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Use of ITS to overcome barriers to the introduction of electric vehicles in the North East of England

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Abstract

The SWITCH-EV trial is a large scale electric vehicle demonstrator trial, funded through the Technology Strategy Board's Ultra Low Carbon Vehicle Demonstrator Programme. According to responses from 107 electric vehicle drivers, the top four barriers to the widespread uptake of electric vehicles are: high purchasing price, limited driving range, limited availability of public charging infrastructure and time required to recharge the vehicle. This paper sets out to discuss how these barriers can be overcome using intelligent transport systems. Findings are based on the driving and charging behaviour of drivers of 44 electric vehicles that are monitored throughout the North East of England over 12 months. Intelligent transport systems were used to record journey start, journey length, GPS and state of charge of the battery on a second-by-second basis through data loggers that were fixed to the vehicles. Those records were combined with energy statistics from over 200 public charging points and 8 fast chargers in the region. The vehicles were placed with both individuals and as part of company fleets. In October and November 2011 alone, the vehicles drove a total of 13,660 km, with an average journey length of 10.1 km.

Keywords:

Driver behaviour, GPRS, GPS, data logger, charging post, public charging infrastructure

Introduction

Concerns about climate change, carbon emission, air quality and peak oil have caused many

Governments to rethink their transport strategy. In 2008, the UK government passed the Climate Change Act that set the legally binding target of cutting greenhouse gas emissions by 2050 by at least 80% [1]. In order to meet this target, the Office for Low Emission Vehicles (OLEV) as started to promote the uptake of electric vehicles in order to decarbonise personal transport [2]. However, the public still see a large number of barriers to the widespread uptake of electric vehicles. Amongst those barriers are limited range, insufficient availability of public charging infrastructure and the high purchasing cost of electric vehicles. This paper explores how the use of ITS can address some of those barriers.

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. Individuals were recruited through media campaigns and had to fulfil a number of selection criteria:

- They had to be able to pay a monthly lease fee
- Pass a credit check
- Satisfy insurance criteria such as no claims discounts and a driving history
- Requirement for owning a house (for domestic charging)
- Requirement for off street parking (for domestic charging)
- Requirement for charging solution – for companies
- Usage to satisfy minimum requirements (2,000 miles per 6 month trial)

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.

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)

Results and Discussion

Figure 1 shows the responses from 162 electric vehicle drivers to the question “On a scale of 1-5, where 1 is "not important at all" and 5 is "extremely important", please indicate how you would rate the following potential barriers to electric vehicles”. The two most important factors were purchasing cost and the availability of driving range. This figure shows, that 95% of respondents thought that the high purchasing price was either a very important or important as a potential barrier. 94% of respondents thought that the limited driving range was a barrier to the uptake of EVs and 93% of respondents thought that the limited availability of charging infrastructure was an obstacle to the uptake of EVs. 92% of respondents thought that the time to recharge the vehicle was a major barrier to the uptake of EVs.

