

Acceptance and Technical Requirements for Electric Cars: Analysis and Discussion of E-Carsharing Impacts

Bachelorarbeit

zur Erlangung des akademischen Grades „Bachelor of Science (B.Sc.)“ im
Studiengang Wirtschaftsingenieur der Fakultät für Elektrotechnik und Informatik,
Fakultät für Maschinenbau und der Wirtschaftswissenschaftlichen Fakultät der
Leibniz Universität Hannover

vorgelegt von

Name: Raschkowski



Vorname: Lars



Prüfer: Prof. Dr. Michael H. Breitner

Hannover, den 17.07.2015

Table of Contents

- Table of Figures..... III**
- List of Tables III**
- List of Abbreviations IV**
- 1. Introduction..... 1**
 - 1.1 Motivation 1
 - 1.2 Scope and Structure..... 2
- 2. Background..... 4**
 - 2.1 Current Research 4
 - 2.2 Technical Background..... 7
 - 2.2.1 Battery Technologies 8
 - 2.2.2 Electric Engine 12
 - 2.2.3 Power Electronics 13
 - 2.2.4 Charging Technologies 14
 - 2.3 Market Overview 18
 - 2.3.1 EVs, Charging Infrastructure, and Market EVI 18
 - 2.3.2 Comparison EV and Conventional Vehicle (TCO)..... 20
 - 2.3.3 Comparison Cost Structure EV and Conventional Vehicle..... 22
 - 2.4 Benefits and Challenges of Electric Car-sharing 24
- 3. Research Design and Method 26**
 - 3.1 Survey Design 26
 - 3.2 Results 27
 - 3.2.1 Profitability 27
 - 3.2.2 Technical and Infrastructural Conditions 32
 - 3.2.3 Acceptance of EVs..... 39
- 4. Discussions and Recommendations 44**
 - 4.1 Discussion of Findings 44
 - 4.1.1 Profitability 44
 - 4.1.2 Technical and Infrastructural Conditions 46
 - 4.1.3 Acceptance of EVs..... 48
 - 4.2 Implications for Research and Practice 49
 - 4.2.1 Implications for Practice 49
 - 4.2.2 Implications for Research..... 53
 - 4.3 Limitations 54

5. Conclusions and Outlook	55
Reference List.....	57
Appendix A: Data Collection	63
Appendix B: Interview Protocol	64
Appendix C: Transcript of Interviews	66
Ehrenwörtliche Erklärung.....	76

1. Introduction

1.1 Motivation

Car-sharing can be considered a “door-opener” to electric mobility (Kley, et al., 2011, p.3397).

The German government aims at achieving 1,000,000 electric vehicles¹ (EVs) in Germany until 2020. Indeed, the amount of EVs in Germany has increased over the last few years from 1,931 in 2006 to 18,948 in January 2015 (KBA, 2015), but following NPE (Nationale Plattform Elektromobilität), achieving this ambitious aim is only possible by additional governmental measures, such as co-financing of charging infrastructure (NPE, 2014, p.4). The German government already promotes EVs. For example, 10 year exemption from vehicle motor tax and the provision of 1 billion EUR for EV development and research. Berlin, for instance, is considering providing bus lanes for EVs (Fojcik and Proff, 2014, p.349).

However, different barriers are slowing down the widespread breakthrough of EVs. Safety issues, uncertainties about new technologies, concerns of battery range and insufficient charging infrastructure lead to hesitation of customers purchasing an EV (Fazel, 2014, p.2; Hinkeldein, et al., 2012, p.4). Comparing the price difference between an EV and conventional vehicle shows another barrier: high acquisition costs. These barriers and environmental issues are overcome by a different approach, which is the central topic of this thesis: electric car-sharing.

Growing concerns about CO₂ emissions, gasoline dependence, congestion and parking space, and an increased general environmental awareness make alternative mobility concepts such as car-sharing attractive (Shaheen and Cohen, 2013, p.5; Heling, et al., 2009, p.2). The concept of car-sharing is based on several people sharing the same vehicle. Instead of having your own vehicle and affording acquisition and operational costs, a fleet of vehicles is available through the car-sharing provider. Registered users are able to book a vehicle for a certain time (Fazel, 2014, p.29). Its enhanced significance is illustrated by an increase from 11,500 vehicles in worldwide car-sharing market in 2006 to 92,200 in 2014 (Frost and Sullivan, 2014).

