What is needed to achieve mass-market adoption of Plug-in Electric Vehicles in the UK?

G Beard, N Kinnear, S Skippon, H Al-Katib

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Foreward

Threats from Car Traffic, a 2007 book edited by Tommy Garling and Linda Steg, highlighted twin threats posed by road transport: its carbon dioxide emissions that contribute to global climate change, and its urban air pollution that causes illnesses and premature deaths. A decade after the book was published these threats remain.

The potential for further improvements in the internal combustion engine technology that today powers most of our cars and vans is limited. It is clear that a new solution is needed. Plug-in Vehicles (PiVs) are the main contenders to be that solution. Battery Electric Vehicles, powered entirely from rechargeable batteries, are true tailpipe zero-emission vehicles. At present they are relatively expensive and can be limited in range, but the pace of improvement is rapid. Meanwhile Plug-in Hybrid Electric Vehicles combine the emission-free driving of an electric powertrain for shorter distances with the range of an internal combustion engine powertrain for longer journeys.

To address the twin threats, the UK government has set the target of a complete transition away from conventional petrol and diesel engines in new vehicles by 2040. PiVs are the main option to replace them. The transition, though, will involve more than just a technological revolution. It will be a socio-technical revolution, dependent as much on how individuals and society respond to PiVs as on the availability of the new vehicles themselves. Although enthusiasts and innovators are already using PiVs, mass adoption by the mainstream of consumer drivers will be needed if this initiative is to succeed.

That is where the TRL-led Consumers, Vehicles, and Energy Integration (CVEI) project, funded by the Energy Technologies Institute, comes in. The majority of UK drivers have no experience of PiVs, so it is very difficult for them to say at what point PiVs will be their preferred choice of vehicle. The CVEI project has given 200 mainstream consumer drivers direct experience of using both a Battery Electric Vehicle and a Plug-in Hybrid Electric Vehicle before exploring their preferences in depth. Their answers will give us the most comprehensive, scientifically rigorous, and representative picture of how far and how fast the transition to PiVs will progress. It is a must-read for policymakers, the electricity and automotive sectors, and others with an interest in helping our society mitigate the environmental and air quality threats we face.

Richard Cuerden
TRL, Academy Director

Introduction: The Consumers, Vehicles and Energy Integration (CVEI) project

Project aim

The CVEI project aims to investigate challenges and opportunities involved in transitioning to a secure and sustainable low carbon vehicle fleet. The project explores how the integration of vehicles with the energy supply system can benefit vehicle users, vehicle manufacturers and those involved in the supply of energy.

The objective of the project is to inform UK Government and European policy and to help shape energy and automotive industry products, propositions and investment strategies. In addition to developing new knowledge and understanding, the project aims to develop an integrated set of analytical tools that can be used to model future market scenarios in order to test the impact of future policy, industry and societal choices.

TRL (Transport Research Laboratory), a global centre of excellence for research and innovation in surface transport, is the lead organisation in the CVEI consortium which consists of Baringa, Cenex, EDF, Element Energy, EV Connect, Shell and The Behavioural Insights Team. The CVEI project is funded by the Energy Technologies Institute (ETI).

Project lead

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Relevance

The UK is bound by legal requirements set out in the Climate Change Act (2008) to reduce CO2 emissions in 2050 by 80% compared with levels in 1990. Legal limits for air pollution are also set out in the European Union's Ambient Air Quality Directive. Over the last few decades air quality has been improving; sulphur dioxide emissions have decreased by 95% since 1970, particulate matter has decreased by 73% and nitrogen oxides have decreased by 69%[1]. Despite this common poor air quality in the UK still represents a significant risk to health[2].

Transport is a significant contributor to air quality, accounting for 27% of overall UK greenhouse gas emissions[3]. Adoption of Ultra-Low Emission Vehicles (ULEVs) is a key step for reducing transport emissions. The CVEI project is generating knowledge to understand the factors which affect adoption of Plug-in Vehicles (PiVs), that is, to understand the barriers and motivators influencing consumers' willingness to adopt. This will feed into policy recommendations for how to increase rates of PiV adoption so as to meet air quality targets.

Why do we need electric vehicles?

