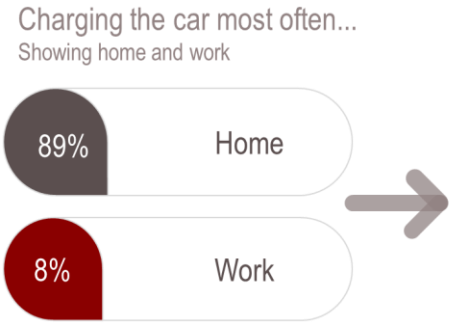
When asked if they have actively changed their charging behaviour, 12% (30 participants) of respondents stated that they had. The majority of these (53%, or 16 participants) stated they had changed the frequency of their charging, of which 10 people charged less.

Figure 24: Stated changed in charging behaviour (30 respondents out of 260 surveys)



Participants reported that they have not changed where they are likely to charge their vehicle. Charging at home is still the most popular location.

Figure 25: Where do participants charge their vehicle most frequently (based on 260 responses)



Charging car most often by Home vs. Work

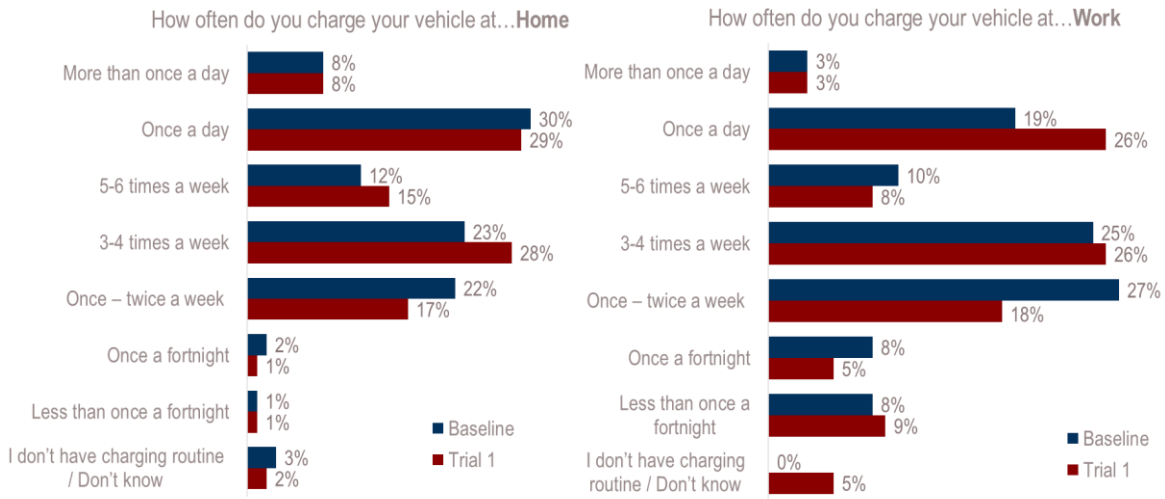
Battery Size				Fuel Type			Charger Type	
<10 kWh	10-25kWh	26-35 kWh	>35 kWh	PHEV	BEV	REX	GF	CC
95% (60)	95% (72)	88% (71)	73% (29)	96% (34)	83% (106)	92% (34)	90% (125)	88% (107)
3% (2)	3% (2)	11% (9)	18% (7)	3% (3)	11% (14)	8% (3)	6% (9)	9% (11)

Participants with larger batteries, or whose vehicles are BEVs are more likely to charge their vehicle at work than other participants.

5.2 Frequency of charging

Participants were asked how frequently they charged their vehicle at their favoured charging location. These responses were compared to the replies received in the baseline survey.

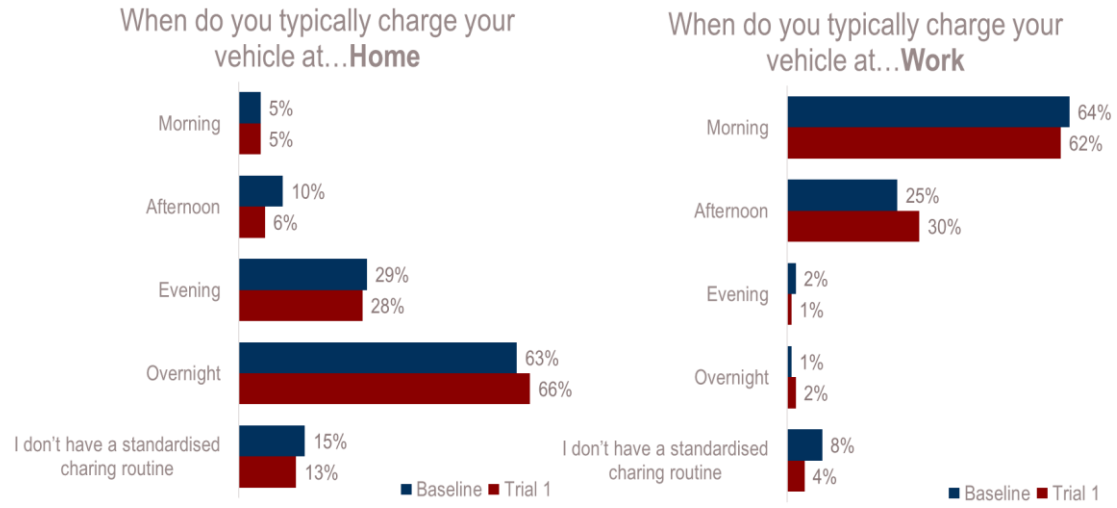
Figure 26: Reported frequency of vehicle charging (Home: 255, baseline 478, Work: 74, baseline 119)



Survey responses indicate that there may have been a slight shift during trial 1 to participants charging their vehicles more frequently at home and at work.

Participants were asked when they typically charge their vehicle, and this was also compared to the Baseline responses.

Figure 27: When participant typically charge their vehicles at their favoured location (Base: Home (256), Baseline Home (478), Work (74), Baseline Work (119))

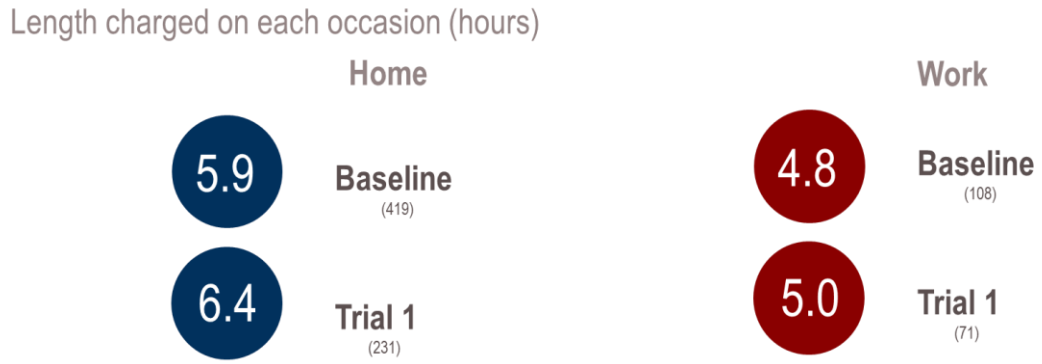


There have been limited changes to participant behaviour, the most noticeable being a slight increase in the number of participants charging their vehicles overnight. The statistical significance of these changes will be investigated when all trial 1 responses have been gathered.

5.3 Reported length of charge duration

Participants are asked about the length of time that they charge their vehicle for. Analysis will also be completed using transaction records from chargers – for example as presented in January 2018 version of this report.

Figure 28: Comparison of reported average length of charging (Base: Those who selected location (231))



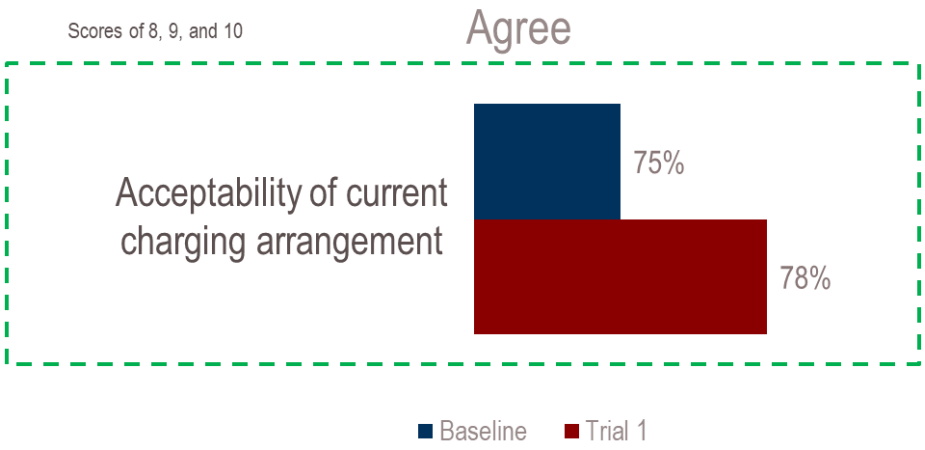
Category	Charger Type	
Trial 1	Green Flux	CrowdCharge
	6.9 (123)	5.8 (108)

There has been a slight increase in the average length of time that participants report that they charge their vehicle compared to the Baseline data.

5.4 Acceptability and satisfaction with charging agreements

Participants were asked whether the current charging agreements were acceptable, by providing a score between 1 and 10.

Figure 29: Acceptability of current charging arrangements (Base: All Trial (260), Baseline (470))

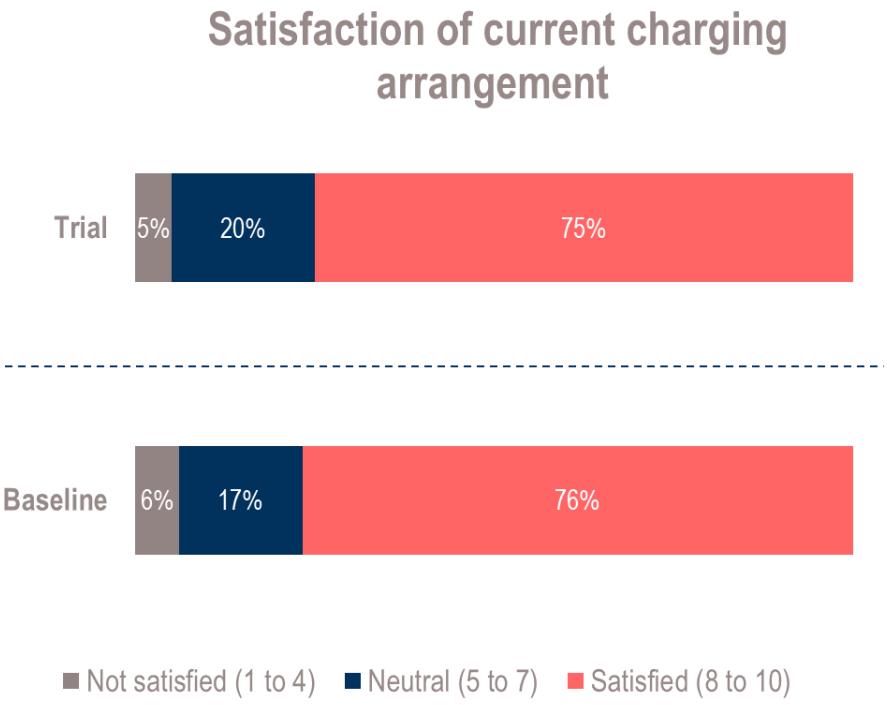


Participants with a battery size between 26-35kWh had a slightly higher than average acceptability rating at 84%, as did BEV owners who had an acceptability rating of 80%. Those

who own a small battery car of less than 10kWh have increased their acceptability score overall, with 4% fewer stating their currently arrangement is unacceptable.

The level of satisfaction with current charging arrangements has decreased slightly compared to the baseline survey, and more participants have expressed passivity toward the arrangements.

Figure 30: Levels of satisfaction with charging arrangements (Base: All Trial (470), Baseline (260), REX (37), PHEV (96), BEV (127))



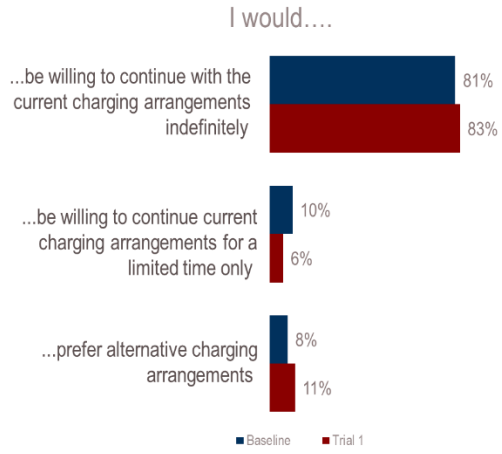
Drivers with BEV vehicles in the CrowdCharge cohort scored a significantly higher level of acceptability than average (85%). This compared to a 75% satisfaction level for BEV drivers in the Greenflux cohort. PHEV drivers in the CrowdCharge cohort were less satisfied than those in the Greenflux cohort (71% compared to 78%). The reason for these differences will be investigated further.

Participants with a battery size higher than 35kWh had a lower level of satisfaction rating (68%) than the general trial population. Further analysis of this participant subsection suggested that they were more likely to be range anxious. 60% of the larger battery group said that they decide when to recharge based on miles left, compare to 43% for all respondents and over one thirds of the larger battery group look to recharge when they have 100 miles or below. This is much higher than the 12% for all respondents. Only 8% of the larger battery group would wait until 20 miles or below, compared to 52% for all respondents. Although all car owners are more likely to charge at home, the majority of the larger battery group also charge at a service/petrol station (68% vs. 33% for all respondents). As a result, they are the least likely to say that they most often charge at home (73% vs. 89% for all respondents). When they do charge at home they charge for the longest length of time (9 hours on average) – this length of time is unsurprising given their

battery size. Further investigation will be carried out to determine any possible causes of this anxiety, especially investigating their driving patterns and energy consumed in home charging (as a proxy for miles driven) compared to other participants.

There has been a slight increase in the percentage of participants willing to continue with demand management indefinitely, however on the whole sentiment remains very similar to the Baseline survey. There are no significant differences. Despite the anxiety amongst drivers will larger than 35kWh batteries identified above 80% of this group (compared to a similar 83% for all respondents) say they are willing to stay on this charging arrangement indefinitely so the overall acceptance of this subsection remains high.

Figure 31: Willingness to continue with current charging arrangements (Base: All Trial (260), Baseline (470))



There are slight variations in **trial** charging behaviour between charger types and fuel types

Charger Type		Fuel Type		
Green Flux (139)	Crowd Charge (121)	PHEV (96)	BEV (127)	REX (37)
86%	79%	79%	87%	78%
6%	7%	6%	4%	14%
8%	14%	15%	9%	8%

Twenty-eight respondents provided reasons for their stated preference for alternative charging arrangements. These can be grouped into three categories:

1. Charger issues with the communications system or other technical issues with their smart charger[5]:

> *"Your demand control leaves me with a low battery at times and I end up using battery capacity instead of mains power when trying to pre-heat the car on a morning."*

2. Many wanted more readily available charging facilities at work/supermarket/petrol station
3. Difficulty managing the physicality of the actual charger and it not being suitable for their needs:

> *"I'd prefer an induction charger at home and at service-stations. I'm a disabled driver it's not that easy to connect and stow a charging cable."*

[5] This category consists mainly of participants who are having technical issues with their charger but also some who are adjusting to demand management

"The charging point is too far from the vehicle, so the cable is fully stretched and very difficult to fit."

Participants were asked whether they were concerned about having their charging managed as part of the trial.

