Transportation Research Part D 34 (2015) 122–136

Contents lists available at ScienceDirect

Transportation Research Part D

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

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

Zeinab Rezvani *, Johan Jansson [1], Jan Bodin [1]

Department of Business Administration, Umeå School of Business and Economics, Umeå University, Umeå, Sweden

ARTICLE INFO

Keywords:
Consumer behavior
Electric vehicles
Adoption behavior
Intention
Literature review

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.

Introduction

Electric vehicles (EVs) are currently being introduced as a solution for the problem of dependency on fossil fuels, increasing carbon dioxide (CO_2) emissions, and other environmental issues. Road transport contributes to nearly one-fifth of the EU's total emissions of CO_2, the main greenhouse gas (European Commission, 2012). Furthermore, CO_2 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 CO_2 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 CO_2 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

* Corresponding author at: Umeå University, SE-901 87 Umeå, Sweden. Tel.: +46 (90)786 5000.
E-mail addresses: zeinab.rezvani@umu.se (Z. Rezvani), johan.jansson@umu.se (J. Jansson), jan.bodin@umu.se (J. Bodin).
[1] Tel.: +46 (90)786 5000.

http://dx.doi.org/10.1016/j.trd.2014.10.010
1361-9209/© 2015 The Authors. Published by Elsevier Ltd.

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,

Table 1
Overview of studies and results.

Study details					Results			
Authors (year)	Sample	EV	Method	Main theory	Technical factors	Contextual factors	Cost factors	Individual and social factors
Axsen et al. (2012)	711 representative households in California, USA	EV	Quantitative, online survey	Lifestyle practices theory				Pro-environmental lifestyle, technology oriented lifestyle and openness to change
Burgess et al. (2013)	55 private drivers in the UK	BEV	Qualitative, interviews after three months of trial	Model of sign	Performance, speed, noise, look and style, environmental attributes, car of the future		Purchase cost, running cost	Symbolic meaning of driving EV, personal resistance, first-hand experience
Caperello and Kurani (2011)	36 households in California, USA, tried PHEV for 4–6 weeks	PHEV	Qualitative, interviews, questionnaire, travel diaries	Grounded theory	Confusion in how battery works, perceiving EV as car of future	Finding an appropriate charging station outside the home	Purchase cost, saving fuel cost	Acquiring recharging habit, changing driving habit, uncertainty in social etiquette and norms related to driving and charging an EV
Carley et al. (2013)	2,302 individuals with driving license in the USA	PHEV, BEV	Quantitative, online survey	Rational choice theory	Recharging time, range	Visible charging stations in public	Purchase cost	Education, gender, age, experience with HEVs, environmental beliefs, believe in fossil fuel dependency
Egbue and Long (2012)	481 students, staff and teachers of a technical university (technology enthusiasts, potential buyers of EVs who own ICEs) in USA	PHEV, BEV	Quantitative, online survey	Theory of planned behavior	Safety, performance, range, decreased use of oil and emissions	Charging infrastructure	Purchase cost	Environmental awareness, technology awareness, experience with EVs, sustainability of EVs, interest in EVs
Graham-Rowe et al. (2012)	40 UK non-commercial and ICE vehicles drivers, 20 per type of EV	PHEV, BEV	Qualitative, semi-structured interviews after driving EVs for 7 days	Grounded theory, mainstream consumers' evaluation of EVs after a couple of weeks driving	Battery material & electricity source, environmental impacts, performance, safety, being a work in progress	Charging infrastructure	Purchase cost, saving fuel cost	Less guilt from feeling good and to be useful for the environment
Jensen et al. (2013)	369 Danish drivers	BEV	Quantitative, online survey in two waves (before and after experiencing EV)	Rational choice theory	Carbon emissions, driving range, top speed	Charging stations on the roads and in public places	Purchase cost, fuel cost	Hands-on experience with EV
Krupa et al. (2014)	911 residents in the USA	PHEV	Quantitative, online survey	Rational choice theory	Carbon emissions	Tax incentives, manufacturer rebates	Purchase cost, potential fuel costs saving	Political beliefs, concern for energy independence and climate change
Lane and Potter (2007)	UK residents (owners vs potential buyers, sample size not available)	BEV	Literature review, qualitative and quantitative, interviews and questionnaire	Theory of planned behavior, Value-belief-norm theory, habits, innovation diffusion model	Performance, ease of use, safety, reliability, energy efficiency	Government environmental regulations, fuel prices, financial incentives for buyers of EVs, fuel infrastructure	Purchase cost, long payback time	Pro-environmental identity and lifestyle, knowledge of environmental problems, concern for environment, values, beliefs, personal moral norms and perceived social norms

Lieven et al. (2011)	1,152 German individuals	EV	Quantitative, online survey	Rational choice theory	Range, performance		Purchase price	
Moons and De Pelsmacker (2012)	1,202 Belgian drivers	EV	Quantitative, online survey	Theory of planned behavior, emotions	Range, performance		Purchase price	Emotions, subjective social norms, environmental concern, perceived behavioral control, education, age
Noppers et al. (2014)	105 Dutch residents	EV	Quantitative, survey	Self-congruency, costly signaling theory	Environmental attributes such as carbon emissions, functional or instrumental attributes			Symbols and social status
Peters and Dütschke (2014)	969 German drivers with different experience and interest in EVs	EV	Quantitative, online survey	Diffusion of innovation	Carbon emissions, energy efficiency	Policy measures to decrease the purchase costs	Purchase cost, fuel cost	Compatibility with own values, experience and needs, subjective social norms, triability and experience with EV
Schuitema et al. (2013)	2,700 driving license holders in the UK who had purchased a new car (less than 2 years old) within the last 5 years so they are the potential buyers of EVs in the next five years	PHEV, BEV	Quantitative, online survey	Consumer innovativeness, self-image congruency theory	Performance, practicality and range, perception of PHEV attributes are more positive than for BEV attributes, especially as main car of household		Purchase cost	Pro-environmental identity, hedonic attributes (pleasure of driving, excitement of new technology) and symbolic attributes (fit to lifestyle, feeling proud, feeling embarrassed) of EV
Skippon and Garwood (2011)	56 UK car owners (no one owned an EV type)	BEV	Qualitative and quantitative, interviews after trial period	Signaling theory	Performance including acceleration, less noise and smoothness lower range and long charging time as barrier, pluging in the BEV is not a concern, BEV with 100 miles range as second car and 150 miles as main car can be accepted by some consumers	Availability of charging stations in the city and at work	Purchase cost, saving fuel cost	Environmental concern, symbolic meaning of EV: driver is open to new ideas, like to plan ahead and high conscientiousness, cares about others, small EV is a symbol of an economical car and thus not a symbol of wealth
Zhang et al. (2011)	299 respondents from various driving schools in a city of China who were trainees at the driving school (potential buyers of EVs)	EV	Quantitative, survey	Rational choice theory	Safety, performance	Low fuel price, non-supportive tax policies in China	Purchase and maintenance cost	Number of driving license holders in the family, opinion of peers

Sage, Science Direct, Springer, Wiley, and also in search engines such as ABI Inform (ProQuest), EBSCO, Google Scholar, and Web of Science. Keyword combinations included Electric Vehicles, Alternative Fuel Vehicles, Plug-in hybrid electric vehicles, Battery electric vehicles, green cars, eco-cars, cleaner vehicles, acceptance, consumer adoption, attitude, intention and behavior. The search included articles from 2007 to 2014 and returned a considerable amount of studies discussing one or several of the keywords combined. The first selection criterion was whether the aim of the study was to identify reasons, antecedents, drivers for and barriers against consumer EV adoption behavior, or intentions to adopt plug-in EVs. This criterion resulted in inclusion of both conceptual and empirical papers. However, for the selection of relevant articles, we only included studies with empirical consumer data and results, as we primarily were interested in how research can inform us about actual consumer intentions and behaviors. Some studies have created models to estimate the demand for EVs based on non-attitudinal and behavioral variables such as oil prices and/or different scenarios of financial incentives (i.e. Musti and Kockelman, 2011). Though important for understanding and modeling wider market factors, such studies were excluded since they inform us little of consumer attitudes and behaviors. References of the selected papers were also analyzed and a list of studies was produced. The list of sixteen empirical papers can be found in Table 1.