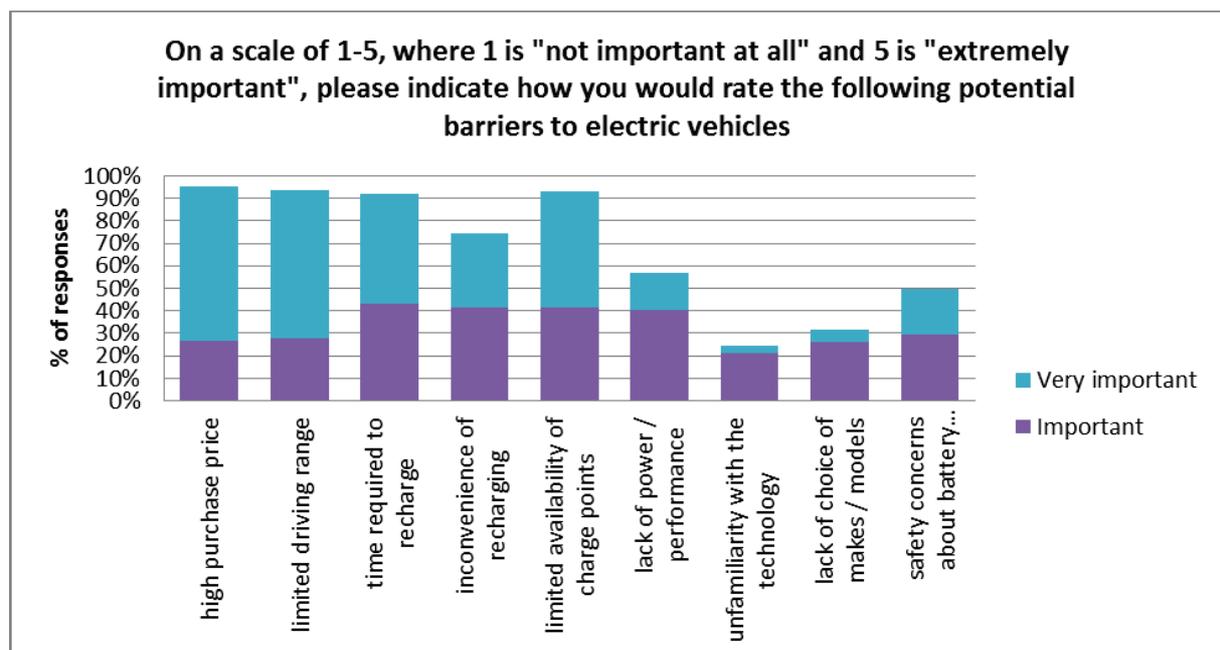


Figure 1 - Barriers to the uptake of electric vehicles; Answers to pre-trial questionnaires by 162 electric vehicle drivers

The following three sections of this paper will describe attitudes towards those barriers in more detail and will examine how those barriers can be addressed using intelligent transport systems.

Limited driving range

Focus groups were conducted towards the end of the six month trial period with three to seven drivers attending per focus group. Drivers were asked to describe their least favourite aspects of driving an EV. Limited range of the vehicles was the issue that was mentioned most. One driver said: “My main concerns were the range and the difference between the publicised range and the actual range“ Yet, drivers often found that they could adapt their driving style in order to increase the range as far as possible. Another driver said: “I think I have to say my driving was quite different in an electric car obviously try to get as much mileage as you can, you’re much more aware about how you drive [...] but it’s not really changed my perception from the focus that the range is still quite limited but you have to think so much more in advance in terms of how you travel and the logistics of things.” The range was seen particularly negatively in the winter, when drivers wanted to use the heater to warm up the car. One driver commented: “it’s a 2kW heater and when you put a rear screen on as well you suddenly find your range is sort of [dropped, if] you had 50 miles and suddenly you’ve got 22 miles. But the nice thing is, you turn the heater off and it goes back.”

Analysis of both soft data and trip data collected by the data loggers however, creates a different picture. Since 2002, the Department for Transport (DfT) conducts a national travel survey every year through face-to-face interview and a one week self-completed written travel diary with approximately 20,000 individuals, in 8,000 households. Figure 2 shows that 93% of all journeys in the UK are within 25 miles. Those journeys fall well within the range of an electric vehicle.

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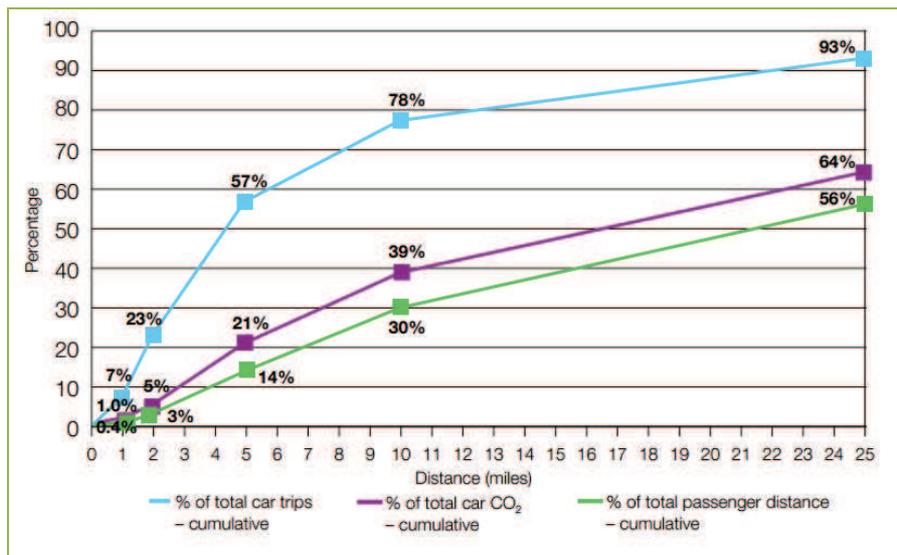


