Dissertation

Management of Barriers to Innovation in E-Mobility

A general framework for relevant stakeholders

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Graz, September 2012

Statutory Declaration

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

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signature

Acknowledgement

I would like to thank all those who supported me in the writing of this thesis.

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Abstract

E-Mobility is not a new invention, as the first concepts of electric vehicles were developed in the late 19th century. Even so, after some initial success, the electrified powertrain did not prevail against the combustion engine in the long term. Due to various factors, such as the declining availability of fossil fuels, climate change and, not least, the increased need for individual mobility, E-Mobility is currently regaining significance. Although there are already existing technical concepts and available models, the broad-based market diffusion of electric vehicles has not yet been successful.

Based on the above mentioned considerations, the aim of this thesis is to develop a holistic approach regarding the system as a whole rather than only the vehicle itself for overcoming the barriers and eventually for a successful market diffusion of E-Mobility. For this reason, the many affected stakeholders are identified and analyzed in the first instance and further on the relevant barriers are explored. The interaction between the identified barriers and stakeholders is then elaborated upon with both an intra- and an inter-organizational perspective, i.e. each stakeholder's contribution for overcoming specific barriers and the resulting need for coordination between the stakeholders. Lastly, a framework for managing barriers in E-Mobility concludes the approach.

The theoretical model is evaluated using a qualitative empirical method. Thirteen non-standardized interviews are conducted with representatives of the different stakeholders with the aim of capturing their perspectives, the considerations of the theoretical model are then verified. Lastly, the empirical findings are discussed in comparison with theoretical elaborations and implications for management practice and for further research are derived.

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1 Introduction to E-Mobility

First, the following chapter explains why E-Mobility is currently so strongly pushed, the drivers of change and the objectives of E-Mobility are then discussed.

Further on, a typology of electric vehicles in individual mobility and, additionally, a typology of the electrification of the powertrain are given in order to delimitate the term "E-Mobility" as to the extent that it is relevant for this thesis.

Based on the general problem description, the research questions which provide the common thread for this thesis are introduced. Lastly, the research design which sets the content structure is described at the end of this chapter.

1.1 Drivers of Change and Objectives of E-Mobility

Currently, at the beginning of the 21^{th} century, E-Mobility is very strongly pushed. In general, there are several external factors in an innovation system, which create inducements for the development of new technologies and innovations:[1]

- *Influencing factors of the natural environment:* Ecological indicators such as availability of resources, avoidance of ecological burden, recycling and sustainability.
- *Technological influencing factors:* Technological indicators such as technology or product life cycle, dynamics of the technological development, availability of new materials and ability for further development of a product.
- *Influencing factors of society:* Socio-cultural indicators such as population development, product acceptance, values, preference of customers and rationality.
- *Regulatory-political influencing factors:* Regulatory-political indicators such as incentives, laws and policies.

[1] Cf. GELBMANN, U.; VORBACH, S. (2007), pp. 97

- *Economic influencing factors:* Economic indicators such as corporate concentration, general economic data, branch structure, potential of manpower and innovative atmosphere.

Based on the aforementioned considerations, the developments towards an electrification of the powertrain are pushed forward by the causal connection of several factors, which are illustrated in Figure 1.1.

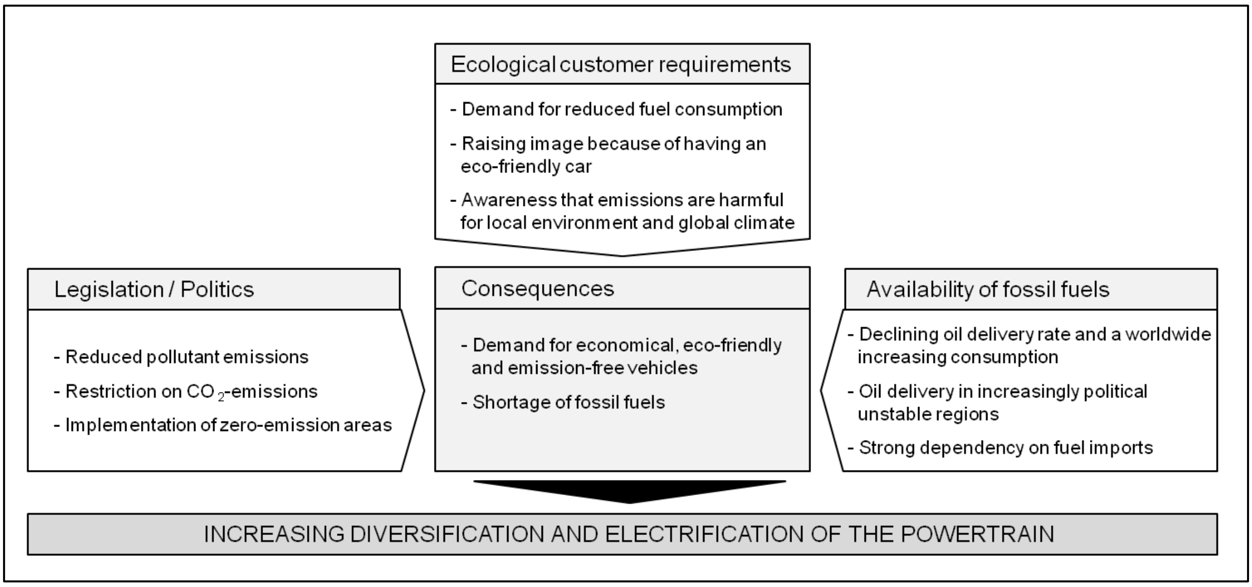

Figure 1.1: Drivers of the increasing diversification and electrification of the powertrain[2]

The basic causal factors are ecological customer requirements, legislation or politics and the availability of fossil fuels, which, at the same time, build the general framework for companies that deal with E-Mobility. The consequences of these factors are a demand for economic, eco-friendly, clean and emission-free vehicles as well as addressing the shortage of fossil fuels. These influences are the drivers of change which lead to the increasing diversification and electrification of the powertrain.[3]

The successful implementation of E-Mobility also pursues a number of objectives:[4]

- Strengthen the business location of Europe and especially Austria through added value and know-how
- Strengthen the technology location through specific R&D competences and capacities
- Contribute to a sustainable, affordable mobility

[2] Referring to FREIALDENHOVEN, A. (2009), p. 112
[3] Cf. FREIALDENHOVEN, A. (2009), p. 112
[4] Cf. BMVIT (2010), p. 8

- Opportunities and tools to raise awareness for a sustainable and eco-friendly mobility
- Reduce CO_2 and pollutant emissions; reduction of noise pollution
- Reduce dependency on fossil fuels

The drivers of change are forcing E-Mobility to be implemented into our mobility concepts of tomorrow. For the business location of Europe this can be a major opportunity. The intensification of solely technical solutions without involving customer requirements of mobility systems and the integrated transport system will not be expedient for reaching the described objectives. It is crucial to develop a holistic approach for a successful implementation.[5]

1.2 Scope of E-Mobility

E-Mobility is a term with broad implications; in general we talk about the electrification of the powertrain and in colloquial language just about electric cars. It is crucial to specify how the term E-Mobility should be understood in this thesis.

For this reason a typology of electric vehicles describes the different types of vehicles in individual mobility. Concepts for public transport are intentionally excluded because customer requirements are fundamentally distinct. Moreover, concepts for public transport already exist and are successfully implemented such as tramways, trains, cable cars, etc. These concepts also profit from the fact that the energy storage does not need to be mobile and carried along in the vehicle. However, the concepts for the electrification of the powertrain in individual mobility need mobile energy storage. Therefore, the typology of electric vehicles in individual mobility gives an overview about the different concepts. As a next step a typology of the various categories and the state of the art of the electrification of the powertrain in passenger cars are given. Based on these considerations, E-Mobility can be delimitated as described in the following section.

1.2.1 Typology of Electric Vehicles in Individual Mobility

E-Mobility can be related to various vehicle concepts used in individual mobility. The typology in Figure 1.2 shows those categories to give an overview.

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[5] Cf. BMVIT (2010), p. 8

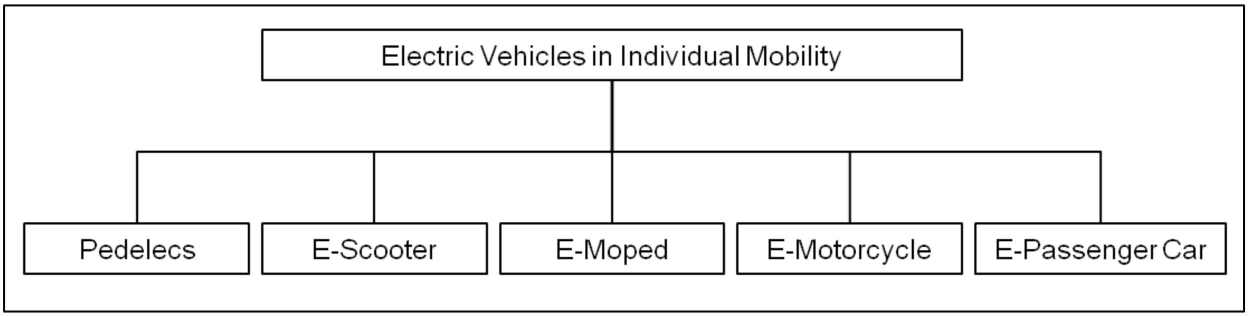

Figure 1.2: Typology of electric vehicles in individual mobility[6]

In the following section the particular vehicle categories are introduced and briefly explained.

Pedelecs

Henceforth referred to as pedelecs, electric bicycles are a category of electric vehicles in individual mobility and are single-lane muscle power-electric-hybrid vehicles. Pure electric driving is not possible with pedelecs. De jure § 1 Abs. 2a KFG 1967 electric powered bicycles are not referred to as motor vehicles as long as the performance is lower than 400 W and the top speed not higher than 20 km/h. Most pedelecs on the market fulfill those conditions but in Germany, for example, there are also models with a top speed higher than 20 km/h. Thus, they have to be registered.[7]

Pedelecs have several advantages:[8]

- Cheap purchase price in comparison to other motorized means of transport
- No driving license, no insurance necessary
- Low energy consumption, low costs
- Positive effect on physical fitness

Yet these advantages are offset by the following disadvantages:[9]

- Although cheap in comparison to other motorized means of transport, pedelecs are expensive compared with conventional bicycles
- Traffic safety especially on cycle paths and combination cycle- and foot paths

Lithium ion accumulators are state of the art and dominate the European market for pedelecs, however, lead accumulators are still dominant in China because of the lower price. At the moment, China, which is followed by Japan, represents the largest markets

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[6] Referring to AUSTRIAN ENERGY AGENCY (2009), p. 30
[7] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 30
[8] Cf. AUSTRIAN ENERGY AGENCY (2009), pp. 30
[9] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 31

for pedelecs. Safety still remains a major issue for pedelecs, because they are getting heavier and faster but they are also almost noiseless which is dangerous for the cyclist himself and for pedestrian.[10]

E-Scooter

As with pedelecs, e-scooters are not referred to as motor vehicles as long as the performance is lower than 400 W and the top speed is not higher than 20 km/h. Frequently, models with a higher top speed are referred to as e-scooters, but technically speaking they still fall into the categories of e-mopeds and e-motorcycles.[11]

The main advantages are as follows:[12]

- Cheap purchase price
- Low energy consumption, low costs

The main disadvantages are:[13]

- Low range
- Traffic safety

E-Moped

E-mopeds are referred to as such if the performance of the electric motor is above 400 W or if the top speed is higher than 20 km/h and below 45 km/h. Most e-mopeds are still produced in China.[14]

The following advantages can be mentioned:[15]

- Cheap purchase price in comparison to e-motorcycles and e-cars
- Low energy consumption

The major disadvantages are:[16]

- Low range
- Expensive compared to mopeds with a conventional combustion engine

[10] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 33
[11] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 33
[12] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 34
[13] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 34
[14] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 36
[15] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 35
[16] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 35

E-Motorcycle

An e-motorcycle is a single-lane motorcycle which is not covered by the definition of mopeds, i.e. its top speed is higher than 45 km/h. Compared to e-mopeds, the development and diffusion of e-motorcycles is far behind. The major barrier to the construction of high-performance motorcycles with electric motors is, besides range limits, where to place the large and heavy batteries.[17]

There is one advantage of e-motorcycles:[18]

- Lower energy consumption than conventional motorcycles

The two main disadvantages are:[19]

- Not very common yet – most motorcycles are test vehicles, few are in serial production
- Expensive compared to motorcycles with conventional combustion engines

E-Passenger Car

The electric car is seen as futuristic, however, it has a long history. A few historical milestones of the electric car: [20]

- 1859: Gaston Plante, a French physicist, invented the rechargeable lead accumulator, which laid a substantial basis for the development of electric vehicles.
- 1881: Gustave Trouvé presented the first electric car with lead accumulator in Paris. The top speed of the three-wheeled vehicle reached 12 km/h.
- 1890: William Morrison, an American, built the first successful model. The car with its 2.5 HP engine reached a top speed of 12 km/h.
- 1899: “La Jamais Contente”, the record-breaking vehicle of Belgian race car driver Camille Jenatzy, reached a top speed of over 100km/h.
- 1900: Ferdinand Porsche presented a new electric car at the Paris International Exposition, which he developed for Ludwig Lohner, a Viennese carriage manufacturer. The car was equipped with 2.5 HP heel hub electric motors as well as a combustion engine, to avoid the problem of range limits. The Lohner-Porsche was the first hybrid car on the market.

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[17] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 37
[18] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 37
[19] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 37
[20] Cf. AUSTRIAN MOBILE POWER (2011a), access date 24.07.2011

- 1900 – 1911: This era of electric cars was very short. At first it seemed they were one step ahead of the combustion engine vehicles, because they were silent, judder-free, clean and simple to use. However, with the invention of the electric starter for combustion engines, more gas stations, cheap oil and clever advertising, the production of electric cars started to wane.
- 1990: In the course of the Clean-Air-Act, which set the objective that 10 percent of all licensed cars in California, USA, must be emission free, the US car manufacturers Ford, Chrysler and General Motors as well as the Japanese companies Honda, Toyota, Mazda, Nissan undertook to bring electric cars onto the market. General Motors with its EV1 and Honda with its Honda EV finally won the race for the market launch of a pure electric vehicle.
- Revival of the electric car: Today the electrification of the powertrain is regarded as a global growth market and is already referred to as the future mobility scenario. There is barely one car manufacturer who is not working on the development of an electric car.