Theoretical frameworks in consumer EV adoption research: a review

Scholars define consumer adoption of an innovation as a behavioral response comprising of the purchase and use of the innovation (i.e. Schuitema et al., 2013; Huijts et al., 2012; Jansson et al., 2010). Different antecedents or predictors have been theorized to motivate this behavioral response. Different types of intentional measures such as consumer readiness and willingness to adopt the innovation, are the main predictors of adoption behavior and, are in many studies considered as a the proxy variable for adoption behavior (Arts et al., 2011; Schuitema et al., 2013). Thus, our review of the literature shows that consumer EV adoption has mainly been studied by focusing on intentions for adoption in contrast to actual adoption. This is understandable due to the current low market shares of EVs. Furthermore, based on our literature review we conclude that consumer adoption of EVs has been studied predominantly utilizing five categories of theoretical frameworks to which we turn below.

Theory of planned behavior and rational choice theory

The theory of planned behavior (TPB) assumes that human beings make decisions based on rational evaluations of stimuli and the possible consequences of decisions (Ajzen, 1991). The behavior is directly predicted by intentions. Consumer attitude, i.e., the perceived sum of positive and negative possible consequences of a behavior, is a predictor of intentions (Bamberg and Möser, 2007). In addition to attitude, perceived feasibility of the decision or perceived behavioral control (PBC) and perceived expectations of certain reference groups or subjective social norms are also predictors of intentions in the TPB framework. According to the theory, the more a consumer perceives behavior to be a social norm, the more likely he/she intends to perform the behavior (Ajzen, 1991).

A few studies have used TPB to explain and predict consumer adoption of cleaner vehicles (Lane and Potter, 2007). In Moons and De Pelsmacker's (2012) study on consumer adoption of EVs, consumer attitude towards EV adoption behavior was measured using the attitude towards EVs in general and EV attributes such as cost of purchase, range of driving and EV maintenance, in particular. Although attitude in the TPB is the evaluation of positive and negative consequences of the behavior, in applying the TPB in innovation adoption behavior, mostly, attitudes toward the innovation has been in focus (i.e. Pickett-Baker and Ozaki, 2008; Moons and De Pelsmacker (2012); Egbue and Long, 2012).

In addition to attitude, the study by Moons and De Pelsmacker (2012) measures the effect of PBC and subjective social norms on consumer intentions to purchase EVs. In their study, PBC dimensions include whether consumers can afford EVs and whether they can use it in their daily lives (considering for example the limitations in driving range). Subjective social norms are examined with consumer perceptions of peers' ideas about EVs and whether they perceive adoption of EVs to be a social norm or not.

Another important factor in the TPB framework is consumer knowledge and experience which affects attitude and PBC. In the consumer EV adoption research, this construct mostly includes consumer knowledge of environmental impacts of driving cars and experiences with vehicles in general and EVs in particular. Moreover, consumer understanding of conventional vehicle (i.e., ICE) costs of ownership and driving compared to EV costs has been suggested as an important factor affecting attitude and intentions (Lane and Potter, 2007; Sovacool and Hirsh, 2009).

Similar to TPB, which theorizes consumer behavior based on rational evaluations of the consequences, rational choice theory asserts benefits and utility maximization as the basis of human behavior. Several scholars in consumer EV adoption research have considered consumer EV adoption behavior as a more or less rational behavior and have measured consumer attitudes towards EVs using different dimensions to predict consumer purchase intentions for EVs (Carley et al., 2013; Egbue and Long, 2012; Jensen et al., 2013; Krupa et al., 2014; Lieven et al., 2011; Moons and De Pelsmacker, 2012; Zhang et al., 2011). In these studies, consumer attitudes include dimensions such as attitudes towards EVs, alternative fuel vehicles, cars in general, and driving. Particularly, consumer attitudes towards EVs' technical attributes (such as range, and speed) EVs' upfront costs (purchase and installation of optional charging stations), operation costs (charging and maintenance) compared to conventional ICE vehicles, and also related policies to alleviate the up-front costs (i.e. tax rebates) are addressed. Consumer attitudes towards environmental issues have also been considered, which is elaborated upon further below.

EVs are generally considered eco-friendly innovations and thus EV adoption behavior is considered as a pro-environmental behavior. As Bamberg and Möser (2007) assert, pro-environmental behaviors are motivated based on a mix of self-interest (as it is theorized by TPB and rational choice theory) and concern for other people and the ecosystem. While the TPB and rational choice theory are utilized to explain pro-environmental behavior with the self-interest category of motivations, normative theories are normally used to explain the pro-environmental behavior from a different perspective than TPB and rational choice theory.

Normative theories and environmental attitudes

Normative theories such as the value-belief-norm (VBN) theory (Stern, 2000) are utilized to explain pro-environmental behavior with the second part of the motivational mix, concern for others and the ecosystem (Bamberg and Möser, 2007). These theories stem from a different assumption than the TPB and rational choice theory and view internal normative beliefs and values as motives for pro-environmental behavior. In studies on consumer EV adoption behavior, consumer environmental values, beliefs, and norms are theorized to influence the adoption behavior and/or intentions. These constructs and their relationship with adoption are explained by value-belief-norm (VBN) theory of Stern (2000) which has been widely utilized to understand motivations for different types of purchase and non-purchase (such as car curtailment) consumer pro-environmental behaviors (Jansson, 2011). In this theory, pro-environmental behavior is the result of personal moral norms, which are feelings of moral obligations to engage in pro-environmental behavior (Schwartz, 1977). Personal norms are activated by beliefs related to the biosphere and the effects of human action. Beliefs regarding general human actions and the consequent environmental harms are measured with the new ecological paradigm scale (NEP) (Dunlap et al., 2000). In addition, specific beliefs related to the specific behavior of study (i.e. car driving) are also usually measured. Beliefs are affected by personal values which comprise the four value dimensions of Schwartz (1977); altruism (self-transcendence), self-interest (self-enhancement), conservation (traditionalism) and openness to change. Thus the intention or behavior in focus is formed through the chain of personal values, beliefs and norms related to the behavior and the environment (Stern, 2000).

In the consumer EV adoption research, environmental beliefs and consumer awareness of environmental issues and human effects have been theorized to affect the intentions to purchase EVs (Lane and Potter, 2007; Carley et al., 2013; Egbue and Long, 2012; Skippon and Garwood, 2011). Consumer attitudes towards EVs as so-called environmentally-friendly vehicles have also been examined (Egbue and Long, 2012; Moons and De Pelsmacker, 2012) since in some exploratory studies (Caperello and Kurani, 2011), consumers expressed doubt about the positive environmental impacts of EVs. It has been argued that consumer concern for the environment will not necessarily result in pro-environmental behavior and there is a gap between the environmental attitude and behavior (Oliver and Rosen, 2010; Kollmuss and Agyeman, 2002; Stern, 2000). One possible explanation for this attitude-behavior gap is that other goals in life are more important and thus prioritized relatively to the pro-environmental goals and values (Stern, 2000).

Symbols, self-identity and lifestyle

In consumer EV adoption literature, scholars assert that symbols and self-identity also play significant roles in consumer adoption behavior and intentions (Skippon and Garwood, 2011; Graham-Rowe et al., 2012; Axsen et al., 2012; Schuitema et al., 2013; Burgess et al., 2013). Symbols or symbolic meanings of products and their relationship with self-identity and purchases of products have been described based on distinctive psychological and sociological theories in the consumer EV adoption literature. Saussure's (1965) model of sign, Sirgy's (1986) self-image congruency theory, Giddens' (1991) narratives of self, and Miller's (2009) costly signaling theory are the theoretical basis in the literature which account for EV symbolism and consumer adoption. Saussure (1965) state that a product like a car is a signifier or symbol of ideas and meanings. An example of signified meaning in the case of EVs is concern for the environment. Symbols are used by consumers in the construction and expression of self-identity. Products like cars do not only satisfy consumers' practical needs such as mobility in the case of cars, but they also have symbolic meanings which help consumers define and express who they are (Skippon and Garwood, 2011; Burgess et al., 2013). Giddens (1991) and Dittmar (1992; cited in Steg, 2005) assert that individuals' choices such as purchase of a car are not only based on practical concerns or instrumental values but also on symbolic values and narratives of self which connects their choices with their self- identity. In the case a person has bought an EV because of concern for environment, he/she may consider him/herself as an environmentalist or perceive that they are signifying this to others. Miller's (2009) costly signaling theory emphasizes the fact that human altruistic behaviors, such as purchase of EVs (Noppers et al., 2014; Skippon and Garwood, 2011), express and signals the identity and status stronger when the behavior costs (financial and non-financial such as behavioral change, time and energy) are higher.