Participants with a battery size greater than 35kWh were statistically more concerned than average in the trial (28% combining 'quite' and 'very' concerned). 60% of the Crowd Charge cohort were 'not at all concerned' about having their charger managed compared to 47% of Greenflux

To conclude, participants have expressed a very slight increase of acceptability of charging arrangements compared to those expressed in the Baseline survey, but a slight move toward passivity in their satisfaction ranking of charge arrangements. The vast majority of participants have very few concerns about having their charge managed. Average reported charge duration has increased slightly for some participants. There are some interesting differences in satisfaction and acceptance amongst different subsections of participants that will be investigated further.

The analysis presented here is interim and could alter as more trial survey results are collected.

6 Trial Design and Update on Demand Management Roll-Out

6.1 Introduction

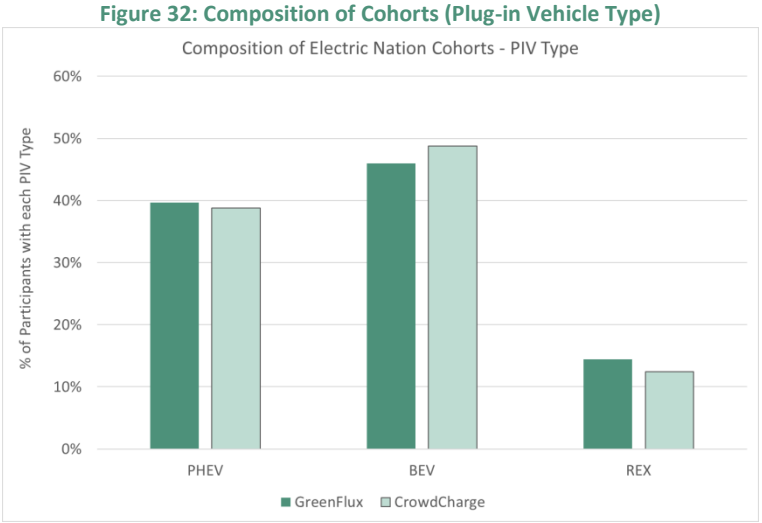
A core part of the Electric Nation project is a large trial of smart charging (demand management) which will encompass all project participants (where reliable communications are established). The aim of this trial is to evaluate the reliability and acceptability to EV owners of a smart charging system 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 reports (published in November 2017 and January 2018). It also reports on the progress with moving all the trial participants into routine demand management.

6.2 Electric Nation Cohorts – GreenFlux and CrowdCharge

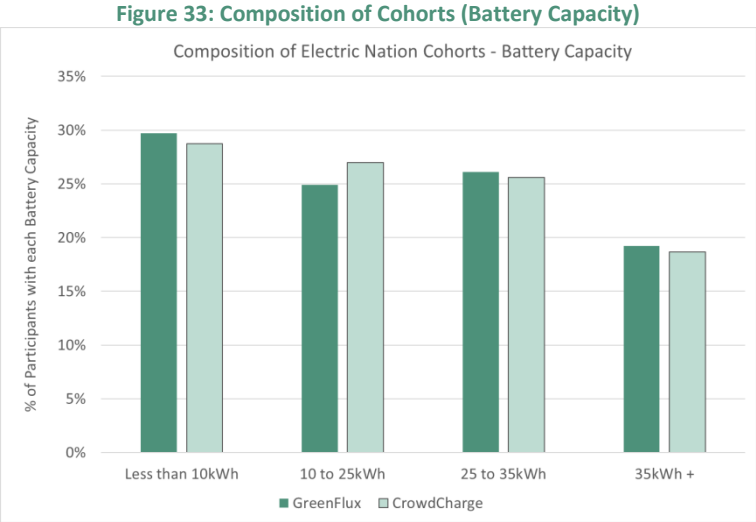
Two demand management providers are being used within Electric Nation, GreenFlux[6] and CrowdCharge[7]. Trial participants are allocated to each group during the recruitment process. Each company uses different algorithms to allocate current to individual chargers. Testing of the first algorithms to be used was reported in the 'Algorithm Development and Testing' Report[8], Section 7 of this report contains details of the next algorithms. 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 32 and Figure 33, based on all chargers installed up to 3rd April 2018.

Figure 32: Composition of Cohorts (Plug-in Vehicle Type)



[6] https://www.greenflux.nl/en/
[7] http://crowd-charge.com/
[8] https://www.westernpower.co.uk/docs/Innovation/Current-projects/CarConnect/CarConnect-Algorithm-Development-and-Testing.aspx

Figure 33: Composition of Cohorts (Battery Capacity)

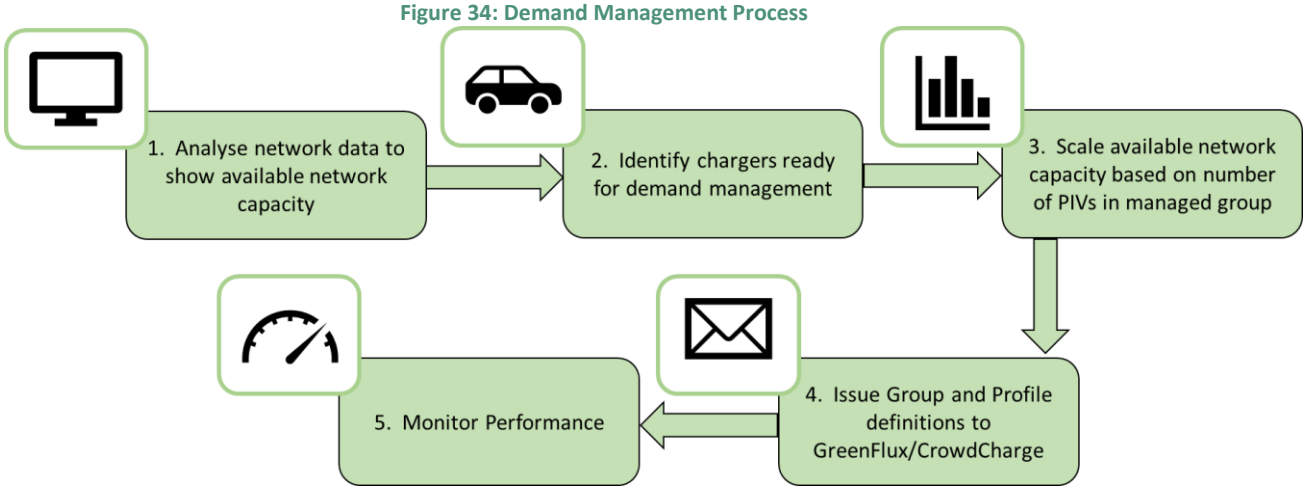


These indicate that the two groups are well balanced. The composition remains broadly similar to that presented in the January 2018 trial update report, which indicated that the Electric Nation trial group has a greater representation of BEVs with larger battery sizes than current UK vehicle sales. However, 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.

6.3 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 34: Demand Management Process



Further details of each of these stages were given in the October 2017 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 was the most restrictive profile used to date, due to higher levels of background loading (i.e. less 'spare' capacity for EV charging). The winter profile was generated based on real network loading data for an HV feeder in the East Midlands, with profiles set to be equivalent to the level of curtailment that would be required when 30% of passenger cars are plug-in vehicles. This has led to regular curtailment of customers in the peak periods. Spring profiles were implemented from w/c 9th April onwards. The use of these profiles will be monitored to ensure a degree of demand management still occurs.
- **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 134 participants are now in routine management. Further details of this are provided in Section 6.4 below.
- **Scale available network capacity based on number of PIVs in the managed group:** a scaling factor continues to be applied to account for communications reliability in the managed group. This is adjusted each time the group is expanded based on current performance.
- **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 6.5.

6.4 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.

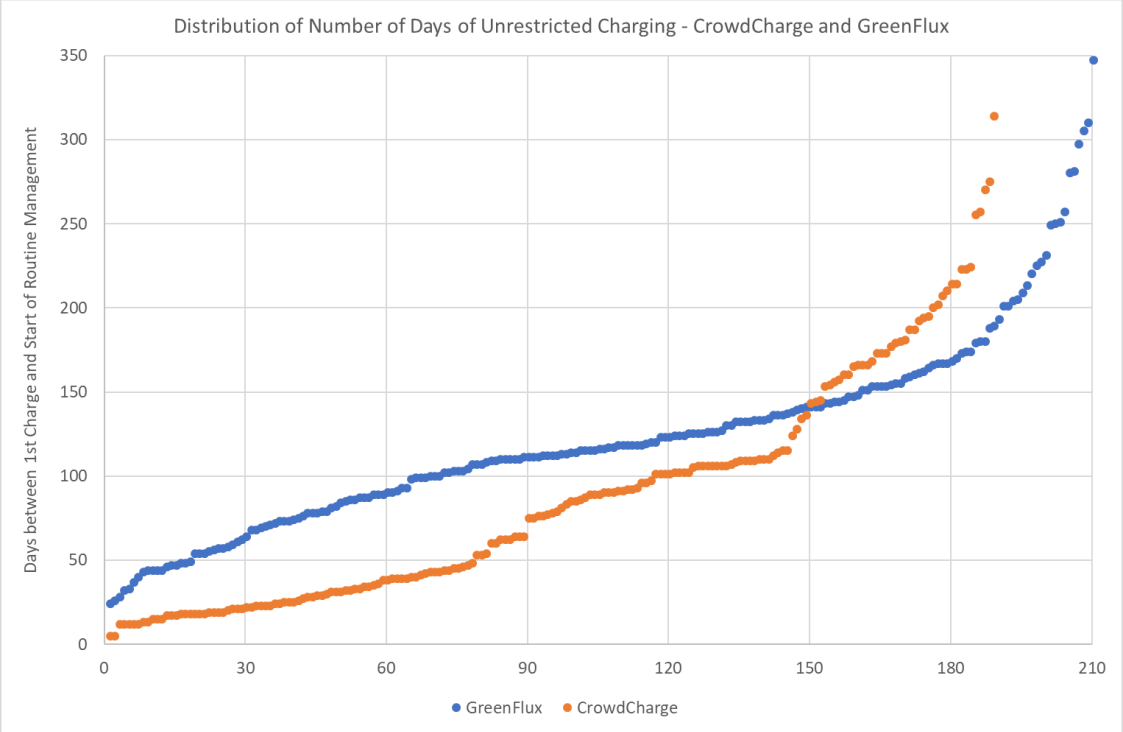
As part of the first year of the trial there was an intention to compare the acceptability of smart charging between two groups of customers, 'Charge at Will' and 'Straight into Management', originally defined as:

- Charge at Will: allowed unrestricted charging for approximately 90 days before demand management is imposed.
- Straight into Management: once the charger is in use approximately two to four weeks is permitted to prove the reliability of the communications from the charger, during which time they are effectively 'charge at will', then the charger enters the managed group.

The first 100 chargers for both CrowdCharge and GreenFlux were assigned to the 'Charge at Will' group and were not considered for routine management until 90 had elapsed from

their first charge event. All subsequent installations were allocated to the 'Straight into Management' group. However, in many cases delays were experienced establishing reliable communications to these chargers, resulting in an extended period before they could be moved into routine management. This applied particularly to the batch of Alfen/GreenFlux chargers installed from August onwards (serial numbers 216 – 317) due to a configuration error in the Alfen factory. The resulting time between the first charge event and entering routine management is shown on the graph below.

Figure 35: Distribution of Number of Days of Unrestricted Charging



In the absence of other delays this distribution would be significantly different, with a cluster of points for both management providers at the extreme ends of the x-axis.

Applying a threshold for 'straight into management' of six weeks (as suggested by Impact Utilities) results in 67 and 7 'straight into management' participants for CrowdCharge and GreenFlux respectively.

The CrowdCharge figure is currently slightly under the threshold required for statistical significance (75), but it is likely that this will be reached by the remaining installations.

This will not be possible for the GreenFlux installations, as the number of remaining installations is insufficient to make the 75 straight into management target for statistical significance.

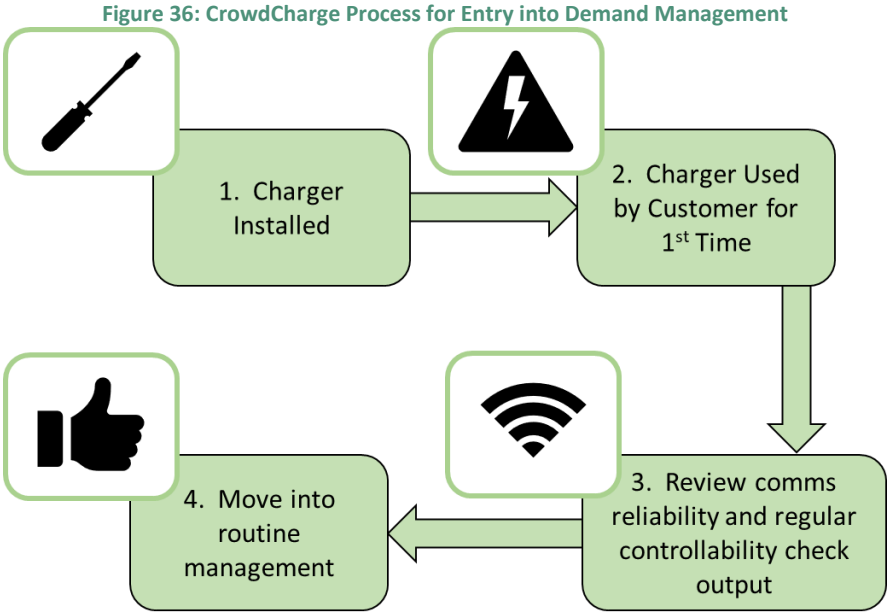
This means that comparison of "charge at will" with "straight in to management" will only be possible with the CrowdCharge cohort. While disappointing not being able to compare and contrast with the Greenflux cohort, this is not a major problem and an analysis of the differences, if any, in satisfaction between these two important groups will be possible later

in 2018. The way in which this will affect the analysis of the trial survey data will be discussed and agreed with Impact Utilities.

6.4.1 CrowdCharge

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

Figure 36: CrowdCharge Process for Entry into Demand Management



The number of chargers at each stage is shown in the following table. The 'route' to demand management is excluded, as this can only be accurately assigned once a customer has moved into routine management.

Stage	Number Passed Stage	Notes
1. Charger installed	296 (based on information until end w/c 9th April)	
2. Charger used by participant for 1st time	272 of 289 (last reviewed 16th April)	A transaction record is not currently available for the remaining 24 chargers. 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 eight of the 'unused' chargers, as they have a communications reliability approaching 100%.
3. Review communications	206 of 272 'used' chargers	66 chargers have been used but cannot be transferred into routine management

reliability and controllability		• 27 either have no communication to any part of the CrowdCharge system, or the reliability of this is poor. • 17 are only communicating with part of the CrowdCharge system. This prevents a controllability check taking place. • 13 are recently installations and appear to have reliable communications with all parts of the CrowdCharge system. These are likely to move into routine management in the coming weeks. • 9 have previously had unreliable communications with CrowdCharge but are improving and should be transferred to routine management in the coming weeks.
4. Move into routine management	206	206 chargers have moved into routine management, and this will continue to expand as other charge points moved through the preceding stages.