The electric car is promoted very strongly but the number of licensed cars shows a different picture, as can be seen in Table 1.1.

Year	2004	2005	2006	2007	2008	2009	2010	2011
Number of e-passenger cars	128	127	127	131	146	223	353	989

Table 1.1: Number of e-passenger cars in Austria 2004 to 2011[21]

As far as the total number of licensed passenger cars in 2011, of 4,513,421[22] vehicles, this is a very low percentage. Therefore, the objectives for the future are set very high. The Austrian government specifies a target value of 250,000 e-passenger cars, including plug-in hybrid vehicles (PHEV) but excluding single-lane vehicles. This number corresponds to approximately 5 percent of the total number of registered passenger cars in 2020. [23]

The following list gives a brief overview of the widely varied advantages of an electric car:[24]

- Environment and climate
    - The technology makes it possible to utilize renewable energy

[21] STATISTIK AUSTRIA (2012a), access date 28.08.2012
[22] STATISTIK AUSTRIA (2012a), access date 28.08.2012
[23] Cf. BMWFJ; BMLFUW (2010), p. 75
[24] Cf. AUSTRIAN ENERGY AGENCY (2009), p. 40

    - Lower CO_2-emissions
    - Less pollutants
    - Less noise
- Economy
    - Utilizing national energy resources positively effects the economic value added
- Technology
    - Higher efficiency of an electric motor compared to a combustion engine
    - Electric motor is simpler and requires less maintenance

Those advantages are offset by the following disadvantages: [25]

- Automotive market
    - Availability: few vehicles in serial production
    - Very high purchase price
    - No second-hand car market yet
- Battery technology
    - Lower energy density compared to fuel, range limits
    - Durability
    - Infrastructure for recharging

Leading car manufacturers publish sustainable value reports where they outline their activities for sustainable mobility, which includes E-Mobility.

Volkswagen's 2010 sustainability report states its focus on further development of efficient combustion engines on the one hand and E-Mobility on the other hand. According to the roadmap for the next few years, the Touareg Hybrid is followed by the Jetta Hybrid, the E-Up! and the Golf blue-e-motion. Volkswagen declares itself to be the first car manufacturer that sells e-cars for everybody.[26] Audi, which is part of the Volkswagen Group, is actively involved in E-Mobility and enters the market with the models A1 e-tron and A3 e-tron.

Sustainability is also at the top of the list of priorities for BMW. In their sustainable value report 2008 BMW names six central fields of activities, one of them is the development of alternative drive concepts. This includes hybrid cars, fuel cell cars and electric cars. "Efficient dynamics" stands for their strategy for sustainable individual mobility.[27] Aside

[25] Cf. AUSTRIAN ENERGY AGENCY (2009), pp. 40
[26] Cf. VOLKSWAGEN AG (2010), p. 47
[27] Cf. BMW AG (2008), p. 26

from the MINI E, BMW is on the market with the ActiveHybrid X6, the ActiveHybrid 7, the megacity vehicle BMW i3 and the sportscar i8.

Daimler AG, in their “The Road to Emission-free Mobility” strategy, focuses on three main areas of activities: the optimization of vehicles with modern combustion engines, the further increase in efficiency by hybridization and the emission free driving with battery or fuel cell electric vehicles. The smart fortwo electric drive, the A Class E-CELL and the Vito E-CELL are battery electric cars which Daimler introduced to the market.[28]

In addition to the previously mentioned car manufacturers, also General Motors developed the Chevrolet Volt as the successor model to the EV1. Ford presents the Focus Electric, the hybrid Escape and the plug-in hybrid C-Max Energi. Toyota was the pioneer with the serial production of a hybrid vehicle, the Prius, which has since also become available as a plug-in hybrid. Other electric cars in serial production are also on the market, e.g. Peugeot iOn, Mitsubishi iMiev and the Citroen C-Zero.

1.2.2 Typology of the Electrification of the Powertrain

In addition to the optimization of the conventional combustion engine, the trend leads, via different hybrid systems, towards pure electric drives. This development is a gradual process to the usage of electric motors as the drive source for vehicles.[29] Figure 1.3 illustrates the path of the electrification of the powertrain and the related functionalities.

[28] Cf. DAIMLER AG (2011), p. 44
[29] Cf. WALLENTOWITZ, H. et al. (2010), p. 36

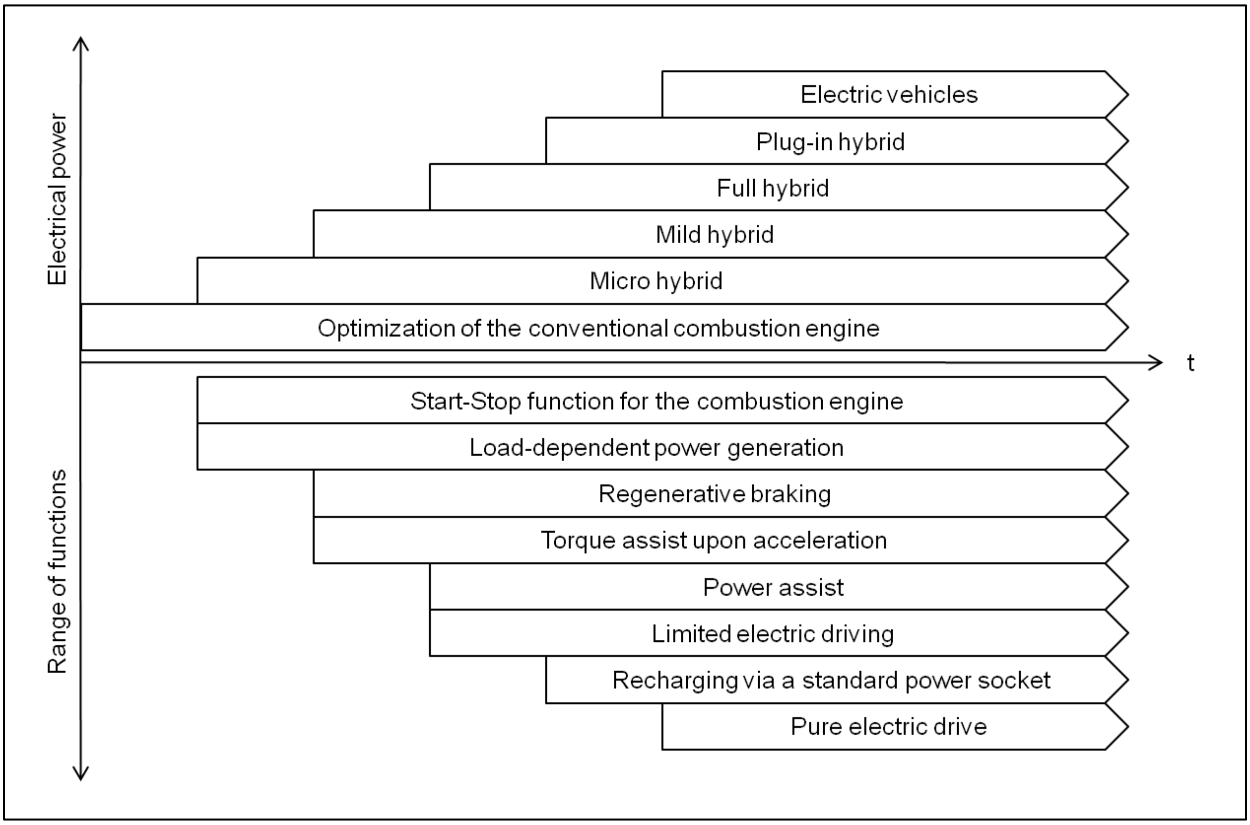

Figure 1.3: Development and functionalities of the electrification of the powertrain[30]

The typology of the electrification of the powertrain distinguishes between the various concepts by explaining the respective technical basics. A priori it is crucial to explain the fundamental differences between a hybrid and a pure electric car.

Hybrids can be seen as an interim step between conventional and electric propulsion. The term hybrid derives from Greek and means “composite” or “of two different origins”. As per the definition of the UNO a hybrid is a vehicle, which at a minimum has two energy storages and two energy converters installed in the vehicle, e.g. an electric motor and a combustion engine as well as a battery and a fuel tank.[31] The initial approach of hybrids is to combine two contrary propulsions in a way that the advantages of one system compensate for the disadvantages of the other.[32]

The disadvantages of an internal combustion engine (ICE) are most of all its poor coefficient of performance under part load, the exhaust gas emissions and, from a macroeconomic point of view, the dependency on fossil fuels. However, those areas are the advantages of electric propulsions. In addition to its high starting torque, an electric drive has no local emissions and the energy can be generated from renewable

[30] Referring to FREIALDENHOVEN, A. (2009), p.113
[31] Cf. WALLENTOWITZ, H. et al. (2010), p. 52
[32] Cf. GIES, S. (2009), p.58

sources.[33] The performance curve of the electric motor and the combustion engine is shown in Figure 1.4.

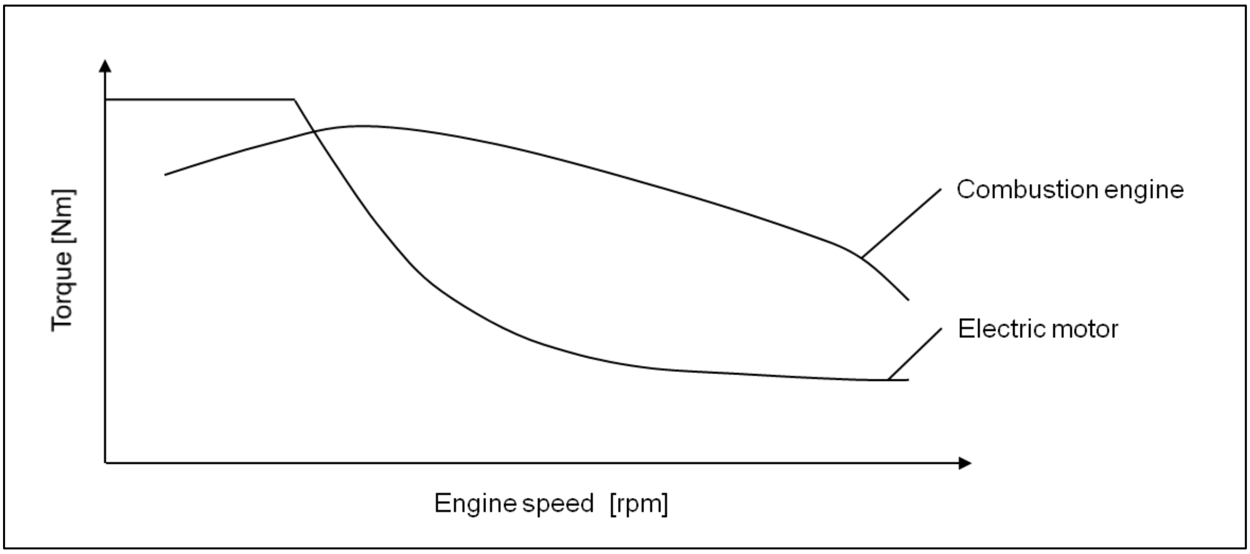

Figure 1.4: Performance curve of the electric motor and the combustion engine[34]

Theoretically, from a technical point of view, electric propulsions thoroughly fulfill the requirements for a powertrain and have a very high potential to be the future concept of individual mobility.[35]

Various propulsion concepts can be referred to as electric drives. The concepts have the electric motor as sole energy converter in common but can be distinguished by the way in which the energy is provided for the electric motor, i.e. with batteries or fuel cells.[36]

Basically, the performance of the electric motor and its functions are used as an indicator for the following typology:[37]

Hybrid vehicles	Electric vehicles
⇨ Micro hybrid ⇨ Mild hybrid ⇨ Full hybrid ⇨ Plug-in hybrid	⇨ Battery electric vehicle ⇨ Fuel cell electric vehicle

Table 1.2: Typology of the electrification of the powertrain[38]

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[33] Cf. WALLENTOWITZ, H. et al. (2010), p. 53
[34] Referring to FISCHER, R. (2011); referring to WALLENTOWITZ, H. et al. (2010), p. 52
[35] Cf. STOCKMAR, J. (2010), p. 34
[36] WALLENTOWITZ, H. et al (2010), p. 58
[37] Cf. FREIALDENHOVEN, A. (2009), p. 113

Micro Hybrid

Micro-hybrids represent the smallest modification to a combustion engine. The starter and the alternator are replaced by a more powerful integrated starter-generator.[39] Furthermore, the capacity of the battery is higher in order to provide enough energy for frequent starting processes. The power of the electric motor is usually about 5 kW.[40]

Mild Hybrid

Mild hybrids are the next step on the path to the electrification of the powertrain. The electric motor, which provides an electric power of about 5 to 15 kW, assists the combustion engine with the additional torque upon acceleration especially at low engine speeds. For the purpose of regenerative breaking the electric motor is used as a generator to save the breaking energy in the battery.[41]

Full Hybrid

The full hybrid is the first concept of the electrification of the powertrain where solely electric and locally zero-emission driving is possible.[42] The electric motor provides more than 20 kW; therefore, the requirements on battery technology are much higher. As per definition, hybrid propulsion has, at a minimum, two energy storages and two energy converters, which already indicates several variants. The distinct basic structures are as follows: [43]

- *Series hybrid:* Main characteristic is the serial-type connection of the energy converters. The combustion engine is coupled to a generator to charge a battery. As a further consequence this battery is the energy source for the electric motor.
- *Parallel hybrid:* Both the combustion engine and the electric motor are mechanically coupled to the drive shaft.
- *Series-parallel hybrid:* As a combination of series and parallel hybrids the combustion engine and a generator can be used solely to charge the battery and to power the electric motor or, if necessary, both combustion engine and electric motor are mechanically coupled to the drive shaft.