Moreover, Schuitema et al. (2013) and Noppers et al. (2014) utilize self-image congruency theory (Sirgy, 1986) to connect self-image/identity with purchase intentions of EVs. This theory asserts that consistency of a product image with consumer's self-image influences the purchase intentions positively. Similar to self-congruency theory and self-narratives, Axsen et al. (2012) utilize lifestyle theory (Giddens, 1991), stating that inconsistency between a technology such as EV and consumer lifestyle or engagement with certain activities and self-identity, may result in the rejection of EVs. As a result, Axsen et al. (2012) hypothesize a relationship between a pro-environmental lifestyle and purchase intentions for EVs. They further elaborate this relationship with examining the respondents' interests in technology and degree of openness to change.

Thus, symbols and lifestyle associated with driving EVs play an important role in consumer adoption of EVs. Moreover, they are related to consumer's attitudes towards different attributes of EVs such as price, performance and style and also the environmental attributes such as energy efficiency. In the study by Schuitema et al. (2013) the role of symbolic attributes of EVs in consumer intentions to purchase EVs has been theorized in relation to consumer innovativeness as well to which we turn to next.

Diffusion of innovations and consumer innovativeness

Peters and Dütschke (2014) utilize diffusion of innovation (DOI) theory (Rogers, 2003) to identify and profile early EV adopters. Rogers (1995, 2003) recognizes five categories of factors that influence the adoption decision, namely relative advantage, compatibility, complexity, trialability and observability. Relative advantage is the degree to which the innovation is perceived to be better than the current product it is replacing. Compatibility determines the consistency of the innovation with values, experiences and needs of consumers. Complexity explains the degree of difficulty for the innovation to be understood and used by consumers. Trialability determines the extent to which the innovation can be trialed, modified, and experienced before the adoption. Finally, observability determines the degree to which the innovation can be visible to others.

Related to DOI, Schuitema et al. (2013) has linked intention to adopt EVs to consumer innovativeness, which is defined as the tendency to buy new products relatively earlier than the majority of consumers (Foxall et al., 1998 cited in Schuitema et al., 2013). They utilize three motivational reasons for consumer innovativeness namely instrumental, hedonic and symbolic motives, suggested by Vandecasteele and Geeuens (2010). Instrumental motives point to the consumer focus on functionality of the car. Hedonic innovativeness highlights the importance of anticipated emotions, such as pleasure from experiencing the car. Symbolic innovativeness indicates the significance of symbolic attributes of a car for the consumers (Schuitema et al., 2013).

The diffusion of innovation (DOI) framework has been extensively utilized to understand early adopters's and potential adopters' perceptions of innovation characteristics in relation to many innovations and eco-innovations. However, most DOI research does not investigate the role of an important factor which some recent research discuss in the adoption of innovations, namely emotions. Recent studies on adoption of innovations suggest considering the role of consumers' emotions in this regard (Wood and Moreau, 2006; Watson and Spence, 2007; Shih and Schau, 2011). For example, consumers' expectation of future events and consequent emotions as factors affecting the adoption behavior has been studied in a recent paper by Shih and Schau (2011). They find that the perceived rate of innovation, or rate at which consumers perceive technological conditions are changing in the market place (Shih and Schau, 2011, p. 2), would result in anticipating regret and consequently delay the purchase of the technological innovation. In another study, Wood and Moreau (2006) show that consumers' expectations of complexity from a technological innovation is a significant factor in creating emotions, which consequently affect innovation evaluations and thus the purchase decision. Based on these findings on the role of emotions in the adoption of innovations, we believe that understanding the role of emotions in the adoption of EVs is important as well.

Consumer emotions

As mentioned in the consumer innovativeness section, affective or hedonic attributes, such as pleasure and joy, are suggested to influence EV purchase intentions (Schuitema et al., 2013). In addition, Moons and De Pelsmacker (2012) has hypothesized consumer emotions towards EVs as an added dimension to the theory of planned behavior (TPB) by Ajzen (1991). They have supported this theorization through other theories of emotions in the consumption area such as Richins (1997) and stated that consumption emotions related to EVs and cars, and driving in general, are expected to influence consumer intentions toward EVs. Based on Norman (2004), Moons and De Pelsmacker (2012) have defined three emotional processing levels: visceral, behavioral and reflective. Visceral emotions are based on consumer's perceptions of instrumental and visual attributes of EVs such as style, design, and size. Behavioral emotions are related to consumer's emotions from using and experiencing driving EVs. Reflective emotions are related to self-image and identity connected to driving an EV. Moons and De Pelsmacker (2012) measured these emotional levels by asking consumers about the extent of feeling positive versus negative emotions from the visceral, behavioral and reflective aspects of EVs. However, this study did not measure specific consumption emotions, as Richins (1997) theorizes, or emotions such as pleasure, joy, pride, embarrassment as was found by Schuitema et al. (2013). Understanding specific emotions related to adoption of EVs are important for designing communication, education and policies which can overcome some of the barriers against consumer adoption of EVs. Although emotions are found to be important and influential in pro-environmental behavior (Bamberg and Möser, 2007; Steg and Vlek, 2009) and choice of cars (Steg, 2005), we are still lacking theorization of emotions in relation to pro-environmental behavior (such as adoption of EVs) and also the link of emotions with other factors such as values, beliefs, and norms.

Consumer EV adoption behavior: a review of empirical research

The second objective of this paper is to provide a comprehensive perspective on the drivers to and barriers against consumer adoption of EVs, and to establish the type of research needed in order to further develop the current understanding of consumer EVs adoption. Thus, this section reviews findings from different empirical studies which comprise predictors of consumer intention to adopt, or actual EV adoption behavior. The findings are categorized into five sub-sections which are connected to the five theoretical frameworks described in the previous section. To illustrate the drivers to and barriers against consumer EV adoption, Table 1 indicates the results of studies, together with the characteristics of these studies such as type of EV (BEV or PHEV, if it was reported by the authors), sample, method and the main theory. Based on the literature review, three categories of attitudinal factors were found. These are presented in the table as technical factors, cost factors, and contextual factors. Factors from the normative theories, symbols and lifestyle theories, diffusion of innovation and innovativeness, and consumer emotions, are categorized in the social and individual factors column of the table.

A behavior influenced by attitudinal factors

Among the attitudinal factors, first, ownership and operation costs of EVs compared to conventional ICE cars are discussed in the majority of research on EVs. Whereas the high front cost of EVs is often found to be a barrier to adoption, the lower operational costs encourage EV adoption (Caperello and Kurani, 2011; Graham-Rowe et al., 2012; Sovacool and Hirsh, 2009; Egbue and Long, 2012; Jensen et al., 2013; Lieven et al., 2011; Zhang et al., 2011). Some studies assert that consumers lack the basic knowledge of calculating the real costs of ICE cars and payback time of EVs (Caperello and Kurani, 2011; Sovacool and Hirsh, 2009; Lane and Potter, 2007). In addition, some authors believe that potential adopters lack the knowledge for calculating the real price of driving an ICE which can affect the adoption of EVs (Caperello and Kurani, 2011; Turrentine and Kurani, 2007). Thus, educating consumers on calculating the real costs of driving ICEs and EVs has been mentioned in previous research (Caperello and Kurani, 2011), and yet no study provides research or suggestions for further research on how to educate consumers on this important matter. Mostly, policy makers are responsible to alleviate the front cost of EVs utilizing different financial incentives. Although financial incentives, provided by governments or manufacturers, are shown to positively influence the intention to adopt EVs in some studies (Krupa et al., 2014; Lane and Potter, 2007; Zhang et al., 2011), the effects of them and related educational efforts need to be further studied in order to avoid some of the pitfalls common when using financial incentives to increase the demand for pro-environmental products.

The second common attitudinal factor is related to consumer perception of supportive policy or the contextual forces. In 2007, EU ministers agreed to outline three 2020 goals: to cut carbon emissions by 20%, increase the share of renewables in the energy mix to 20% and improve energy savings by 20%. In line with these goals, the European Commission supports a Europe-wide electro-mobility initiative, Green eMotion, worth €41.8 million, to exchange and develop know-how and facilitate the market roll-out of electric vehicles in Europe (European Commission, 2012). In addition to such supports, national governmental bodies develop their own supportive policies for reducing the emissions and enhancing the adoption of EVs. For example Sweden has a goal for 2030 to become fossil fuel independent. Considering that Sweden produces more than 50% of its electricity from renewables such as hydro power (European Commission, 2012), such policy mainly targets the transportation sector and can possibly drive increased adoption of EVs and AFVs.