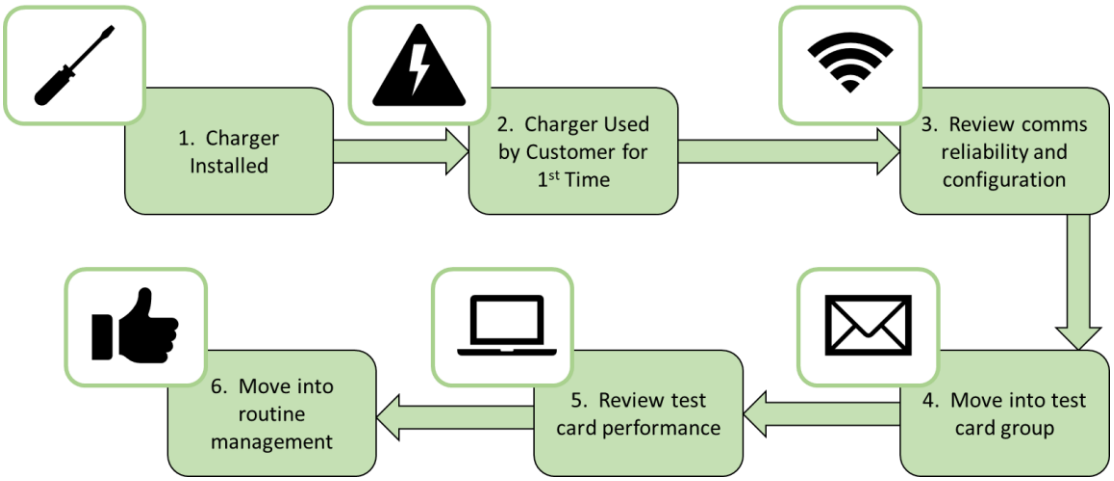
Table 5: Roll-Out of Demand Management to CrowdCharge Participants

Two forms of communications failures remain the dominant reason for delays entering routine management. This is either due to unreliable communications between the charger and all of the CrowdCharge system, or a specific configuration error which results in some chargers not communicating with part of the back office. Chargers which are not communicating with all parts of the system cannot be controlled and so cannot move into routine management. An audit has recently taken place to identify chargers which are not communicating with the entire system and these units have been referred to CrowdCharge for further investigation. The Tech Factory will continue to visit chargers with unreliable communications until the end of May, with the aim to bring as many chargers are possible into routine management.

6.4.2 GreenFlux

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

Figure 37: 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	332 (based on information until end w/c 9th April)	
2. Charger used by participant for 1st time	311 of 332 (last reviewed 19th April).	Of the 21 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.
3. Review communications reliability and configuration	275 (of 311 which have been used)	275 chargers have passed a review of their communications performance and configuration. Of the remaining 36 chargers (i.e. those that have been used but are not yet ready for the test card phase): • 34 have not yet passed a check of their communications performance. Four of these may pass this stage if they remaining online throughout Week 16. • 1 is awaiting a configuration update when it is next online • 1 participant has left the project
4. Move into test card	267	267 chargers have entered the test card phase since early July 2017. Eight will be transferred to the test card phase early in w/c 23rd April.
5. Review test card performance	249 passed of 267 reviewed	The causes for failure or a delay at the test card phase are: • Lack of transactions in test card phase (10 of 18): successful transactions are required to pass this phase. Where a participant uses their charger infrequently the test card phase may last longer. • Charger offline (3 of 18): this prevents meter values being sent to the online portal, therefore the test card performance cannot be evaluated. • Failure at test card phase due to BMW issue (2 of 18) • Unusual behaviour in test card phase (1 of 18): these cases are referred to GreenFlux and/or Alfen for investigation before customers move into routine management. • Prior use of a timer (1 of 18): 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 18): this participant no longer owns an EV.
6. Move into routine management	249 chargers	249 chargers have moved into routine management. To date, 12 of these participants have either left the project (one participant) or have had to be removed from smart charging. Of the 11, 5 drive a BMW 330e and a further 4 drive other BMW models. There is a known issue affecting some BMW vehicles under smart charging, which is under investigation on the test system at the time of writing.

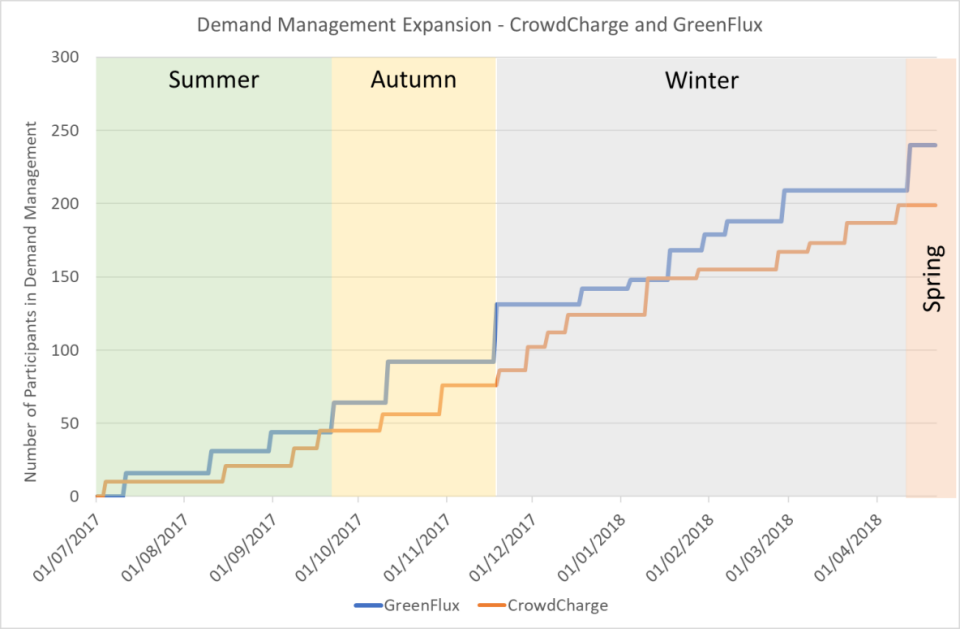
Table 6: Roll-Out of Demand Management to GreenFlux Participants

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 54 chargers are delayed at various stages due to a communications problem (although this figure is substantially reduced from the previous report). Alfen have engaged Siemens to carry out site visits to these units to ensure they are updated to the latest firmware version and brought online if at all possible.

6.5 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. These group expansions are shown by the steps on the graph below.

Figure 38: Demand Management Expansion over Time - with Seasons



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 was applied in mid-April. Winter profiles were in operation during the periods of particularly cold weather in late February/early March. Charging behaviour (e.g. frequency and timing of charging, energy consumed vs. battery capacity etc.) will be analysed and published later in the trial, including examining seasonal effects.

6.5.1 Occurrence of Demand Management at a Group Level

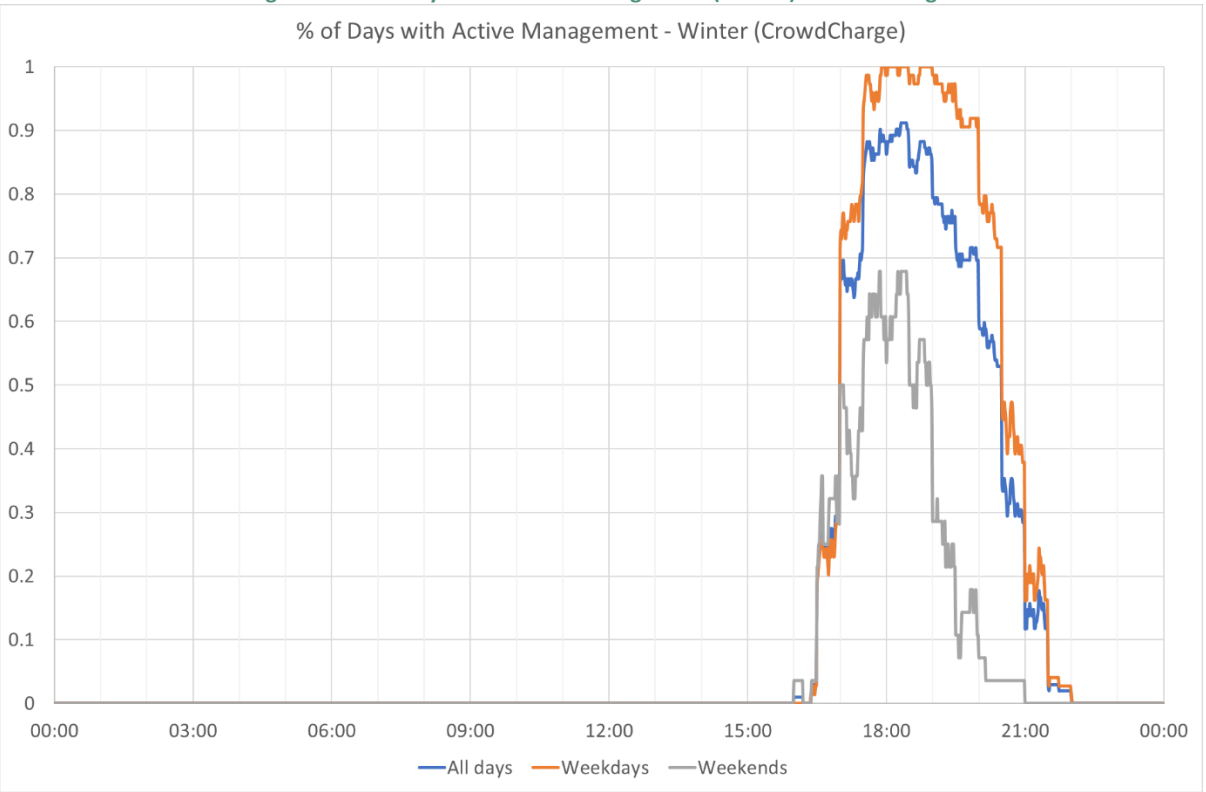
The level of demand management which occurs is a function of the demand limit profile and the charging diversity of the managed group. As increasing numbers of participants in the group plug-in at the same time then it becomes more likely that demand management will occur. Management (curtailment of available current from chargers) also becomes increasingly likely as the seasons change through the year, as the 'spare' network capacity available for EV charging decreases due to increases in other loads. The current allocated to a group of chargers can be compared to the limit which applies to the group to show whether management (curtailment) was active **at a group level.** The effect of this curtailment on individual chargers requires a secondary level of analysis and this is presented below and in Appendix 6. This sub-section shows the level of management which has occurred for CrowdCharge and GreenFlux over the winter period (mid-November to early April).

6.5.2 CrowdCharge Group Level Management

CrowdCharge begins to curtail the current available from active chargers when there is insufficient capacity available to allocate all active stations at 32A. For example, if the group limit is 300A then no management occurs with nine active chargers, but curtailment will apply once a 10th charger becomes active.

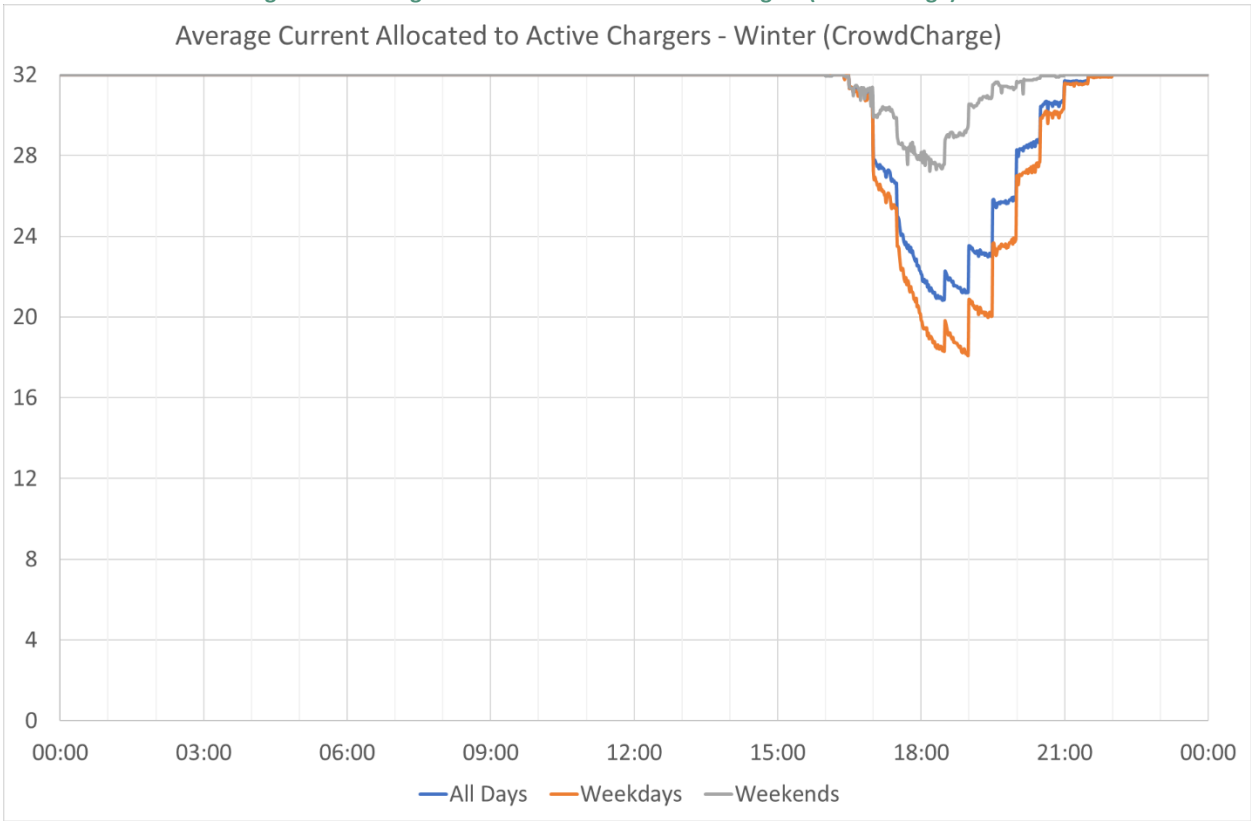
The graph below shows the % of days (all days, weekdays and weekends) over the winter period for which management has been active, by time of day.

Figure 39: % of Days with Active Management (Winter) - CrowdCharge



As expected this shows that management has only been required over the evening peak period, based on the capacity of existing demand used by the project. Management is considerably more likely on weekdays, with periods of curtailment tending to last further into the evening. The level of curtailment required is shown below, both as an average value and minimum and maximum current available.

Figure 40: Average Current Allocated to Active Chargers (CrowdCharge)



This indicates that the management required on weekend days is generally less severe than weekdays, as well as being active for a shorter duration. The minimum and maximum current allocated on weekdays and weekends are shown below.