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[38] Referring to WALLENTOWITZ, H. et al. (2010), pp. 52
[39] Cf. GIES, S. (2009), p. 66
[40] Cf. WALLENTOWITZ, H. et al. (2010), p. 54
[41] Cf. WALLENTOWITZ, H. et al. (2010), p. 54
[42] Cf. NAUNIN, D. (2007), p. 70
[43] Cf. WALLENTOWITZ, H. et al. (2010), pp. 55

Plug-In Hybrid

The same as full hybrids, also plug-in hybrids have an additional energy storage. However, as a further development in regards to full hybrids, plug-in hybrids can also recharge the battery externally via a standard power socket. Typically those concepts are parallel or series-parallel hybrids, thus the combustion engine directly powers the drive shaft if the battery is discharged. However, if the plug-in hybrid is built as a series hybrid and the focus is put on the electric motor, it can also be referred to as the so called “Range Extender”, as the combustion engine is only used to extend the limited electric range. These concepts are closest to pure electric vehicles, as demonstrated in Figure 1.5. [44]

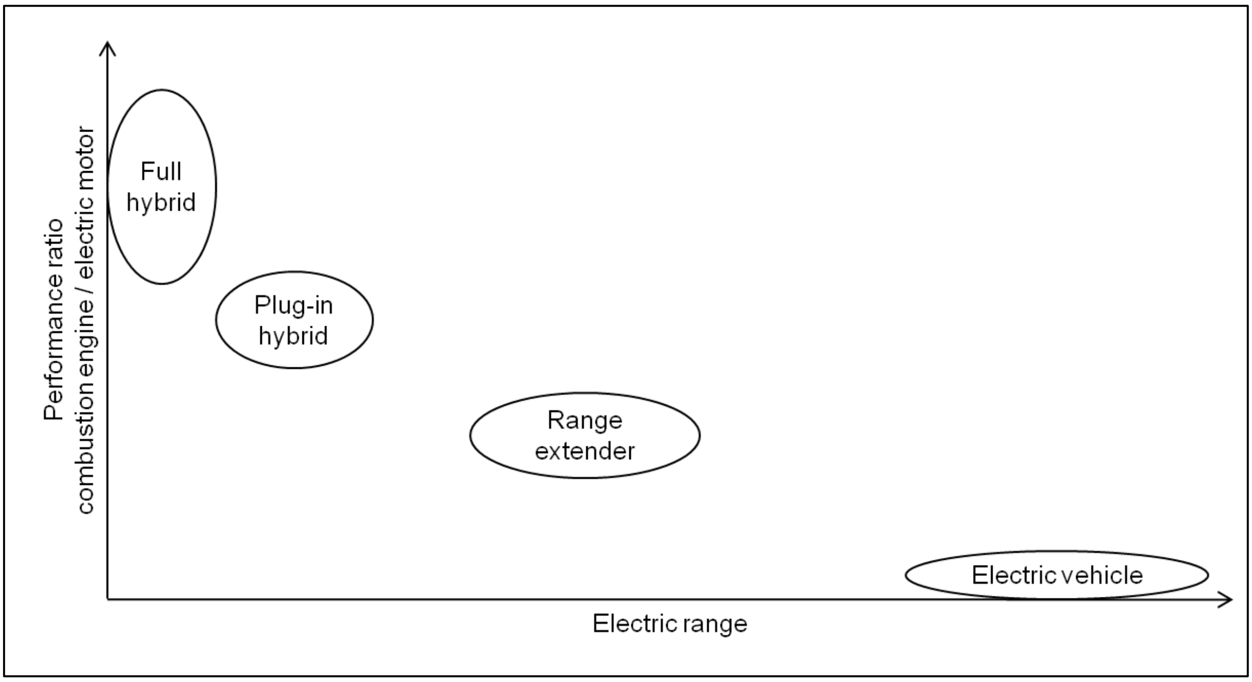

Figure 1.5: Characterization of plug-in hybrids and range extenders[45]

Battery Electric Vehicles

An electric vehicle is solely driven by an electric motor which completely substitutes the combustion engine. The necessary energy is provided by a battery which needs to be recharged externally at a charging station.[46] Therefore, it is possible to generate the energy from renewable sources which is a great advantage of battery electric vehicles (BEV).[47]

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[44] Cf. GIES, S. (2009), pp. 76
[45] Referring to GIES, S. (2009), p. 78
[46] MCKINSEY & COMPANY (2009), p.12
[47] Cf. WALLENTOWITZ, H. et al. (2010), p. 59

Here, zero-emission driving refers to “Well-to-Tank” and “Tank-to-Wheel” greenhouse gas (GHG) emission rate indicators:[48]

- *Well-to-Tank GHG Emission rate [g CO_2/MJ]:* The amount of GHGs, in CO_2-equivalent, emitted per MJ of energy used in producing the fuel.
- *Tank-to-Wheel GHG Emission rate [g CO_2/MJ]*: The amount of GHGs, in CO_2-equivalent, released from using 1 MJ of fuel in the tank.

BEVs do not have any Tank-to-Wheel emissions. The Well-to-Tank emission rate depends on whether the source for power generation is renewable or not.

The system design of the powertrain of BEVs is rather simple and mainly consists of the energy storage, i.e. the battery, the electric motor and the electronic control units. But as this drive technology substitutes the combustion engine it also requires a rethinking in other sectors which are indirectly dependent on the combustion engine, thus e.g. an electric heating has to be installed because there is not enough waste heat of the electric motor.[49]

Fuel Cell Electric Vehicles

A fuel cell electric vehicle produces its electricity on-board. Fuel cells are electrochemical energy converters, i.e. chemical energy is converted to electric energy. Hydrogen and oxygen react to water and release energy. This energy is buffered in a battery which supplies the electric motor. The oxygen can be taken from ambient air; however, the hydrogen has to be stored in a tank as liquid or compressed hydrogen.[50]

In addition to things such as zero emission driving, high range and the availability of water for the hydrogen production,[51] one of the major advantages of fuel cells is the direct conversion of chemical to electrical energy. In comparison with this, combustion engines first have to convert chemical energy into heat, then mechanical energy and further, if necessary, with an electricity generator. The conversion of heat into mechanical energy, in particular, has a limited coefficient of performance which can, as a maximum, reach the Carnot coefficient of performance. As the current state of the art, aforementioned advantages are offset by some disadvantages such as high production costs of fuel cells, limited durability, safety concerns, and especially the high costs of production, distribution and storage of hydrogen.[52]

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[48] KROMER, M. A.; HEYWOOD, J. B. (2007), p. 28
[49] Cf. WALLENTOWITZ, H. et al (2010), p. 59
[50] Cf. NAUNIN, D. (2007), pp. 132
[51] Cf. WALLENTOWITZ, H. et al. (2010), p. 63
[52] Cf. EICHELSEDER, H.; KLELL, M. (2010), pp. 219

1.2.3 Scope of the term E-Mobility within this Thesis

The typology of electric vehicles in individual mobility and the typology of the electrification of the powertrain are used as a basis for the scope of the term E-Mobility.

To begin, the focus is on passenger cars due to their special characteristics as compared to utility vehicles and one-track vehicles. The further delimitation of vehicle concepts which are relevant for this thesis is derived from to the Electric Vehicle Index EVI[53]. This index was published by McKinsey & Company for the "Wirtschaftswoche" to measure the importance and distribution of electric vehicles, and thereby afford business people and politicians an indication as to whether the efforts expended on E-Mobility were successful when compared internationally. The EVI is made up of nine different criteria, which include the market for electric vehicles as well as production in each country. Figure 1.6 depicts the parameters and their general influence on the EVI.[54]

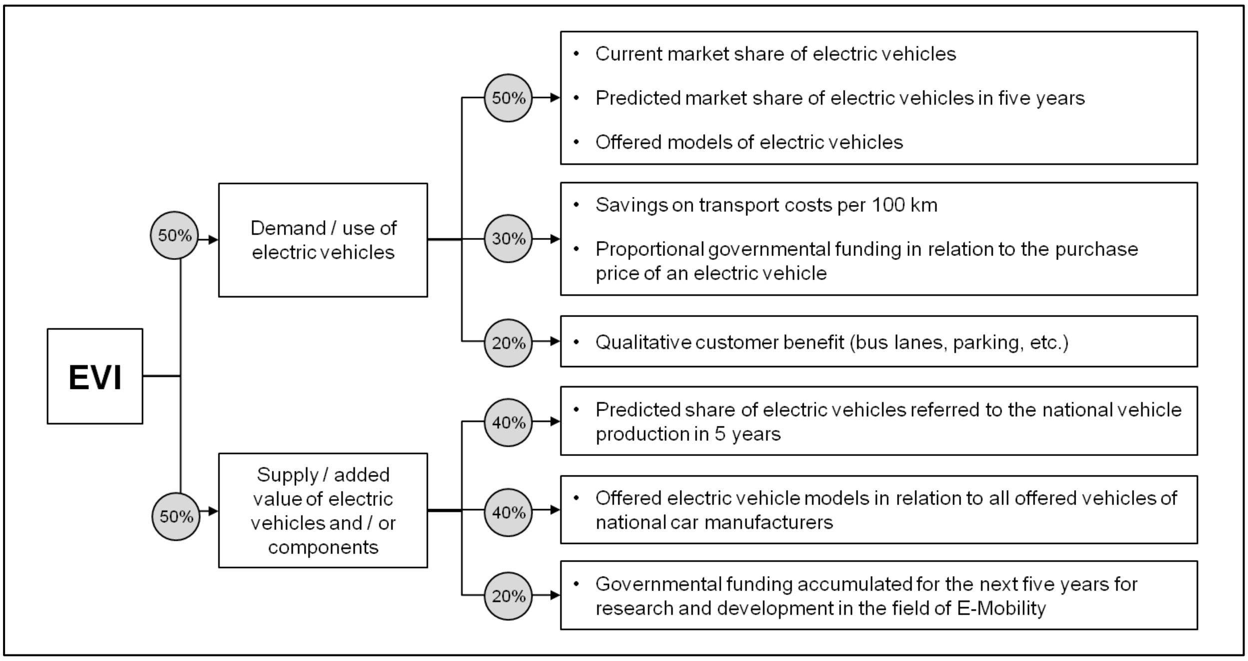

Figure 1.6: Influence of the parameters on the electric vehicle index[55]

Battery electric vehicles and plug-in hybrids are taken into account in the calculation base for the electric vehicle index.[56]

[53] WIWO (2010), access date 01.08.2011
[54] Cf. WIWO (2010), access date 01.08.2011
[55] Referring to WIWO (2010), access date 01.08.2011
[56] Cf. WIWO (2010), access date 01.08.2011

This thesis looks to the EVI to define E-Mobility, thus the relevant vehicle concepts are passenger cars, in particular battery electric vehicles and plug-in hybrids.

1.3 Problem Description

Due to climate change, increasing CO_2-emissions, restricted availability of fossil fuels and last but not least the need for individual mobility, the electrification of the powertrain is promoted as an alternative to conventional vehicles with an internal combustion engine and, therefore, as a possible future mobility concept. However, until today, the broad-based market diffusion of electric vehicles has not yet succeeded, even though some original equipment manufacturers (OEM) already offer a number of solutions.

On the one hand, E-Mobility is currently strongly pushed for the reasons previously outlined, yet, on the other hand it is a very controversial issue. Discussions about E-Mobility reveal a high number of arguments including both pros and cons, which are at times debated in a non conducive way.

E-Mobility appears to be a highly complex issue. Firstly, as described in the previous part of this chapter, there are many distinct concepts of the vehicle itself, i.e. in regards to the degree of the electrification of the powertrain, but also with reference to individual mobility vs. public transport and other alternative drive concepts besides battery electric vehicles. But principally, the complexity is caused by the circumstance that the implementation of electric vehicles does not represent an equal substitute of conventional vehicles. Electric vehicles imply different as well as new requirements, for example usage and charging infrastructure and also open new opportunities for energy supply. These issues do not fall exclusively in the field of competence of car manufacturers, whose focus is on the development of the vehicle and its market success. Instead, E-Mobility involves completely new players who are new in the automotive business.

Hence, the efforts and considerations for a successful market diffusion of electric vehicles can hardly be assessed as trivial.

Conventional market launch activities for a new product by one single company are highly unlikely to respond to this new challenge in an adequate way nor are they likely to address all the questions that come up as regards a successful market diffusion of electric vehicles. Moreover, the approach of one stakeholder is assumed to be determined by its own perspective, which carries the risk that some possible issues are disregarded or not even recognized. In the end, E-Mobility refers to a system which is characterized by many different stakeholders and their interaction in regards to the upcoming challenges.

As to this, it appears to be most advisable to approach this complex situation from a neutral and comprehensive view. Consequently, the resulting research gap constitutes the need for research, at which this thesis is targeted.

Therefore, this thesis aims at capturing all stakeholders and their perspectives from a neutral point of view, so that the requirements and challenges towards the market diffusion of E-Mobility can be analyzed and investigated in a way which is not determined by just one single company.

At this point, it is particularly noted that this research work is intended to approach the topic of E-Mobility neither from a positive- nor from a negative- but rather from a neutral perspective.

The following section presents the research questions which are addressed within this thesis.

1.4 Research Questions

As discussed in the problem description in the previous section, see chapter 1.3, the market penetration of electric vehicles constitutes a major challenge as there are multiple barriers which must be dealt with. Moreover, there are many different stakeholders who are involved in E-Mobility, such as the automotive industry, the energy industry, service providers, etc. who should address the barriers, which are partly beyond the influence and field of competence of any given one single stakeholder, and therefore need to interact in a purposeful way.

The relevance of the topic gives rise to the addressing of the following research question.

Research Question 1: How can the E-Mobility system be defined?

- ⇨ Who are the relevant stakeholders?
- ⇨ What part do they play with regards to E-Mobility?

Research Question 2: What barriers to innovation, with regards to E-Mobility, can be identified?

- ⇨ How can the barriers to innovation be explored?
- ⇨ How can the barriers to innovation be categorized?

Research Question 3: How can the barriers to innovation, with regards to E-Mobility, be overcome?

- ⇨ What approach is purposefully applied in order to manage the barriers to innovation in the E-Mobility system?
- ⇨ What implications can be deduced for the relevant stakeholders for managing the barriers in E-Mobility?

The goal of this thesis is to extend the perspective from a vehicle-based view to a holistic perception including all relevant stakeholders involved in the power play of E-Mobility. The challenges and also the barriers which hinder the market diffusion of electric vehicles need to be identified. Lastly, this thesis is aimed at developing an approach for overcoming the barriers identified.

1.5 Research Design

In order to approach the problem and the deduced research questions in a structured way, the research design according to WOHINZ is applied in this thesis, as illustrated in Figure 1.7.