However, researchers in consumer behavior have concerns about the consumer's perception and acceptance of policies. Lane and Potter (2007) argue that government regulations regarding environment, fuel prices and financial incentives for buyers of cleaner vehicles, together with development of fuel infrastructure will influence the adoption. Moreover, they argue that policies should be well understood by consumers otherwise policies will fail to affect adoption. A similar argument by Sovacool and Hirsh (2009) also highlights that some policies, or frequent changes in policies, can create uncertainties for consumers and make them resistant and consequently hinder the adoption of for example EVs. Still, as Stern et al. (1999) state, policy acceptance can have positive effects on consumers' attitude and intention to act pro-environmentally. Future research could disentangle consumers' perception of certain policies related to EVs and its effect on the attitude and intention towards EVs. For instance, consumer perception and acceptance of certain policies, such as Sweden's policy for becoming fossil fuel independent, and the effect on consumers' attitude and intention to buy EVs can potentially be interesting for policy makers in order to develop future supportive policies. While UK and mainland European countries' regulations and especially fuel prices are mostly in-line with reducing emissions of the transportation sector, environmental regulations and fuel prices are often found to be a barrier of EV adoption in the USA and China (Sovacool and Hirsh, 2009; Zhang et al., 2011). Low fossil fuel (gasoline and diesel) prices make fuel saving more or less meaningless for consumers. However, apart from consumers being motivated by the financial incentives like tax rebates or government's cash refunds on purchase of EVs in USA and UK (Ozaki and Sevastyanova, 2011; Krupa et al., 2014), some EV adopters in the USA and UK touch upon the national independency from foreign oil as a motivation to purchase PHEVs (Krupa et al., 2014) and BEVs (Skippon and Garwood, 2011).

Consumer's attitudes towards EVs' technical features and perceptions of utility of EVs are the third group of factors that has been shown to both drive and hinder the rate of intention and/or adoption. Several studies have assessed consumer perceptions of instrumental or functional attributes of EVs (i.e. Egbue and Long, 2012; Ozaki and Sevastyanova, 2011; Zhang et al., 2011; Skippon and Garwood, 2011; Jensen et al., 2013; Carley et al., 2013; Krupa et al., 2014). Among the technical attributes, the limited range of BEVs is a well-known adoption barrier (Skippon and Garwood, 2011) while the range is of less concern for potential PHEVs adopters (Krupa et al., 2014). In a study by Skippon and Garwood (2011), 56 UK households were given the opportunity to drive a BEV for a week. The limited range of 100 miles was perceived to be sufficient to own a BEV as a second car and 34% of the participants of the study stated that 150 miles would make BEV suitable as the first car. It has been argued that limited driving range is more of a perceived barrier than an actual one. However, Jensen et al.'s (2013) study of 369 Danish drivers who drove BEVs for a trial period found that the range of BEV is a real concern, even after experiencing the BEV, since it is less than what individuals wish to have.

Moreover, range limitation and charging behavior can be considered as the adaptation demand or the needed change of behavior relative to conventional ICE cars. Such changes of behavior make consumers resistant to the acceptance of BEVs (Caperello and Kurani, 2011; Lane and Potter, 2007). However, it is likely that "range anxiety" will disappear altogether among consumers who may consider BEVs mainly for urban transportation. As researchers point out (Franke et al., 2011; Pearre et al., 2011), there are psychological barriers in adaptation to limited range of BEVs which can possibly be overcome by interventions such as interface design and driver training. Further research can explore innovative design and charging processes for BEVs which pose less behavioral change and resistance for consumers.

Other than range, EVs' performance, safety, size and style have been reported as barriers to adoption in the studies of potential buyers' intentions to adopt EVs for some potential buyers (Egbue and Long, 2012). For some UK consumers who tried BEVs in a trial period, some aspects of performance such as acceleration, smoothness and less noise were evaluated as positive (Skippon and Garwood, 2011), while for some other UK consumers in the study by Graham-Rowe et al. (2012) performance and safety of EVs were evaluated negatively after the trial period. In a study in Denmark, Jensen et al. (2013) showed that hands-on experience with BEVs would alter the consumer's preferences and attitudes in a positive way towards them. The implication being that providing opportunities for consumers to get hands-on experience with EVs through manufacturers or municipalities trial programs can potentially change some consumers' attitudes towards EVs.

Technological improvements will continue to develop performance, safety, size and style for EVs. However, consumer perceptions of these attributes remain important for researchers and practitioners to understand. As Schuitema et al. (2013) has shown, consumer perceptions of instrumental attributes affect their perceptions of symbolic and hedonic attributes, which influence the intention to purchase EVs. Thus, continuous research on consumers' perceptions of EVs' instrumental attributes and the resulting symbolic and hedonic meanings can help car manufacturers in improving EVs and the marketing of them.

In addition to the attitudinal factors, knowledge and perceived behavioral control, social norms or the neighbor effect have also been shown to significantly influence consumer intentions to adopt EVs (Kahn, 2007; Lane and Potter, 2007; Ozaki and Sevastyanova, 2011; Egbue and Long, 2012; Moons and De Pelsmacker, 2012). While studies confirm the effect of green neighborhoods (Kahn, 2007) on consumer behavior, the ways in which such green neighborhoods have been formed is not studied. Further understanding of green neighborhoods and factors contributing in constructing them can have implications for policy makers to further develop policies which not only support individuals but also their neighborhoods for green behaviors such as adoption of EVs.

A pro-environmental behavior

Various studies on consumer adoption of EVs have assumed that EVs are eco-innovations which have the potential to reduce the environmental problems of the transportation sector (i.e. Egbue and Long, 2012; Lane and Potter, 2007; Schuitema et al., 2013). Consequently, EV adoption behavior has been considered as a pro-environmental behavior and factors related to pro-environmental behavior are often included in the analysis of predicting EV adoption. In this regard, consumer EV adoption literature has mainly examined the roles of pro-environmental attitudes, values, beliefs and norms and their relationship with intentions to purchase EVs. The role of these environmental-related variables has also been found in exploratory studies (i.e. Skippon and Garwood, 2011) where some EV adopters expressed protecting the environment as a motivation for their choice of car. Perception of EVs' positive environmental impacts also affected the intention to adopt EVs for potential EV adopters (Egbue and Long, 2012). However, the opposite has also been found, i.e. in the exploratory study by Graham-Rowe et al. (2012), while discussing the environmental impacts of battery production and electricity generation, consumers expressed doubt about positive environmental consequences of EV adoption. Interestingly, in a study by Caperello and Kurani (2011) the environmental impact of EVs was not mentioned by consumers who drove a PHEV for a trial period as either a positive or a negative attribute of the vehicle. On one hand, these results may imply that the environmental impact of EVs is among the least important attributes, at least for some of the consumers (Lane and Potter, 2007). On the other hand, these results can amplify the importance of making the electricity and battery production and usage less environmentally harmful and also then communicating the environmental benefits of EVs. A study by Axsen and Kurani (2013) shows that coupling green electricity and EVs will increase the intentions to adopt EVs in some consumer groups in the USA. However, little is known about the perception of EV's environmental impacts in many countries (other than US and UK) where electricity is generated from different mixes of renewable and non-renewable sources.

Although some consumers might be unaware or skeptical about the possible environmental benefits of EVs, adoption of EVs are shown to be motivated by consumer's pro-environmental attitudes, values, and beliefs in some studies (i.e. Egbue and Long, 2012; Carley et al., 2013; Krupa et al., 2014). Pro-environmental values and concern for the environment was mentioned as important reasons by some drivers who drove EVs for trial periods (Graham-Rowe et al., 2012; Skippon and

Garwood, 2011). Pro-environmental values among potential adopters have also been shown to affect attitudes and intentions to adopt EVs in a positive way. In addition, knowledge and beliefs about environmental issues are also among the motivating factors for potential buyers of EVs (Axsen et al., 2012; Egbue and Long, 2012; Carley et al., 2013; Krupa et al., 2014; Lane and Potter, 2007).