It is evident that large numbers of the population are exposed to harmful levels of air pollution, and poor quality air has a significant detrimental effect on health (Public Health England, 2014[4]). Figures from the UK Department for Business, Energy and Industrial Strategy (BEIS) estimate total greenhouse gas emissions from road transport were around 114 million tonnes in 2016; this accounts for approximately 27% of all emissions in the UK, with passenger cars and light duty vehicles accounting for 19% of all emissions[5]. It is clear that transport emissions must be reduced.

Ultra-low emission vehicles (ULEVs) – and ultimately, zero emission vehicles (ZEVs) – are crucial to achieve this aim. Investment into the development of ULEVs, ZEVs and accompanying infrastructure is increasing. In 2011, the UK government's 'Carbon Plan'[6] set out the vision that "almost every car and van will be a ULEV" by 2050 (p.47) and that this would require "almost all new cars and vans sold to be near-zero emission at the tailpipe by 2040" (p. 47). This strategy was reconfirmed in the 2017 'Air quality plan' [7] and the 2018 'Road to Zero' strategy[8], which outline £2.7 billion of funding to tackle roadside pollution, including around £1 billion investment into ULEV development, £100 million for new buses and retrofit of existing buses, £50 million for a Plug-in Taxi programme and £80 million for charging infrastructure.

To ensure investments are effective, the factors which affect adoption of PiVs must be understood; in other words, the barriers and motivators influencing consumers' willingness to adopt. It is not sufficient to simply assume the mass-market will adopt these vehicles. Instead the needs of mass-market consumers must be understood and catered for in order to encourage adoption of these technologies over traditional higher polluting vehicles.

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1. UK plan for tackling roadside nitrogen dioxide concentrations (July, 2017): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633269/air-quality-plan-overview.pdf
2. Public Health England (2014): https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
3. BEIS (2018). Final UK greenhouse gas emissions national statistics: 1990-2016, Department for Business, Energy and Industrial Strategy (BEIS): https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016
4. Public Health England (2014): Estimating Local Mortality Burdens associated with Particulate Air Pollution: https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
5. BEIS (2018). Final UK greenhouse gas emissions national statistics: 1990-2016, Department for Business, Energy and Industrial Strategy (BEIS): https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016
6. HM Government: The carbon Plan: Delivering our low carbon future: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf
7. UK Government plan for roadside NO2 concentrations: https://www.gov.uk/government/news/plan-for-roadside-no2-concentrations-published
8. UK Office for Low Emission Vehicles (2018) – Reducing emissions from road transport: Road to Zero Strategy: https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy

How do we predict EV adoption?

New technologies and innovations, including PiVs, are typically first adopted by a small proportion of the population early (the 'Innovators') before the majority of the population adopt a bit later (the 'early adopters' and 'mass-market'). Differences in adoption behaviour are driven by individual characteristics and attitudes. For example, the Innovators who adopt earliest do so largely without direct social influence from others and are likely to have particular personal motives which are supported by the adoption behaviour.

The most widely accepted and used theory of technological adoption is Rogers' Diffusion Theory. In Diffusion Theory adopters are segmented operationally by a behavioural measure – their time to adoption. 'Innovators' are defined statistically as those whose times to adoption are shorter than two standard deviations away from the population mean time to adoption. In other words, Innovators represent the first 2.5% (approximately) of the eventual adopter population, assuming a normal distribution.

In the UK there are around 32 million passenger cars. The share of this market accounted for by PiVs has increased substantially; from around 0.15% in 2013 to just less than 2% in 2017 (Figure 1).

