Driver-Specific Added Value Analysis of Electric Vehicles' Car-IT

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Abstract

Electric-powered vehicles are becoming more important with each passing day. Because of the individual traits of e-Cars, such as limited range and extended recharge time, the Car-IT in these cars has to be adjusted to the individual needs of the driver. This thesis aims to investigate and analyze the added values created by the Car-IT of electric cars. The current implementations of Car-IT (on-board and smartphone-based) are compared. Expert Interviews are conducted in order to analyze the specific requirements of e-Cars' Car-IT. From this research, recommendations are derived.

1 Introduction

With the current shift in the energy market, the increase in petrol prices and the decrease of oil reserves, alternative energy sources are needed in order to keep the current infrastuctures working. Especially around town and crowded city centres, such as New York, London, Berlin or Tokyo, the pollution due to high CO2-Emissions is increasing and alternative methods of transport are needed. According to German federal studies, an average citizen drives up to 39 km per day.[1] Thus, (fully or partly) electric-powered vehicles are becoming more important and useful with each passing day due to their low or non-existant emissions. In turn, they are able to keep people moving, possibly with lower costs.[2] A study from De Gennaro et al. shows that over 80% of all urban trips can be covered by electric cars without the need of "range anxiety".[3]

While there were electric engines (first in 1881) even before combustion engines were invented (in 1885), electric cars have not completely been relevant until the early 21st century.[4] The European Union (EU), beginning in 2008, and Germany, in 2011, have agreed to limit the total carbon dioxid emissions, thus giving electric vehicles a significantly bigger meaning.[5]

The demand of e-Cars has risen within the last years partly because of federal incentives. The increasingly demanding emission limits by the European Union are also responsible for a rise in sales. While the overall part of electric cars in today's society is relatively small, more e-Cars are being sold in 2014 than ever before.

There are unique problems that arise due to the use of e-Cars. First, the range of most cars, except for Tesla's Model S and Roadster, is serverly limited. A range between 80 and 200 km, depending upon the model and type of battery, is realistic if the car is driven primarily in town. The "fear of limited range" or "range anxiety" which is currently present, is accompanied by more time needed in order to recharge the battery. Using a conventional plug from a socket located at home, a complete recharge can take up to eight hours. There are faster

[1] cf. Infas (2008), p. 4
[2] cf. Pearre et al. (2010), p. 1181-1182
[3] cf. De Gennaro et al. (2014), p.115
[4] cf. Stan (2012), p. 265
[5] cf. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2012), p. 6

ways of recharging, some of them are explained later in this thesis. At the moment, however, it is not possible to charge a car in less than 30 minutes which is significantly more than the time needed to refill a non-electric car. These problems need to be adressed not only by the driver, but by the car itself. That is why there needs to be a constant flow of information to, from and in the car in order to drive as efficiently as possible while maintaining comfort and enabling a high safety standard.

Car-IT is one of the most important (and relatively new) areas in the automotive industry. IT-solutions in cars are needed in order to process all the information which is coming from and to the driver and passengers. The possiblity of connecting a car to the internet and other cars has proven valuable in the last years. Safety features have improved, infotainment systems are more capable than ever and an overall connectivity is possible. There are constantly updating maps as well as the possiblity to use Twitter and Facebook in the car. Traffic information gathered by sensors and electronics from one car can be transmitted to others in a matter of seconds. That is why Car-IT can generate an enormous added value for potential buyers. This value is big enough to allow market advantages if a car is equipped appropriately.

Due to the special properties of e-Cars, their drivers have their own requirements and needs. The limited range, the potential energy-draining sources within and outside the car, different methods of charging up the battery and the unique ways of power delivery from the engine make driving an electric vehicle different from driving a conventional petrol-powered car. Because of these differences, Car-IT in e-Cars must be different and address these differences and (dis-)advantages. In order to generate as much added value as possible, the driver and his needs in terms of e-Mobility have to be anticipated and dealt with.
Car-IT, however, does not only include the on-board devices, such as built-in navigational systems. Smartphones and their continual evolution have the potential to add value and convenience for the driver - possibly with less costs and effort than standard solutions provided by the car manufacturers themselves. This integration of smartphones into the Car-IT, for example, to remotely charge a car or to cool the cabin before you enter, is interesting for the car companies as well as for third party distributors.

