

Hübner Y, Blythe PT, Neaimh M. [ITS for Quick Chargers for Electric Vehicles](#).
In: 9th ITS European Conference. 2013, Dublin, Ireland: ERTICO.

Copyright:

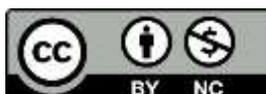
This is the author's manuscript of a paper that was presented at 9th ITS European Conference held 4th to 7th June 2013 in Dublin, Ireland.

Link to conference:

<http://www.itsineurope.com/its9/>

Date deposited:

06/12/2017



This work is licensed under a [Creative Commons Attribution-NonCommercial 3.0 Unported License](#)

Analysis of the Use of Quick Chargers for Electric Vehicles in the North East of England

Dr Yvonne Hübner, Prof Phil T. Blythe, Myriam Neaimeh

Newcastle University, Civil Engineering and Geosciences, Cassie Building, Claremont Road,
Newcastle Upon Tyne, NE1 7RU
Tel: +44(0)191 222 6855, e-mail: yvonne.huebner@ncl.ac.uk

Dr Colin Herron, Josey Wardle

Zero Carbon Futures, Skills Academy for Sustainable Manufacturing and Innovation,
Washington Road, Sunderland, SR5 3HE, UK

John R. Austin

Future Transport Systems, Milburn House, Dean Street
Newcastle upon Tyne, NE1 1LE

Abstract

The North East of England is one of the pioneering regions of ElectroMobility. This paper summarises the findings of the UK Government funded Plugged in Places NE Charge Your Car infrastructure trial and the Technology Strategy Board funded Ultra Low Carbon Vehicle Demonstrator Programme Switch EV trial. Since 2010, over 600 charging posts have been installed in the region, including 12 quick chargers at key transport links. At the same time, 44 production electric vehicles were deployed in the region and the driving and charging behaviour was monitored through data loggers. This paper provides an overview of how and when early adopters use the existing quick charging infrastructure, their attitudes towards driving EVs and the use of quick chargers and how ITS can create the link between the driver and the infrastructure.

Keywords: electric vehicle charging, quick chargers, charging infrastructure

1. INTRODUCTION

North East England is at the forefront of low carbon vehicle development with Nissan manufacturing both the Nissan LEAF and Lithium-ion batteries at its Sunderland plant from 2013. Since 2010, the region has installed a comprehensive charging infrastructure and has become a major hub for vehicle and battery research and development, manufacturing, and training facilities, throughout the electric vehicle (EV) supply chain.

The charging infrastructure has been installed through Plugged in Places (PIP), a government funded programme operated by the Office for Low Emission Vehicles (OLEV) which has awarded funding to 8 areas within the UK in order to establish EV charging infrastructure to seed the uptake of low carbon vehicles. The aims of the programme are to feedback the experience gained by creating and operating EV charging infrastructure into future policy decisions at both regional and national levels. This includes the development of standards, evaluation of technologies, harmonisation of local incentives, understanding users' behaviour and its impact upon the infrastructure.

North East England's Plugged in Places project; Charge Your Car (CYC) has created an integrated charging network for Electric Vehicles (EV) spanning a region of 8,600 sq km, enabling EV journeys to become feasible across neighbouring regions in the UK, Scotland and Europe. By December 2012, CYC had installed over 600 charging points in public places, workplaces and in the homes of EV drivers. CYC has installed a combination of 3, 7 and 22 kW AC charge points and, as one of the UK's EV industry pioneers, was the first network to introduce 50 kW DC quick charge points which enable EVs to be recharged to 80% in just 30 minutes.

The second key elements of the North East Electric Vehicle activity is centred around 44 electric vehicles being trialled under the TSB Ultra-low carbon vehicle demonstrator (ULCVD) programme. The Switch EV trial brings together a consortium of vehicle manufacturers, data collection experts and project managers to deliver 44 new and innovative full- electric production vehicles onto the roads of the North East of England.

The trial started in November 2010 and extends until May 2013. The vehicles are fitted with data loggers that provide a range of driving and vehicle performance data as well as GPS and a time stamp. These data points are collected and analysed at Newcastle University. In parallel driver attitudes towards EVs are gathered through questionnaires and focus groups. These two sets of data are correlated to explore trends, changes in driving and charging behaviour and attitudes to electric vehicles, charging and key issues such as cost and 'range anxiety'.