Figure 41: Min and Max Current Available in Winter (Weekdays)

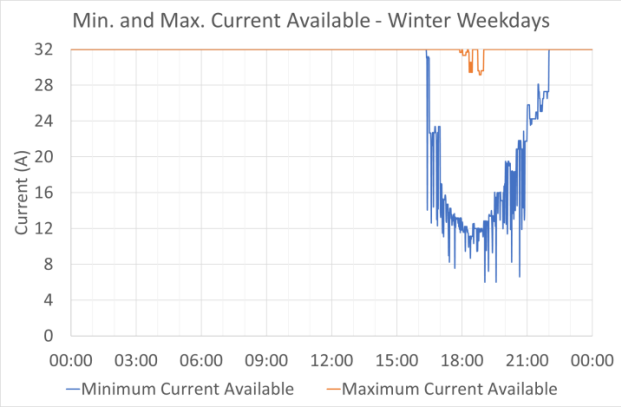
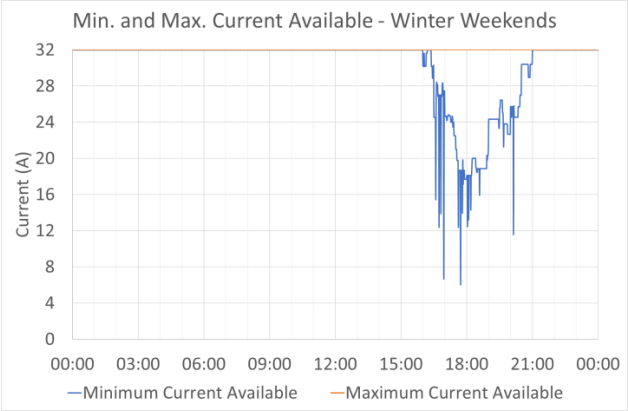


Figure 42: Min and Max Current Available in Winter (Weekends)

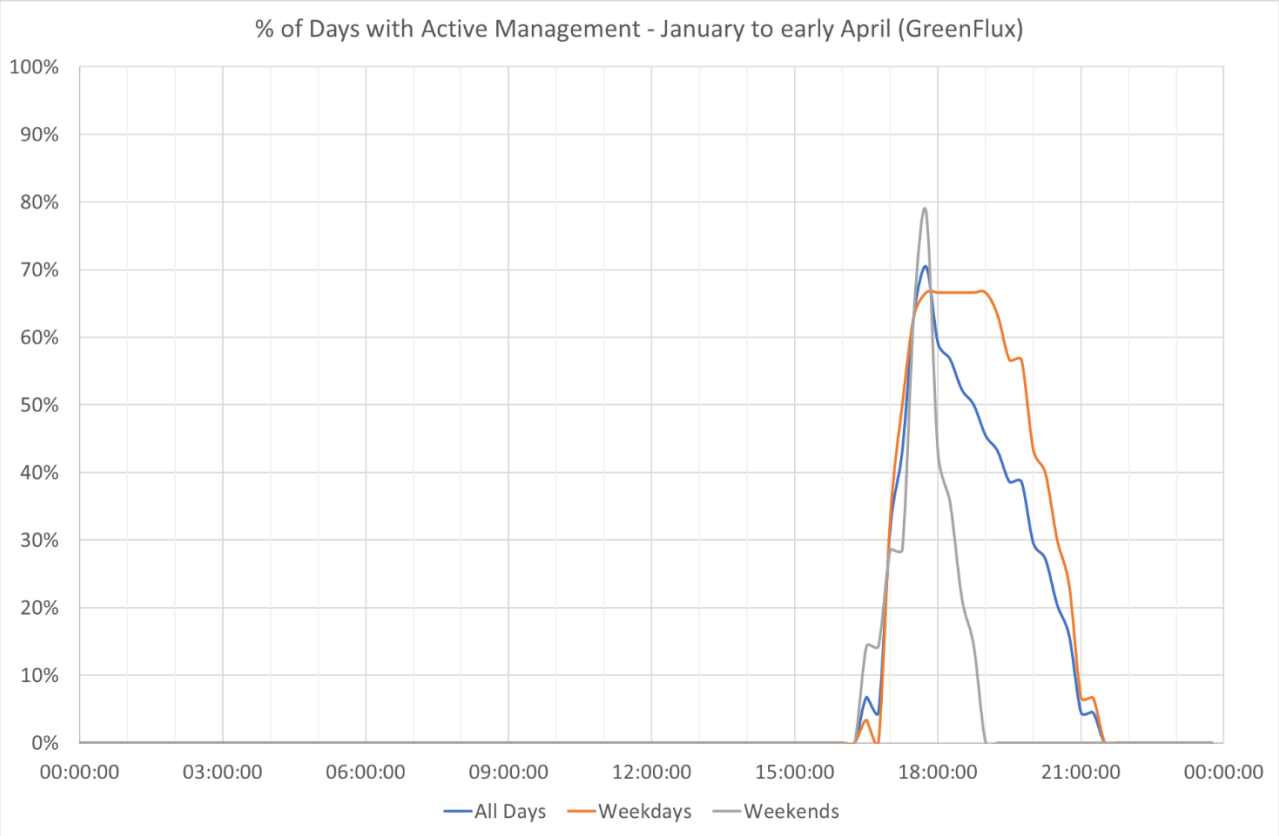


This shows on some weekdays for a considerable period of the evening peak both 32A and 16A rated vehicles would have been affected by demand management on some days. The impact on 16A vehicles on weekend days is much lower. The impact of these group level events on individual transactions is explored in more detail in Section 6.6.1.

6.5.3 GreenFlux Group Level Management

The graph below shows the % of days when group level management has occurred for the GreenFlux cohort, again split by all days, weekdays and weekends.

Figure 43: % of Days with Active Management (GreenFlux)



The timing of management events are similar to the CrowdCharge cohort – only occurring in the evening peak period. In common with CrowdCharge weekend events tend to be much shorter. Management occurs less frequently in the GreenFlux group, probably as a result of a more efficient distribution of available current amongst active chargers. This is due to a distinction being made between 32A and 16A vehicles at the start of each charge cycle.

6.6 Occurrence of Demand Management for Individual Charging Events

The graphs above indicate the periods when a group of chargers was subject to some curtailment. However, it is easy to imagine scenarios where this management event did not actually impact the charging of an individual car, for example:

- During the most restrictive part of the event all chargers in a group were limited to 20A. However, a PHEV was charging at a nominal rate of 16A.
- The restriction began at 17:30 and was over by 20:30. A vehicle was plugged in at 17:00 but was using a timer so did not charge until 23:30.

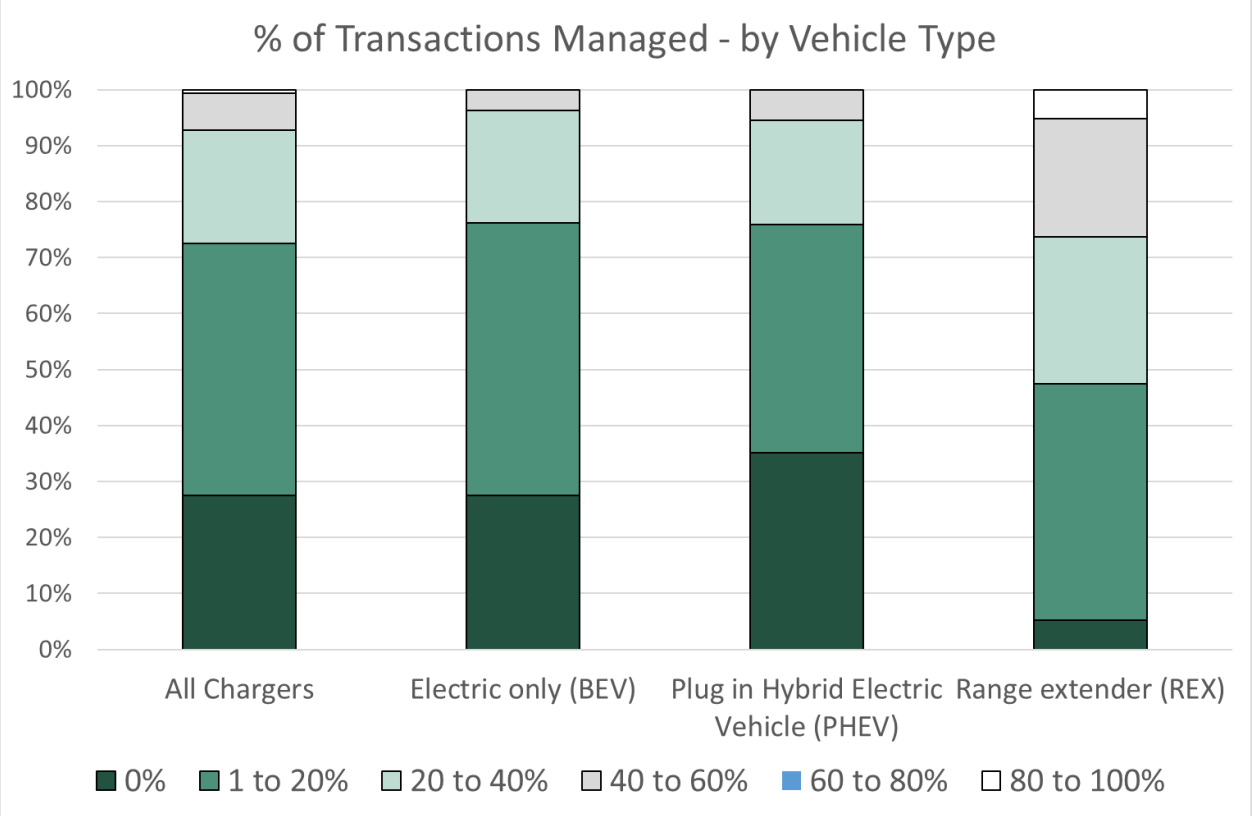
Further logic is therefore required to identify whether any individual charger was affected by a group level management event. Appendix 6 describes this logic in detail for both CrowdCharge and GreenFlux.

This methodology has been applied to CrowdCharge transactions which have occurred between mid-November 2017 and the end of February 2018. This may be further refined during the course of the project and re-applied to the data received from CrowdCharge. It will also be applied to the autumn and summer periods and the remaining part of winter. Finalised data will be published in the project outputs. Work on the database is ongoing at the time of writing to apply the necessary logic to the GreenFlux data.

6.6.1 CrowdCharge – Management of Individual Chargers

The logic used to identify management of individual transactions is set out in detail in Appendix 6. This has been applied to the period from 20th November to 26th February inclusive (99 days) and includes 6,407 transactions (all transactions where energy consumed is greater than 0.5kWh) from 153 individual chargers. 111 of these chargers have experienced management at least once (73%). The graph below shows the distribution of the degree of management experienced by each charger ID.

Figure 44: % of Transactions Managed - by Vehicle Type

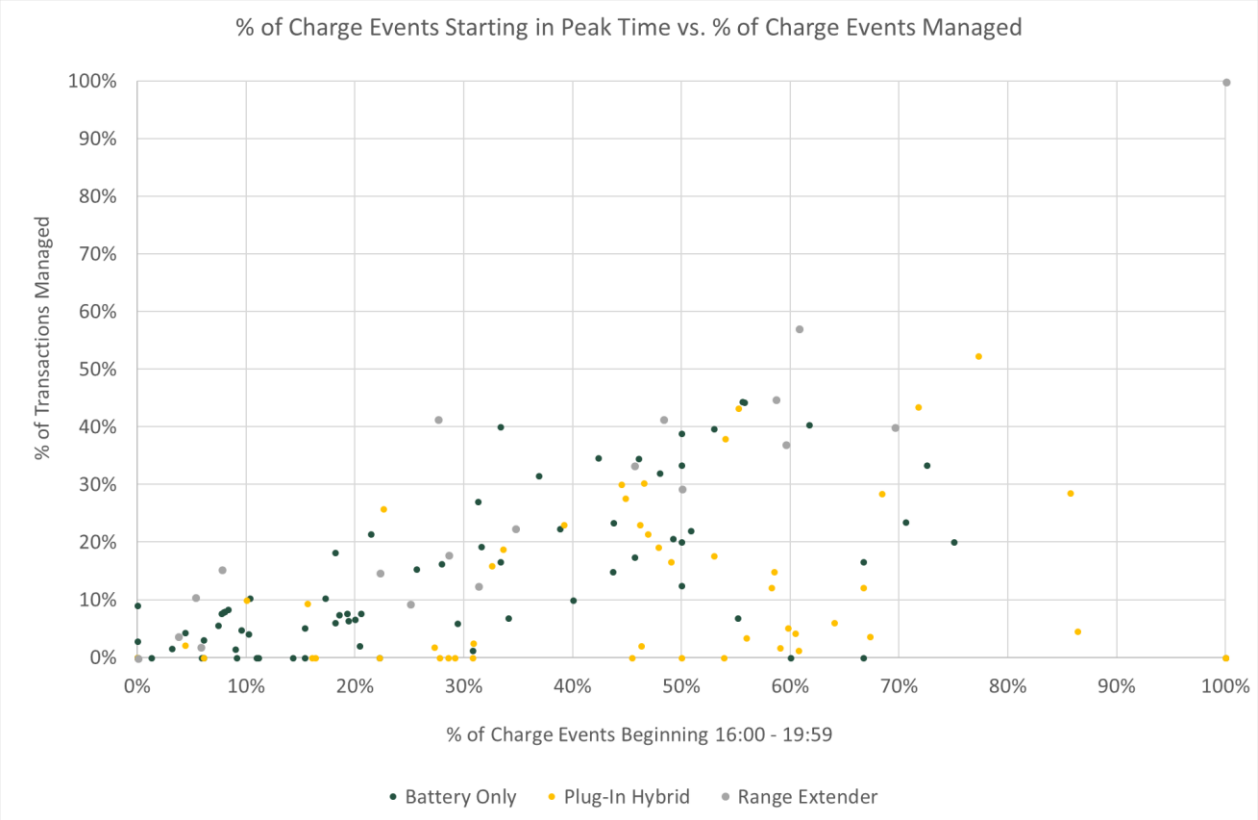


The graph above is based on sample containing 80 BEV, 52 PHEV and 19 REX vehicles. This shows that for the majority of chargers (approximately 70%) less than 20% of their transactions during the November – February period were managed, whilst still ensuring that the capacity limits (set based on existing demand profiles) were not breached. The distribution is not significantly affected by the distinction between battery only and plug-in hybrid vehicles. Once the degree of management of curtailment is included it is expected that battery only vehicles (generally rated at 7kW) will have been curtailed for longer, based

on the average current available shown in Figure 40. Range extenders appear to have experienced management more frequently. The only factors affecting whether or not an individual charging session is managed are: whether the time of charging overlaps with group level management events, and whether the nominal current drawn is greater than the amount of current available. Further details are given in Appendix 6. Based on these factors there is no clear reason for a higher frequency of management events for REX vehicles as distinct from other 7kW PIVs. This will be investigated further – e.g. looking for any differences in the timing of charging between different vehicle types.

The graph below compares the percentage of charge events which began in the evening peak period (16:00 to 19:59) with the percentage which were managed, for each of the 153 charge points, split by plug-in vehicle type.

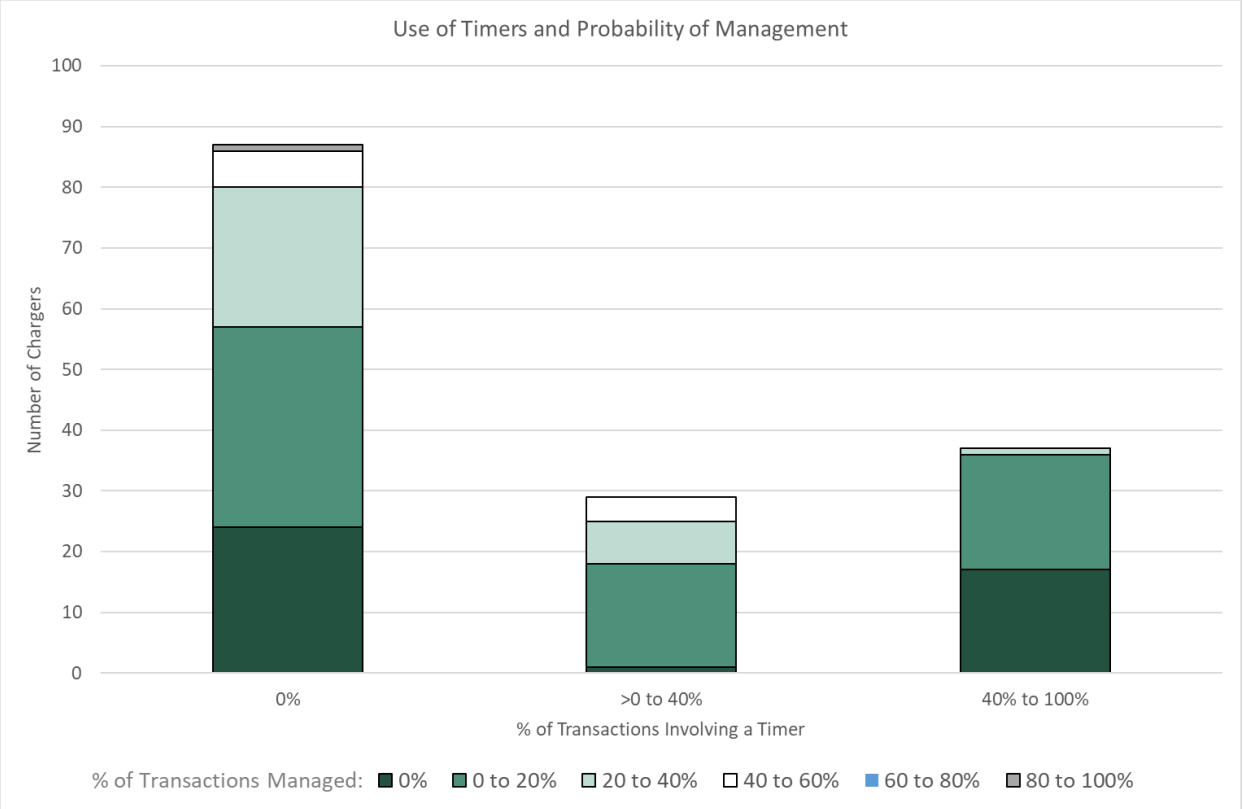
Figure 45: % of Charge Events Starting in Peak Time vs. % Managed



The general trend observed here is to be expected – with participants who begin charging in the peak period more frequently experiencing more regular management. There is some spread in the data, with a slight trend towards BEV and REX vehicles which begin charging in the peak time experiencing more regular management than plug-in hybrids. Use of timers to schedule vehicle charging may also affect the probability of being managed – for example, a participant who is on an Economy 7 tariff and always charges their vehicle in the off-peak period (typically around 00:00 – 7:00) would not be managed according to Figure 39.