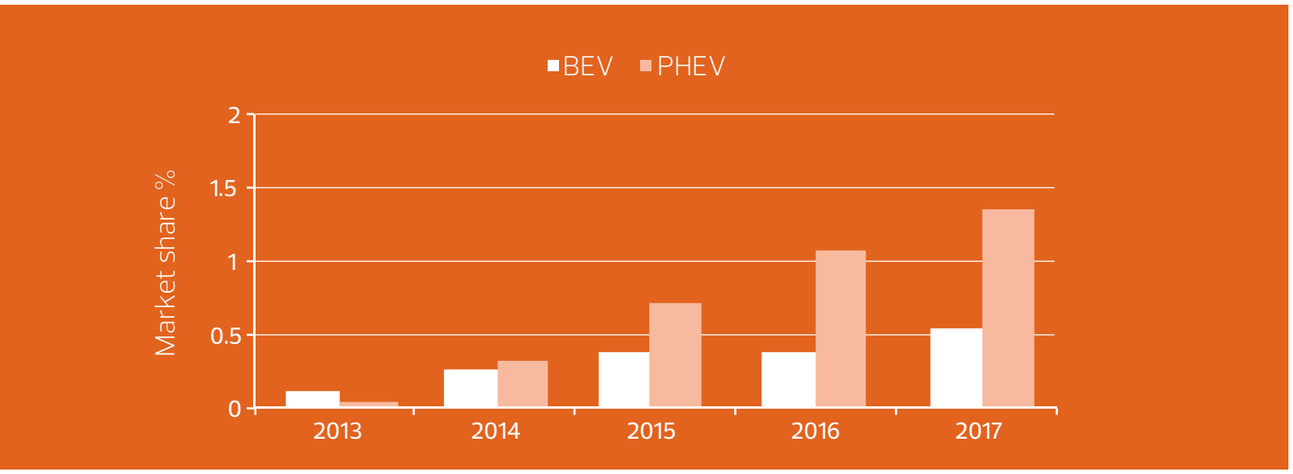

Figure 1: PiV market share in the UK (2013-2017)[9]

Nevertheless, the market share is still relatively small compared to other parts of Europe; the UK failed to make the list of Top 10 European countries in 2017, which is largely dominated by Norway, particularly in terms of BEVs (Figure 2). According to Diffusion Theory, all current PiV owners in the UK are Innovators, meaning the technology has not yet broken through into the early adopters and mass-market. Further, the market share of PHEVs is over twice as large as BEVs. PHEVs may be seen as a useful 'gateway' vehicle to help familiarise consumers with the practical implications of operating a plug-in vehicle; they are still classed as 'ultra-low' emission, so are a positive step for achieving the UK government's air quality targets, but clearly are more polluting than BEVs which are zero emission.

9. Data retrieved 27th April 2018 from www.eafo.uk/content/united-kingdom

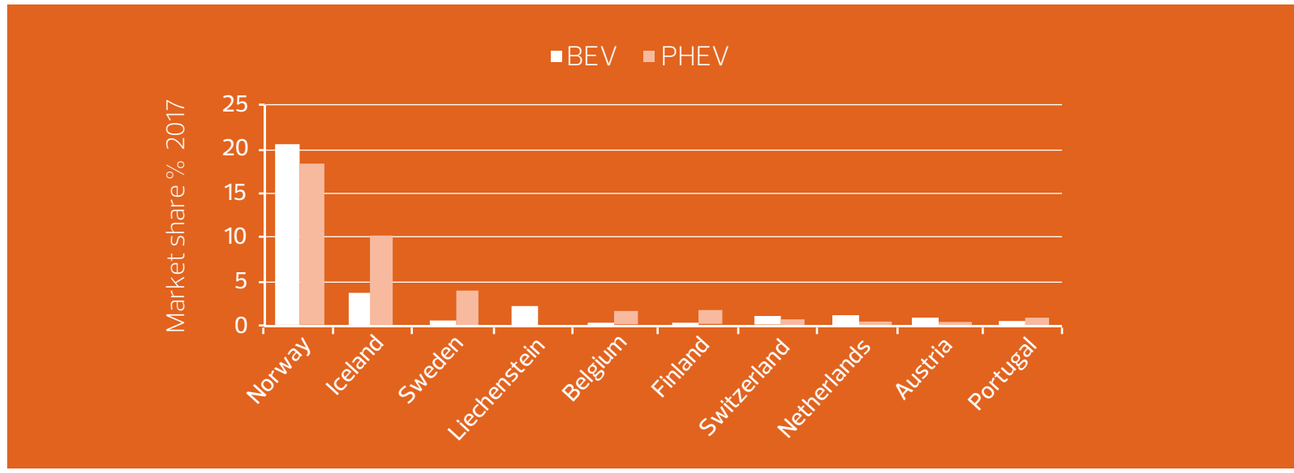

Figure 2: Top 10 countries in Europe with highest PiV market share (2017)[10]

To predict the likely uptake of PiVs in the UK it is important to understand the barriers and motivators which influence a consumer's decision to purchase a PiV; in particular, work is required to understand how to increase the market share of BEVs which are zero emission. Previous literature to date has identified a range of barriers and motivators for purchasing PiVs, which includes:

- The 'All Electric Range' (AER) and charge time of the vehicle
- Purchase cost, running costs, and depreciation rate
- Availability of public charging
- Access to public transport and alternative vehicles
- 'PiV perks' (e.g. bus lanes access, free congestion charge, etc)
- Consumer perceptions of PiVs and the extent to which they match or mismatch their own personal, social and environmental goals

However, this has mainly stemmed from research with Innovators (i.e. the segment of consumers who adopt PiVs first) and individuals who have limited knowledge or experience of PiVs (i.e. consumers who are 'psychologically distant' from PiVs). The attitudes and behaviours of Innovators cannot be used to accurately predict the adoption behaviour of this group. Further, if individuals lack direct experience with PiVs (i.e. they are psychologically distant from them), they will tend to construe PiVs at a high-level, in abstract terms, rather than in concrete terms that relate directly to their lifestyle.

These limitations hinder our ability to accurately predict adoption in the mass-market, that is, to understand how the majority of consumers in the UK will respond to PiVs, and what the most salient barriers and motivators are. To improve understanding of what is needed to achieve mass-market uptake of PiVs, the relative importance of the barriers and motivators for mass-market consumers' willingness to purchase a PiV must be established.

10. Data retrieved 27th April 2018 from www.eafo.uk/content/united-kingdom

What is the CVEI project doing?

The CVEI project includes trials on PiV uptake and PiV charging. This report is concerned with the Consumer Uptake Trial, and a later report will cover the Consumer Charging Trials.

The Consumer Uptake Trial is a world-first. It aims to understand the willingness of mass-market consumers to adopt PiVs. This is critical information if we are to understand how to develop the wider UK energy system so that it can cope with the demands that will be placed upon it by electric vehicles.

Between September 2017 and May 2018, 200 members of the public were loaned a Battery Electric Vehicle (BEV), a Plug-in Hybrid Electric Vehicle (PHEV), and a regular petrol vehicle, and asked to compare them in their everyday driving. TRL collected data from more than 11,000 journeys – around 84,000 miles of driving - and over 1,700 charging events.

Through a series of detailed surveys, including a Choice Experiment, the factors which influence these consumers' decisions to purchase a PiV are being explored. Ultimately, the trial seeks to provide evidence to address the question:

What will be the rates of adoption of BEVs and PHEVs by mainstream consumers between now and 2050?

There is no other trial in the UK in which mass-market consumers have been given direct experience of using both a BEV and a PHEV for their everyday driving. It is therefore unique in its application of a controlled scientific experimental design to measure mainstream consumers' willingness to adopt both PHEVs and BEVs following experience with a mid-sized family vehicle of both types, and an equivalent petrol car as a control.

The wider goal of the CVEI project is to model the impact of increased PiV charging demand on the wider UK energy system for the period to 2050. The validity of that analysis depends on having a clear picture of the adoption of PiVs over the coming decades. The data collected from this study will advance understanding of mainstream consumers' willingness to adopt and will ensure that the outputs of modelling the uptake of PiVs are as valid as possible.

From the previous literature, a range of PiV attributes such as AER, cost, and recharge time, plus external factors such as availability of public charging, have been identified as potential barriers and motivators to willingness to purchase a PiV. A specific set of research questions will be explored in the Consumer Uptake Trial to build on this knowledge, and will include investigation of the impact of several factors on willingness to purchase a PiV:

- AER
- Charge time
- Purchase cost
- Running costs
- Rate of depreciation
- Personal characteristics (e.g. personality, demographics)
- Personal-situational variables (e.g. income, annual mileage)
- Access to public transport, public charging, and alternative vehicles
- 'PiV perks' (e.g. bus lanes access, free congestion charge, etc

The outputs of this study will feed into policy recommendations for interventions which are needed to optimise the uptake of PiVs in the mass-market. It will also help us to better understand and plan for the UK's future electric vehicle charging needs.

Disclaimer

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Report prepared by: G Beard, N Kinnear, S Skippon, H Al-Katib

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enquiries@trl.co.uk
www.trl.co.uk
TRL Crowthorne House, Nine Mile Ride,
Wokingham, Berks, UK, RG40 3GA

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