2. METHODOLOGY

Vehicles used in this trial are mostly commercially available vehicles and include Nissan LEAF, Peugeot iOn, Avid Cue-V, Liberty electric cars eRange, and the Smith Electric Vehicle Edison Minibus. Trial participants were a mixture of companies and Local Authorities who used the vehicles as part of their fleet as a pool vehicle or for the sole use for one individual. A small number of cars were also leased to private individuals.

2.1 DATA LOGGING FROM ELECTRIC CARS

The hard data on the cars are derived from the controller area network (CAN) bus of the vehicle and transmitted to a secure database through wirelessly enabled data loggers within the car. Those data are overlaid with GPS and time stamps derived from an additional logging

unit in the vehicle. The Avid Cue-V vehicles were equipped by Avid Analyticals with a logger that connects to the CAN bus through the vehicles on-board diagnostics (OBD) port. The Peugeot iOn vehicles were equipped with loggers provided by RDM. The loggers have been designed to take some external analogue and digital inputs. These inputs include the GPS and time-stamp data as well as a number of analogue inputs from current-clamps which are attached to various electrical systems of the vehicle to measure current flow and battery drain. Data that were collected included:

- Time/date – start, end and duration of events (for both trips and recharging events)
- Distance travelled
- Energy used per trip
- Energy transferred per recharge
- Recharging location (home, work, public charging infrastructure)

In this paper, home charging events have been removed from the Switch EV data set, in order to compare both data sets since the CYC data do not include home charging.

2.2 DATA LOGGING FROM CHARGING INFRASTRUCTURE

EV drivers joined the project's membership scheme and were issued with their own personal RFID card which had a unique tag identifier attached to it, enabling them to access all makes of EV charge points across the North East region. All charge points had their own unique identifying code denoting:

- the charge point type (power delivery rating (3, 7 or 50 kW), single or double outlet),
- location category (on street, public place, workplace, commercial place)
- location id (latitude & longitude coordinates).

All Charge Point activities were then recorded by the Back Office system managing the charge point network for the project, creating a charge point management system (CPMS). For each charging activity, the tag id, the transaction start and end date and time and the energy drawn were then transmitted via the GSM network to the Back Office operating the CPMS. Live charge point availability status was also displayed on the charge point location map, available to all users of the CPMS at www.chargeyourcar.org.uk to enable them to plan their EV journeys effectively. Both charge point owners and EV drivers also had access to their own charging data and history via a Members Portal within the CPMS.

2.3 SOFT DATA COLLECTION

Attitudinal data were collected through online pre- and post-driving questionnaires and focus groups. The driver recruitment process and dissemination of questionnaires is undertaken by Future Transport Systems, the data analysis is largely carried out by Newcastle University. The analysis is based on more than 100 responses from two 6-month trial periods that took place between March 2011 and April 2012. The number of drivers exceeds the number of vehicles because some of the vehicles are used as pool and fleet vehicles and multiple drivers have access to those vehicles.

3. RESULTS

3.1 COMPARISON BETWEEN THE USE OF STANDARD CHARGERS AND QUICK CHARGERS

The Charge Your Car Network has now over 100 EV drivers as members and provided 154 MWh of electricity through 24,599 transactions since its launch in 2010. The first 1.5 years of Switch EV trials have monitored nearly 50,000 drive events, covering a distance of over 450,000 km. Over the same period, 12,770 charge events were recorded of which 294 were using quick chargers. Answers to the quick charger questionnaire show that quick chargers are rarely used as primary means of charging. When asked how often they used a quick charger, most drivers answered that they used quick chargers either once a month (32%) or once or twice (24%). Only 8% of drivers said that they used quick chargers on a daily basis. A further 8% said that they used quick chargers on a weekly basis.

Table 1 shows a comparison of the CYC data and the Switch EV data. Analysis of the CYC data shows that characteristics of use differ between standard and quick chargers. Overall, 14% of recorded CYC charge events were using quick charges, while only 3% of charge events recorded by the Switch EV trial were on quick chargers. The difference in charging behaviour might be explained by the difference in composition of members of CYC and Switch EV trial participants. While 56% of CYC members were businesses, 87% of vehicles in the Switch EV trial were leased by businesses. In focus groups, many company car drivers explained that they only used the EV for journeys that were within the range of the car. If a planned journey was likely to exceed the range of the electric car, they would use a different car from the company car pool. This might explain, why there are relatively few quick charge events recorded through the Switch EV trial.

