



Advances in consumer electric vehicle adoption research: A review and research agenda



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ABSTRACT

In spite of the purported positive environmental consequences of electrifying the light duty vehicle fleet, the number of electric vehicles (EVs) in use is still insignificant. One reason for the modest adoption figures is that the mass acceptance of EVs to a large extent is reliant on consumers' perception of EVs. This paper presents a comprehensive overview of the drivers for and barriers against consumer adoption of plug-in EVs, as well as an overview of the theoretical perspectives that have been utilized for understanding consumer intentions and adoption behavior towards EVs. In addition, we identify gaps and limitations in existing research and suggest areas in which future research would be able to contribute.

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Introduction

Electric vehicles (EVs) are currently being introduced as a solution for the problem of dependency on fossil fuels, increasing carbon dioxide (CO₂) emissions, and other environmental issues. Road transport contributes to nearly one-fifth of the EU's total emissions of CO₂, the main greenhouse gas (European Commission, 2012). Furthermore, CO₂ emissions from road transport increased by approximately 23% between 1990 and 2010 and are still rising within the EU. Light-duty vehicles – cars and vans (often called passenger cars) – are a major source of greenhouse gas emissions, producing around 15% of the EU's CO₂ emissions (European Commission, 2012). The majority of these cars currently in traffic are owned by private individuals (ICCT, 2013). Citing the importance of taking action on climate change, many governments have initiated policies for reducing CO₂ emissions by stimulating the production, introduction and adoption of EVs (Brady and O'Mahony, 2011). In spite of the purported positive environmental consequences of electrifying the light duty vehicle fleet the share of EVs in the total number of vehicles sold is still small. In 2011, the EV market share was only 0.06% of the 51.1 million light duty vehicles sold in the EU, U.S., and the key Asian markets (European Commission, 2012). One perspective on such modest adoption figures is that the mass acceptance of EVs is mainly reliant on consumers' perception of them (Schuitema et al., 2013). Consequently, in order to promote EV adoption, it is important to understand how consumers perceive EVs and what the possible drivers for and barriers against consumer EV adoption are. In other words, we need to know what factors influence consumer intentions to purchase EVs.

Literature on consumer EV adoption has analyzed several factors affecting the adoption of EVs. The focus of published studies has been on various aspects of adoption and non-adoption behavior. They have utilized different theories and studied different EVs in different parts of the world. This has made the research fragmented and increasingly hard to know where

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important knowledge gaps lie and where contributions can be made in future research. Consequently there is a developing literature that is in need of an overview in order to point at future research directions. Since the early 2000s, non-rechargeable EVs (mostly known as hybrid electric vehicles) have been offered at commercial scales and a considerable number of studies on consumer perception of these have been published. However, as these types of cars can be viewed as more fuel efficient cars that do not require a significantly different behavior from ordinary cars, the main focus of this paper is on cars that require a different consumer behavior (i.e. plugging the car in to the grid for charging). These cars are most often referred to as plug-in electric vehicles (PEVs). However, since notions from research on non-rechargeable cars to some extent also have implications for PEVs, studies on non-rechargeable cars are discussed where relevant as well. For a more in-depth discussion on different types of EVs, see the method section.

The first objective of this paper is to present a comprehensive overview of the drivers for and barriers against consumer adoption of plug-in EVs. The second objective is to identify gaps and limitations in existing research and suggest a research agenda for the future. The method used for the review will be discussed in next section. Prevalent theoretical frameworks and empirical studies are thereafter reviewed in sections three and four respectively. Finally, in the conclusions and research agenda sections, research opportunities based on the review, contemporary consumer behavior and psychology studies in order to motivate future research on consumer adoption of EVs are elaborated upon.

Method

Different types of EVs

Alternative fuel vehicles (AFVs) are generally described as all types of cars that can be fuelled fully or in part by alternative fuels such as biofuels (ethanol, biogas) and electricity (e.g., [Jansson, 2011](#)). In turn, EVs include vehicles with different technologies such as plug-in hybrid electric vehicles (PHEVs), extended-range battery electric vehicles (E-REVs), battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs). Even though some researchers recognize the use of electric vehicles back to the beginning of the last century ([Daziano and Chiew, 2012](#)), the wider introduction of HEVs to the US and Japanese markets began in the beginning of the current century. From 2007 until now, EVs have evolved to a category of vehicles that do not only include HEVs but also PHEVs, E-REVs and BEVs. These technological advances carry implications for consumer behavior and thus for the type of research that is necessary in order to further our understanding of consumer adoption behavior.

One of the most known forms of an EV today is the hybrid electric vehicle (such as the Toyota Prius). A HEV has an internal combustion engine (ICE) alongside a supplementary electric powertrain consisting of an electric motor driven by a battery. The battery is charged by recovering the energy that would be lost during breaking or directly by the ICE powertrain. Therefore, all the HEV's energy originally comes from the liquid fuel and it can thus be seen as a more fuel-efficient car ([Schuitema et al., 2013](#); [Proff and Kilian, 2012](#)). A plug-in hybrid electric vehicle (PHEV) is a development of the HEV with improved battery capacity and a plug-in charger, which makes it possible to recharge the battery from the electricity grid ([Sovacool and Hirsh, 2009](#); [Egbue and Long, 2012](#)). A PHEV runs on electricity or ICE, but generally has a short all-electric range. An extended-range electric vehicle (E-REV), similar to PHEV, runs on a battery that can be charged from an electric outlet and has a fuel tank which allows the driver to extend the range of driving. A battery electric vehicle (BEV) has an all-electric drivetrain powered from a large capacity battery (compared to PHEV and E-REV), which is recharged from the electricity grid ([Proff and Kilian, 2012](#)). The range of driving on electricity is usually longer in BEVs than PHEVs, as electricity is the only driving power of BEVs.

Similar to [Schuitema et al. \(2013\)](#), we argue that even though HEVs have been considered as EVs in some previous research, they are mainly fuel-efficient cars that do not require a drastic behavior change by consumers, and these cars are therefore not the main focus in this review. In this review we consider EVs as electrified vehicles with batteries that can be charged from an electric outlet. In other words, we term EVs as rechargeable cars and include studies on consumer responses to plug-in EVs which are BEVs, PHEVs and E-REVs. The major challenges for researchers and practitioners is to understand consumer behavior toward PHEVs, E-REVs and BEVs ([Proff and Kilian, 2012](#)) which are more disruptive innovations in transportation technology ([Proost and Van Dender, 2010](#); [Schuitema et al., 2013](#)) and pose different behavioral demands on consumers. For instance, to run on electricity with a PHEV, E-REVS or BEV, drivers should accustom themselves to plugging in the car to the electricity grid and charging the battery while it is not in use and plan ahead for their next drive ([Axsen et al., 2012](#)). Another example of driver concern is experiencing range anxiety. The anxiety is a result of a perceived limited driving range of electric batteries versus the perceived range needed in daily car use, charging time of batteries and lack of infrastructure of charging stations compared to fossil fuel stations ([Sovacool and Hirsh, 2009](#)). Based on these arguments, we mainly review studies from 2007 and forward and we believe that future research on consumer EV adoption behavior would contribute more to overall understanding by focusing mainly on BEVs, but also to some extent on PHEVs and E-REVs.

Identifying relevant studies

To achieve the first objective of this paper a systematic literature review was conducted. Research studies in published peer-reviewed journals focusing on consumer adoption of EVs were searched for in the following databases; Emerald, Jstor,

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