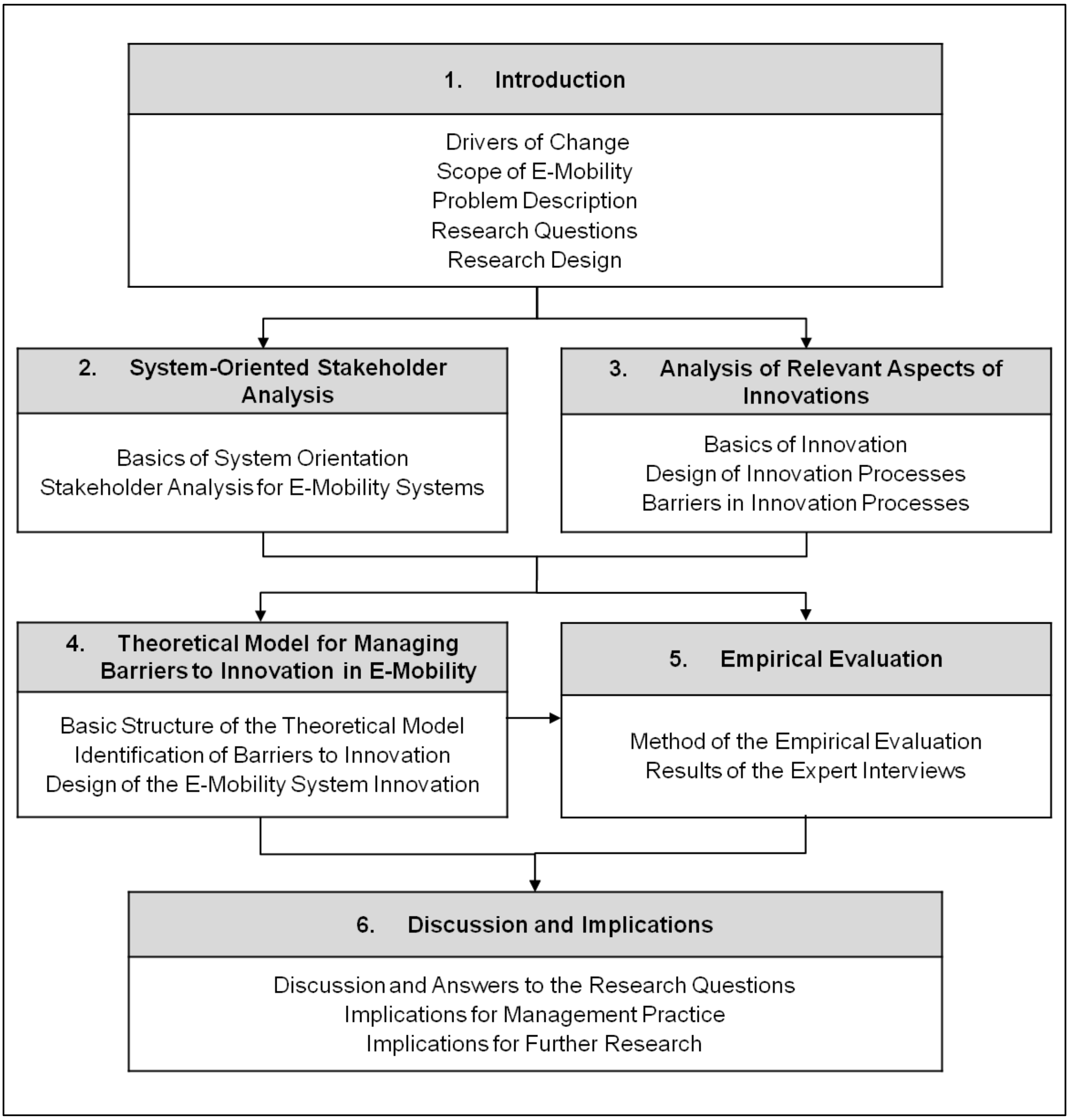

Figure 1.7: Research design of this thesis[57]

The first chapter describes the current situation. Therefore, it starts with the drivers of change plus the scope of the term E-Mobility, i.e. what is meant by E-Mobility in general and in this thesis in particular. As to this, a typology of electric vehicles is given and the various concepts of the electrification of the powertrain are explained. Then, the problem description, the research questions and the research design are introduced.

[57] Research design according to WOHINZ, J.W. (2009), p. 12

The next two chapters cover the theoretical considerations. On one side, chapter two contains the basics of system orientation and a stakeholder analysis in E-Mobility systems, which is a crucial part of this thesis. Therefore, all relevant parties are described in regards to their involvement in E-Mobility. On the other side, chapter three treats the analysis of relevant aspects of innovations. The essential terms are then defined and different types of innovation and innovation processes are discussed. The last section deals with the theoretical basis of barriers to innovation and their key characteristics.

On this basis, chapter four constitutes the distinct part of this thesis, i.e. the theoretical model for managing barriers to innovation. In the first step the barriers to innovation in E-Mobility need to be identified and then categorized, while the further considerations provide an approach to overcoming those barriers. The design of the system innovation in E-Mobility involves the affected stakeholder and the identified barriers, implications are deduced and a framework is developed for overcoming the barriers to innovation in E-Mobility.

Chapter five describes the empirical evaluation of the theoretical model. Non-standardized interviews with a question guideline are used as qualitative method. Thirteen expert interviews are conducted in order to collect the various perspectives of the stakeholders.

To conclude, the sixth chapter summarizes the results of the empirical findings and discusses them in comparison to the theoretical elaboration. Then, implications for managerial practice, on the one hand, and for further research, on the other, are deduced.

2 System-oriented Stakeholder Analysis

The following chapter covers the system-oriented stakeholder analysis in E-Mobility. To begin, the basics of system orientation in innovation management are discussed, including the relevance and the definition of the term. The last part of this chapter covers the identification and analysis of the stakeholders in E-Mobility systems.

2.1 Basics of System Orientation

The activities in strategic innovation and technology management do not refer solely to internal factors of one company independent of its environment. Rather, there are various influencing factors which can arise from internal as well as external sources. The specific field of activities, which can be actively set by one company, is surrounded by an environment determining crucial framework conditions.[58] In this respect, socio-demographic, social, economic, technological and political factors plus the natural environment must all be taken into consideration.[59]

The central focus of the environment analysis is the claims and influences of stakeholders on a company.[60] The term stakeholder is derived from “stockholder” and “stake”,[61] and is defined as “individuals or groups which depend on the company for the realization of their personal goals and on whom the company is dependent. In that sense, employees, owners, customers, suppliers, creditors as well as many other groups can be regarded as stakeholders in the company.”[62] However, the most accepted definition of stakeholders[63] is, in short: “A stakeholder […] is any group or individual who can affect or is affected by the achievement of the organization’s objectives.”[64]

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[58] Cf. GELBMANN, U.; VORBACH, S. (2007), p. 95
[59] Cf. HUXOLD, S. (1990), p. 51; cf. GELBMANN, U.; VORBACH, S. (2007), p. 95
[60] Cf. GELBMANN, U.; VORBACH, S. (2007), p. 95
[61] Cf. STAHLE, H. W. (1999), p. 395
[62] FREEMAN, R. E. (1984), p. 41
[63] See FASSIN, Y. (2009), p. 116
[64] FREEMAN, R. E. (1984), p. 46

Hence, the crucial precondition for developing an innovation strategy is to precisely analyze the company's environment from a general as well as from a branch-specific perspective, aside from the internal determinants.[65] Moreover, special importance is attached to system-orientation in the event of new product launches. In order to conceptualize new product launch activities, literature mainly focuses on overcoming customer resistance, however, it often neglects other stakeholders who become involved and may cause obstacles. Nonetheless, the point is made that companies which interact with other relevant stakeholders in a more proficient way are more successful on the market.[66]

In the course of identifying the stakeholders according to the basic definition, FREEMAN provides a rather simple concept, which is expressed by means of a visual model.[67] Figure 2.1 illustrates a generic stakeholder map as the starting point for a stakeholder analysis.

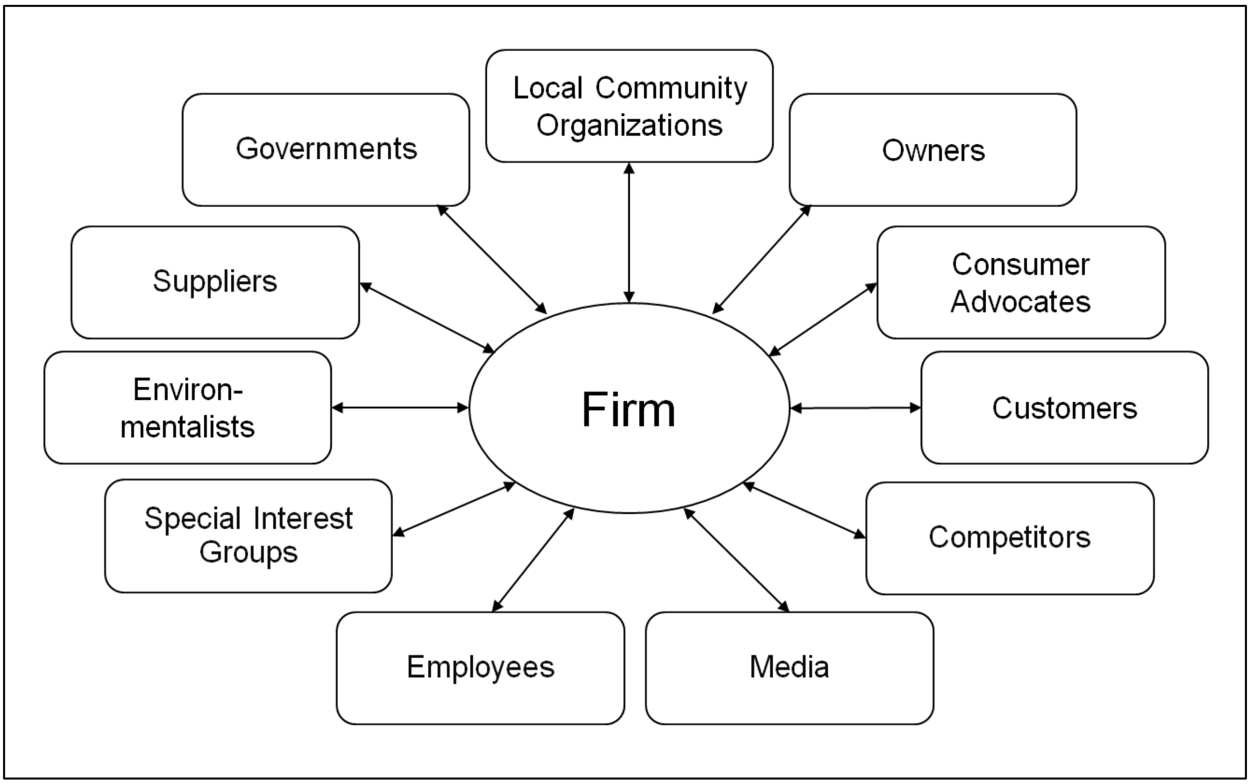

Figure 2.1: Generic stakeholder map[68]

With regards to the simplified stakeholder map, FREEMAN points out that the categories can be divided into several smaller categories as the employees are not all

[65] Cf. GELBMANN, U.; VORBACH, S. (2007), p. 96
[66] Cf. TALKE, K.; SALOMO, S. (2009), pp. 248
[67] See FASSIN, Y. (2009), p. 114
[68] FREEMAN, R. E. (1984), p. 25

alike, neither are the governments or other interest groups.[69] Apart from the definition of stakeholders by FREEMAN, there are many others by various authors.[70] Due to the wide range of definitions and the broadened scope of the term, the discussions of who the actual stakeholder is determined to be often comes up in literature,[71] as FASSIN states that "those who can affect a firm are not always the same as those who can be affected by it"[72]. There are many attempts aimed at classifying stakeholders according to various criteria such as the following:[73]

- primary vs. secondary
- direct vs. indirect
- generic vs. specific
- legitimate vs. derivative
- strategic, core, environmental, etc.

In addition, another theory offers the stakeholder identification and salience in due consideration of the following three attributes: "(1) the stakeholder's *power* to influence the firm, (2) the *legitimacy* of the stakeholder's relationship with the firm, and (3) the *urgency* of the stakeholder's claim on the firm."[74] Moreover, a further theory attempts at clarifying the term by introducing three distinct categories for the potential stakeholders, which are:[75]

- "the stakeholders, who have a real stake in the company,"
- "the stakewatchers [..] such as pressure groups, who do not really have a stake themselves but who protect the interests of real stakeholders", such as consumer associations and activists, and
- "the stakekeepers […], the independent regulators, who have no stake in the firm but have influence and control" such as governments, courts and certification organizations.

There are various attempts made to cope with the confusion that arises from the myriad definitions of stakeholder; still, the concept by FREEMAN expresses the fundamental idea of considering and analyzing an organization's environment in a very simplified way and, therefore, seems to be well suited for a general first approach.

[69] Cf. FREEMAN, R. E. (1984), p. 25
[70] See MITCHELL, R. K. et al. (1997), p. 858
[71] see also FASSIN, Y. (2009); MITCHELL, R. K. et al. (1997)
[72] FASSIN, Y. (2009), p. 117
[73] Cf. FASSIN, Y. (2009), p. 116
[74] MITCHELL, R. K. et al. (1997), p. 854
[75] FASSIN, Y. (2009), p. 121

2.2 Stakeholder Analysis in the E-Mobility System

In terms of system orientation, it is crucial to analyze the expectations and attitudes of the environment of E-Mobility. This chapter aims at identifying the stakeholders according to FREEMAN's[76] concept, which seems to be most suited to comply with the analysis of the E-Mobility system in a first step due to its simplified approach. However, with regards to E-Mobility, his definition is adapted inasmuch as the center is not constituted by a firm but rather by E-Mobility in general, i.e. any group or individual who can affect or is affected by the accomplishment of the purpose of successfully establishing a reasonable concept of E-Mobility on the market is referred to as a stakeholder.[77] Based on aforementioned considerations, Figure 2.2 illustrates the relevant interest groups in E-Mobility systems in a very simplified way.