	CYC data	Switch EV data (public and work only)
Average charge duration (quick charger)	19 min 39 s	28 min 27s
Average charge duration (standard charger)	2h 7min 32s	2h 52min 32s
Average energy use (quick charger)	6.98 kWh	7.19 kWh
Average energy use (standard charger)	6.12 kWh	5.89 kWh
Total energy use (quick charger)	28 MWh	2.1 MWh
Total energy use (standard charger)	126 MWh	53 MWh
Total number of charges (quick charger)	4,009	294
Total number of charges (standard charger)	24,599	9,080

Table 1: Comparison of charging data recorded by CYC and through the Switch EV trial.

Furthermore, it can be seen, that on average, EV drivers draw more energy from quick chargers (6.98 kWh/charge) than from standard chargers (6.12 kWh/charge) per charge event. The Switch EV data show a similar trend. However, the energy used per charge at standard public and work based charging posts was slightly lower (5.89 kWh/charge) and the energy

used per charge at quick chargers was slightly higher (7.19 kWh/charge). This might be explained by understanding the reasons for using quick chargers. As shown in Figure 1, 58% of respondents said that they used the quick charger to extend the range of their EV for a long journey. This means, that EV drivers are more likely to drive further when they use quick chargers and hence need more energy. This is further confirmed when analysing the driving patterns of 10 EV drivers who regularly used quick chargers. Results show, that all combined journeys before and after a quick charging event are on average 21% longer than those before and after a standard charge event.

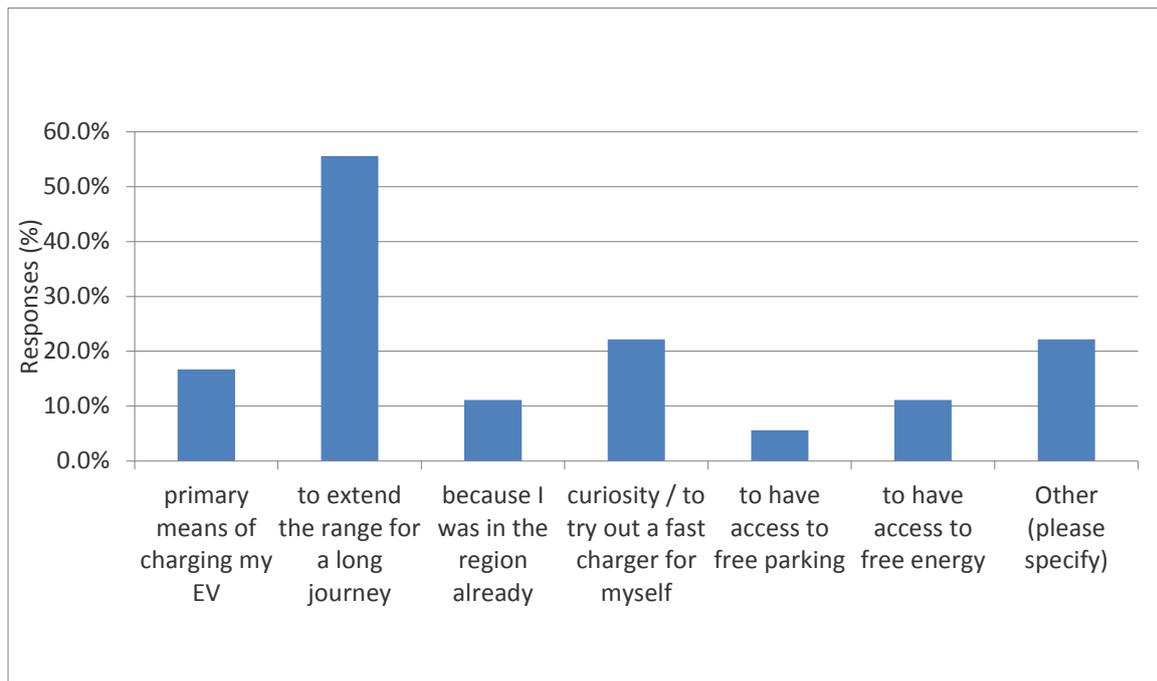


Figure 1: Responses to the question ‘What is your main motivation for using the quick charger?’ in the quick charger questionnaire (n=30)

On the 3 and 7 kW standard chargers over 90% of use takes place between the hours of 06.00 and 19.00, of which only 12% take place at the weekend, over 90% of charging events last less than 4 hours and an average of 6.4 kWh of energy is drawn. When comparing the Switch EV findings, it can be seen, that the charging behaviour of individuals changes less throughout the week than that of business users.