So far, the added value caused by the differences and changing demands of e-Cars' IT has not been researched. There are, however, significant possibilities in terms of gaining and keeping customers and, in turn, generating profit. Thus, the motivation of this thesis is to explore this gap and to analyze the current and future situation concerning the evolution of Car-IT in electric-powered vehicles.
That is why this thesis researches and analyzes if and in what way the Car-IT in electric vehicles does generate added value for the driver. Furthermore, the possibility of increasing

this added value in addition to the future evolution of Car-IT are important questions to this thesis.

In regards to the content of this work, the second chapter depicts the current literature on the topics of Car-IT and electric vehicles. Chapter 3 illustrates the research design of this thesis. In order to define the key terms of this thesis, namely electric cars, Car-IT and added value, section 4 is needed. Chapter 5 deals with the current implementations of Car-IT in electric vehicles. Not only on-board solutions are of high interest, but smartphone technology is also integrated into today's cars. The current possiblites of smartphone integration are explained and an app review analyzes the best and most useful applications which are currently available. The current state of smartphone integration is subject of a discussion afterwards. To conclude this section, on-board and smartphone solutions are compared. Chapter 6 uses the research method of expert interviews introduced in section 3. First, the experts are presented. Then, the interviews are implemented into this thesis. This part is concluded by a discussion of the results. The thesis ends with recommendations based on its findings, the limitations of this work and a conclusion followed by an outlook.

2 Literature Review

For this thesis, various literature and resources have been studied and analyzed.
The studies concerning the average distance of a EU citizen were published by the German Federal Government in 2008. It had introduced the total limitation of carbon dioxide emissions in 2012 along with the European Union. The relevancy and history of electric cars has been explored by Stan (2012). De Gennaro et al. (2014) created extensive studies to show that many of the current urban trips can be covered with electric vehicles. A similar study is provided by Pearre et al. (2010).

The research design concerning the use of expert interviews and their relevancy is based on the work of the TU Kaiserslautern (2014) and Meuser and Nagel (2009). The design of the questionnaire is based on Kuss (2012) and Olbrich (2012).

The definitions for electric cars are explained by Bosch (2013a). In their work, many of the mechanical and electrical components are explained. The term "Car-IT" and its definitions are not always clearly described and tend to be subjective. MHP (2012), a daughter of Porsche, developed a rather objective definition. Their study, which is not completely available to the public, was used as a news item by Car-IT.com, thus adding to the defitions of Car-IT. Car-to-Car- (C2C) and Car-to-X- (C2X) communications are explained by Mercedes (2014). Driver Assistance Systems are analyzed and explained by Bosch (2013b) and Continental (2014). The constant flow of information using a built-in SIM-card is adressed by

The on-board solutions, depicted in section 5.1, are specific. In order to structure the possible uses of on-board Car-IT, smaller applications are deliberately overlooked. There is also the possibility of new features which either have not been featured in the used literature or have been developed in the time of the review of this thesis.

The amount of apps featured in the app review is limited. The focus of the analyzed apps is to introduce their various uses and features. However, not all available apps are featured in this work. While there are requirements which have to be fulfilled in order to be featured (relevance, downloads and support among others), it cannot be guaranteed that all relevant apps are featured. In addition, new apps which low downloads may be relevant, but not popular enough in order to be implemented.

The decision on how to feature the apps which help to locate and navigate to charging stations can also be limiting. There is no certainty that all relevant apps are featured and that the determined features are objectively as important as they are in this work.

The expert interviews are an insightful way of enhancing the research on this topic. However, there is a limited amount of interviews featured in this thesis. A quantative analysis of the subject could be equally interesting and recommendable. However, due to the novelty of the topic and the strong limitations regarding the interviews themselves, this is not possible in this work.

The open nature of the expert interviews has proven to be difficult at times when the interviews were conducted. The quality and quantity of answers could vary tremendously depending on the IE. A more strict and conformative approach to this research method might be useful in the future.

9 Conclusion and Outlook

This thesis deals with a driver-specific added value analysis of the Car-IT solutions in electric vehicles. While the literature on the exact topic is scarce, the brochures of specific e-cars as well as new information provided by car manufacturers help to analyse the topic.

The research design is effectively split into three main methods. First, the reviewed literature is used to gain information. In addition, an app review is created in order to give an overview about the best and most popular applications in regards to electric cars. If available, demo versions have been tested in order to verify or deny the various app features. The third method is the use of expert interviews to gain new insights into the subject.

The thesis not only includes pure (100 %) electric-powered vehicles, but also plug-in-hybrids (e.g. the Porsche Panamera e-Hybrid) because of their unique requirements to the driver. The definition of Car-IT is not completely unanimous in the literature. Therefore, a definition is used which is used most frequently. Thus, Car-IT includes all the technology concerning information and communication in a vehicle as well as the "streams of information" from and to the car. Lastly, added value is defined as improved benefits in comparison to other brands.