In conclusion, similar to other types of pro-environmental behaviors, level of pro-environmental values, beliefs, norms and attitudes can be a predictor of consumer intention or actual adoption behavior toward EVs. However, several researchers such as Lane and Potter (2007) discuss the familiar attitude-behavior gap in this regard and believe that expressing a positive attitude will not necessarily result in a consistent consumer EV adoption behavior. To close the gap, the environmental self-efficacy, as theorized by Oliver and Rosen (2010), has shown to have the potential to shrink the gap and increase the likelihood of pro-environmental behavior. However, ways in which environmental self-efficacy can be enhanced need further exploration. Oliver and Rosen (2010) suggest policy and education as potential interventions, and call for further research. Further research could also investigate the prevention versus promotion focus, framing of policies and education, and their effect on consumer's environmental self-efficacy. Prevention focused cues aim at minimizing negative outcomes or losses, and promotion focus cues aim at maximizing positive outcomes or gains (Lee et al., 2010). Research in the context of consumer EV adoption behavior can further explore the potential impact of policy and education related to environmental issues on consumer self-efficacy or self-esteem related to driving EVs.

Furthermore, on the basis of social cognitive theory (Bandura, 1986), self-efficacy can be enhanced by vicarious learning which is learning from observing peers performing a task. Accordingly, it is possible that consumer's environmental self-efficacy in the context of adopting an EV would be enhanced by communicating about current EV adopters' thoughts and viewpoints of their vehicle' environmental impacts. Additionally, while the existence of green neighborhoods in the study by Kahn (2007) is usually interpreted as the neighbor effect and a social norm, it can also imply the vicarious learning in the neighborhood.

Finally, recent studies propose some interventions, which have been examined in order to close the attitude-behavior gap for pro-environmental behaviors. For instance, 'imagined group discussion' is an intervention studied by Meleady et al. (2012) to promote cooperative and pro-social behavior. The results in their study show that just asking consumers to imagine themselves in a group discussion on environmental issues would increase the consumer intention for pro-environmental behaviors. Such interventions could be studied in the EV adoption context and possible effects on intentions can be investigated.

An innovation adoption behavior

Similar to other innovations and eco-innovations, the issue of compatibility of EVs in the everyday lives of consumers and their habits has also been found as an important contributing factor for potential adopters (Graham-Rowe et al., 2012; Peters and Dütschke, 2014). Governments in charge of infrastructure can do much to increase the compatibility of EVs in the daily life of drivers for example in creating a suitable and visible charging infrastructure (Carley et al., 2013; Egbue and Long, 2012; Jensen et al., 2013; Krupa et al., 2014). In addition, the ways in which EVs are provided for consumers by companies, can play an important role (Budde Christensen et al., 2012; Lane and Potter, 2007; Sovacool and Hirsh, 2009). For example, separating the battery and car ownership from each other, could play an important role (Budde Christensen et al., 2012).

A dark side of technological improvements is consumers' perception and anticipation of product obsolescence (Graham-Rowe et al., 2012). Consumer perceptions of speed at which technology is improving can create resistance in the purchase of current technologies as consumers might expect that new and better technologies will arrive soon and make the current products obsolete. Accordingly, some consumers view PHEVs, BEVs and HEVs as the car of the future (Flamm and Weinstein, 2012; Graham-Rowe et al., 2012). Caulfield et al. (2010) found that 55% of respondents agreed that the HEV would be the car of choice in the future. Technological innovation adoption literature also finds this perception important. Holak et al. (1987) and Shih and Schau (2011) have found that consumers express their expectation of future product improvements together with an expected sense of regret, and incorporate it in their behavior, which mostly results in delays in purchasing new technological products. Furthermore, Shih and Schau (2011) studied the moderating effect of justification or using accessible reasons for resolving the conflict, regret and guilt associated with a choice, and found high levels of regret among consumers who were justified for the purchase of technology based on their acute need for it. These findings which are contradictory to the previous findings on the role of justifications (e.g., Shih and Schau, 2011), calls for more research on the role of justifications in alleviating the consumers' regret in the adoption of EVs and eco-innovations. In the EV adoption context, different justifications related to technological or environmental aspects of EVs and their role in resolving the EV obsolescence issue for consumers can be investigated and findings can have implications for the communication and promotion of EVs.

A symbolic behavior

EVs do not only satisfy the transportation needs for adopters, but they also act as symbols to construct and express identity (Skippon and Garwood, 2011; Graham-Rowe et al., 2012; Axsen et al., 2012; Schuitema et al., 2013; Burgess et al., 2013). In the study by Graham-Rowe et al. (2012), mainstream UK drivers, after seven days of driving EVs (BEVs and PHEVs), expressed three different symbolic meanings of EVs and associated self-identity. One group of drivers associated BEVs with a slow-moving lifestyle and stated feelings of embarrassment when driving an BEV and consequently asserted disinterest in the lifestyle and the BEV. A second group of drivers, although concerned for environment, did not want to be associated with the green-driving identity related to BEVs. A third group, viewed driving the PHEV as gaining social identity related to a forward-thinking, modern and technology-oriented personality. In another qualitative study in the UK, participants, after driving the BEV for a trial period, stated that owning a BEV signals being open to new ideas and caring for others (Skippon and Garwood, 2011).

In two quantitative studies, congruency of EVs with the self-identity of consumers was shown to influence adoption intentions. Schuitema et al. (2013) examined two different identities, namely environmentalist and car-authority identity, in potential adopters of EVs and show that consumers with pro-environmental identity perceive EV attributes more positively than consumers who do not have such a self-identity. Nevertheless, consumers with a car-authority identity (who serve as authority figures for their peers concerning cars), have neither positive, nor negative perceptions of EV attributes. Thus, these authority figures are still not convinced that EVs offer environmental benefits (Schuitema et al., 2013).

Axsen's et al. (2012) study identifies five clusters of potential adopters in the USA, namely engaged greens, aspiring greens, low-tech greens, traditionalists and techies. Engaged green are involved in pro-environmental and technology oriented lifestyle practices and are open to change. Aspiring greens are less involved with pro-environmental practices and have less interest in technology compared to engaged greens but also show openness to change. The engaged greens and aspiring greens are more prone to adopt EVs according to the study. Low-tech greens show the least openness to change and interest in technology, and compared to the last two clusters of greens, they are more likely to practice curtailment and non-consumption behavior (driving less and use of alternative mode of transportation instead of driving) rather adopting EVs. The two clusters of traditionalists and techies are low in engaging in pro-environmental practices and openness to change. However, techies show interest in technologies and thus are prone to adopt EVs for the technological reasons and not the environmental reasons (Axsen et al., 2012). These results are somewhat contradictory to Jansson et al. (2009) who studied general AFV adoption and found that adopters were motivated by both environmental and technology reasons for adoption.

The studies by Schuitema et al. (2013) and Axsen et al. (2012) consider pro-environmental orientation as a self-identity or lifestyle. The second self-identity, car-authority identity (Schuitema et al., 2013) can be thought of as a subclass of technology orientation (Axsen et al., 2012) where individuals are experts on cars. However, car-authority consumers state neither positive nor negative perceptions of EV attributes and were not convinced about the environmental impacts of EVs (Schuitema et al., 2013), while non-greens with technology oriented lifestyle are likely to adopt EVs (Axsen et al., 2012). These results can imply that communicating EVs to technology oriented-consumers may need to put less emphasis on environmental benefits of EVs and mainly focus on technological aspects of the innovation. However this might not be true for all types of AFVs as the Jansson et al. (2009) study points to.

While the symbolic meanings of EVs in the qualitative studies of Graham-Rowe et al. (2012) and Skippon and Garwood (2011) are not limited to the environmental aspect and embracing new technology, recent research has mostly focused on these two symbolic meanings and self-identities. As stated in these studies, new products such as EVs need to be identified with symbolic meanings and self-identities which are desired by the target consumers. Therefore, understanding the symbolic meanings of EVs for potential adopters and the role of these meanings in forming intentions to purchase EVs can be important for future studies on EVs. Of particular interest can be identifying and examining the symbolic meanings of EVs for potential adopters in different countries, as the symbolic meanings are expected to be different in different parts of the world (Heffner et al., 2007). Moreover, in previous research, different symbolic meanings were attached to different EV types, BEVs and PHEVs. Future research can examine the differences between BEVs and PHEVs in terms of symbolic meanings and also certain aspects in the symbolic meaning of EVs. Noppers et al. (2014) point out to the fact that potential adopters of EVs can indicate less importance for the symbolic meanings of EVs compared to instrumental and environmental attributes of EVs for social desirability purposes. "They may not fully know or want to acknowledge that they buy and use sustainable innovations in order to show off or to feel good about themselves. Rather, people stress instrumental and environmental attributes of sustainable innovations." (Noppers et al., 2014, p. 11). Thus, examining the ways in which social desirability bias in research on symbolic meanings can be reduced is suggested as well as asking about the symbolic meanings in an indirect way (e.g., Noppers et al., 2014).