Figure 2 - Cumulative trips, passenger distance and CO₂ emissions from household car journeys by trip length, GB, 2002/2006. (Source: DfT Analysis, 2012)

Similar results have been found when tracking the EVs during the SwitchEV trial, where 57% of all journeys were under 5 miles and 75% of all journeys were under 10 miles. However, drivers have been seen to over-estimate journey distances as shown in Figure 3. Only 5% of drivers thought that their journeys were below 5 miles. Those estimates increased to 12% after the trial was completed. The slight improvement in estimating distances might be due to the range estimators in the vehicles. Focus group discussions confirmed that drivers did not feel that there were many journeys they could not make because of the range of the electric vehicles.

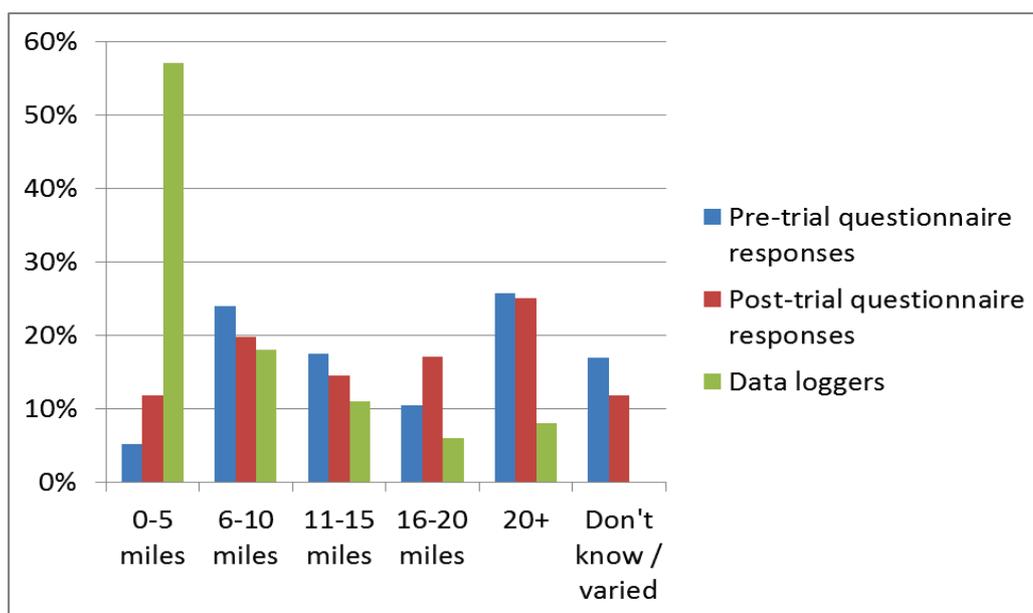


Figure 3 – Comparison between estimates of average trip distance and actual distance driven

Since drivers largely overestimate their journey length, ITS could help people make better estimates of their journey length. Examples of range estimators already exist both as web tools (for example on the Nissan US website) and as on-board units (for example Nissan Carwings, TomTom for Renault Fluence Z.E). In-car navigation systems estimate the available range of the vehicle based on information on the battery state of charge. The range is estimated based on previous driving style, weather, speed, climate control use and battery usage. It is important however that those range estimators take into account other factors such as topology and congestion.

Lack of available charging infrastructure

The UK's Office for Low Emission Vehicles has funded eight pilot projects installing and trialling up to 8,500 charging points in Central Scotland, the East of England, Greater Manchester, London, the Midlands, Milton Keynes, the North East of England and Northern Ireland. Most of these schemes currently use a membership model where with EV drivers can access charging points using a RFID card after they paid a membership fee. To date over 300 standard EV charging points have been installed by Charge Your Car (CYC) across the North East with a total of 1000 scheduled to be installed by the end of March 2013. The UK's first publicly accessible 50 kW DC Quick Charger has also been installed in the region. The total number of quick charges has since increased to 11 locations.