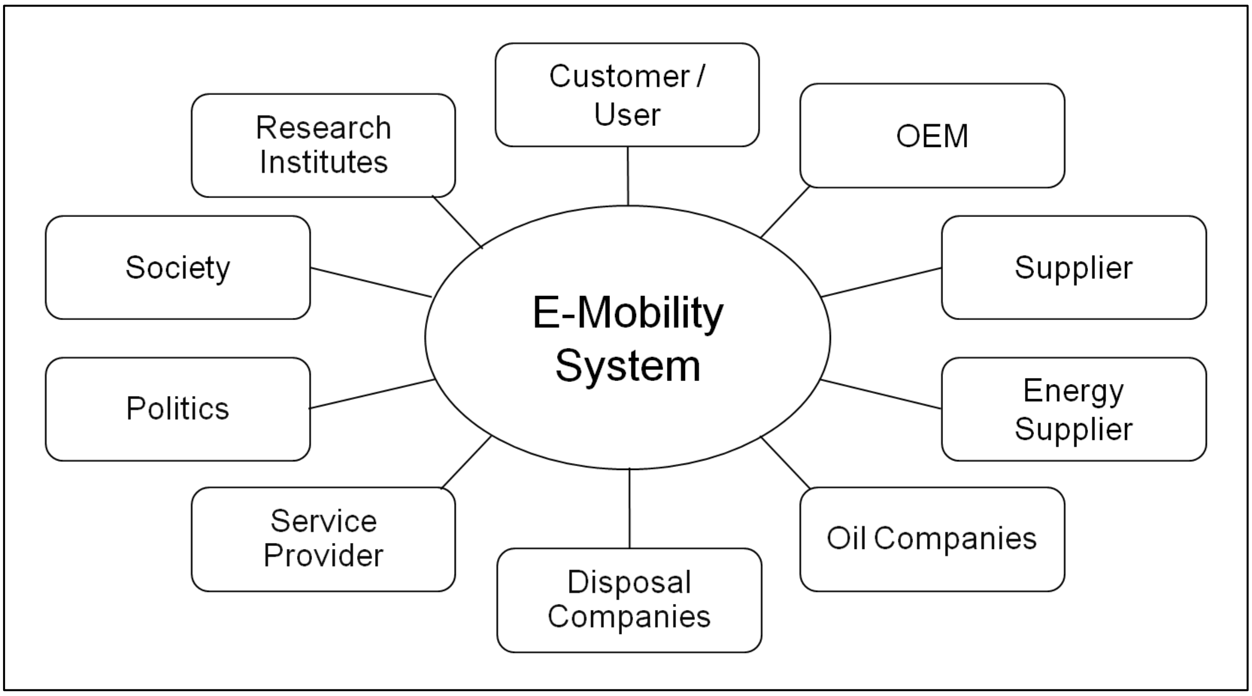

Figure 2.2: Stakeholders in E-Mobility systems[78]

In the following considerations, various aspects of the stakeholders, who take part in this power play of E-Mobility, are described in order to analyze their specific attitudes.

[76] FREEMAN, R. E. (1984)
[77] Referring to the definition of stakeholders by FREEMAN, R. E. (1984), p. 46
[78] Referring to FREEMAN, R. E. (1984), p. 25

2.2.1 Customer / User

This stakeholder category deliberately includes customers and users. The term customer can also refer to a company or public authority that buys a product, while users actually use the product. In the following paragraphs aspects like market potential, reaction to climate change, the inclination to buy and customer requirements, as well as the path of development and early adopters are discussed to give an overview about the customers' as well as users' attitude towards E-Mobility.

Market potential

Forecasts for worldwide annual sales of plug-in hybrids and battery electric vehicles vary between studies. A study by McKinsey predicts a market potential of 3-16 % in Europe in 2020, dependent upon circumstances like oil prices, regulations and battery prices. The forecast for Asia proceeds with 1-11 %, followed by North America with 1-3 % of the total annual sales. As a result, there is a global market potential of 1-9 % for BEVs and PHEVs with an estimated number of 77 m. vehicles worldwide.[79] However, the reality cannot be known until real customers actually buy real cars and they are on the market.

Reaction to climate change

As a basis for a possible change, the customers' reaction to climate change and their willingness to react are crucial. Figure 2.3 shows the results of an opinion survey about mobility and how customers say they are going to react to climate change.

[79] Cf. MCKINSEY & COMPANY (2009), p.17

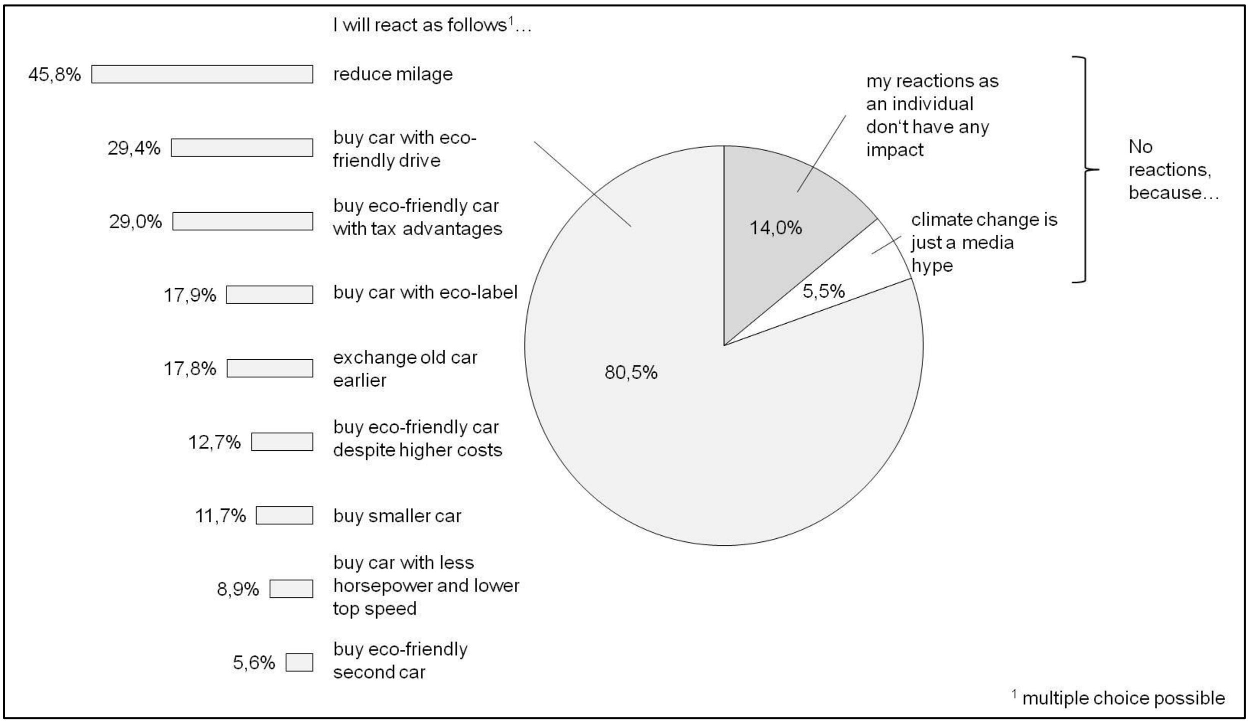

Figure 2.3: Reaction to climate change in the EU[80]

This result refers to respondents in the EU, but the USA shows very similar figures.[81]

The most common reaction is the reduction of mileage. But there is a large number of respondents who are planning to take the aspect of eco-friendliness into account for their next car purchase.

Inclination to buy and customer requirements

A study by Roland Berger and TNS Infratest states that the inclination to buy an electric vehicle is already rather high. 37 % of Germans would consider buying an electric vehicle likely or very likely, 63 % would perhaps buy one and 0 % answered rather unlikely or very unlikely.[82]

The customer's requirements and needs, in respect of mobility, are defined by Roland Berger as follows:[83]

- *General needs of mobility:* Range, unlimited mobility
- *Financial requirements:* Purchase price and total cost of ownership (TCO)
- *Vehicle requirements:* Model, size, comfort

[80] Referring to OLIVER WYMAN (2007a), p. 60
[81] Cf. OLIVER WYMAN (2007a), p. 64
[82] Cf. ROLAND BERGER (2010b), p.12
[83] Cf. ROLAND BERGER (2010a), p. 19

An Oliver Wyman study also verifies the importance of the TCO as a buying criteria as shown in Table 2.1. A very interesting fact is that “eco-friendly” is ranked under the top five for the first time.[84]

Criteria at purchase of a new car	**EU** [1...very important] [5...not important]	**USA** [1...very important] [5...not important]
Reliability	1.3	1.1
Safety	1.4	1.4
Price / Performance Ratio	1.6	1.3
TCO	1.6	1.4
Eco-Friendly	2.1	2.2
Design / Style	2.3	2.2
Good Relationship with Dealer	2.5	2.4
Brand / Prestige	2.9	2.9

Table 2.1: Criteria at purchase of a new car[85]

On the basis of customers’ needs, in respect of mobility, a closer look is taken at the willingness to spend according to the importance of the purchase price and the TCO as well as the range limits in the following paragraphs.

The willingness to spend more money and the real cost difference are creating a gap. Studies say that the cost difference between a BEV and an ICE were about €14,000 in 2010, and will still be about €4,500 in 2020.[86] Compared to the price people are willing to pay for eco-friendliness it is still very high. Figure 2.4 shows the premium price people are willing to spend for an electric car compared to a conventional car.

A glance at not just the purchase price but also consideration of the total cost of ownership and the image changes, because average running costs are still lower for BEVs, however this can change depending on electricity costs and state funding.[87]

[84] Cf. OLIVER WYMAN (2007b), p. 1
[85] Cf. OLIVER WYMAN (2007a), p.13
[86] Cf. ROLAND BERGER (2010b), p.19
[87] Cf. MCKINSEY & COMPANY (2009), p. 16

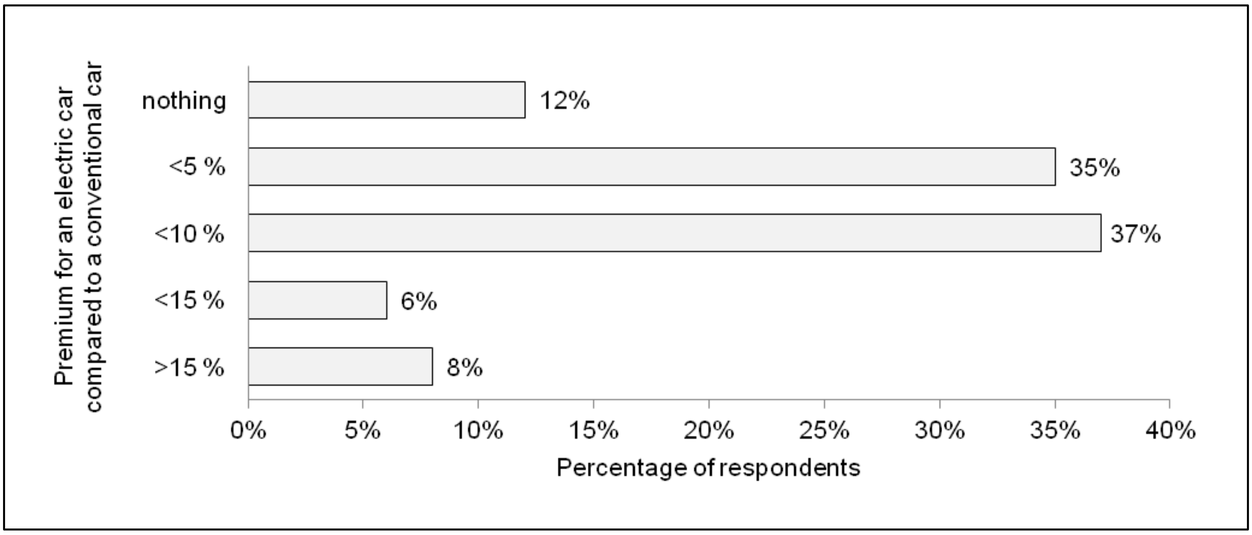

Figure 2.4: Premium for an electric car compared to a conventional car[88]

Range limits as non-buying criteria turn out to be more of a psychological matter than a technical one. About 80 % of driving distances are less than 40 km and 50 % are only up to 10 km which can be covered with the current state of the art of electric vehicles. Furthermore, there are only 20 % of customers who use their car more often than 6-7 times a day.[89] Considering this, the expectations on range are rather high, as shown in figure Figure 2.4.

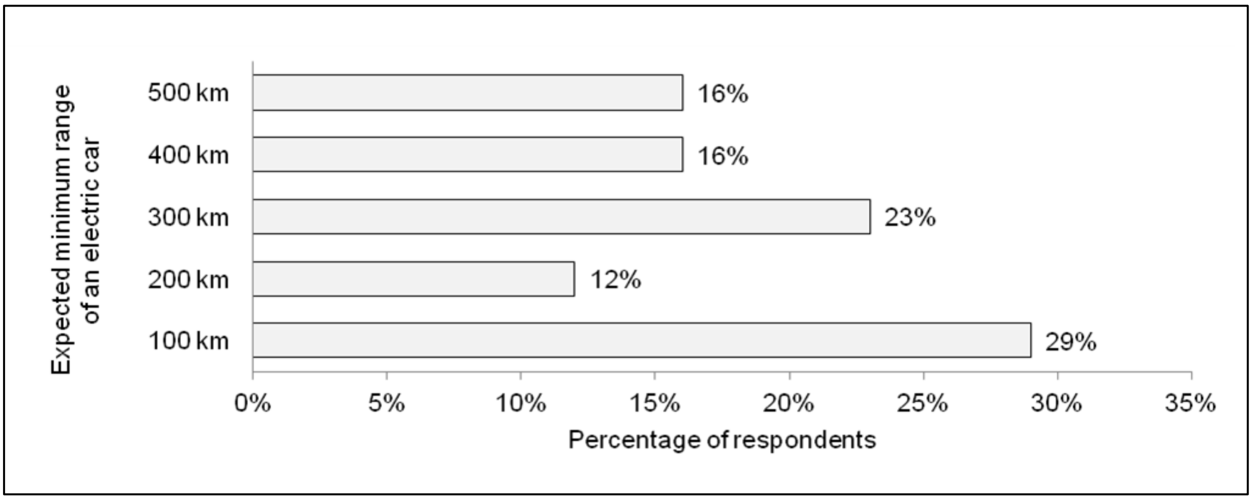

Figure 2.5: Expected minimum range of an electric car[90]

29 % of the respondents expect a range of 100 km, as a minimum, for an electric car, all other respondents expect even more. It is crucial to deal with customer requirements and their psychological needs concerning mobility.[91]

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[88] Referring to ACCENTURE (2009), p. 8
[89] Cf. OLIVER WYMAN (2009), p 20
[90] Referring to ACCENTURE (2009), p. 7

Path of development and early adopters

Customers can be divided into different groups of vehicle owners which include private, companies and public authorities. Furthermore, there are distinct types of usage, i.e. city, commuter, regional, national and international. The path of development can be illustrated in this array as shown in Figure 2.6.