The current implementations of Car-IT in electric cars can be split in on-board solutions and the integration of smartphones. On-Board solutions focus on Driver Assistance Systems, Navigational Systems (including Charging Point Finder) and the ability of C2C/C2X-Communication. The ways of displaying information vary and are explained as well.

The integration of Smartphones into the Car-IT of an e-Car enables certain features and increases comfort for the driver. The on-board navigational systems can be enhanced and synchronized with smartphones. There are various remote features, such as remote information about the battery and range, recharge of the battery (once it is connected with a socket) and other remote services. Efficient driving can also be encouraged by mobile analysis of the driver's driving style.

There are two possible information flows between smartphone and cars. A one-way flow uses the smartphone as an extern compunational unit and uses its data to project it on a (touch)screen in the car. An example for one-way flows is the Opel Adam. A two-way communication implies the (constant) exchange of data and information between the on-board computers and the smartphone via mobile applications. Examples include Porsche Car Connect or BMW i Remote.

Applications as the aforementioned can be split into three categories. There are E-Car Enhancement Applications which are the ones used for two-way information flows. Charging Station finder do not neccesarily need a constant connection to the car in order to work and display the closest stations to recharge an e-Car. The last category include miscellaneous applications, e.g. for simulation.
The most popular and best applications are part of an app review in this thesis. In the category of Enhancement Applications, BMW's i Remote and Porsche Car Connect serve as two good examples for the current state of smartphone integration. In addition, Charging Station finder are compared to each other and some miscellaneous apps are also included.

The main purposes of Car-IT in electric vehicles are determined as comfort, safety, entertainment and environmental awareness. They can be attributed to smartphones and on-board devices. Conclusively, safety and entertainment are two issues mostly adressed by on-board devices while comfort is dealt with by smartphone integration. Environmental Awareness is an intersection of both.

The research method of expert interviews is used to determine the importance of Car-IT, smartphone integration and added value. In addition, a customer profile is asked and it is analyzed wheather Car-IT can add value to electric vehicles. Experts from Porsche, BMW and Nissan are interviewed. Despite some differences in their philosophy of e-Mobility, Car-IT is determined as a very important issue in e-Cars and can indeed contribute added value. Especially smartphone integration is vital as the aforementioned added comfort benefits the driver and is an aspect in the buyer's decision for or against an e-Car. There are no clear profiles of potential buyers for electric vehicles, but across all companies, technophiles are as interested as environmentalists and the "follower". The latter notices more e-Cars on the streets which peaks their interest.

E-Mobility also allows the car companies to maintain or enhance their own styles and philosophies. An electric porsche can still be a sports car much like a Nissan LEAF can be a family hatchback. All experts claim that new customers are attracted to their respective brands due to e-Mobility. Despite this, there is still scepticism among the regular customers and long-time drivers of these brands when it comes to range, longevity and power of the battery and the infrastructure of charging stations. These issues must be adressed in the future in order to make e-Mobility grow and appealing.

There are multiple research opportunities based on this paper. A quantitive analysis of potential e-Car customers may prove revealing, especially considering the current "range anxiety" among the customers and interested groups. New apps are released by car companies (and their associates) as well as by third party contributors. A work about an updated app review, concentrating on the differences between iOS and Android with more thorough testing seems to be useful. Since the infrastructure of charging stations is often referrenced, a work based on a proposal or the optimization of charging stations can be interesting. A universal model for payment across different distributors of charging stations has yet to be made as well.

The points made by all the interviewed experts in section 6.4 are important in order to conclude this thesis. It has been shown what Car-IT solutions of the present are and how they can benefit the driver. This technology, especially involving smartphone integration, can add value and influence a person to choose one car over another. In order to support more sales of e-Cars, a better infrastructure needs to be in place. Not only the amount of charging stations is important, but also how a driver is able to use one in terms of occupancy and payment. If the government then decides to subsidize e-Mobility, more people will have the incentive to inform themselves about it. With more cars and a better infrastructure, range anxiety should not be as omnipresent as it currently is.

With the increase in emissions and more urban centers being concerned about congestions and health, e-Mobility may not be an option in the future, but necessary. Because of that, infrastructure and technology need to be as good as possible to let drivers and passengers enjoy driving. As seen in this thesis, Car-IT and its smartphone integration may be one key aspect to improve driving an electric vehicle in the future.