The graph below shows the number of chargers who have used a timer for varying percentages of their transactions – e.g. 87 participants did not use a timer during the period analysed. 24 of these also never experienced any demand management.

Figure 46: Use of Timers and Probability of Management



These results are also shown in table below, using the % of the total in each category (rather than the raw numbers as shown above).

% of Transactions Involving a Timer	% of Transactions Managed						
	0% (all transactions un-managed)	Greater than 0, less than 20%	20 – 40%	40 – 60%	60 – 80%	80 to 100%	Total
0%	28%	38%	26%	7%	0%	1%	100% (87 chargers)
Greater than 0%, less than 40%	3%	59%	24%	14%	0%	0%	100% (29 chargers)
40% to 100%	46%	51%	3%	0%	0%	0%	100% (37 chargers)

Table 7: % of Transactions Managed for CrowdCharge Participants, by Use of Timers

When comparing the two groups at the extreme ends of timer use (0% and 40 to 100%) a greater percentage of the customers who regularly use a timer experienced no

management during the period analysed. Those who use a timer less frequently are more likely to have experienced more management (e.g. 26% of participants who never use a timer have had 20 to 40% of their transactions managed, vs. 3% of those who use a timer 40 to 100% of the time.

The figures above are based on a provisional analysis of whether transactions are managed. This methodology may be refined further and will be applied to a wider time period. It will also be expanded to quantify the extent of management. This is likely to show further trends – e.g. less curtailment of plug-in hybrids (16A vehicles) vs. battery only vehicles.

7 Algorithm Iteration 2 – Development, Testing and Roll-Out to Customers

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, as far as possible. Alongside this activity participants who are under routine management will experience different levels of demand management as the year progresses.

From July 2017 all participants in routine management have been subject to the first algorithm iteration[10]. This was tested in Q1 2017 and results were reported in the Algorithm Development and Testing Report[11]. Relatively simple algorithms have been used by both CrowdCharge and GreenFlux to share the available current between active chargers. Participants do not have a way to interact with the first iteration of either algorithm to influence the current allocated to their vehicle. The majority of participants who have experienced this type of management have been surveyed to assess the customer acceptability of this type of system and results are reported in Section 5 of this report.

The 2nd iteration will add in elements of customer interaction for both GreenFlux and CrowdCharge. This section describes the updated version of the algorithm, testing completed and progress with rolling out the updated algorithm to customers.

7.1 CrowdCharge

The 2nd iteration of the CrowdCharge algorithm aims to estimate the energy requirements of vehicles in order to prioritise them when constraints become necessary. The timeline of the testing completed to date is described below:

- Late December 2017 – February 2018: Initial version of the algorithm tested using two vehicles, according to test plan provided by CrowdCharge. A series of observations regarding the behaviour of the algorithm were fed back to CrowdCharge as a result of this testing; observations that required further development of the algorithm by the CrowdCharge team.
- March 2018 – mid April 2018: the algorithm was updated based on the feedback from the first round of testing. The algorithm used in both the first and second rounds of testing made use of journey planning and estimates of vehicle state of charge in order to determine the energy requirements for each vehicle, including a departure time, in order to prioritise chargers. In the second round of testing EA Technology devised a series of two and three car tests in order to confirm the correct prioritisation of vehicles and behaviour under scenarios such as loss of comms and use of timers.

[10] One minor revision was implemented by GreenFlux to resolve an unforeseen issue which affected customers using timers. Customers who were affected by this issue have been highlighted to Impact Utilities.
[11] Available from: https://www.westernpower.co.uk/docs/Innovation/Current-projects/CarConnect/CarConnect-Algorithm-Development-and-Testing.aspx Accessed April 2018.

Regular use of the journey planning app by EA Technology during the second round of testing, and further reflection from CrowdCharge, has resulted in the decision to simplify the interface to be deployed to customers with algorithm 2. This simplified interface is still under consideration at the time of writing but will exclude the journey planning element, instead focussing on an input of state of charge and mileage required in next journey. By implementing a simpler interface, the likely level of customer engagement may increase, allowing for greater prioritisation than in a case where the majority of customers do not provide information. A more complex interface could be deployed as part of algorithm 3.

The next steps in order to roll-out algorithm 2 to the field are:

- Confirmation of design to be used and implementation on the test system – scheduled for w/c 23rd April 2018 to 4th May.
- Basic testing including input of information via mobile devices w/c 7th May.
- Identification of a pilot group and testing of algorithm 2 with this group – w/c 14th May.
- Receipt of feedback from the pilot group and then a decision regarding rolling out to the whole population.

7.2 GreenFlux

The 2nd algorithm iteration introduces a customer app. 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, or where a vehicle is on a timer and not yet actively charging). Therefore, if all active sessions choose to enact the request for high priority, all chargers will have the same priority and will be treated equally.

Since the previous Customer Research and Trial Update Report (January 2018) work has focussed on:

- Testing of the app using the Electric Nation test rig at Capenhurst.
- Updates to the app interface by GreenFlux and release to app stores for Android and iOS phones.
- Preparation of instructions and FAQ information.
- Roll-out to participants including a 'pilot' group.

7.2.1 Testing of App

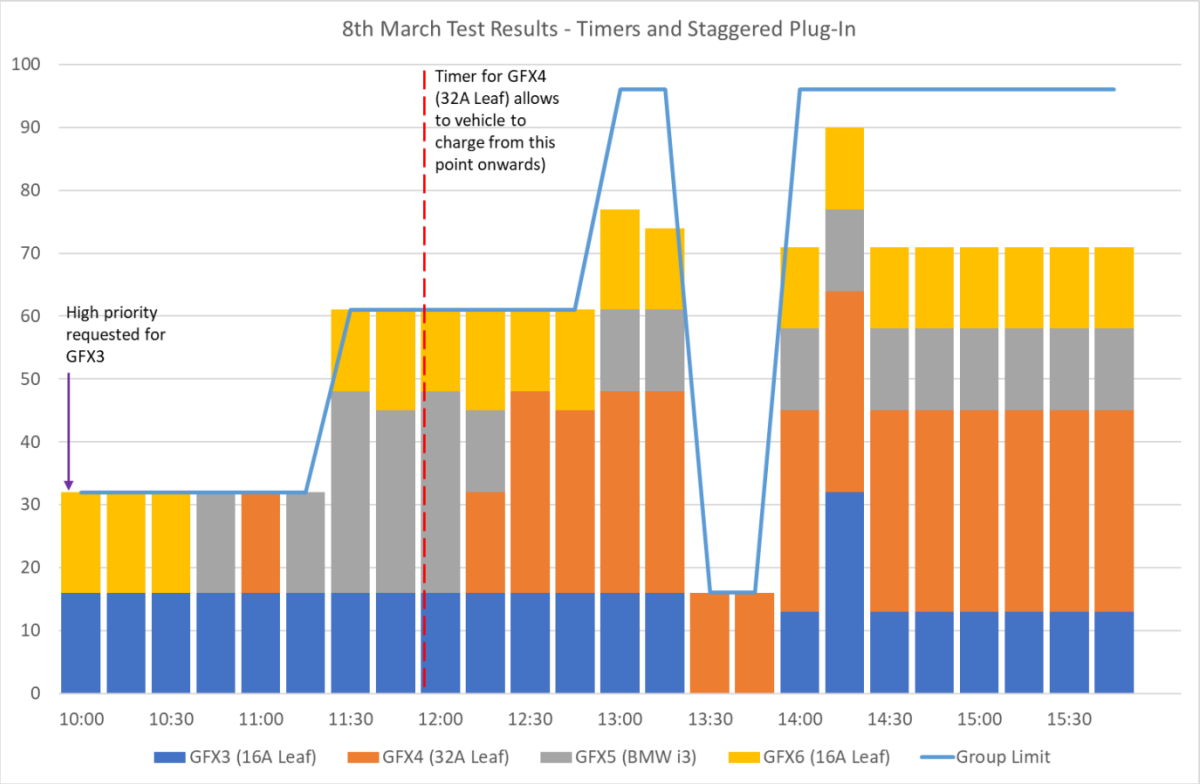
Results from a simple test were presented in the January 2018 version of this report. In the last quarter more complex tests have been undertaken including:

- Confirming that high priority is lost when a vehicle unplugs.
- Behaviour as a result of loss of communications, both on chargers where high priority has been requested and elsewhere in the group.
- Vehicle on a timer requests high priority.
- Staggered plug-in of vehicles and use of high priority button.

These tests were completed successfully. It was proven that where a vehicle on a timer requests high priority this is not enacted (unless the vehicle begins charging shortly after plugging in). This is expected behaviour and has been communicated within the instructions for the app. Customers who use timers are less likely to be affected by demand management and therefore shouldn't need to use the high priority button.

An example result is shown below.

Figure 47: GreenFlux 2nd Algorithm Example Test Result – 8th March



The test progressed as follows:

- GFX3 (blue fill) – high priority request was successfully enacted. It was allocated 16A until 13:30, when the current being drawn had declined (battery full).
- GFX4 (orange fill). Current was made available when this vehicle was plugged in at 11:00. As the vehicle was on a timer it was not allocated any current again until the 15 minute block immediately following the point where the timer elapsed (12:15). The vehicle proved it was a 32A model and was then treated equally by the algorithm. As all the other vehicles had finished charging by 13:30 only GFX4 was offered current during the two blocks with only 16A available.
- GFX5 and 6 (grey and yellow fill): these were both on 'normal' priority and were treated fairly by the algorithm whilst they were actively charging.

7.2.2 Updates to the App

Further developments to the app were made by GreenFlux. Screenshots of the version of the app provided to customers are shown below.

Figure 48: 1st Welcome Screen (new app users)

Figure 49: Login Screen

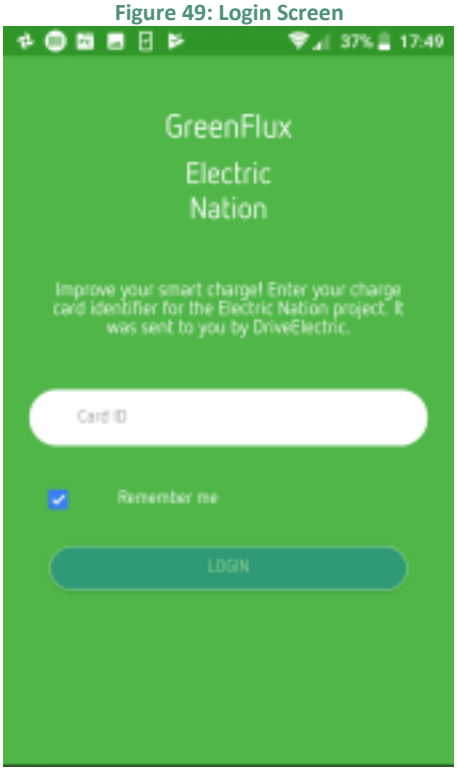
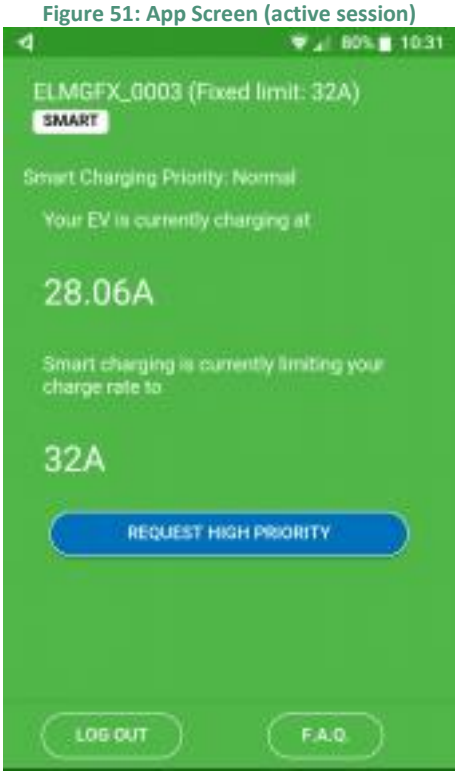


Figure 50: App Screen (no active session)

Figure 51: App Screen (active session)



The main developments from a participant point of view are in two areas:

- A change was made to the format of the login codes used by participants. Previously these codes were linked closely to the charger ID. An alternative code has been used to reduce the potential impact of typing mistakes made by participants.
- The app screen now displays the current being drawn by the EV and the limit being applied. This provides greater visibility to participants of the way their charging is being managed.

The app is now available to download from both the Apple App Store and Google Play. Customers are directed to the store when they are invited to use the app.

7.2.3 Preparation of Instructions and FAQs

In order to support participants in using the app instructions and frequently asked questions (FAQs) have been developed and uploaded to the Electric Nation website[12]. This information is held on an 'orphan' webpage so is not readily accessible to the general public but is linked into the app via the 'FAQ' button (see Figure 50 and Figure 51). Participants are also provided with a link in the email inviting them to use the app. A pilot group was used (see below) in order to refine the instructions given.

7.2.4 Roll-Out to Participants, including a 'Pilot' Group

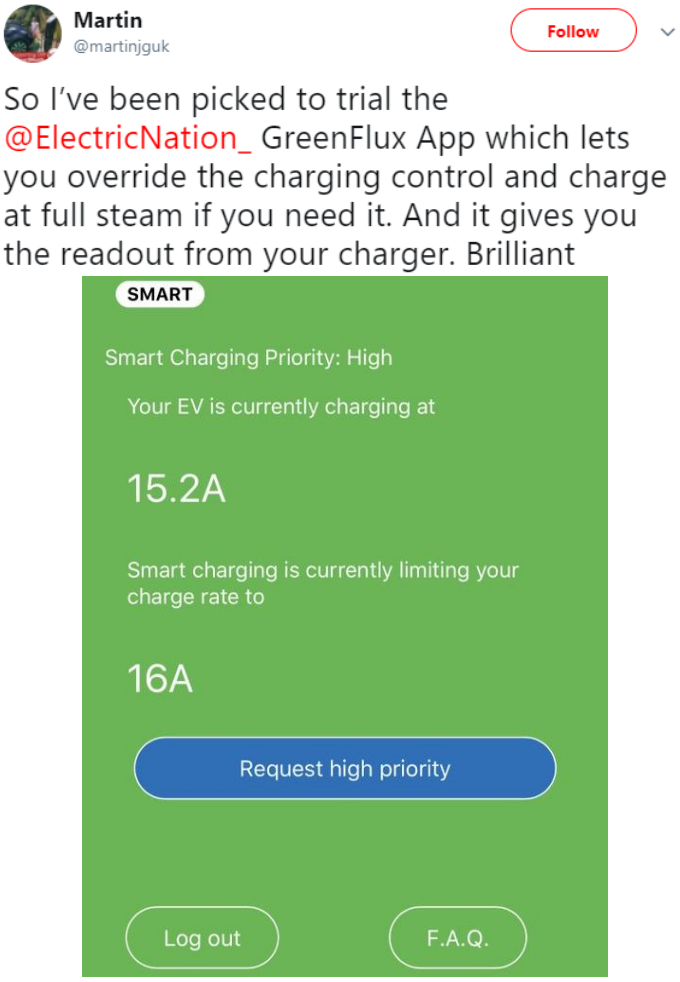
The project team intend to roll-out the app to all participants in routine management by the end of May 2018. An initial batch of 20 participants were issued with the app on 3rd April as a 'pilot' group. These were selected to be representative of the wider project group in terms of battery capacity, plug-in vehicle type and use of timers. This allowed the following processes to be tested:

- Issue of login codes to Drive Electric from GreenFlux
- Sending login details and instructions to participants
- Updated transaction records from GreenFlux showing time of high priority request.