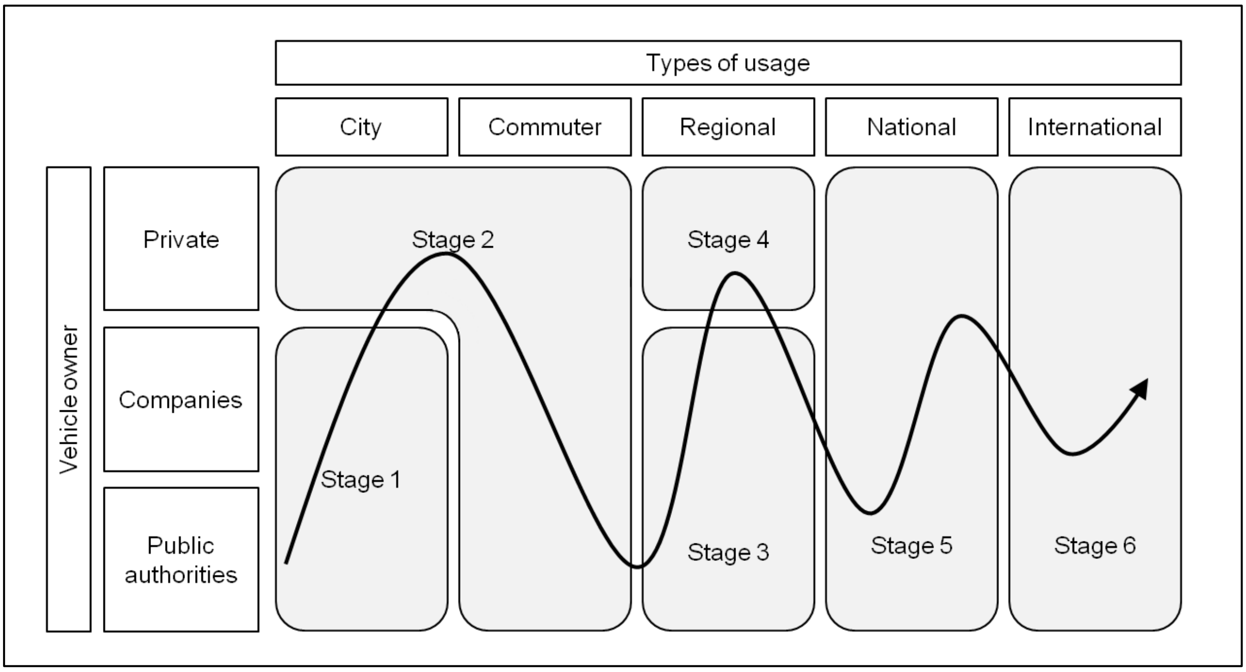

Figure 2.6: Path of development for electric vehicles[92]

The very first adopters are public authorities and companies for mainly city. This first stage is closely followed by private vehicle owners, not only for the city but also for commuting. Then regional, national and finally international usage follows. For the near future, thus for a short-term opportunity, this implies that the early adopters and first private adopters mostly live in cities, megacities and/or agglomerations and mainly use the cars for short distances, e.g. for commuting to work and shopping.[93]

2.2.2 OEM

The automotive industry has been working on efficiency since the first combustion engine car was developed. Since the first oil crises in the 1970s it became more of an economic criterion than a technical challenge. Due to constant optimization, mobility is much more efficient than it was 30 years ago. Since then, performance has increased

[91] Cf. OLIVER WYMAN (2009), p 20
[92] Referring to A.T. KEARNEY (2011), p. 10
[93] Cf. ROLAND BERGER (2010a), p. 20

so that even higher efficiency was not able to compensate for fuel consumption. The trend is turning now and downgraded cars are gaining importance. Tightened legal regulations on environmental protection are leading in a similar direction. New cars must comply with CO_2-restrictions determined by the European Union as well as other regions and those that do not comply face penalties. The main interest of an OEM must be to ensure as well as enhance their sales while avoiding penalties due to tightened CO_2-restrictions. Consequently, there are some noticeable trends: the shift in model mix, the ever-increasing efficiency of the ICE and the development of alternative propulsion systems associated with a shift in competence.[94]

Shift in model mix

Eco-friendliness and costs are among the top five buying criteria.[95] The smaller and downgraded car segment is growing; moreover, rising oil prices emphasize the current trend. E.g. the small Honda Civic was the best-selling car in the USA in 2010, in contrast to the heavy Chevrolet Silverado pick-up the year before. This indicator is highly important to the automotive industry because there is less profit to make with the small car segment than with the larger cars. On the one hand, there is simply less quantity and, on the other hand, quality features are often copied by the smaller segments without compensating for them with higher prices. On top of this, there are a lot of international competitors on the market of small cars.[96]

Efficiency increase of the ICE

The research and development on ICE has not yet reached its boundary. There is still a lot that can be done in terms of efficiency, i.e. higher performance and at the same time lower fuel consumption. These measures combined with, for example, lightweight construction allow the opportunity to be more eco-friendly and cost-conscious with a conventional drive concept.[97]

Development of alternative propulsion systems and a shift in competence

Among various concepts for alternative propulsion systems of vehicles, the electrification of the powertrain seems to have a promising future. Since the beginning

[94] Cf. MCKINSEY & COMPANY (2009), pp. 9
[95] Cf. OLIVER WYMAN (2007a), p. 13
[96] Cf. MCKINSEY & COMPANY (2009), p. 10
[97] Cf. MCKINSEY & COMPANY (2009), p. 10

of automotive industry, electric drives have remained an important issue for the propulsion system.[98]

Due to the electrification of the powertrain there has been a shift in competences and in the value chain between car manufacturers and suppliers. Up to now the internal combustion engine and the transmission have been the core competences of car manufacturers, thus crucial for their brand identities, while battery technology is not. Conversely, the supplier's primary competence is generally the development and/or production of components. Now, the extent to which car manufacturers and suppliers take on the competence for the electric components must be clarified. As there is no uniform approach, various strategies are being pursued by car manufacturers, as some examples show in Table 2.2.[99]

	Battery suppliers	E-Motor suppliers
DAIMLER	• In-house production of cells and complete batteries in Joint Venture with Evonik	• In-house production of motors for hybrid vehicles in Berlin factory • Joint Venture with Bosch for production of electric motors for EVs/full hybrids
VW	• Battery cells produced by Sanyo • Assembly of complete batteries carried out by VW itself	• Up to now, reliance on suppliers for low volume vehicles • Plans for in-house production in future in Kassel factory
Ford	• Ford sources battery cells and complete batteries from Sanyo, LG Chem and Johnson Controls-Saft	• Reliance on a number of suppliers, including Magna and Toshiba • No in-house production at present

Table 2.2: OEM shares of value creation for e-motors/batteries[100]

2.2.3 Supplier

The following section discusses aspects such as shifts in competences and value creation, new components and production technologies as well as joint ventures and partnerships.

[98] Cf. MCKINSEY & COMPANY (2009), p.10
[99] Cf. ROLAND BERGER (2011), pp. 10
[100] ROLAND BERGER (2011), p. 11

OEM or Supplier - Shift in competence and value creation

The boundaries between supplier and car manufacturers are becoming increasingly blurred through the electrification of the powertrain. The core issue is how the value creation of the electric components is shared between the OEM and the supplier.[101] The OEMs are not voluntarily compromising their position in either the product definition process or the value chain and are, therefore, forcing research and development activities in the field of electric propulsion. However, the shift in value creation implies not only threats but also enormous opportunities within the supply industry.[102]

New components and production technologies

The market entry of electric vehicles entails a decline in sales for conventional propulsion components, i.e. the combustion engine, the gearbox, the exhaust system and the fuel tank. Suppliers whose core competences are in those fields are especially impacted by the electrification of the powertrain. The components are substituted by electric components, i.e. mainly the battery, the electric motor, electronic control units, which create a different cost structure, in which the focus is clearly on the battery. [103]

The electric drive is associated with new components and production technologies which have rarely been used in the automobile industry to date. The relevant production technologies, especially in battery production, such as mixing and coating, become more important in contrast to the technologies for metal processing, i.e. and shaping and machining. Suppliers who were previously successful do not automatically play an equally important role in the field of E-Mobility. The relevant technologies for the automotive industry can also come from other companies in different industry sectors.[104]

As previously shown in Table 2.2 “OEM shares of value creation for e-motors/batteries” in chapter 2.2.2, some OEMs source the battery cells or even the complete battery from suppliers. Nonetheless, battery cell production alone still represents nearly half of actual battery costs. Figure 2.7 gives a typical example for the breakdown of battery costs.

[101] Cf. ROLAND BERGER (2011), p. 11
[102] Cf. MC KINSEY (2009), pp. 25
[103] Cf. MC KINSEY (2009), pp. 25
[104] Cf. ROLAND BERGER (2011), p. 14

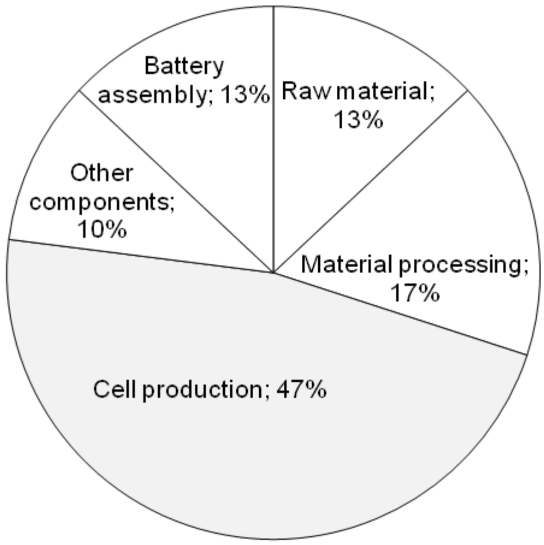

Figure 2.7: Breakdown of battery costs[105]

With almost 50 % share of costs, cell production is important leverage in reducing the total battery costs, which can be realized through increased productivity and lower reject rates. The past shows some examples of how the development of production technology has influenced the drop of costs, cases in point are semiconductors, flat panel monitors and photovoltaic cells. Furthermore, the quality of battery cells also depends heavily on a stable and optimized production technology. In the past, machines and plants for vehicle battery cell production were designed for small series, experimental purposes and small-scale vehicle project. As the requirements for major serial production are concomitantly different, the crucial issues are an increased productivity and a consistent level of quality.[106]

Joint ventures and partnerships

Economies of scale and an optimized productivity are essential issues for a cost decrease of the electric components. In order to realize this effect and to exploit market potential, joint ventures and partnerships are crucial within the supply industry as well as between suppliers and OEMs. These partnerships, as driving forces, are already very common with the aim that all parties involved benefit from a symbiotic relationship

[105] ROLAND BERGER (2011), p. 17
[106] ROLAND BERGER (2011), pp. 16

e.g. by sharing development costs, by being able to offer customers system solutions and/or the participation in development of standards.[107]

2.2.4 Energy Supplier

The implementation of electric vehicles causes some changes and provides opportunities for the energy supply industry. Energy suppliers have to face some central questions in order to clarify their strategic position in the market. Accordingly the expected benefit of E-Mobility, possible business models and renewable energies as well as the realization of those projects with adequate partners is described as follows.

Expected benefit of E-Mobility

First of all, energy suppliers need to evaluate what benefit is to be expected from entering the market of E-Mobility. On the one hand, there is the additional sales potential and, on the other hand, it may imply a positive image effect. Furthermore, it includes the long term opportunity for new business development.[108]

The additional demand of electricity in Germany is estimated, by Roland Berger, at 4 % in 2020 based on 25 %[109] market share for BEVs and PHEVs, which is already a fairly high assumption, compared to the 3-16 %[110] market share in Europe stated by a McKinsey study. A.T. Kearney estimates the additional demand of electricity in Europe to be 1 % in 2020 and 3-5% in 2030. Thus, in a short term perspective, the benefit in terms of additional sales potential is limited.[111]

Possible business models and renewable energies

Up to now, energy conversion, transport and distribution have been the core businesses of energy suppliers. In order to take advantage of new market potential arising from electric vehicles there are new opportunities in the future energy system.[112] Figure 2.8 gives an overview of the traditional as well as the new business models for energy suppliers along the value chain.[113]

[107] Cf. ROLAND BERGER (2011), pp. 5
[108] Cf. ROLAND BERGER (2010a), p. 27
[109] ROLAND BERGER (2010a), p. 30
[110] MCKINSEY & COMPANY (2009), p. 17
[111] Cf. A.T. KEARNEY (2009), p. 2
[112] Cf. ROLAND BERGER (2010a), p. 31
[113] Cf. A.T. KEARNEY (2009), pp. 1

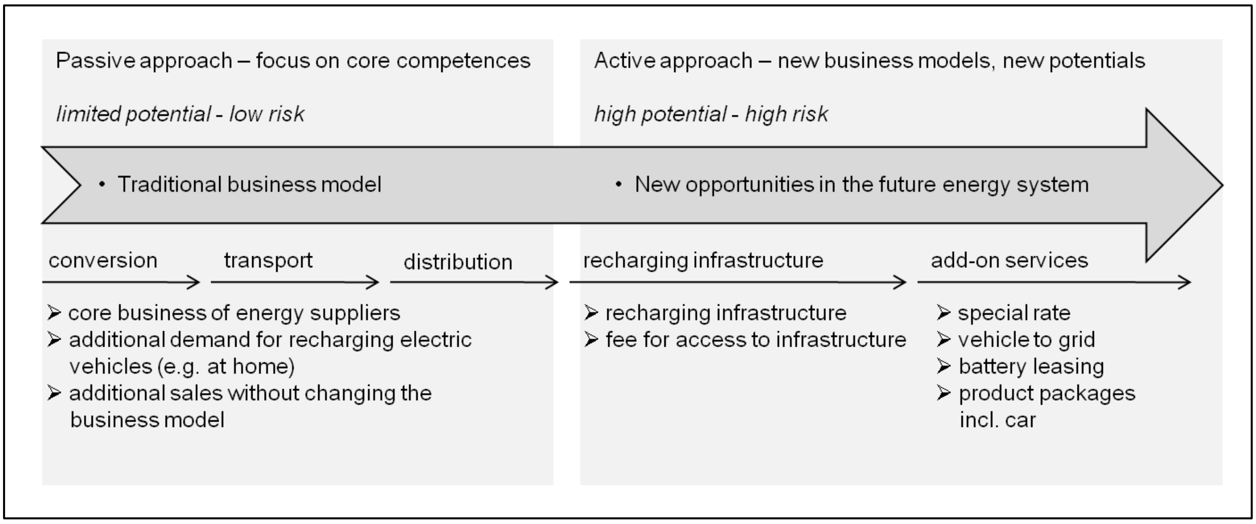

Figure 2.8: Traditional vs. new business models for energy suppliers[114]