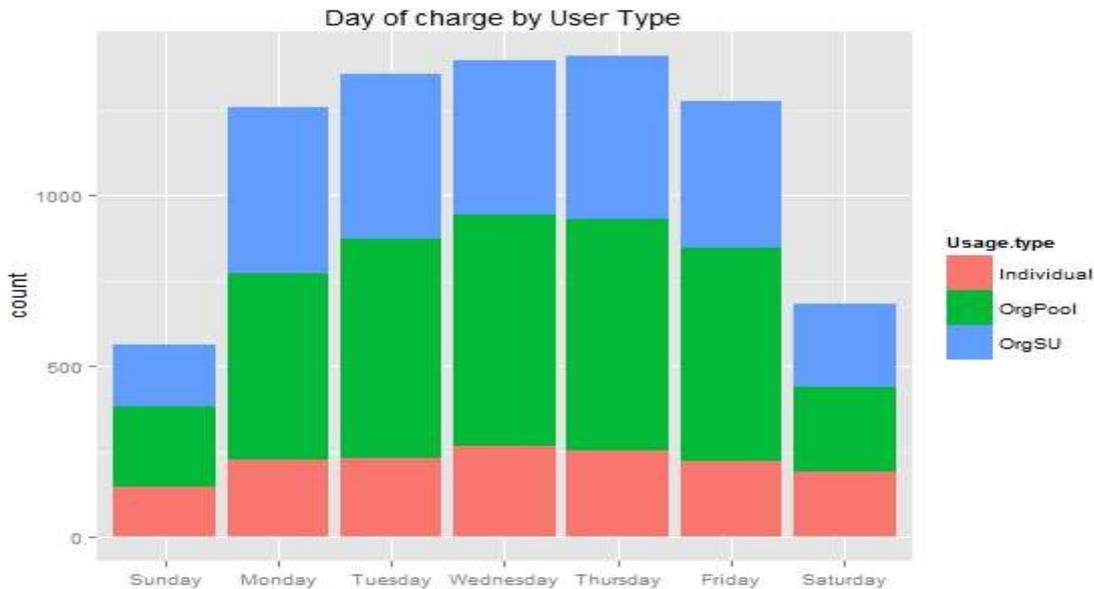


Figure 2: Comparison of the charging behaviour of Individual users (Individual), Business pool car users (OrgPool) and Company car users (OrgSU)

Comparatively, on 50 kW DC quick chargers time of use is between 09.00 and 21.00 and does not tail off over the weekends, and the average power drawn per transaction is 9 kWh. Data have shown a quick increase of the use of quick chargers since their installation.

3.2 ATTITUDES TOWARDS THE USE OF QUICK CHARGERS

Attitudinal data have been collected using both questionnaires and focus groups. Electric vehicle drivers were recruited from the Switch EV trials and from the Charge Your Car membership. To date, over 400 drivers had the opportunity to drive the cars and 178 Pre-trial questionnaires, 71 post-trial and 30 quick charger questionnaires have been completed. 42 drivers participated in 9 focus groups and 12 individual exit interviews were conducted. Ten drivers were interviewed on the day they received the cars.

Anecdotal evidence from the focus groups has shown that EV drivers often chose their leisure destinations according to the placement of charging infrastructure. One driver for example said “[the placement of charging infrastructure] wouldn’t determine where I went but it would determine whether or not I took the electric vehicle. [...]If I’m going places I usually look to see if there’s a charging post in advance so that I can know that I can plug it in if I want to. So yeah that is a determinant, you know, the location of the charging points.” Another driver said: “I might, yes, there are a couple of restaurants that I would have gone to rather than go all the way out to [a restaurant at] Battlesteads. But because it has a charge point there, I can have Sunday lunch and charge at the same time.”

The questionnaires revealed that the majority of drivers spend money in nearby shops and restaurants while they wait for the car to charge at a quick charger. Only 22% of respondents answered that they do not spend any money whilst waiting for the car to charge at the quick charger. 34% of respondents answered that they spend up to £10, 22% answered that they

spend up to £20 and the remaining 22% of respondents answered that they spend more than £20. The majority of respondents answered that they bought beverages (57%) or food (43%). The analysis of 10 drivers who used quick chargers has shown that on average, the combined journey length before and after recharging was 14 km longer when quick chargers were used compared to when the same drivers used standard chargers.