Participants in the pilot group were asked to use the high priority button for the first three transactions after installing the app. A week after issuing the app 11 of the 20 participants had used the app. Initial feedback has been positive, with only a small number of enquires via the support line. One participant shared their use of the app via their Twitter account:

[12] Electric Nation GreenFlux App Support: http://www.electricnation.org.uk/greenflux-help/greenflux-app/ Accessed April 2018

Figure 52: User Feedback via Twitter for GreenFlux App[13]



User feedback has been requested via a short questionnaire. This will be used to refine the instructions further.

At the time of writing a second batch of 40 participants had been selected to receive the app. The 'app' participants operate in a separate capacity group – this prevents other participants experiencing a higher level of demand management due to the high priority requests. All participants who are under routine management will be transferred into the app group over the next month. The graphs below show requests for high priority since the beginning of the first pilot group, and the number of installations of the app.

[13] Twitter account of an Electric Nation Participant. Tweet available at: https://twitter.com/martinjguk/status/981271741774385158 Accessed April 2018

Figure 53: High Priority Requests from GreenFlux App

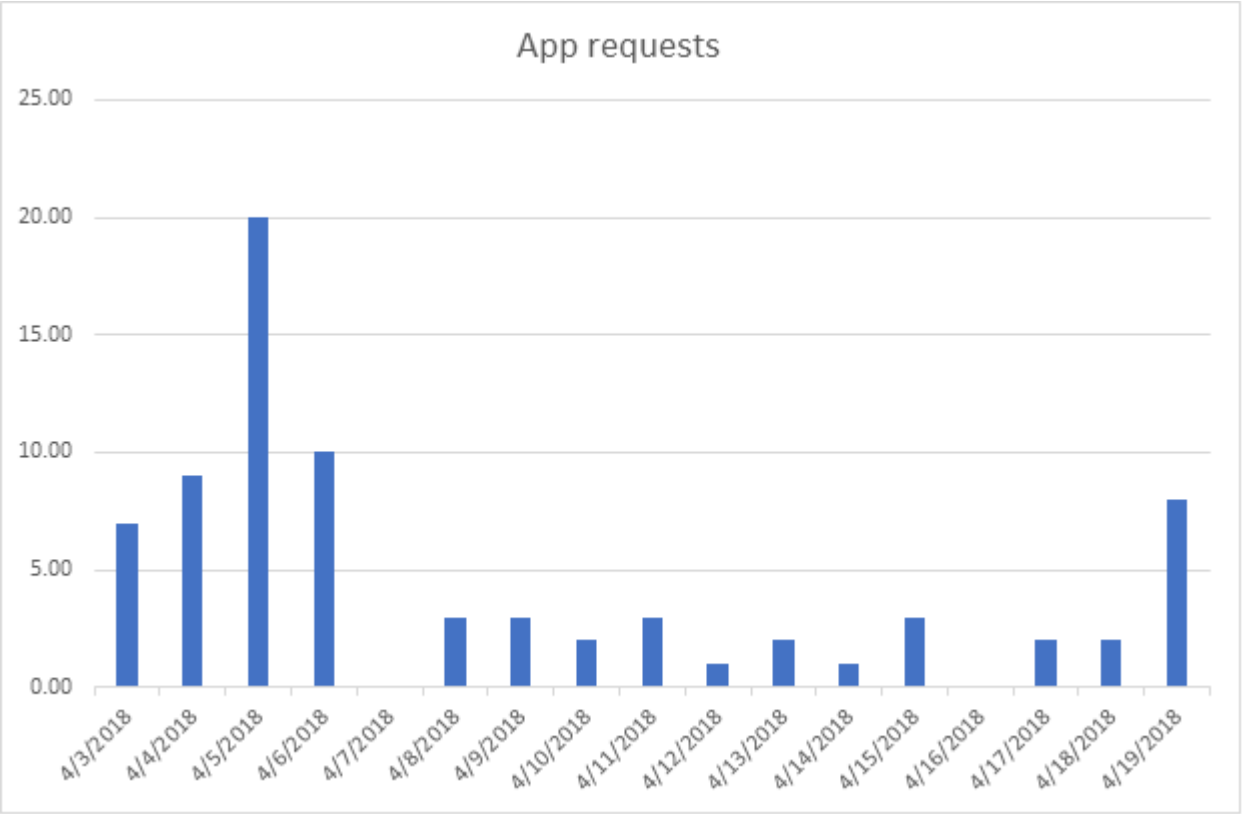
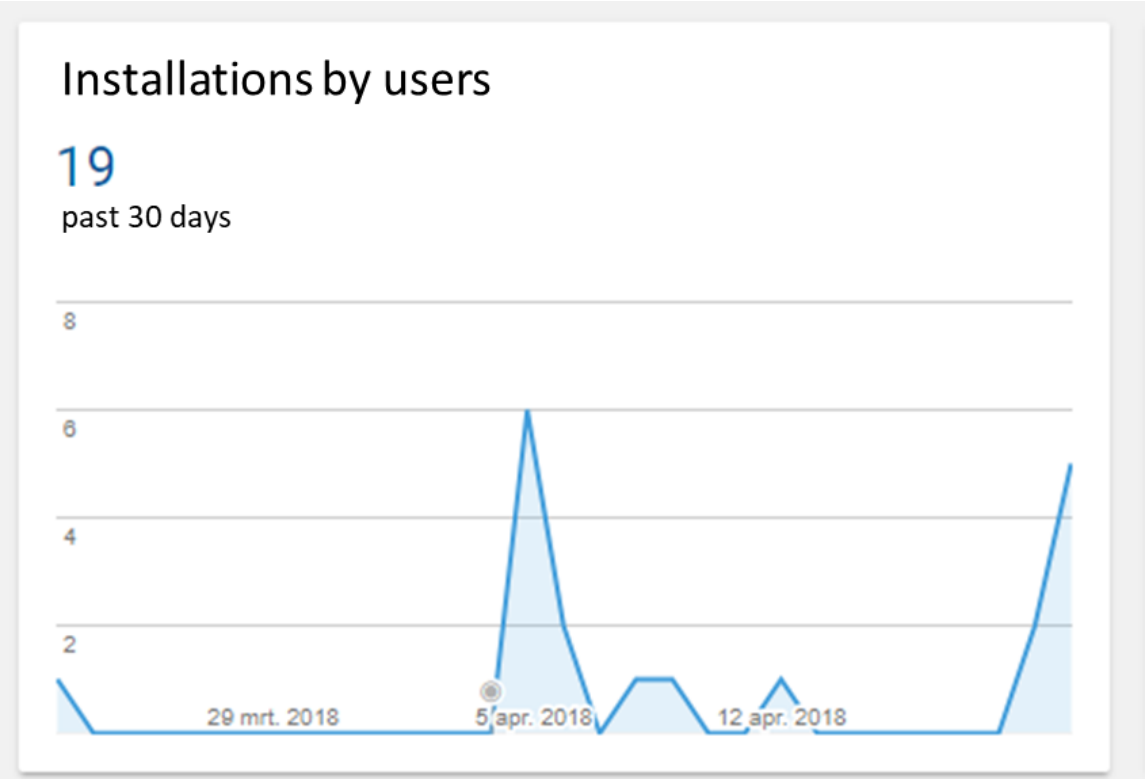


Figure 54: Installations of the GreenFlux App



This iteration of the algorithm will be operational until August/September 2018, when participants will be surveyed again to understand the acceptability of this type of solution.

8 Next Steps

8.1 Customer Research

Impact Utilities are continuing to distribute and collect the Recruitment survey. Installation of Smart Chargers will be complete in the Spring. A complete analysis of participants characteristic and demographics will be undertaken when this this phase of the trial is complete.

Final analysis of the customer acceptance of the demand management experience from trial 1 will be undertaken once all surveys have been collected from project participants.

Surveys will be distributed to project participants to measure their satisfaction and acceptance of the demand management under trial 2 in late Spring/early summer 2018.

8.2 Smart Charging Trials – Activity for May to July 2018

The main area of activity for the customer trial in the coming quarter (May to July 2018) will focus on the deployment of the 2nd algorithm configuration and transferring as many remaining participants into routine management as possible. The project team will continue to work with the Tech Factory (systems integration specialist to the project) until the end of May to resolve existing communications issues and transfer these participants into routine management. For a number of chargers, it will not be possible to establish reliable communications. These installations will be of minimal value to the trial but do demonstrate the likely reliability of similar solutions if they were to be deployed as a business as usual solution.

GreenFlux customers will be transferred into the app group by the end of May 2018. Deployment of the CrowdCharge app is likely to continue into June, depending on the further development work and testing required prior to deployment. In order to understand the value of the apps and enabling participants to prioritise their charging session it is likely that a period of 'winter' profiles will be enacted during the coming quarter, increasing the likelihood that customers will experience demand management and will therefore have a need to override smart charging actions.

The project team will also review the requirements for the final (3rd) algorithm iteration and develop these with both CrowdCharge and GreenFlux. This iteration will be deployed to customers in August/September 2018 and so will enter testing during Q3 of this year.

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

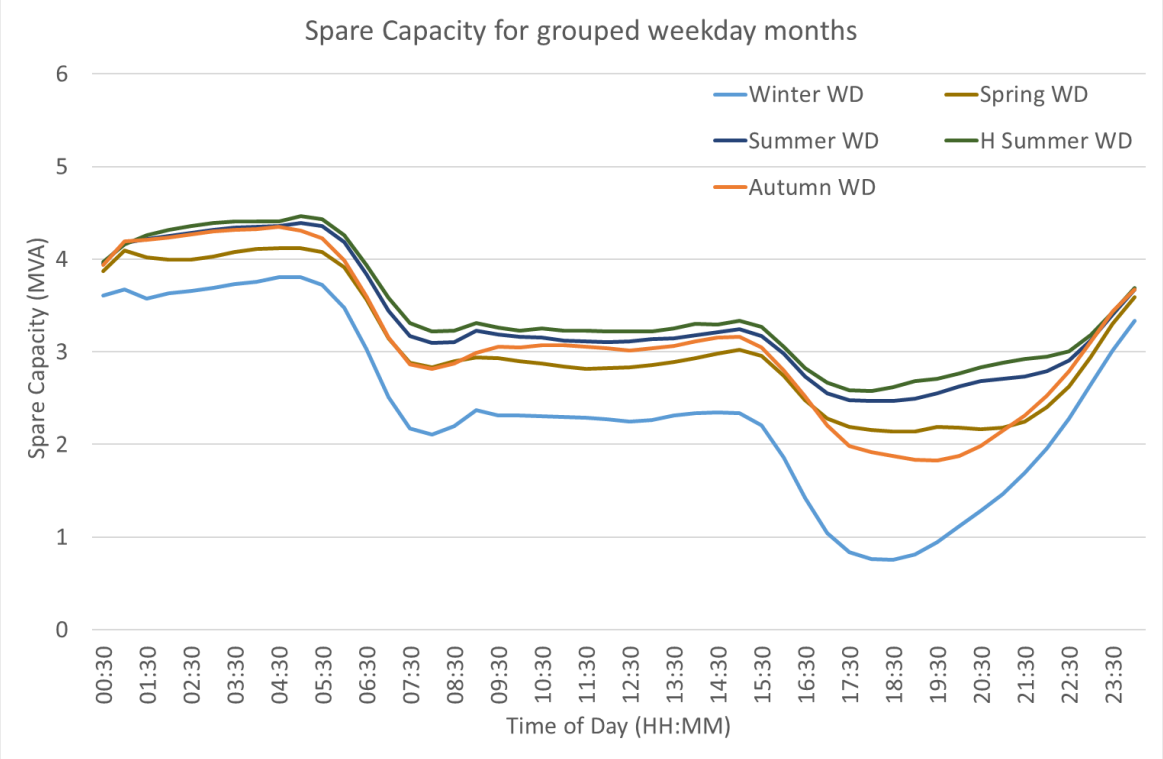
Appendix 5 – Smart Charging Roll-Out Process

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 55: 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 6.4 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.

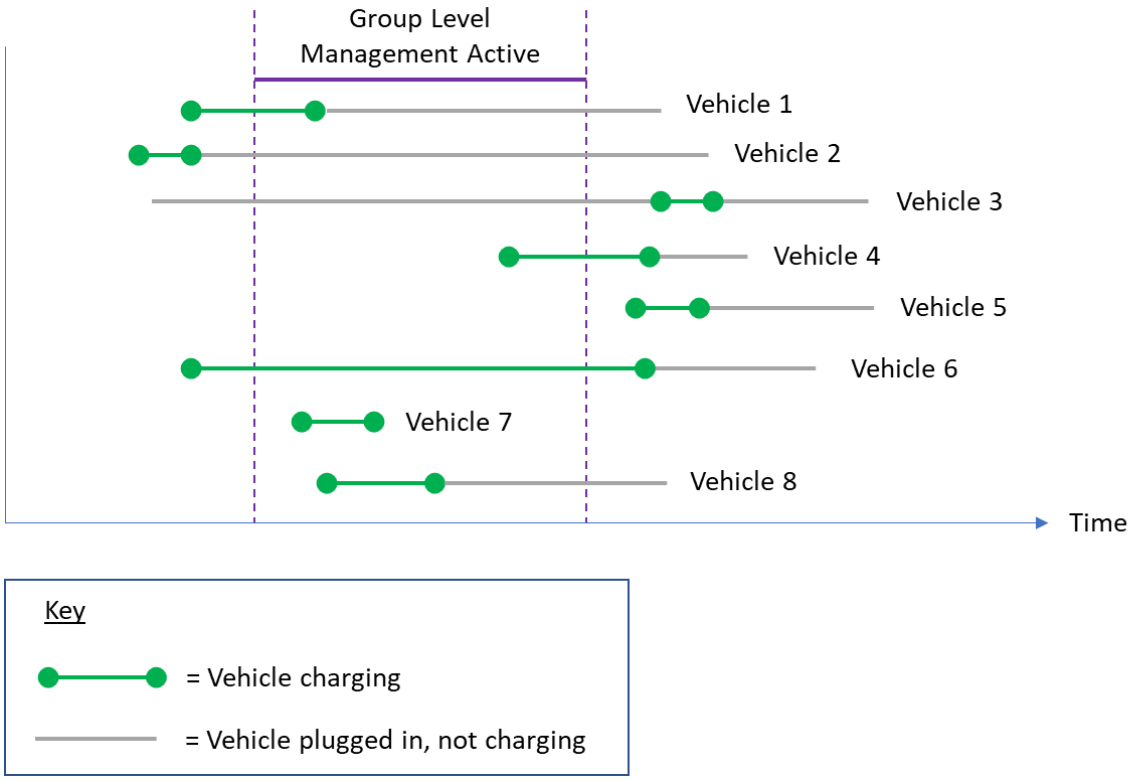
Monitor Performance

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.