An emotional behavior

Consumer emotions and feelings have been shown to affect attitudes and intentions to adopt EVs (Moons and De Pelsmacker, 2012; Schuitema et al., 2013). For potential buyers of EVs, the perception of positive feelings from driving an EV was positively correlated with consumer attitudes and intentions to adopt EVs (Moons and De Pelsmacker, 2012). However, this study does not provide further information on the type of positive feelings that consumers anticipated to experience with EVs.

In the exploratory study of Graham-Rowe et al. (2012), various emotions were expressed by consumers who drove EVs (BEVs and PHEVs) for a trial period. On one hand, "feeling good" or "less guilt" from driving a purportedly environmentally friendly car was mentioned by some consumers. On the other hand, some consumers stated the feeling of "embarrassment" from driving a small and economic car (Graham-Rowe et al., 2012). Built on this study, Schuitema et al. (2013) examined the role of hedonic or emotional attributes of EVs in consumer intentions to adopt. They used the emotions expressed by consumers in the Graham-Rowe et al. (2012) study for measuring consumers' perceptions of EVs' hedonic attributes. Therefore the emotions or hedonic attributes include pleasantness and joy, excitement, embarrassment and pride. The results show that more positive perceptions of instrumental attributes of EVs lead to more positive emotions towards EVs, which in turn positively influence the intention to adopt EVs (Schuitema et al., 2013).

Consumer emotions are shown to be important in the domain of car purchase (Steg, 2005), pro-environmental behavior (Bamberg and Möser, 2007; Onwezen et al., 2013; Steg and Vlek, 2009), consumer adoption of innovations (Shih and Schau, 2011; Watson and Spence, 2007) and consumer adoption of EVs (Graham-Rowe et al., 2012; Moons and De Pelsmacker, 2012; Schuitema et al., 2013). However, we find consumer emotions as being a relatively overlooked aspect in consumer EV adoption research as the antecedents and consequences of this important factor has not been fully investigated. Previous research on consumer adoption of innovations and pro-environmental behavior found different antecedents to the emotions such as consumer's environmental beliefs and norms, internal attribution, social norms, and perceptions of uncertainty and change of technology (Bamberg and Möser, 2007; Frijda et al., 1989; Lazarus, 1991; Shih and Schau, 2011; Watson and Spence, 2007). Moreover, the influence of emotions on intentions to adopt are theorized and shown to be varied in different pro-environmental behavior contexts (Bamberg and Möser, 2007; Onwezen et al., 2013). Thus we believe that investigating the antecedents and consequences of emotions in consumer EV adoption behavior can contribute to the understanding of consumer EV adoption and consequently provide implications for designing communication, education and policy related to the diffusion EVs.

Discussion and research agenda

As shown in this review, consumer EV adoption has been studied using several theoretical frameworks. Based on the published literature, we find five main themes on consumer EV adoption behavior. Although treated separately here, these themes co-exist and are integrated into each other in many studies. For example in some studies (Moons and De Pelsmacker, 2012; Schuitema et al., 2013), consumer EV adoption behavior has been explained as a mix of planned, emotional and symbolic behavior. These types of studies, where several theoretical perspectives are used in furthering the understanding of EV adoption, are promising since they provide a deeper understanding.

In addition to the themes, we argue that the literature on consumer EV adoption has some methodological limitations, which call for future research and alternative methodological approaches. Many studies take the form of surveys, with participants who have had no direct experience of EVs on which to base their responses. In this way, they are psychologically distant from EVs, and this limits the validity of inferences about adoption drawn from their responses. Among those studies where participants have been given direct experience of using EVs, many have sample biases, of which the most common is to use samples of potential early adopters or people already especially motivated to consider EVs. Such samples cannot be considered representative of the majority of consumers, and it is treacherous to generalize to the majority from findings based on their responses. Studies using representative samples and not only focusing on intention to adopt, but actual ("unforced") adoption, are necessary to understand how attitudes influence EV adoption and how these relations change over time. As the market for EVs is developing it becomes much more feasible and important to focus on the actual adoption behavior concerning EVs and not only on intentions. In addition, the gap between the intention and actual behavior is important to understand in the EV context. For closing the well-known attitude-behavior gap (Stern, 2000), examining interventions such as imagined group discussions can provide further understanding of consumer EV adoption behavior/intentions.

Another important limitation of the current research concerns consumer knowledge and skills to calculate and compare the financial benefits and costs of EVs and ICEs (Lane and Potter, 2007). Future research on how to educate consumers on this matter can have implications for policy makers and marketing specialists for communicating the financial benefits and costs of EVs versus ICEs. Considering that this ratio is likely to change over time, for example by ICEs continuously becoming more fuel efficient, makes this type of understanding even more important.

Consumer perceptions of current policies related to the environment, fuels, vehicles and particularly EVs can affect their behavior towards EVs (Lane and Potter, 2007; Sovacool, 2009). Research as such can provide further understanding of individuals' perceptions of policies and the possible consequences for policy makers. An important area of study here is to understand when consumers actively support a policy or merely accept it. Furthermore, the prevention versus promotion focus (Lee et al., 2010), framing of policies and education, and their effect on consumer's environmental self-efficacy can be investigated.

As detailed in the review, social norms and the neighbor effect have been found to influence consumer EV adoption behavior (Egbue and Long, 2012; Zhang et al., 2011). The ways in which green neighborhoods (Kahn, 2007) are formed can be a subject for future research. The findings can help policy makers in designing policies which not only empower individuals but also neighborhoods for pro-environmental behaviors.

In relation to attitudes and behavior, a fundamental question is whether consumers see a connection between EVs and protecting the environment. This is important to explore since several EVs marketed today, as well as promotional policies, use environmental arguments and imagery. However, there are also examples of car manufacturers that do not market their EVs primarily using environmental arguments and instead focus on the superior performance of their cars (e.g., Tesla Motors). In the exploratory study by Graham-Rowe et al. (2012), while discussing the environmental impacts of battery production and electricity generation, consumers expressed doubt about any positive environmental consequences of EV adoption. Little is known about the perception of EV's environmental impacts in many countries (other than the US and UK) where electricity is generated from different mixes of renewable and non-renewable sources.

Another attitudinal factor is consumer self-efficacy or perceived effectiveness which has been shown to have important roles in consumer intentions to adopt HEVs (Oliver and Rosen, 2010). Policy and education are suggested to influence consumer's self-efficacy. Examining the effect of differently framed policies and educational messages in the forms of promotion versus prevention focus on consumer's self-efficacy and intentions to purchase EVs can yield important findings and implications.

Consumer's perception of EVs as car of the future which is also known as the obsolescence aspect can hinder adoption (Graham-Rowe et al., 2012). The role of different justifications in the communication of EVs in resolving this consumer perception is an important research topic. The justifications can be related to the environmental aspects or the technical aspects of EVs for example.

During the last few years, the fuel efficiency of ICEs has increased rather dramatically. Thus, the EV, perceived as an innovation by consumers, might get more competition from ICEs with new types of innovative engines and other technologies. This poses challenges to EV manufacturers to continuously re-innovate EVs if the aim is to make consumers perceive it as an innovation over time. This also calls for continuous research on the perceived differences of ICEs and EVs among consumers.

In relation to behavioral changes an overlooked area in EV research is habits and routines, which according to Stern (2000) are important determinants of environmentally significant behaviors. Habits, regarded as automated behaviors, might take a long time to change but once established, will make consumers reflect less upon their behaviors. This might mean that current infrastructure for fuelling fossil dependent car fleet might become obsolete and new types of infrastructure and thus traffic patterns might develop. In relation to this, habits might be more important to study in relation to BEVs than HEVs since HEV behavior is more similar to ICE behavior. Researchers have called for future research to explore the design and the charging process in BEVs which pose less behavioral change and resistance for consumers (Caperello and Kurani, 2011; Lane and Potter, 2007)

While different symbolic meanings are attached to EVs by EV adopters in the USA (Caperello and Kurani, 2011) and UK (Graham-Rowe et al., 2012; Skippon and Garwood, 2011), little is known about symbolic meanings of EVs in other countries. There is a need to explore and compare symbolic meanings of EVs in a diversity of cultures, since symbolic meaning is context-dependent. Moreover, limited numbers of the symbols associated with EVs have been used in exploratory studies (i.e. Graham-Rowe et al., 2012; Skippon and Garwood, 2011), while mainly environmentally and technologically oriented ones, are examined in relation to potential adopters' intentions towards EVs. Also, further studies can investigate the symbolic meanings that are associated to the different types of EVs (PHEVs and BEVs).