85% of drivers said that they charge their vehicles either at work or at home most of the time, but that they also had access to public infrastructure. The high density of charging points meant that drivers were within 5 km reach of the nearest charging point 90% of the time as shown in Figure 4. The North East of England has got three times as many charging posts as cars. Availability of charging posts therefore has not been seen as a problem amongst SwitchEV drivers. When asked "What did you do when a charging point you wanted to use was already taken?" 74% of drivers said that that never happened. A further 17% of drivers answered that they found another charging post. Yet, when asked about the importance of access to charging points at different locations, 63% of drivers thought that access to public charging points was most important.

In order to gain access to the public charging infrastructure run by CYC, EV drivers need to pay either a monthly membership of £10 or £100 for an annual subscription. The membership provides members with free parking and free electricity whilst recharging on all CYC bays in the region. Many EV drivers therefore reported that they used those charging bays as convenient parking spaces. One driver said: "I've been parking [at a charging post] which has been a godsend, my office is 25 feet away, and free parking". Other drivers said: "I take the

[EV] not because I think I'm going to get a free parking space. It's just convenience. There's lots of [charging points], they're in good locations and I know I can get one and its convenience rather than cost".

Following the focus groups, an analysis was carried out to estimate whether public infrastructure was used for parking or for charging. Results showed that 68% of all CYC charge events could have been avoided and EV drivers would have been able to complete the following journeys without the additional charge at CYC. 37% of drivers left the charging points more than 15 minutes after completion of the charge. The average time delay is 3h 37mins for those drivers. This suggests that EV drivers currently use the public infrastructure as a convenient and cheap alternative for inner city parking. In order to reduce the incentives for drivers to use charging posts as parking locations, ITS could be used to notify the driver when the EV is fully charged. The Northeast of England is one the first regions to implement a pay-as-you-go scheme for some of the charging posts, which makes it easier for EV drivers from different areas of the UK to access public infrastructure, but removes the cheap parking option.

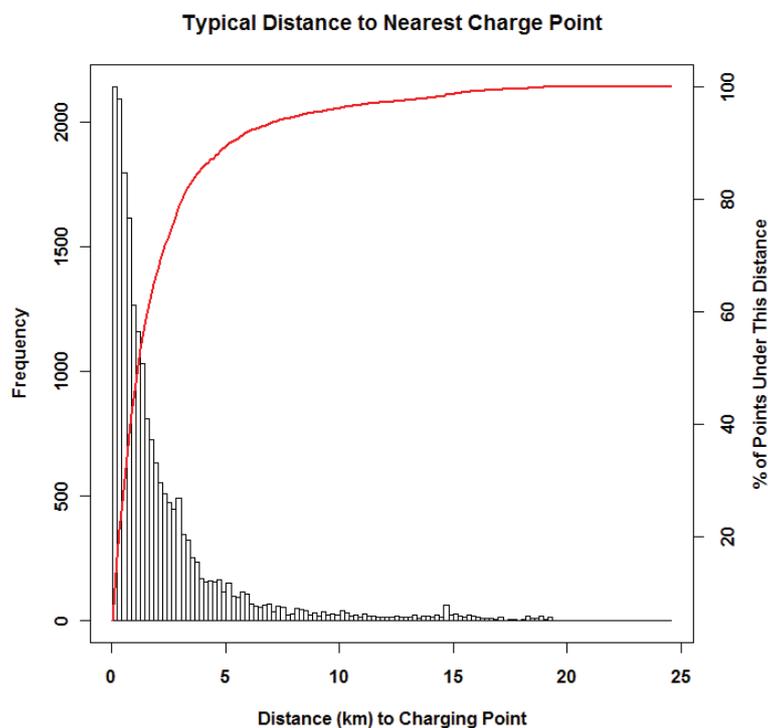


Figure 4 – Distance to the nearest charging point when driving in the North East of England. This graph shows is that for over 90% of the time driving in the North East, the EV is within 5km of a charging point and 99% of the time within 15km of a charge point.