Appendix 6 – Identification of Management of Individuals Chargers

Regardless of the demand management provider (CrowdCharge or GreenFlux), a plug-in event generally consists of a period of active charging (i.e. car drawing current) followed by an inactive period while the vehicle is still connected to the charger but has completed its cycle and is no longer drawing power. Other combinations are also possible – e.g. inactive before a period charging (using a timer) or no inactive period ('hot unplug' before the battery is full). The timing of this individual charging may or may not overlap with a period when management is active at a group level. Potential permutations are shown below, which aims to capture the majority of charging events. It is also possible that none of the transaction (from plug-in to plug-out) overlapped with a group level management event and this is excluded from the diagram below.

Figure 56: Alignment of Individual Charging with Management Events



These scenarios are described below:

Vehicle Number	Description of Scenario
1	Vehicle began charging before management event began and was still charging towards the start of the management period. It finished charging during the event. It was plugged in until after the event had finished.
2	Vehicle had both started and stopped charging before the event began. It was plugged in throughout the event.
3	The vehicle was plugged in before the event began but was on a timer and didn't draw any current until after the event had finished.
4	The vehicle was plugged in and began charging during the event. It continued to charge after the event had finished.
5	All activity was after the event finished
6	The vehicle began charging before the event started and continued afterwards.
7	Vehicle was plugged in briefly within the event. It was unplugged before it finished charging and before the event finished.
8	The vehicle was plugged in during the event, finished charging before the event was over and was left plugged in.

The aim of the analysis of individual level charging events is to apply a series of queries (questions), the results from which determine whether an individual charging event was affected by management. Based on the scenarios above, and current data availability, the first question to be applied is:

$$\text{Is } t_{\text{Start Charge}} \leq t_{\text{end of management event}}?$$

where:

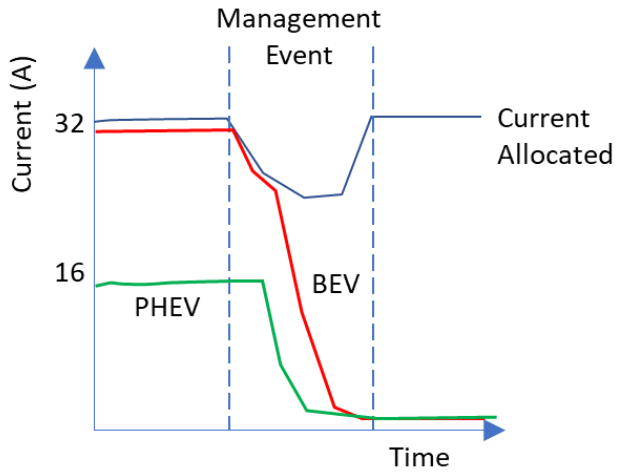
- $t_{\text{start charge}}$ = the time at which the vehicle started charging (not the plug-in time) – indicated by the first green dot in Figure 56 above.
- $t_{\text{end of management event}}$ = the time at which the management event finished – the 2nd dotted vertical line in Figure 56.

Applying this criterion to the scenarios listed above it is already clear that vehicles 3 and 5 were not affected, these are excluded from the further analysis below. Further queries are required to determine the status of the remaining 6 charging events. These queries will vary between CrowdCharge and GreenFlux because of differences in the control algorithms used and the data being supplied. The sub-sections below describe the logic applied for both providers.

CrowdCharge – Management of Individual Chargers

Illustrative individual charging curves can be drawn up for the remaining customers. These have been separated into an example BEV vehicle (i.e. nominally 7kW) and a PHEV (or other, nominally 16A vehicle).

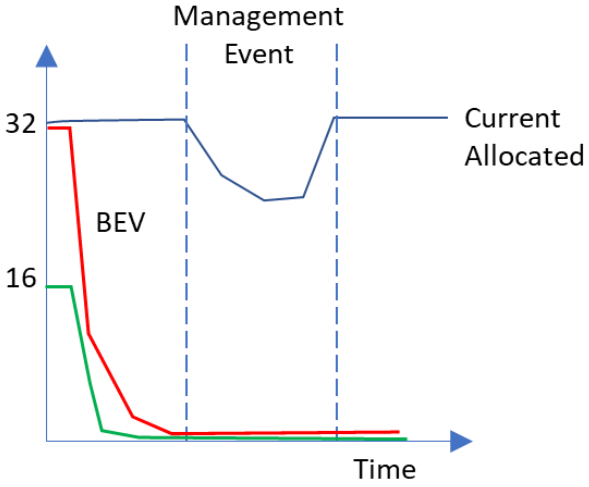
Vehicle 1: Vehicle began charging before management event began and was still charging towards the start of the management period.



As drawn above, the BEV was curtailed by the management event – it is likely that if the allocation hadn't been reduced then it would have continued to charge at 32A for a short while longer.

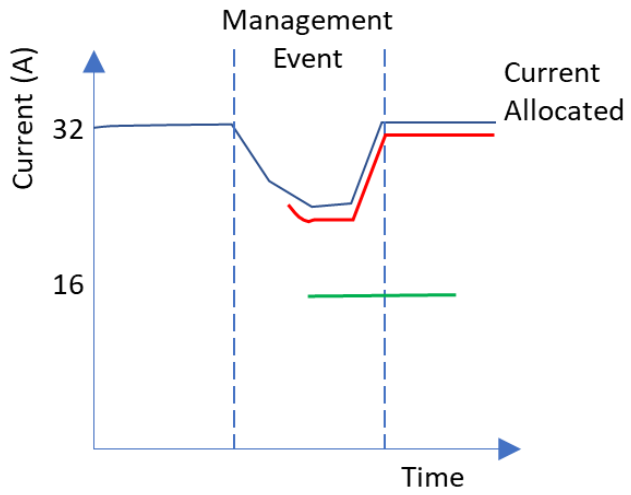
The PHEV was not curtailed as it was always drawing substantially less current than the allocation.

Vehicle 2: Vehicle had both started and stopped charging before the event began. It was plugged in throughout the event.



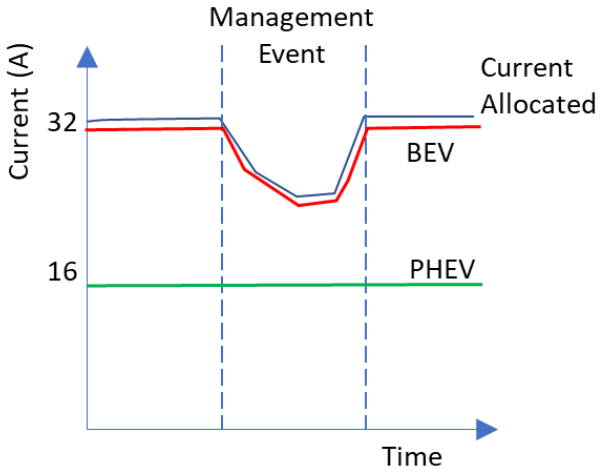
Neither vehicle was curtailed. The current being drawn had already declined prior to the demand management event starting.

Vehicle 4: The vehicle was plugged in and began charging during the event. It continued to charge after the event had finished.



The BEV was curtailed from when it was plugged in until the end of the management event.
The PHEV was unaffected as the allocation remained higher than the nominal charge rate of the vehicle.

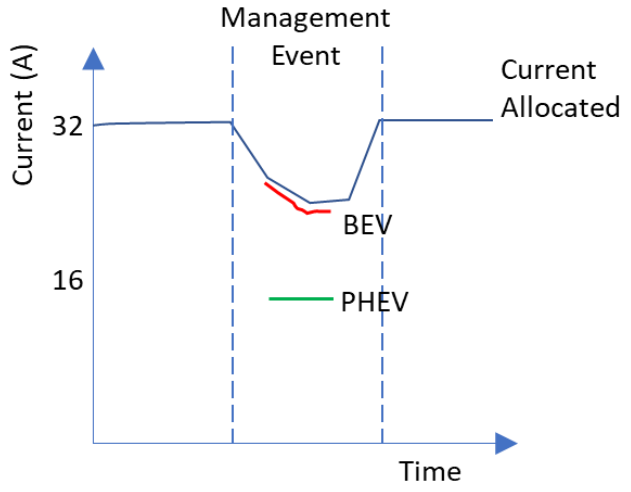
Vehicle 6: The vehicle began charging before the event started and continued afterwards.



The BEV was curtailed throughout the length of the management event.

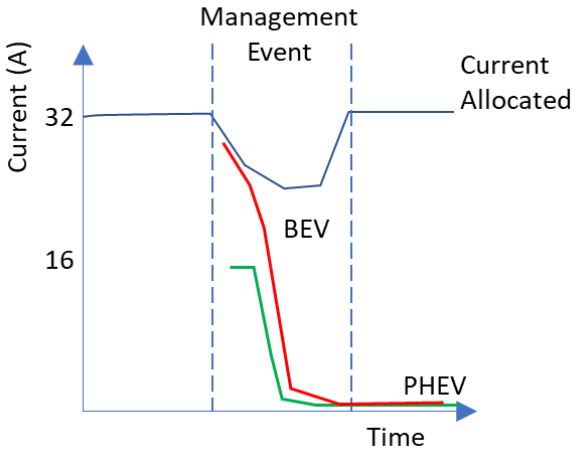
The PHEV was unaffected as the allocation remained higher than the nominal charge rate of the vehicle.

Vehicle 7: Vehicle was plugged in briefly within the event. It was unplugged before it finished charging and before the event finished.



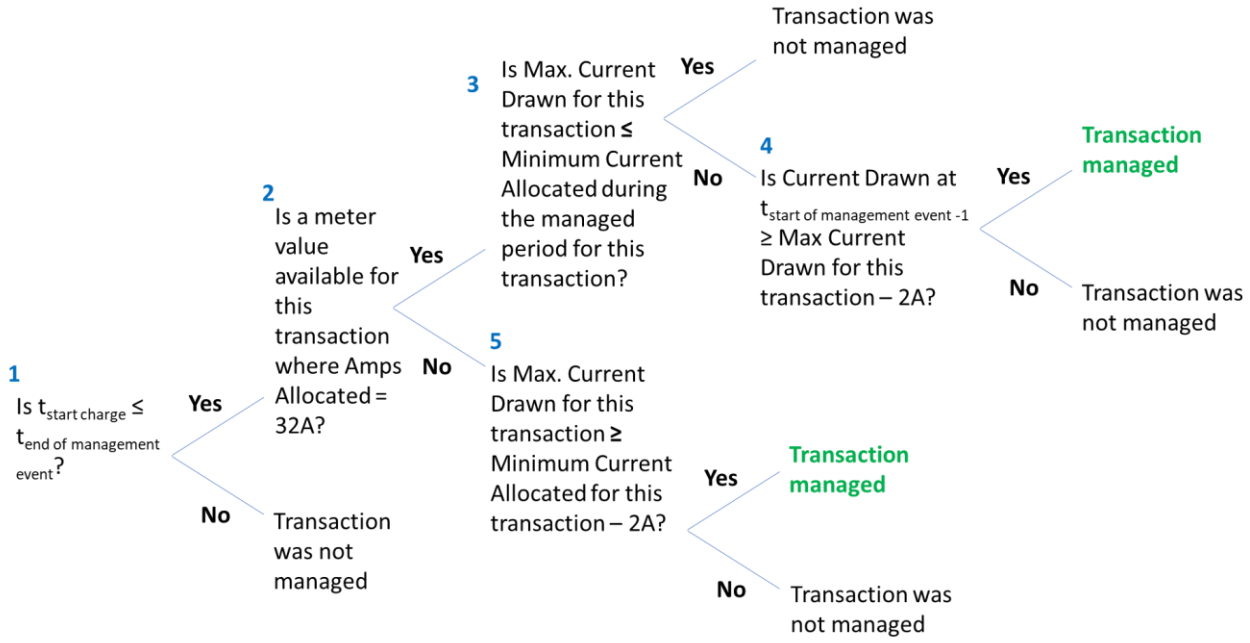
The BEV was curtailed throughout the transaction. The PHEV was unaffected.

Vehicle 8: The vehicle was plugged in during the event finished charging before the event was over and then left plugged in.

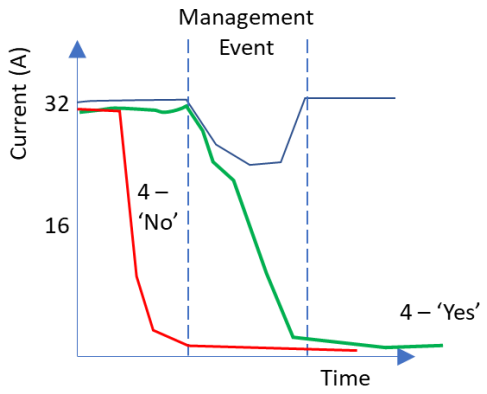


The BEV was affected at the start of the charge event. The PHEV was unaffected.

A series of tests have been developed to determine whether a transaction was affected by a management event. These are shown in the decision tree below.

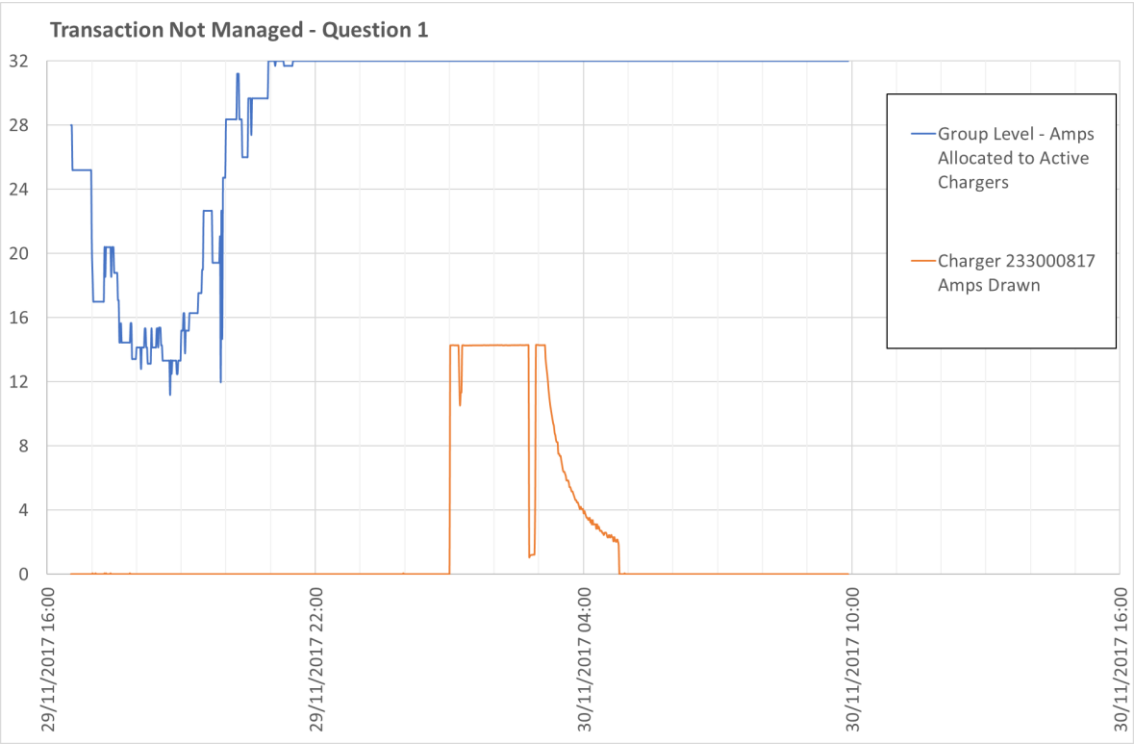


Decision Point	Explanation
1: Is $t_{start\ charge} \leq t_{end\ of\ management\ event}$?	Yes: the vehicle might have been charging during the management event No: charging did not overlap with the management period – e.g. vehicle 3 and 5 above.
2: Is a meter value available for this transaction where Amps Allocated = 32A?	The logic used to determine whether a vehicle was truly curtailed varies depending on the presence of an unconstrained meter value. This value is available in the vehicle 1, 2, 4 and 6 scenarios above.
3: Is Max Current Drawn for this transaction ≤ Minimum Allocated during management for this Transaction	Yes: the maximum current drawn (which will be when the vehicle was offered 32A) is, e.g. 15A compared a minimum allocated of 20A. The vehicle was not affected – e.g. the PHEV in the vehicle 1, 2, 4 and 6 scenarios. No: the vehicle may have been affected, unless the charging event was nearly over before management began – see Decision 4.
4: Is Current Drawn at $t_{start\ of\ management\ -\ 1}$ ≥ Max Current Drawn for this transaction – 2A	Yes: if the current drawn immediately prior to management beginning is still close to the maximum for the transaction then the curtailment is likely to have affected charging. No: the vehicle had begun to finish its charging session. These two scenarios are illustrated below:

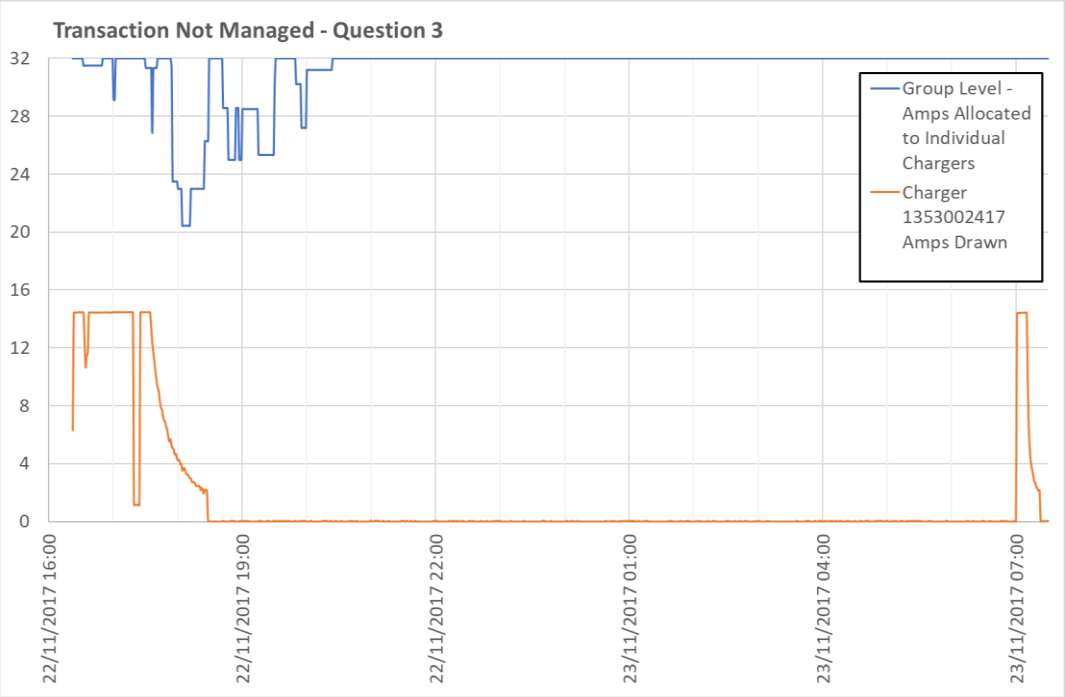
	
5: Is Max. Current Drawn for this Transaction ≤ Minimum Current Allocated for this Transaction -2A?	No: the current drawn was always less than the minimum available current so the transaction was not curtailed – e.g. the PHEV in the Vehicle 7 scenario. Yes: the vehicle was curtailed. A 2A threshold is applied to account for some vehicles which always draw slightly less than the allocation (e.g. a Kia Soul never draws more than 27A).

These queries can be applied to all transaction records (where meter values are available) in order to show whether each individual transaction experienced some curtailment. Further analysis is required to determine the level of the curtailment, e.g. using the concept of 'restrictiveness' discussed in earlier reports. This will be further developed in the next reporting period and applied to the database.

This logic has been applied to the database and some illustrative examples of 'managed' and 'unmanaged' transactions are shown below (all taken from the 29th November).

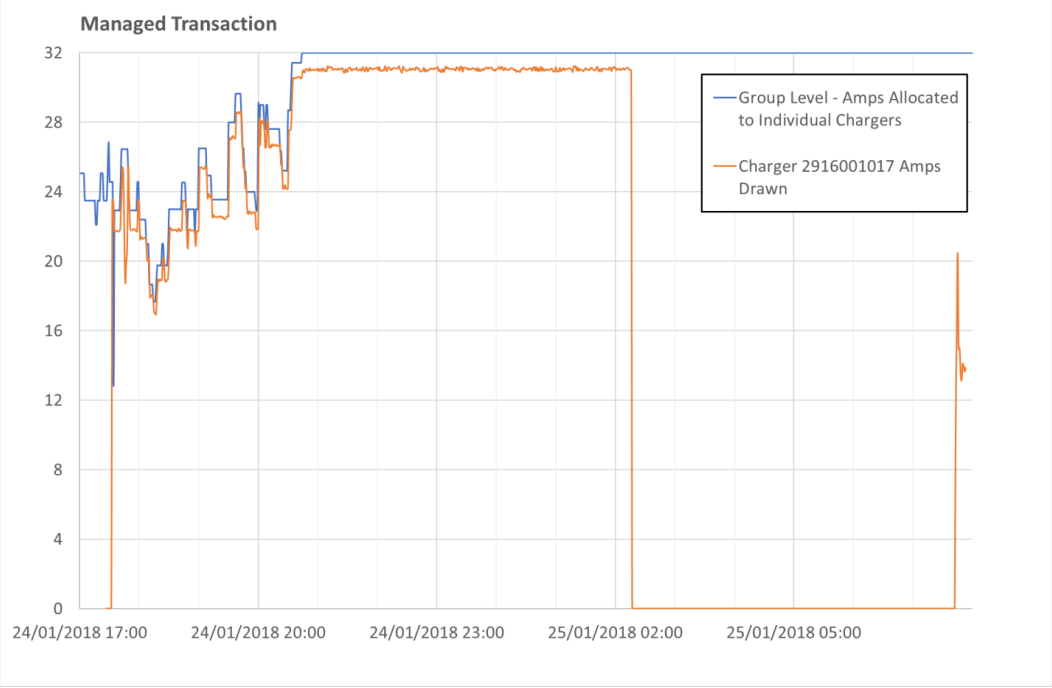


A vehicle was connected to the charger above at 16:32 on 29th November. However, it did not begin charging until 01:00 on 30th November, after the management event was over. This transaction was not managed.



This vehicle was connected at 16:22 on 22nd November. A management event began at 16:32 on this day. Although the vehicle charged throughout the management event it's maximum current drawn was less than the minimum allocated during the event. This transaction was not managed.

An example of a managed transaction is shown below.



The vehicle plugged in during the management event and roughly followed the allocation until the event ended just before 21:00. It continued to charge until the battery was full just after 02:00 on 25th January.

GreenFlux – Management of Individual Chargers

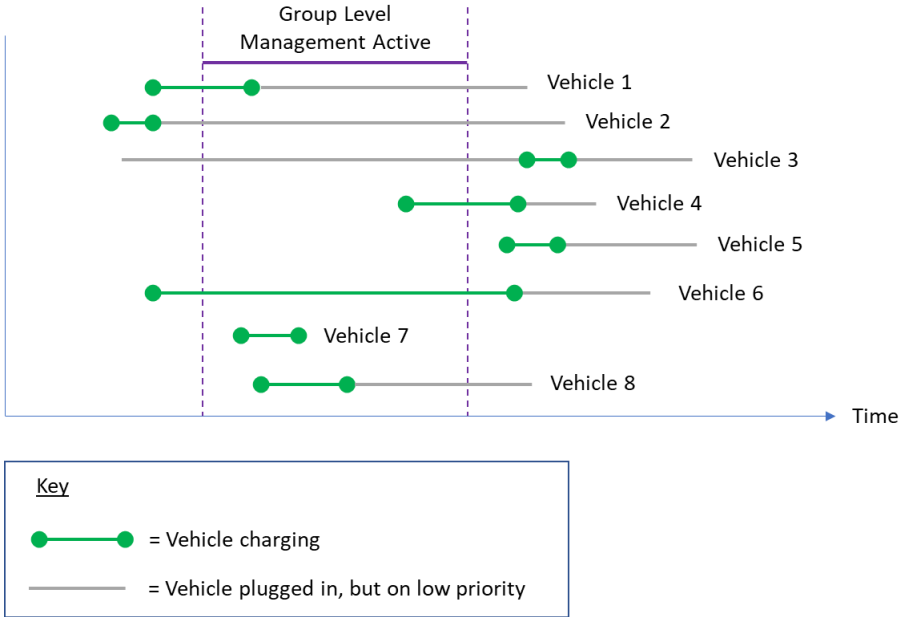
The logic to determine whether an individual charger is affected by demand management needs to be tailored based on both the data available, and the control algorithms used. The following section follows a similar logic to that described above but develops a suitable methodology for GreenFlux chargers.

In the absence of demand management the GreenFlux system will allocate the following values to active chargers:

- 32A: allocated to a car which is in the main part of its charge cycle, if it draws more than 16A when it first plugs in.
- 16A: allocated to a car which is in the main part of its charge cycle, if it draws less than 16A when it first plugs in.
- 13A: allocated to both 32A and 16A vehicles once they have been transferred to low priority.

Low priority is activated when the current drawn by the vehicle (averaged over a 15-minute time period) is less than 25% of the allocated value. For example, a car which has been allocated 32A but draws an average of 6A will be put onto low priority.

The scenarios used for the CrowdCharge individual level management query can be applied to GreenFlux. However, in this case the key time period to study is between the start of charging and the time when the charger was switched onto low priority. "Curtailment" (i.e. a reduced allocation) after $t_{low\ priority}$ is a normal part of the algorithm and not as a result of demand management. These scenarios are shown below.

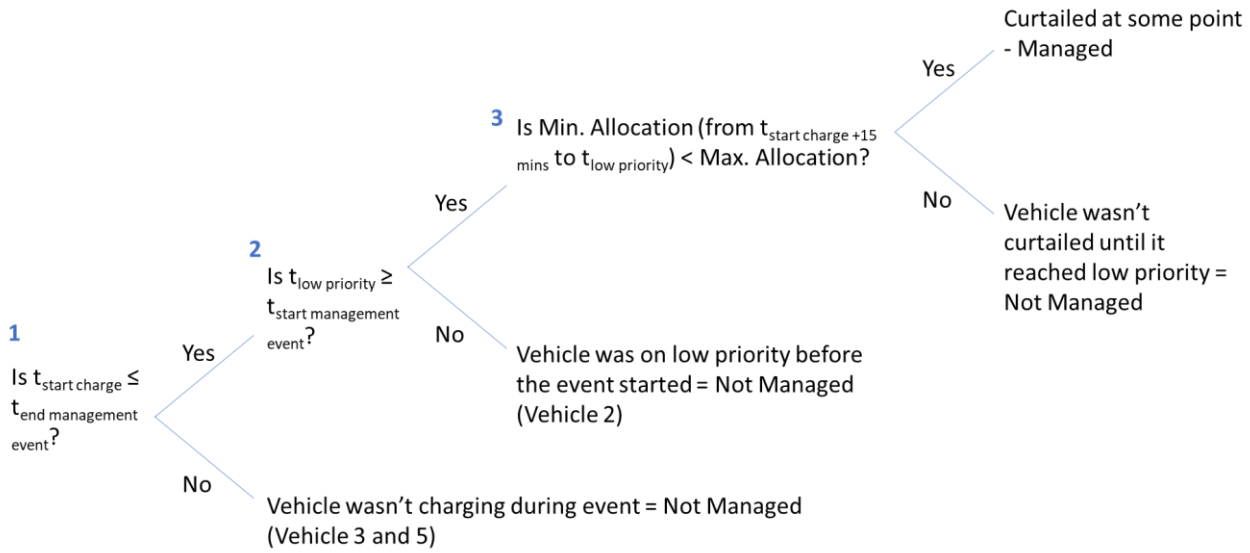


Vehicle Number	Description of Scenario
1	Vehicle began charging before management event began and was still charging (not on low priority) towards the start of the management period. It finished charging during the event. It was plugged in until after the event had finished.
2	Vehicle had started charging and was already on low priority before the event began. It was plugged in throughout the event.
3	The vehicle was plugged in before the event began but was on a timer and didn't draw any current until after the event had finished.
4	The vehicle was plugged in and began charging during the event. It continued to charge after the event had finished.
5	All activity was after the event finished
6	The vehicle began charging before the event started and continued afterwards.
7	Vehicle was plugged in briefly within the event. It was unplugged before it finished charging (before reaching low priority) and before the event finished.
8	The vehicle was plugged in during the event, reached low priority before the event was over and was left plugged in.

Several variables are required to determine whether an individual transaction was managed in the GreenFlux system:

- $t_{start\ management}$: the time the management event started. This is determined using allocation data supplied by GreenFlux, which is compared to the group demand limit.
- $t_{end\ management}$: the time the management event finished.
- $t_{start\ charge}$: the time the vehicle began charging. $t_{start\ charge\ +\ 15\ minutes}$ is also used within the logic – this is 15 minutes after the vehicle started charging. This is explained in more detail below.
- $t_{low\ priority}$: the time at which the charger entered low priority – i.e. the time when the average amps drawn in a 15 minute block was less than 25% of the amps allocated. $t_{low\ priority}$ must be after $t_{start\ charge}$ in order to account for transaction where a charger is put onto low priority shortly after the plug-in time due to use of a timer.
- Minimum allocation between $t_{start\ charge\ +\ 15\ minutes}$ and $t_{low\ priority}$. The minimum current allocated to the charger between these two time periods. When a vehicle first plugs in (unless on a timer) it will draw current for a minute. This meter value may be enough to trigger a 'start charge' point. However, the allocation data reports a zero allocation until the first time this charger is included within the algorithm calculations. For example, a vehicle which plugged in at 10:05 may report a $t_{start\ charge}$ of 10:05. The allocation data for 10:00 – 10:15 would be 0A, followed by either 16A or 32A at 10:15 – 10:30. The zero value for 10:00 – 10:15 is not indicative of management and so should be excluded from the logic – hence the use of $t_{start\ charge\ +\ 15\ minutes}$.
- Maximum allocation between $t_{start\ charge\ +\ 15\ minutes}$ and $t_{low\ priority}$. The maximum current allocated to the charger between these two time periods.

The logic to be used is shown by the decision tree below.



Decision Point	Explanation
1: Is $t_{start\ charge} \leq t_{\ end\ of\ management\ event}$?	Yes: the vehicle might have been charging during the management event No: charging did not overlap with the management period – e.g. vehicle 3 and 5 above.
2: Is $t_{low\ priority} \geq t_{start\ management\ event}$?	Yes: the vehicle reached low priority after the event started, so it may have been curtailed. No: the vehicle was already on low priority before the event started – e.g. vehicle 2 above.
3: Is the Min. Allocation (from $t_{start\ charge\ +15\ minutes}$ to $t_{low\ priority}$) < Max. Allocation?	Yes: at some point during the main part of the vehicles charge cycle its allocation was reduced, therefore it was managed. No: the allocation remained at the maximum value throughout the vehicles charge cycle and so it was unaffected by the management event.

This logic is currently being implemented in the Electric Nation database. It may be refined further where necessary.