The existing literature has predominantly focused on consumer adoption of EVs while light-duty fleet managers can also be buyers of EVs. Sierzchula (2014) identifies several motivations for adoption of EVs by fleet managers of 14 firms in the Netherlands. "Testing new technology, lowering environmental impacts, government grants and improving the organization's public image" generally influence the fleet manager's decision to adopt EVs (Sierzchula, 2014). Future research in this area can further explore the adoption of EVs by fleet managers in different countries with different governmental incentives to identify the factors that influence the fleet manager's adoption decision. Moreover, future research can further explore whether driving and experiencing an EV at work can potentially influence the drivers to adopt EVs as a private car or not.

Finally, we find consumer emotions an overlooked aspect in consumer EV adoption research. A recent study by Schuitema et al. (2013) has provided a stepping stone for the study of emotions and their antecedents in the consumer EV adoption context. To continue the research, we see an opportunity in developing this area further with theoretical frameworks of emotions in psychology, PEB, ethics and consumer behavior areas. Communication messages, education and policies can create specific cognitive and emotional responses in consumers and consequently influence their decisions and behaviors. Understanding the cognitive and emotional responses can help marketing specialists and policy makers in designing their communication, education and policies to possibly overcome some barriers to adoption of EVs.

Acknowledgment

The authors would like to thank the anonymous reviewers for their constructive and valuable comments. In addition, Jansson acknowledges the financial support from The Swedish Energy Agency and from The Swedish Foundation for Humanities and Social Sciences.

References

Ajzen, I., 1991. The theory of planned behavior. Organizational Behav. Human Decision Processes 50, 179–211.

Arts, J.W.C., Frambach, R.T., Bijmolt, T.H.A., 2011. Generalizations on consumer innovation adoption: A meta-analysis on drivers of intention and behavior. Int. J. Res. Mark. 28 (2), 134–144. http://dx.doi.org/10.1016/j.ijresmar.2010.11.002.

Axsen, J., Kurani, K.S., 2013. Connecting plug-in vehicles with green electricity through consumer demand. Environ. Res. Lett. 8 (1), 014045. http://dx.doi.org/10.1088/1748-9326/8/1/014045.

Axsen, J., TyreeHageman, J., Lentz, A., 2012. Lifestyle practices and pro-environmental technology. Ecol. Econ. 82, 64–74. http://dx.doi.org/10.1016/j.ecolecon.2012.07.013.

Bamberg, S., Möser, G., 2007. Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behaviour. J. Environ. Psychol. 27 (1), 14–25. http://dx.doi.org/10.1016/j.jenvp.2006.12.002.

Bandura, A., 1986. Social Foundations of Thought and Action: A Social Cognitive Theory. Prentice-Hall.

Brady, J., O'Mahony, M., 2011. Travel to work in Dublin. The potential impacts of electric vehicles on climate change and urban air quality. Transp. Res. D Transp. Environ. 16 (2), 188–193. http://dx.doi.org/10.1016/j.trd.2010.09.006.

Budde Christensen, T., Wells, P., Cipcigan, L., 2012. Can innovative business models overcome resistance to electric vehicles? Better place and battery electric cars in Denmark. Energy Policy 48, 498–505. http://dx.doi.org/10.1016/j.enpol.2012.05.054.

Burgess, M., King, N., Harris, M., Lewis, E., 2013. Electric vehicle drivers' reported interactions with the public: Driving stereotype change? Transport. Res. F Traffic Psychol. Behav. 17, 33–44. http://dx.doi.org/10.1016/j.trf.2012.09.003.

Caperello, N.D., Kurani, K.S., 2011. Households' stories of their encounters with a plug-in hybrid electric vehicle. Environ. Behav. 1–16. http://dx.doi.org/10.1177/0013916511402057.

Carley, S., Krause, R.M., Lane, B.W., Graham, J.D., 2013. Intent to purchase a plug-in electric vehicle: a survey of early impressions in large US cites. Transp. Res. D Transp. Environ. 18, 39–45. http://dx.doi.org/10.1016/j.trd.2012.09.007.

Caulfield, B., Farrell, S., McMahon, B., 2010. Examining individuals preferences for hybrid electric and alternatively fuelled vehicles. Transp. Policy 17 (6), 381–387. http://dx.doi.org/10.1016/j.tranpol.2010.04.005.

Daziano, R.A., Chiew, E., 2012. Electric vehicles rising from the dead: data needs for forecasting consumer response toward sustainable energy sources in personal transportation. Energy Policy 51, 876–894. http://dx.doi.org/10.1016/j.enpol.2012.09.040.

Dunlap, R.E., Van Liere, K.D., Mertig, A.G., Jones, R.E., 2000. Measuring endorsement of the new ecological paradigm: A revised NEP scale. J. Soc. Issues 56 (3), 425–442. http://dx.doi.org/10.1111/0022-4537.00176.

Egbue, O., Long, S., 2012. Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. Energy Policy 48, 717–729. http://dx.doi.org/10.1016/j.enpol.2012.06.009.

European Commission, 2012. Transport. Clean Transport. Retrieved July 2013 from: http://ec.europa.eu/transport/themes/urban/vehicles/road/electric_en.htm.

Flamm, B.J., Weinstein, A., 2012. Constraints to green vehicle ownership: a focus group study. Transp. Res. Part D 17 (2), 108–115. http://dx.doi.org/10.1016/j.trd.2011.09.013.

Franke, T., Neumann, I., Bühler, F., Cocron, P., Krems, J.F., 2011. Experiencing range in an electric vehicle: understanding psychological barriers. Appl. Psychol. http://dx.doi.org/10.1111/j.1464-0597.2011.00474.x.

Frijda, N.H., Kuipers, P., ter Schure, E., 1989. Relations among emotion, appraisal, and emotional action readiness. J. Pers. Soc. Psychol. 57 (2), 212–228.

Giddens, A., 1991. Modernity and Self-Identity. Stanford University Press, Stanford.

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., Stannard, J., 2012. Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: a qualitative analysis of responses and evaluations. Transp. Res. A Policy Pract. 46 (1), 140–153. http://dx.doi.org/10.1016/j.tra.2011.09.008.

Heffner, R.R., Kurani, K.S., Turrentine, T.S., 2007. Symbolism in California's early market for hybrid electric vehicles. Transp. Res. D Transp. Environ. 12 (6), 396–413. http://dx.doi.org/10.1016/j.trd.2007.04.003.

Holak, S.L., Lehmann, D.R., Sultan, F., 1987. The role of expectations in the adoption of innovative consumer durables: some preliminary evidence. J. Retail. 63 (3), 243, http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=6353729&site=ehost-live.

Huijts, N.M.A., Molin, E.J.E., Steg, L., 2012. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. Renew. Sust. Energ. Rev. 16 (1), 525–531.

Jansson, J., 2011. Consumer eco-innovation adoption: assessing attitudinal factors and perceived product characteristics. Bus. Strategy Environ. 210, 192–210. http://dx.doi.org/10.1002/bse.690.

Jansson, J., Marell, A., Nordlund, A., 2009. Elucidating green consumers: A cluster analytic approach on proenvironmental purchase and curtailment behaviors. J. Euromarketing 18 (4), 245–267. http://dx.doi.org/10.1080/10496480903364242.

Jansson, J., Marell, A., Nordlund, A., 2010. Green consumer behavior: determinants of curtailment and eco-innovation adoption. J. Consumer Mark. 27 (4), 358–370. http://dx.doi.org/10.1108/07363761011052396.

Jensen, A.F., Cherchi, E., Mabit, S.L., 2013. On the stability of preferences and attitudes before and after experiencing an electric vehicle. Transp. Res. D Transp. Environ. 25, 24–32. http://dx.doi.org/10.1016/j.trd.2013.07.006.