In both short- and midterm perspectives there are additional market potentials such as the installation of a recharging infrastructure as well as further add-on services, for example, special rates, vehicle to grid, battery leasing and offering of complete product packages. The entry into those new business models requires investments and thus is associated with higher risks than the traditional business models, but inevitable for those wanting to benefit from E-Mobility. However, as energy conversion and, therefore, power generation is part of the energy suppliers' core business, they are also required to make a considerable contribution in terms of renewable energy. [115]

Realization with appropriate partners

Partnerships have a determining influence on the successful realization of new business models. This refers to OEMs, but for a sustainable and successful positioning on the market it also includes local communities, governments and regulators, as well as other branches such as service providers, e.g. car rental services and car park operators for the installation of a recharging infrastructure. Appropriate partners are limited, as only a few players dominate the market.[116] A number of OEMs are already in a partnership with energy suppliers and/or local communities, e.g. Volvo and Vattenfall, Daimler and RWE, VW and e-on together with Vattenfall, or Toyota with eDF and PG&E Corporation.[117] For smaller and regional energy suppliers, who have lower financial

[114] Referring to ROLAND BERGER (2010a), p. 31; referring to A.T. KEARNEY (2009), p. 3
[115] Cf. A.T. KEARNEY (2009), pp. 2
[116] Cf. A.T. KEARNEY (2009), pp. 2
[117] Cf. ROLAND BERGER (2010a), p. 33

resources, it is even more important to find intelligent strategies and realize the projects with selected partners.[118]

2.2.5 Oil Companies

At first glance, the question arises as to what extent oil companies are stakeholders in E-Mobility. In the following paragraphs, aspects like the decline of dependency on fossil fuels, renewable energies for power generation and oil companies as stakeholders in E-Mobility are discussed in order to address this question.

Decline of dependency on fossil fuels

The principal reason for implementation of electric vehicles is to meet challenges such as the reduction of CO_2-emissions and dependency on fossil fuels.[119] The battery as the energy storage of electric vehicles can be recharged by any energy source; thus, renewable energies gain importance in the energy mix while fossil fuels lose proportionally.[120] In fact, that does not seem to be very advantageous for the oil industry, as petroleum is their core business.

Renewable energies for power generation

In order to lay the foundation for eco-friendly mobility, the intention must be to realize power generated from renewable energies. Otherwise, the well-to-wheel primary energy demand and the CO_2-emissions of an electric vehicle are similarly high compared to conventional cars with an optimized and efficient internal combustion engine.[121] In a short term perspective, considering the still small share of renewable energy in the energy mix,[122] the oil industry is not seriously affected by the implementation of electric cars.

Oil companies as stakeholders in E-Mobility

The oil industry is aware of the finiteness of resources and the increasing world energy demand, therefore the oil companies expend considerable efforts toward a sustainable and cleaner energy future. In the following paragraphs, the oil companies Saudi

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[118] Cf. A.T. KEARNEY (2009), pp. 2
[119] Cf. VOLKSWAGEN AG (2011), p. 2
[120] Cf. INTERNATIONAL ENERGY AGENCY (2010), p. 9
[121] Cf. VOLKSWAGEN AG (2011), p. 10
[122] Cf. INTERNATIONAL ENERGY AGENCY (2010), p. 9

Aramco, ExxonMobil, BP and Royal Dutch Shell are singled out as examples to describe the current trend in the oil industry.

Saudi Aramco, the state-owned oil giant of Saudi Arabia, is the world's largest oil exporter.[123] In 2008, *Petroleum Intelligence Weekly* ranked ExxonMobil, BP and Royal Dutch Shell among the top 10 of the world's top 50 oil companies[124] and among the top 5 in the annual ranking of the world's largest companies.[125]

Saudi Aramco is actively engaged in researching for cleaner energy. One of their initiatives is a partnership with the Massachusetts Institute of Technology Energy Initiative (MITEI) to do research into new energy technology and processing techniques. Furthermore, they collaborate with Solar Frontier, a Japanese based supplier for solar energy solutions, to pilot solar power generation plants.[126]

In its Corporate Citizenship Report of 2009 ExxonMobil states that expanding supplies from renewable sources is one of their key areas in addressing the sustainability challenge.[127] They also support research efforts in the field of vehicle technology, such as algae biofuels, lithium-ion batteries and hydrogen fuel cells. [128]

BP is greatly involved in developments for alternative energy technology. They are convinced that renewable resources like biofuels, wind and solar will play an important role in the energy mix in satisfying the increasing energy demand as well as meeting the challenges imposed by climate change. BP disputes whether renewable energies are currently financially feasible but states that they are also working with external partners on the development and deployment of alternative energy technology, such as wind farms and solar technologies, in order to make them economically viable.[129]

Royal Dutch Shell, which is also the leading supplier of natural gas, contributes to a cleaner energy future e.g. by supporting wind power activities in the energy mix, as they are involved in a substantial number of onshore wind projects in North America.[130] The company is also actively engaged in making transport more sustainable and are, therefore, also investing in and working on biofuels.[131]

Oil companies are involved in topics such as the increasing world energy demand and climate change. They are expected to contribute to a sustainable and cleaner energy

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[123] Cf. FINANCIAL TIMES (2011), access date 04.08.2011
[124] Cf. OILVOICE (2008), access date 04.08.2011
[125] Cf. CNNMoney (2011), access date 04.08.2011
[126] Cf. SAUDI ARAMCO (2011), access date 04.08.2011
[127] Cf. EXXONMOBIL (2010), p. 5
[128] Cf. EXXONMOBIL (2011), access date 04.08.2011
[129] Cf. BP (2011), pp. 24
[130] Cf. ROYAL DUTCH SHELL (2011), pp. 8
[131] Cf. ROYAL DUTCH SHELL (2011), pp. 22

future and have a determining influence on the power generation with renewable energies. Therefore, they have a decisive role regarding the impact and eco-friendliness of electric vehicles.

2.2.6 Disposal Companies

The disposal of electric vehicles holds some changes for disposal companies. The following section discusses how automotive recycling is regulated in general, the extent to which electric vehicles hold new challenges and what activities are made in the field of battery recycling.

Automotive Recycling

Automotive recycling is regulated by EU Directive 2000/53/EC on end-of-life vehicles, which contains the following key points:[132]

- the directive applies to “any vehicle designated as category M1 [...]” (passenger cars) “or N1 [...]” (light commercial vehicles) “and three wheel motor vehicles”;
- the directive claims area-wide infrastructure of authorized treatment facility for end-of-life vehicles and determines concrete environmental standards for reuse, recycling and recovery;
- “[...] the delivery of the vehicle to an authorized treatment facility [...] occurs without any cost for the last holder and/or owner [...]; the producers meet all, or a significant part of, the costs of the implementation of this measure and/or take back end-of life vehicles under the same conditions [...]”; this applies “as from 1 July 2002 for vehicles put on the market as from this date, as from 1 January 2007 for vehicles put on the market before the date referred to in the first indent”, but may also be applied “in advance of the dates set out”.
- “no later than 1 January 2006, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 85 % by an average weight per vehicle and year. Within the same time limit, the reuse and recycling shall be increased to a minimum of 80 % by an average weight per vehicle and year”;
- “no later than 1 January 2015, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 95 % by an average weight per vehicle and year. Within the same time limit, the reuse and recycling shall be increased to a minimum of 85 % by an average weight per vehicle and year”;

[132] Cf. BMLFUW (2002), p. 1 and DIRECTIVE 2000/53/EC (2002), pp. 2

- “materials and components of vehicles put on the market after 1 July 2003 do not contain lead, mercury, cadmium or hexavalent chromium” other than in few exceptional cases.

New challenges – battery and light weight material recycling

As for electric vehicles, the issue of disposal holds new challenges for disposal companies, particularly when it comes to batteries and lightweight material.[133]

Lightweight materials are increasingly used for electric vehicles in order to reduce the weight of the vehicle and thereby the CO_2-emissions throughout their life cycle. As described above, EU Directive 2000/53/EC specifies that reuse and recovery has to be increased to 95 % per vehicle no later than 2015. As car manufacturers have to take back end-of-life vehicles, they are forced to consider the recycling and dismantling of new models as early as in the conception phase. The use of lightweight material such as fiber-reinforced plastic and aluminum makes this more difficult compared to conventional materials such as iron and steel. Fiber-reinforced plastic is very difficult to separate and recycle, but efforts are being taken to develop new materials which can be recycled[134], for example, at the CFK Valley Stade Recycling GmbH & Co. KG in Stade near Hamburg[135]. In aluminum lightweight construction the focus is on a mixed construction, i.e. a combination of aluminum and steel, which is challenging in terms of joining technology and recycling due to the different material properties.[136] Furthermore, the production of primary aluminum is highly energy intensive; thus, aluminum is an asset regarding CO_2-emissions only when using secondary aluminum made of recycled material.[137]

Another problem is that current recycling processes for batteries are not suitable for a great number of traction batteries on an industrial scale. The lithium is not recovered and the battery manufacturers currently focus on safety rather than on ease of dismantling. Moreover, there is no network for the collection and safe dismantling process of batteries.[138]

[133] Cf. LINDER, E. (2010), p. 54
[134] Cf. LINDER, E. (2010), pp. 54
[135] CFK Valley Stade Recycling (2011), access date 17.08.2011
[136] Cf. KRINKE, S. et al., pp. 442
[137] Cf. LINDER, E. (2010), p. 57
[138] Cf. BÄRWALDT, G. (2010), p. 5

Activities in the field of battery recycling

Various activities are currently undertaken in the recycling of lithium-ion batteries.[139] The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety supports the research and development projects “LithoRec” and “LiBRi” for the recycling processes of lithium-ion batteries from an economic and ecological point of view.[140]

The goal of the LithoRec consortium is to achieve a high recycling efficiency and to establish the basis for recycling in an industrial scale. The project partners are the Braunschweig University of Technology, Audi AG, Chemetall GmbH, Electrocycling GmbH, Evonik Litarion GmbH, Walch Recycling & Edelmetallhandel GmbH & Co. KG, H. C. Starck GmbH, I+ME ACTIA GmbH, Recylex GmbH, Süd-Chemie AG, University of Münster and Volkswagen AG.[141]

The LiBRi project also takes into account the whole process chain, i.e. dismantling-friendly battery design, logistics process (collection, transport and storage), dismantling and recovery of materials. The project partners are Umicore AG & Co. KG, Daimler AG, Öko-Insitute Darmstadt and Clausthal University of Technology.[142]

Another example for the activities in the recycling of lithium-ion batteries is given by Nissan. The Japanese car manufacturer started a joint venture with Sumitomo, who deals with the reuse of old batteries from electric vehicles. They aim to install the used traction batteries for solar and/or wind power plants as electricity storage or use them as reserve storage. However, as the residual performance of the batteries used is still 70 to 80 %, they can still be sold to electric car drivers with low range requirements.[143]

2.2.7 Service Providers

Diverse service providers, such as mobility services providers, car repair shops, providers of charging infrastructure, IT-companies as well as financial service providers need to take action in order to achieve a successful implementation of E-Mobility. In the following paragraphs a few service providers, taken as examples, are discussed in order to give an overview about their activities in E-Mobility.

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[139] Cf. MROTZEK, A.; LOHMANN, H. (2011), p. 25
[140] Cf. BMU (2011), pp. 63
[141] Cf. BMU (2011), pp. 64
[142] Cf. BMU (2011), pp. 64
[143] Cf. LINDER, E. (2010), p. 55

Exemplary service providers and their activities in E-Mobility

Mobility service providers like car dealers and even railway companies are particularly suitable for providing E-Mobility services such as integrated multi-modal-mobility concepts and pay-per-use offerings.[144]

Car repair businesses need to adjust to the new requirements of electric car repair; moreover, there must be employees trained to repair electric vehicles, which are quite different from conventional vehicles. In light of the aforementioned issues, the TÜV, to name an example, offers various seminars and trainings covering electric vehicles.[145]

The requirements of recharging batteries give rise to new providers of charging infrastructures. In addition to parking companies, this also includes supermarkets with large parking areas. The parking company APCOA entered into co-operation with The Mobility House, a provider of E-Mobility solutions in Austria, Switzerland and Germany, and the RWE group[146], a leading electricity and gas company in Europe, in order to install charging infrastructures in car parks.[147] Moreover, the supermarket chain SPAR is very active in the installation of charging spots.[148]

Providers for IT-solutions are also affected by E-Mobility.[149] The BEKO Engineering & Informatik AG, with interests in Austrian Mobile Power, is very dedicated to providing new IT infrastructure processes, in particular for intelligent billing systems, telematics and logistics.[150] Another example is BOSCH, who provides a software solution for E-Mobility services called "eMobility Solution". Thus, charging spots can be connected to each other as well as to drivers and other relevant parties for the purpose of finding and reserving time at charging stations, billing of energy consumption and services, operating and maintaining charging infrastructure, etc.[151]

Financial service providers are also active in E-Mobility and therefore a relevant stakeholder, such as the Raiffeisen Leasing GmbH, which rents cars in co-operation with partners like Citroen and is a partner in various projects in terms of vehicle procurement, financing and fleet management.[152] They mainly consider the total cost of

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[144] Cf. A.T. KEARNEY (2009), p. 3
[145] Cf. TÜV Rheinland (2011), access date 18.08.2011; cf. TÜV SÜD (2011), access date 18.08.2011
[146] Cf. RWE (2011), access date 18.08.2011
[147] Cf. THE MOBILITY HOUSE (2011), access date 18.08.2011; cf. APCOA (2011), access date 18.08.2011
[148] Cf. SPAR (2011), access date 18.08.2011
[149] Cf. A.T. KEARNEY (2009), p. 3
[150] Cf. MM Erneuerbare Energien (2011), access date 18.08.2011
[151] Cf. BOSCH (2011), access date 18.08.2011
[152] Cf. RL-MOBIL (2011), access date 18.08.2011

ownership rather than the purchase price, whereas the residual value is still a major question.