3.3 TRENDS IN THE UPTAKE OF QUICK CHARGERS

As shown in Figure 3, the number of charge events has rapidly increased since the installation of public charging infrastructure in 2010. Overall, quick chargers constitute 14% of all charge events recorded by CYC.

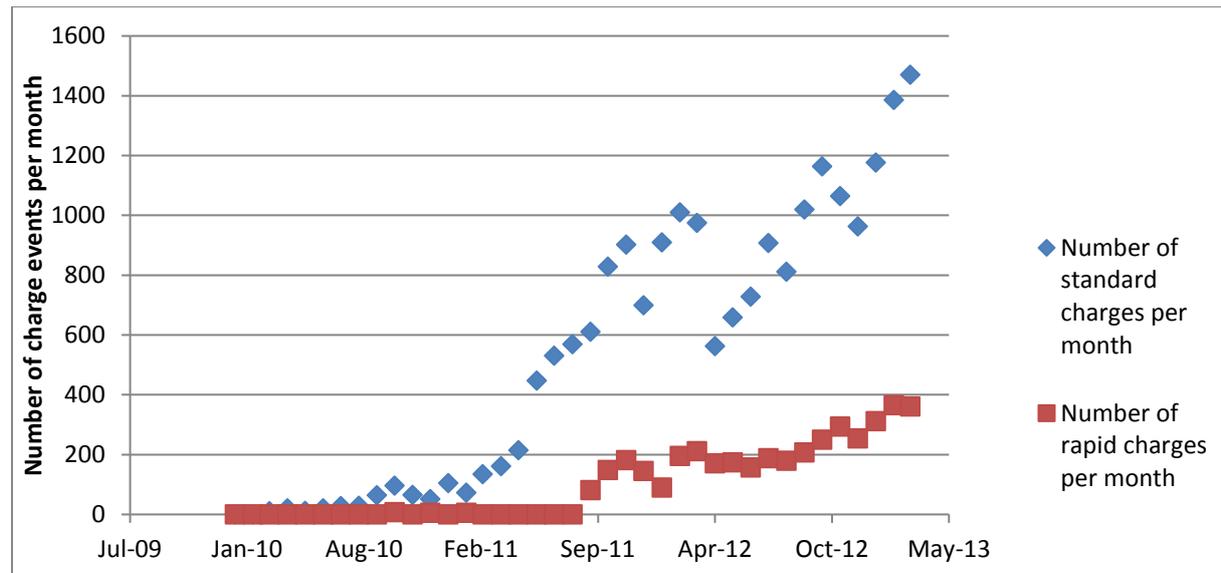


Figure 3: Number of charge events on CYC network, separated into standard chargers and quick chargers

Interestingly, once a critical mass of quick chargers was installed, the percentage of quick charge events remained nearly constant at around 19% of all charge events recorded by CYC.

4. INTELLIGENT TRANSPORT SYSTEMS FOR ELECTRIC VEHICLES

Quick chargers provide an opportunity to change the perception of EVs from predominantly urban use to a vehicle that is used most of the time. However, in order to make this transition, it is important to support EV drivers with the relevant ITS technologies. In this section, the use of RFID cards, membership schemes and pay-as-you-go schemes are discussed and their implications to the charging network operator and EV driver.

The majority of EV charging infrastructure has to date been operated under very low or zero cost subscription schemes. This has been driven by the desire of engaged public and private bodies to demonstrate their readiness for EV adoption, and to attract early EV adopters by minimising recharging costs as a barrier to EV uptake. Whilst the low number of EVs in use to date has enabled this to take place at relatively low cost, in order for the EV market to grow new approaches are likely to and indeed must emerge. As EV use increases, charging equipment owners are likely to find difficulty in continuing to absorb the costs of the electricity supplied and the lost parking revenue some of these schemes incur. Therefore, payment mechanisms enabling charging equipment owners to recoup these costs are now coming to market through Charge Point Network Operators, with the introduction of alternative payment mechanisms such as “pay as you charge”. Each of these payment

mechanisms has its own ITS implications, some of which are common to EV charge point technology and others of which are specific to the payment mechanism.