Kahn, M.E., 2007. Do greens drive Hummers or hybrids? Environmental ideology as a determinant of consumer choice. Journal of Environmental Economics and Management 54 (2), 129–145. http://dx.doi.org/10.1016/j.jeem.2007.05.001.

Kollmuss, A., Agyeman, J., 2002. Mind the gap : why do people act environmentally and what are the barriers to pro-environmental behavior? Environ. Educ. Res. 8 (3). http://dx.doi.org/10.1080/1350462022014540.

Krupa, J.S., Rizzo, D.M., Eppstein, M.J., Brad Lanute, D., Gaalema, D.E., Lakkaraju, K., Warrender, C.E., 2014. Analysis of a consumer survey on plug-in hybrid electric vehicles. Transp. Res. A Policy Pract. 64, 14–31. http://dx.doi.org/10.1016/j.tra.2014.02.019).

Lane, B., Potter, S., 2007. The adoption of cleaner vehicles in the UK: exploring the consumer attitude–action gap. J. Cleaner Prod. 15 (11–12), 1085–1092. http://dx.doi.org/10.1016/j.jclepro.2006.05.026.

Lazarus, R.S., 1991. Progress on a cognitive-motivational-relational theory of emotion. Am. Psychol. 46 (8), 819–834, Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1928936.

Lee, A.Y., Keller, P.A., Sternthal, B., 2010. Value from regulatory construal fit: the persuasive impact of fit between consumer goals and message concreteness. J. Consumer Res. 36 (5), 735–747.

Lieven, T., Mühlmeier, S., Henkel, S., Waller, J.F., 2011. Who will buy electric cars? An empirical study in Germany. Transp. Res. D Transp. Environ. 16 (3), 236–243. http://dx.doi.org/10.1016/j.trd.2010.12.001.

Meleady, R., Hopthrow, T., Crisp, R.J., 2012. Simulating social dilemmas: promoting cooperative behavior through imagined group discussion. J. Pers. Soc. Psychol. 104 (5), 839–853. http://dx.doi.org/10.1037/a0031233.

Miller, G.F., 2009. Spent: Sex, Evolution, and Consumer Behavior. Viking, New York, NY.

Moons, I., De Pelsmacker, P., 2012. Emotions as determinants of electric car usage intention. J. Mark. Manage. 28 (3–4), 195–237.

Musti, S., Kockelman, K.M., 2011. Evolution of the household vehicle fleet: anticipating fleet composition, PHEV adoption and GHG emissions in Austin, Texas. Transp. Res. A Policy Pract 45 (8), 707–720. http://dx.doi.org/10.1016/j.tra.2011.04.011.

Noppers, E.H., Keizer, K., Bolderdijk, J.W., Steg, L., 2014. The adoption of sustainable innovations: driven by symbolic and environmental motives. Global Environ. Change 25, 52–62. http://dx.doi.org/10.1016/j.gloenvcha.2014.01.012.

Norman, D.A., 2004. Emotional Design. Basic Books, New York.

Oliver, J.D., Rosen, D.E., 2010. Applying the environmental propensity framework: a segmented approach to hybrid electric vehicle marketing strategies. J. Mark. Theory Pract. 18 (4), 377–393. http://dx.doi.org/10.2753/MTP1069-6679180405.

Onwezen, M.C., Antonides, G., Bartels, J., 2013. The norm activation model: an exploration of the functions of anticipated pride and guilt in pro-environmental behaviour. J. Econ. Psychol. 39, 141–153. http://dx.doi.org/10.1016/j.joep.2013.07.005.

Ozaki, R., Sevastyanova, K., 2011. Going hybrid: an analysis of consumer purchase motivations. Energy Policy 39 (5), 2217–2227. http://dx.doi.org/10.1016/j.enpol.2010.04.024.

Pearre, N.S., Kempton, W., Guensler, R.L., Elango, V.V., 2011. Electric vehicles: how much range is required for a day's driving? Transp. Res. C Emerg. Technol. 19 (6), 1171–1184. http://dx.doi.org/10.1016/j.trc.2010.12.010.

Peters, A., Dütschke, E., 2014. How do consumers perceive electric vehicles? A comparison of german consumer groups. J. Environ. Policy Plan. (September), 1–19. http://dx.doi.org/10.1080/1523908X.2013.879037.

Pickett-Baker, J., Ozaki, R., 2008. Pro-environmental products: marketing influence on consumer purchase decision. J. Consumer Mark. 25 (5), 281–293. http://dx.doi.org/10.1108/07363760810890516.

Proff, H., Kilian, D., 2012. Competitiveness of the EU automotive industry in electric vehicles. 30, p. 355. Available from: http://ec.europa.eu/enterprise/sectors/automotive/files/projects/report-duisburg-essen-electric-vehicles_en.pdf.
Proost, S., Van Dender, K., 2010. What Sustainable Road Transport Future? Trends and Policy Options, OECD, Paris.
Richins, M.L., 1997. Measuring emotions in consumption experience. J. Consum. Res. 24 (2), 127–146.
Rogers, E.M., 2003. Diffusion of Innovations, fifth ed. Free Press, New York.
Saussure, F., 1965. Course in General Linguistics. McGraw Hill, New York.
Schuitema, G., Anable, J., Skippon, S., Kinnear, N., 2013. The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. Transp. Res. A Policy Pract. 48, 39–49. http://dx.doi.org/10.1016/j.tra.2012.10.004.
Schwartz, S.H., 1977. Normative influences on altruism. In: Berkowitz, L. (Ed.), Advances in Experimental Social Psychology, vol. 10. Academic Press, New York.
Shih, E., Schau, H.J., 2011. To justify or not to justify: the role of anticipated regret on consumers' decisions to upgrade technological innovations. J. Retail. 87 (2), 242–251. http://dx.doi.org/10.1016/j.jretai.2011.01.006.
Sierzchula, W., 2014. Factors influencing fleet manager adoption of electric vehicles. Transp. Res. D Transp. Environ. 31, 126–134. http://dx.doi.org/10.1016/j.trd.2014.05.022.
Sirgy, J.M., 1986. Self-Congruity. Praeger, New York, USA.
Skippon, S., Garwood, M., 2011. Responses to battery electric vehicles: UK consumer attitudes and attributions of symbolic meaning following direct experience to reduce psychological distance. Transp. Res. D Transp. Environ. 16 (7), 525–531. http://dx.doi.org/10.1016/j.trd.2011.05.005.
Sovacool, B., Hirsh, R., 2009. Beyond batteries: an examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. Energy Policy 37, 1095–1103. http://dx.doi.org/10.1016/j.enpol.2008.10.005.
Sovacool, B.K., 2009. Rejecting renewables: the socio-technical impediments to renewable electricity in the United States. Energy Policy 37 (11), 4500–4513. http://dx.doi.org/10.1016/j.enpol.2009.05.073.
Steg, L., 2005. Car use: lust and must. Instrumental, symbolic and affective motives for car use. Transportation Research Part A: Policy and Practice 39 (2–3), 147–162. http://dx.doi.org/10.1016/j.tra.2004.07.001.
Steg, L., Vlek, C., 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. J. Environ. Psychol. 29 (3), 309–317. http://dx.doi.org/10.1016/j.jenvp.2008.10.004.
Stern, P.C., 2000. Toward a coherent theory of environmentally significant behavior 56 (3), 407–424.
Stern, P.C., Dietz, T., Abel, T., Guagnano, G.A., Kalof, L., 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. Human Ecol. Rev. 6 (2), 81–97.
Turrentine, T.S., Kurani, K.S., 2007. Car buyers and fuel economy? Energy Policy 35 (2), 1213–1223. http://dx.doi.org/10.1016/j.enpol.2006.03.005.
Vandecasteele, B., Geuens, M., 2010. Motivated consumer innovativeness: concept, measurement, and validation. Int. J. Res. Mark. 27, 308–318.
Watson, L., Spence, M.T., 2007. Causes and consequences of emotions on consumer behaviour: a review and integrative cognitive appraisal theory. Eur. J. Mark. 41 (5/6), 487–511. http://dx.doi.org/10.1108/03090560710737570.
Wood, S.L., Moreau, C.P., 2006. From fear to loathing? how emotion influences the evaluation and early use of innovations. J. Marketing 70, 44–57.
Zhang, Y., Yu, Y., Zou, B., 2011. Analyzing public awareness and acceptance of alternative fuel vehicles in China: the case of EV. Energy Policy 39 (11), 7015–7024. http://dx.doi.org/10.1016/j.enpol.2011.07.055.