Transportation Research Part A 67 (2014) 96–109

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Who will buy electric vehicles? Identifying early adopters in Germany

Patrick Plötz *, Uta Schneider, Joachim Globisch, Elisabeth Dütschke

Fraunhofer Institute for Systems and Innovation Research (ISI), Breslauer Strasse 48, 76139 Karlsruhe, Germany

ARTICLE INFO

Article history:
Received 25 October 2013
Received in revised form 6 June 2014
Accepted 20 June 2014

Keywords:
Electric vehicles
Early adopter
Market diffusion
Consumer behaviour

ABSTRACT

Electric vehicles (EVs) have noteworthy potential to reduce global and local emissions and are expected to become a relevant future market for vehicle sales. Both policy makers and car manufacturers have an interest to understand the first large EV user group, frequently referred to as 'early adopters'. However, there are only a few empirical results available for this important group. In this paper, we analyse and discuss several empirical data sets from Germany, characterising this user group from both a user and a product perspective, i.e. who is willing to buy an EV and who should buy one. Our results show that the most likely group of private EV buyers in Germany are middle-aged men with technical professions living in rural or suburban multi-person households. They own a large share of vehicles in general, are more likely to profit from the economical benefits of these vehicles due to their annual vehicle kilometres travelled and the share of inner-city driving. They state a higher willingness to buy electric vehicles than other potential adopter groups and their higher socio-economic status allows them to purchase EVs. In contrast to this, inhabitants of major cities are less likely to buy EVs since they form a small group of car owners in general, their mileage is too low for EVs to pay off economically and they state lower interest and lower willingness to pay for EVs than other groups. Our results indicate that transport policy promoting EVs should focus on middle-aged men with families from rural and suburban cities as first private EV buyers.

1. Introduction

Electric vehicles (EVs) are an innovative propulsion technology that can help to reduce greenhouse gas emissions from the transport sector as well as local emissions (Chan, 2007; Bradley and Frank, 2009). Currently, most passenger cars worldwide are powered by internal combustion engines (ICEs), whereas EVs are fully or partially powered by electric motors. Here, we reserve the term "EV" for plug-in electric vehicles, i.e. vehicles that store the energy for propulsion in a battery that can be recharged via an external power supply (Chan, 2007). Thus, EVs in the following comprise battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and range-extended electric vehicles (REEVs).

EVs were originally invented more than 150 years ago, but the passenger vehicle market has remained dominated by ICE vehicles (ICEVs). Several attempts to re-introduce EVs to major markets after the oil-price shocks in the 1970s failed (Chan, 2007). However, the situation today is a different one with constantly rising fuel prices, the increasing awareness of the

* Corresponding author. Tel.: +49 721 6809289.
E-mail address: patrick.ploetz@isi.fraunhofer.de (P. Plötz).

http://dx.doi.org/10.1016/j.tra.2014.06.006
0965-8564/

anthropogenic causes of global warming and therefore a growing acceptance of political greenhouse gas emission reduction targets.

Electric propulsion is more efficient than propulsion using ICEs and supports the transition from oil to other energy sources (Helmers and Marx, 2012). Governments and institutions worldwide are therefore fostering the market introduction and market diffusion of electric passenger cars (IEA, 2011). Financial support is available for research and development as well as in the form of subsidies for manufacturers and consumers. However, the market is still in an early phase and so far the share of EVs on the roads is very small compared to conventional vehicles (e.g. in Europe BEVs attain one of the highest market shares in Denmark where they account for 0.3% of vehicle sales, ICCT Europe, 2012). The efficient and effective allocation of public and private investments in electric mobility depends on the identification of promising strategies for market diffusion; i.e. it is essential to identify the likely first buyers of commercially available EVs. It will only be possible to improve the development of EVs in line with the needs and expectations of these groups if there is enough knowledge about them. Similarly, car manufacturers and their marketing strategies are more likely to be successful if they are tailored to likely customers. Governmental support will also be more efficient and effective if incentives address the needs of these groups. Thus, reliable estimates of the characteristics of future customers are of great interest to policy makers and vehicle manufacturers alike.