4.1 ACCESS TO CHARGING POSTS: RFID CARDS AND SUBSCRIPTION SCHEMES

The majority of public access EV Charge point operating schemes currently use RFID cards to provide EV drivers with authorised access to charge points. RFID cards are usually associated with a low or zero cost subscription scheme, requiring pre-registration by the EV driver and the receipt of a pre-programmed access card prior to journey start. This poses problems to the driver as not all schemes are currently interoperable. Through the installation of quick chargers however, it is more likely for EV drivers to cross from one scheme to another. Fundamentally, RFID access schemes therefore require on-going whitelist/blacklist management and refresh activities which incur on-going operating costs for the Charge Point Network Operator. There are also costs of printing, programming and issuing RFID cards, and managing lost card consequences. Interoperability solutions, which enable EV drivers to charge across different schemes, also add a further cost burden. These operating costs are currently bourn by public and private subsidy. For the EV driver though the subsidised charging costs are currently low and standardised and the access method is simple making this an attractive operating mechanism.

4.2 PAY AS YOU CHARGE SCHEMES

As EV use increases, public charging equipment owners and operators are likely to find difficulty in continuing to absorb the costs of the electricity supplied, lost parking revenue, lack of asset payback and operating costs. “Pay as you charge” schemes provide a mechanism for the asset owner to set the cost and conditions of use and to receive some recompense for his costs. The EV driver does not necessarily need to pre-register with a scheme provider in order to receive a charge. Instead s/he can use a mobile App on his smartphone to activate the charge point, make payment and charge his EV. A pay by phone method per charging event has been successfully trialled in North East England and an easy to use App will be available from the summer of 2013.

However, the stability and quality of the communications signal and reception become increasingly important for such schemes. In areas of poor or unstable quality communications signal, the guarantee of access becomes more risky, presenting another barrier to an already challenged early marketplace.

One solution to poor communications signal in some areas of North East England has been to hardwire expensive quick charger units into existing Local Area Network (LAN) connections on site, in order to provide greater stability for EV drivers. However this comes at additional install cost, and does not remedy the smart phone access problems described above.

Therefore, RFID access cards are likely to remain a reality of public charge point use for some time to come whilst more robust solutions to the communications challenges are developed.

4.3 STANDARDIZATION

At the point of use, the required actions of the EV driver are relatively simple, and are in the main dictated by the charge point manufacturer’s user interface design. There has to date been little formalised standardisation of charge point specification with the deliberate aim of standardising the user’s experience. However, the recent developments of the still evolving Open Charge Point Protocol (OCPP) and charge point manufacturer’s organisation may enable this to grow in the future.

OCPP also enables charge points from all compliant manufacturers to be operated by

agnostic Charge Point Network Operators, which should encourage greater coverage, more choice and stability for EV drivers, an important consideration at this early stage of the market.

4.3 DRIVER INFORMATION

Another important issue where the need for ITS solutions is key relates to the different behaviour of EV drivers in comparison to drivers of conventional ICE vehicles. There are so many ICE fuel stations in operation that ICE drivers have become confident of the ready availability of fuel and are almost desensitised to the risk of running out and being unable to complete their journey. Whilst EV charging is comparatively a new technology with a longer “re-fuelling time” (20- 30 minutes using a quick charger) EV charge points are also relatively few and far between, so range anxiety is still a real concern for EV drivers.

This heightened risk requires EV drivers to plan their journeys ahead in order to monitor distance versus charge and locate nearby charge point locations. It also makes diversions and significant delays genuine concerns for EV drivers. EV Charging Scheme providers and Charge Point Network Operators therefore provide information about charge point locations using on-line maps, although not all provide live availability and detailed access information as yet. Mobile phone and satellite navigation technology can therefore help by providing valuable information at a specific point in time to meet an EV driver’s need.

5. CONCLUSION

The on-going technical development of charging technology by EV manufacturers has taken many varied courses to date, reacting to early research and product innovations. The management of charging networks is still in its infancy and a continued investment in quick charging infrastructure is needed in order to overcome some of the barriers to the introduction of EVs. Continuing developments in technology and competition in the marketplace are however likely to result in multiple types of charging infrastructure. This proliferation causes complication and confusion for those considering using EV, representing a significant barrier to market growth and investment. For example, a number of different rapid charging mechanisms currently exist across Europe, the US and Asia and also between the manufacturers operating within these areas. This is causing confusion amongst EV drivers and investors as to what charging equipment is required for which EV and how available this necessary infrastructure is to them in their geographic area and beyond. However, this paper has shown how ITS can be used to understand charging behaviour, to inform charging post operators about the most efficient operation of their network and EV drivers about how to get the most from their EV.