Time spent for recharging

Charging duration was not mentioned by any of the drivers in the focus groups as a potential barrier to the uptake of EVs even though it featured prominently in the questionnaire answers. The average time per recharge was 2.6 hours. Since privately owned electric vehicles are idle approximately 95% of the time, it is not difficult to fully charge the EV provided sufficient access to charging infrastructure has been provided [5].

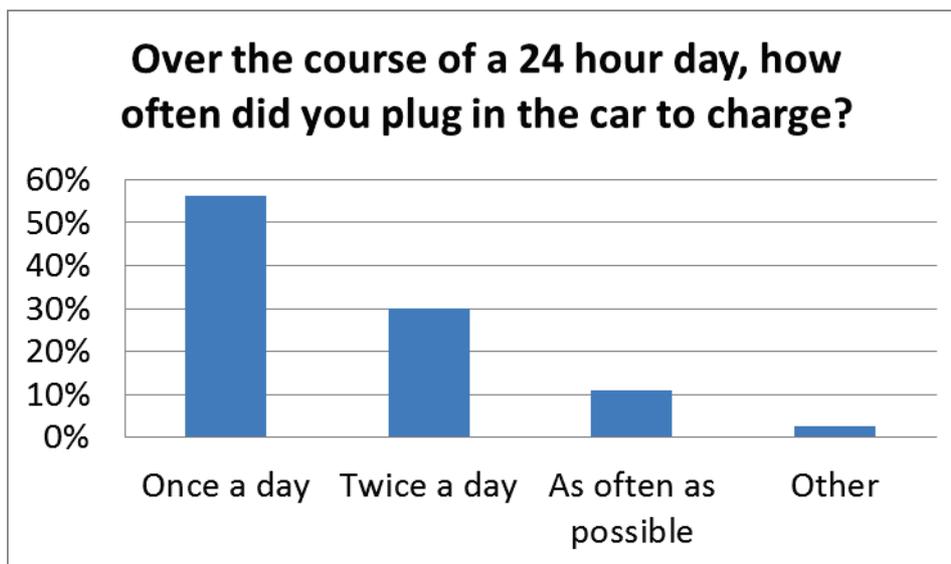


Figure 5 – Recharging frequency as described by EV drivers in the post-trial questionnaire.

As shown in Figure 5, 56% of drivers answered that they charged their vehicles once per day. A further 30% of drivers said that they charged their vehicle twice a day. 11% of drivers charged as often as possible. Most of the charge events took place during the day and only 10% of all recorded charge events took place during the night between 0:00am and 6:00am, when electricity demand is lowest in the UK. Smart charging could therefore be used to start charging events when either renewable energy is available or when demand on the energy grid is lowest. There have been numerous local and small-scale trial across Europe to demonstrate EV charging management systems. However, these trials should be widened in order to harmonise communication protocols between EVs and the grid, to increase the number of vehicles on trial and to standardise energy billing. It is also important to understand driver behaviour better. Large scale trials need to take into account future smart grid capabilities and develop the understanding of real world charging behaviour of drivers.

Conclusion and further work

The North East of England has become a prominent test bed for electric vehicle technology and infrastructure. Through the joint effort of industry, academia and the Local Authorities in this region an ambitious vision to become a low carbon region enabled by renewable energy, intelligent networks and innovative design has been developed. As part of this strategy, over

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300 standard publicly accessible EV charging points and Domestic chargers have been installed across the North East. Results of the SwitchEV demonstrator trial have shown how individuals and pool drivers use electric vehicles.

Potential barriers to the uptake of EVs such as available range, lack of charging infrastructure and charging length are often only perceived problems. Intelligent transport systems such as satellite navigation systems, range estimators, smart chargers could help overcome some of those barriers and increase drivers' confidence in EVs.

Other trials such as smartCEM [6] will demonstrate the use of intelligent transport systems such as EV-navigation, EV-efficient driving, EV-trip management, EV-charging station management and EV-sharing management in order to determine how the use of ITS can improve drivers' confidence in EVs and increase the uptake of those vehicles.

Acknowledgement

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