Like many other countries, Germany has also launched extensive research programmes for battery and vehicle development and introduced field trials to test technology and explore mobility solutions and business models (German Federal Government, 2009). The German government has initiated several programmes and projects since 2009 such as the pilot regions of electro-mobility and four so-called 'show cases for electro-mobility' which aim to help the country achieve its self-set goal of becoming a lead market for electric mobility. In addition, local governments have also become active to promote electric mobility. The ambitious goal as lead market for electric mobility has its roots in the fact that Germany is already a leading player in the market for conventional vehicles (Legler et al., 2009): The car industry is the backbone of the German economy. Worldwide, Germany is fourth on the list of motor vehicle producers (OICA production statistics, 2011) and the most important one in Europe. In order to be able to maintain this position, the German government aims to have one million EVs in Germany by 2020 (German Federal Government, 2009).

So far, however, there are very few EVs on German roads; for passenger cars, the stock share of full EVs was 0.02% in January 2013, hybrid cars had a share of 0.15% (KBA, 2013). Moreover, many of the several thousand vehicles on the roads at present are part of state-funded fleet trials, and have not been purchased by regular customers. If a relatively fast market run-up of EVs is to be successful in Germany and elsewhere, it would be useful to identify those consumer groups that are most likely to actually buy an EV. Against this background, we aim to identify the most likely early adopters of EVs based on data from Germany.

The first consumers of innovative technologies in general are a subject of much interest in the literature, as they are usually decisive for the successful introduction of a new technology. If an innovation is supported early on by a large group of consumers, it is far more likely to successfully and lastingly enter the market. The term "early adopter" is frequently used to refer to such an early user group (Rogers, 2003; Santini and Vyas, 2005). However, the term itself has been defined in different ways. Rogers (2003) distinguishes several groups of innovation adopters and called the second group "early adopters". While he defines the first 2.5% of adopters as "innovators", he calls the following 13.5% "early adopters". These early adopters are described by Rogers (2003) as "typically younger in age, have a higher social status, have more financial lucidity, advanced education, and are more socially forward than late adopters." Santini and Vyas merge Rogers' innovators and early adopters as defined by Moore (2002) into one group. For our analysis of potential EV buyers, we apply the term in a more pragmatic way and use it to refer to those private consumers who are the most likely buyers of EVs in the next few years. With regard to EVs, we refer mainly to BEVs. We make additional reference to PHEVs and REEVs for comparison. Only electric passenger cars are examined in this analysis as the conditions for two-wheelers are different.

The paper is structured as follows. Section 2 provides additional background on EVs and the existing literature on the potential first buyers of EVs. Our approach is introduced in Section 3, followed by the data and methods used (Section 4). Section 5 contains the results of our analysis, followed by a discussion in Section 6. We conclude with a summary.

2. Background and existing literature on potential EV adopters

Today, EVs differ (and will continue to do so at least in the near future) in several respects from ICEVs. An EV is typically more expensive than an ICEV of a comparable size and standard of equipment and has an electric driving range that is smaller than the driving range of a conventional vehicle (Helmers and Marx, 2012). Furthermore, it is typically cheaper to operate and, if driven a sufficient number of vehicle kilometres, its lower operation costs can compensate the higher initial investment (Plötz et al., 2012). From a technical point of view, electric motors deliver high torque even at low motor rotation frequency with short reaction times. Users typically perceive this as dynamic driving with good acceleration. Additionally, electric motors are less noisy and users state this to be an advantage (Dütschke et al., 2012; Graham-Rowe et al., 2012; Skippon and Garwood, 2011; Vilimek et al., 2012). Thus, from a user perspective, driving an EV implies more than a simple exchange of the propulsion technology. It means that users have to take into account the restricted range and the longer time needed for charging instead of quickly filling the fuel tank; they have to adapt to new ways of handling the vehicle, i.e. the implications of the high torque as well as of regenerative braking. Furthermore, they need to develop charging routines and