Electric car-sharing means deploying EVs in car-sharing fleets and enables various advantages. High acquisition costs and maintenance is avoided by means of cost

¹ In this thesis electric vehicles (EVs) will be considered as battery electric vehicles (BEVs). BEVs are purely battery powered vehicles (TAB, 2012, p.298).

distribution to several electric car-sharing users, so that only the actual use of EVs has to be afforded (TAB, 2012, p.77). This leads to an easy way of testing EVs. Testing EVs through electric car-sharing provides the possibility of dismantling existing barriers (Peters and Hoffmann, 2011, p.56; Barth and Shaheen, 2002, p.110). Furthermore, users are able to judge, if concerns about range and charging are justified, and if electric mobility matches with their life style. Electric car-sharing can also contribute to environmental issues. It is stated that one car-sharing vehicle is able to replace five sold cars (Lee, et al., 2011). Consequently, CO₂ and noise emissions as well as congestion and required parking space can be reduced. Moreover, deploying EVs in car-sharing fleets can enhance the visibility and awareness of electric mobility. Thus, among other things, these benefits of electric car-sharing could contribute to increased acceptance of EVs and will be investigated in this thesis.

1.2 Scope and Structure

This thesis will be investigate, if electric car-sharing is able to enhance the acceptance of EVs. The main topics of electric mobility and electric car-sharing will be described and discussed from an economic and technical point of view. At first a literature review will be conducted to provide an opinion of the current status of electric car-sharing. The technical background and market overview is then described, which provides a theoretical base for the subsequent electric car-sharing discussion. These are relevant components on the technical side for the electric power train in EVs and charging technologies. Then, on the economical side, an international overview of EVs, charging infrastructure, and the market Electric Vehicle Index (EVI) is given to understand the popularity of electric mobility by nations. After that EVs will be compared to conventional vehicles by means of total cost of ownership (TCO), and the cost structure of both vehicle types will be broken down. This could be relevant for car-sharing providers that consider deploying EVs in car-sharing fleets to support their decision. The last part of the background will analyse the benefits and challenges of electric car-sharing in detail.

Subsequently, an empirical study in the form of expert interviews was conducted. Electric car-sharing providers were asked in order to evaluate electric car-sharing regarding its profitability and basic conditions in terms of current status, issues, and developments. Furthermore, impacts of electric car-sharing on customer acceptance have been considered within the study to obtain direct information towards the research question. The statements will be analysed by qualitative content analysis in accordance with Mayring (2014). Followed by an evaluation and discussion of the results. Using this study as evidence, implications for research and practice will be

given to face existing issues of electric car-sharing and to forward the acceptance of EVs. The evaluation of the empirical study ends with a description of its limitations. At last the conclusion and outlook are provided.

5. Conclusions and Outlook

The aim of this thesis was to investigate on the impacts of electric car-sharing on EV acceptance. An empirical study was conducted and showed existing issues and revealed results, which contributed towards the research question. It has been shown that electric car-sharing has positive impacts on EV acceptance. It can be a “door opener” to electric mobility. A main contributor for that is the test effect. High acquisition costs of EVs can be avoided and existing barriers towards EV usage and battery range can be dismantled. Then electric car-sharing increases the visibility of electric mobility within cities. This provokes curiosity and results in the multiplier effect, which spreads acceptance bit by bit. However, electric car-sharing has not yet been able to cause satisfactory effects on increased EV acceptance. The main reason for that is electric car-sharing still being a niche market. This is on the one hand caused by non-profitability of electric car-sharing and on the other hand caused by unfavourable technical, infrastructural and political conditions, which lead to hesitation of widespread EV deployment in car-sharing fleets.

It has been illustrated that high battery costs are a main contributor to high acquisition costs and in reducing profitability of electric car-sharing. Additionally, insufficient charging infrastructure and non-compatibility between plug systems are complicating electric car-sharing operation. Besides this, political basic conditions such as special parking permissions for EVs or treatment of parking offenders do not exist.

However, electric car-sharing is able to be profitable and able to be established in the future. Profitability will improve through decreasing acquisition costs. Since more people will get used to electric mobility and technologies such as V2G will be advanced, utilisation intensity can be increased as well and contribute to profitability. New business models will be established and will enable new markets to emerge. Furthermore, public authorities have to support providers and have to create basic conditions: Municipalities need to co-finance charging infrastructure expansion and need to allow EVs to be exempted from parking fees. Parking spaces for EVs in car-sharing fleets need to be provided combined with a charging station. Its accessibility has to be ensured through creating compatibility by means of a uniform plug usage. Furthermore, other interest groups such as energy providers have to be integrated to provide charging technologies and to develop profitable business models for charging stations. These aspects will enable the establishment and profitability of electric car-sharing providers. Meaning that electric car-sharing is not only a “door opener” to electric mobility, but will be a significant contributor towards increasing the acceptance of EVs in the future due to enhanced visibility.

However, the government needs to guarantee that green energy will be provided for filling EVs. This is indispensable to ensure the environmental balance of EVs, to maintain credibility of electric car-sharing providers and thus to avoid an acceptance threat of electric mobility.

In conclusion, all interest groups need to collaborate to face existing issues of electric car-sharing and thus to enhance positive impacts on acceptance of EVs. Moreover, considering the economic, technical, infrastructural, and political conditions of electric car-sharing is necessary to increase the acceptance of EVs. Facing single aspects will not contribute to a sufficiently improved electric car-sharing situation and therefore will not provoke the desired effects on EV acceptance.