2.2.8 Politics

Politics gain importance in the new power play of E-Mobility as politicians want to reduce the dependence on fossil fuels, substantially drive the change with specific levers and fight for their local car industry within the competition for future leadership. In the following section, various levers for supply and demand of electric vehicles are discussed and an overview of CO_2-emission limits, as well as concepts and funding is given.

Supply vs. demand levers

In order to reduce pollutant emissions and, in addition, the dependency on oil and gas with its concomitant dependence on Arabic countries plus the implied instability, politicians are urged to support a more environmentally friendly mobility. As far as E-Mobility is concerned, as one possibility to achieve this goal, there are several levers to increase the supply of electric vehicles on the part of industry, on the one hand, and the demand on the part of customers, on the other[153]. Figure 2.9 shows several supply and demand levers that pertain to regulators, governments and local communities which speak to the reduction of CO_2-emissions.

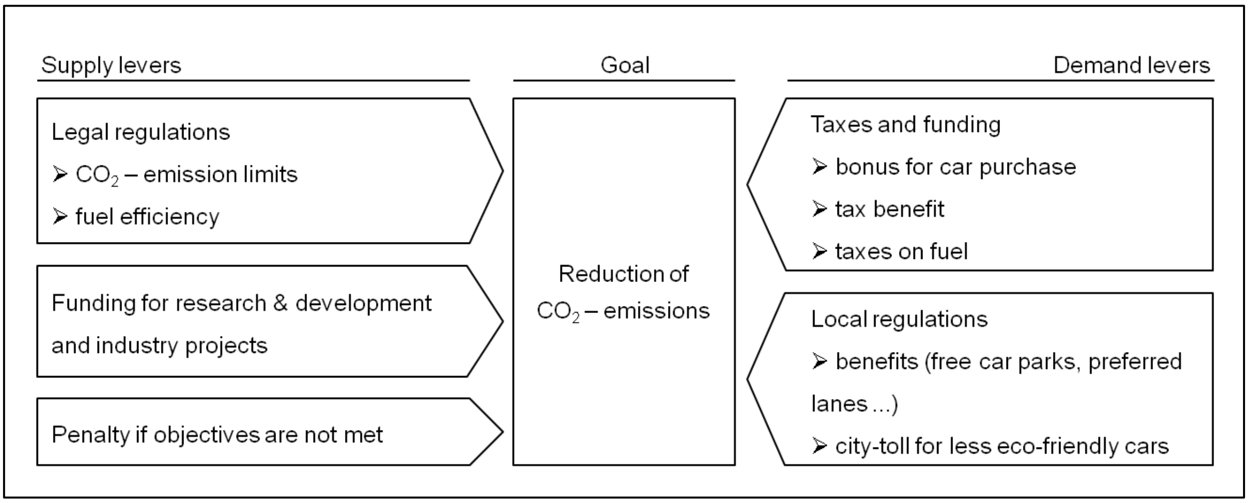

Figure 2.9: Supply vs. demand levers[154]

[153] Cf. ROLAND BERGER (2010a), p. 17
[154] Referring to ROLAND BERGER (2010a), p. 17

CO_2-emission limits

CO_2-emissions are regulated by directives and therefore penalties are incurred if objectives are not met such as CO_2-taxes.[155] The CO_2-goals for EU, USA, Japan and China are shown in Figure 2.10.

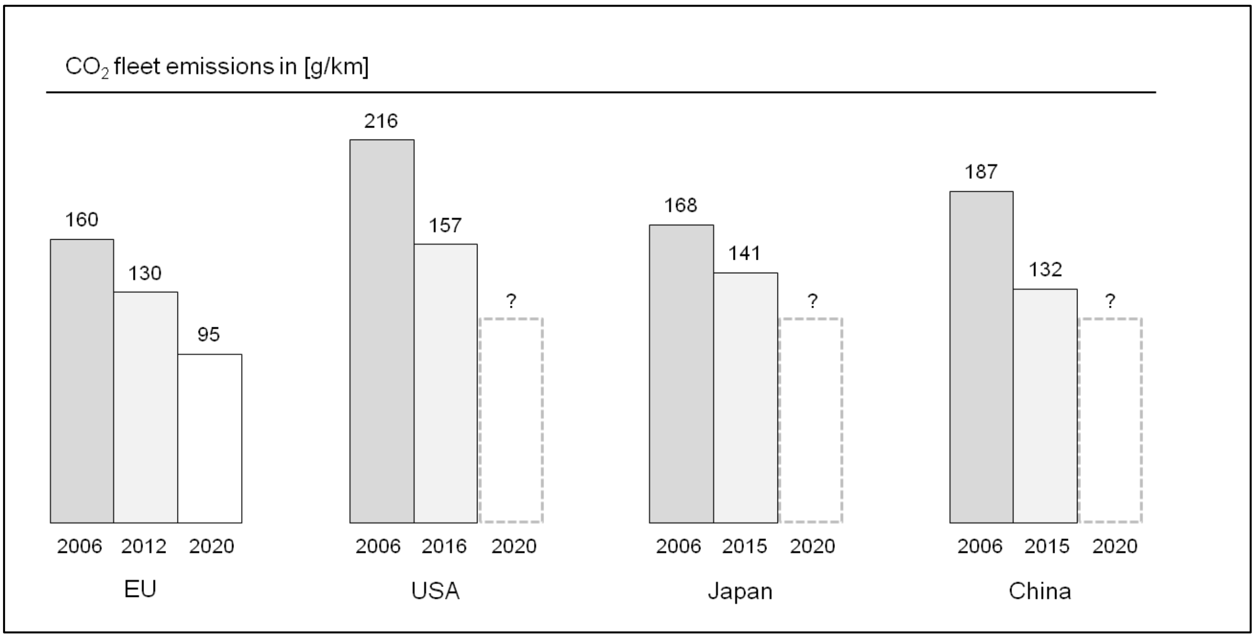

Figure 2.10: CO_2-fleet emissions[156]

With no changes in the model mix there are very few vehicle fleets able to meet the future CO_2-limits, thus OEMs are forced to find alternatives.[157]

Governmental initiatives and funding

The US Department of Energy made a loan of €17 bn. within the "Advanced Technology Manufacturing Loan Program" for the production of efficient fuel-saving vehicles. Japan supported the development of future generation batteries for electric propulsion systems with €150 m. over seven years. The central government in China provided €1 bn. to support car manufacturers in the development of alternative propulsion systems.[158] The European Investment Bank EIB made a loan via European Clean Transport Facility ECTF of €3.5 bn. This facility supports programs for research, development and innovation in order to reduce CO_2-emissions.[159]

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[155] Cf. ROLAND BERGER (2010a), p. 16
[156] Referring to REGULATION (EC) No 443/2009, pp. 1; referring to U.S. Environmental Protection Agency (2009), access date 19.08.2011; referring to ROLAND BERGER (2010a), p. 16
[157] Cf. ROLAND BERGER (2010a), p. 15
[158] Cf. ROLAND BERGER (2010a), p. 18
[159] Cf. EIB (2010), p. 1

On a national level, several initiatives have also been set up in Austria, such as the industry platform Austrian Mobile Power, the “Nationaler Einführungsplan Elektromobilität” by the Federal Ministry for Transport, Innovation and Technology and the “10 Punkte Aktionsprogramm zur Markteinführung von Elektromobilität” by the Federal Ministry of Agriculture, Forestry, Environment and Water Management.[160]

2.2.9 Society

Society as a stakeholder in E-Mobility is discussed in the following paragraphs in respect of the need for individual mobility, crises as an important role in change processes and the influence of social norms.

Need for individual mobility

Individual unlimited mobility can be considered a basic mobility requirement,[161] as well as an essential characteristic of our society. In Austria, there were 4,513,421[162] registered passenger cars in 2011; therefore, in relation to a population of 8,433,250[163] in the fourth quarter of the year 2011 and the distribution by age, this is a significant number. Currently, distances, from very short up to very long, are covered by car, which is also represented by the average mileage per year of less than 5,000 km per year by even 20 % of the respondents and more than 20,000 km per year by 18 %.[164] These indicators suggest that the car, as a means of transport, is taken for granted and considered to be available at any time.

Role of crisis in change processes

The implication of E-Mobility signifies a considerable change to the well-known and self-evident usage of conventional cars with combustion engines. In order to realize a successful change, the very first important step is, according to the Eight-Stage Process of Creating Major Change by KOTTER, to establish a sense of urgency that something needs to be done.[165] Moreover, in order to raise the urgency level, a crisis can be extremely helpful and always plays a significant role.[166]

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[160] Cf. A.T KEARNEY (2011), p. 5
[161] Cf. ROLAND BERGER (2010a), p. 19
[162] STATISTIK AUSTRIA (2012a), access date 28.08.2012
[163] STATISTIK AUSTRIA (2012b), access date 28.08.2012
[164] AXA (2009), p. 99
[165] Cf. KOTTER, J. P. (1996), pp. 33
[166] Cf. KOTTER, J. P. (1996), p. 45

One major topic of today is climate change, which can be referred to as a crisis in respect of the environment. Furthermore, there was an economic and financial crisis in the late 2000’s.[167] It raises the question as to what extent those crises are influencing factors on the recent hype about E-Mobility. However, it can be generally stated that a crisis has an impact on getting people’s attention on the need to change,[168] thus, it may be an opportunity for an upcoming trend.

Influence of social norms

In addition to a number of other various factors, social norms, i.e. the perceived expectations of others, can also have an influence on the intention to use or apply a new technology. Concerning E-Mobility, this means that the probability of a successful market implementation is also affected by the general societal perception of electric vehicles.[169] According to ROGERS, this societal influence, as well as peer pressure, is especially significant for late-adoption groups. Social norms definitely have to be in favor of new technology in order to convince the late majority of adopting it.[170]

2.2.10 Research Institutes

In the following section, the contribution of research and exemplary research activities in E-Mobility are discussed.

Contribution of research

Research institutes can make a valuable contribution to successful implementation of E-Mobility. In order to become a lead market for E-Mobility and to establish necessary value chains, considerable and accelerated efforts are needed in the field of research and development, including key technologies as well as education and training.[171] The basic prerequisite is a systemic and integrated approach in research and development.[172]

Research activities

A great number of research activities are currently being undertaken by research institutes in the area of E-Mobility. These range all the way from energy conversion,

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[167] Cf. UNITED STATES SENATE (2011), pp. 45
[168] Cf. KOTTER, J. P. (1996), p. 45
[169] Cf. PETERS, A. et al. (2011), p. 984
[170] Cf. ROGERS, E. M. (2003), p. 284
[171] Cf. BMWi; BMVBS; BMU; BMBF (2011), pp. 18
[172] Cf. BMBF (2011), access date 24.08.2011

transport and distribution, vehicle to grid interface, up to energy storage, new vehicle concepts, recycling, infrastructure, billing systems as well as socio-political issues.[173]

2.2.11 Classification and Overview of the Stakeholders in E-Mobility

The previously discussed stakeholders can be categorized into market players, the further environment and, not least, the customer.[174] Figure 2.11 illustrates this classification.

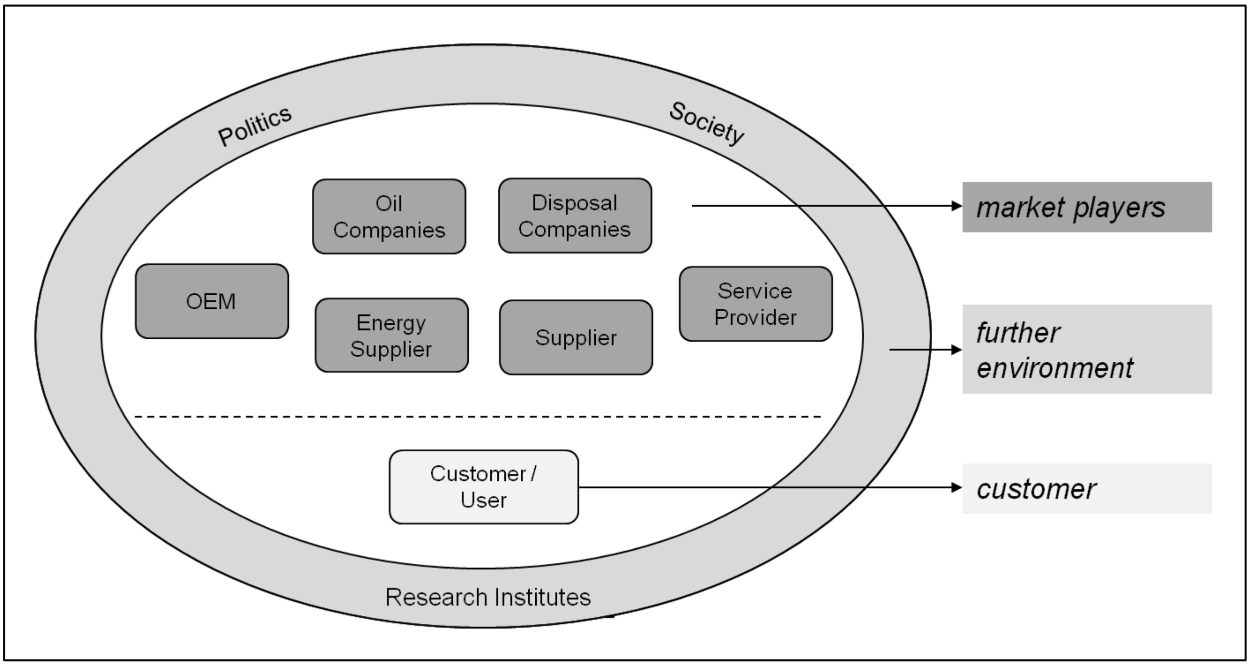

Figure 2.11: Classification of the stakeholders in E-Mobility (author's illustration)[175]

The market players, such as OEMs, suppliers, energy suppliers, oil companies, service providers and disposal companies, and customers are embedded in an environment which consists of research institutes, politics and society in general.

Lastly, the various aspects of the stakeholders, which are discussed in chapter 2.2 explaining how they are affected by or how they affect E-Mobility themselves, are depicted in an overview in Figure 2.12.

[173] Cf. FRAUNHOFER (2011), access date 24.08.2011
[174] Cf. TALKE, K.; SALOMO, S.; TROMMSDORFF, V. (2007), p. 130
[175] Referring to TALKE, K.; SALOMO, S.; TROMMSDORFF, V. (2007), p. 130

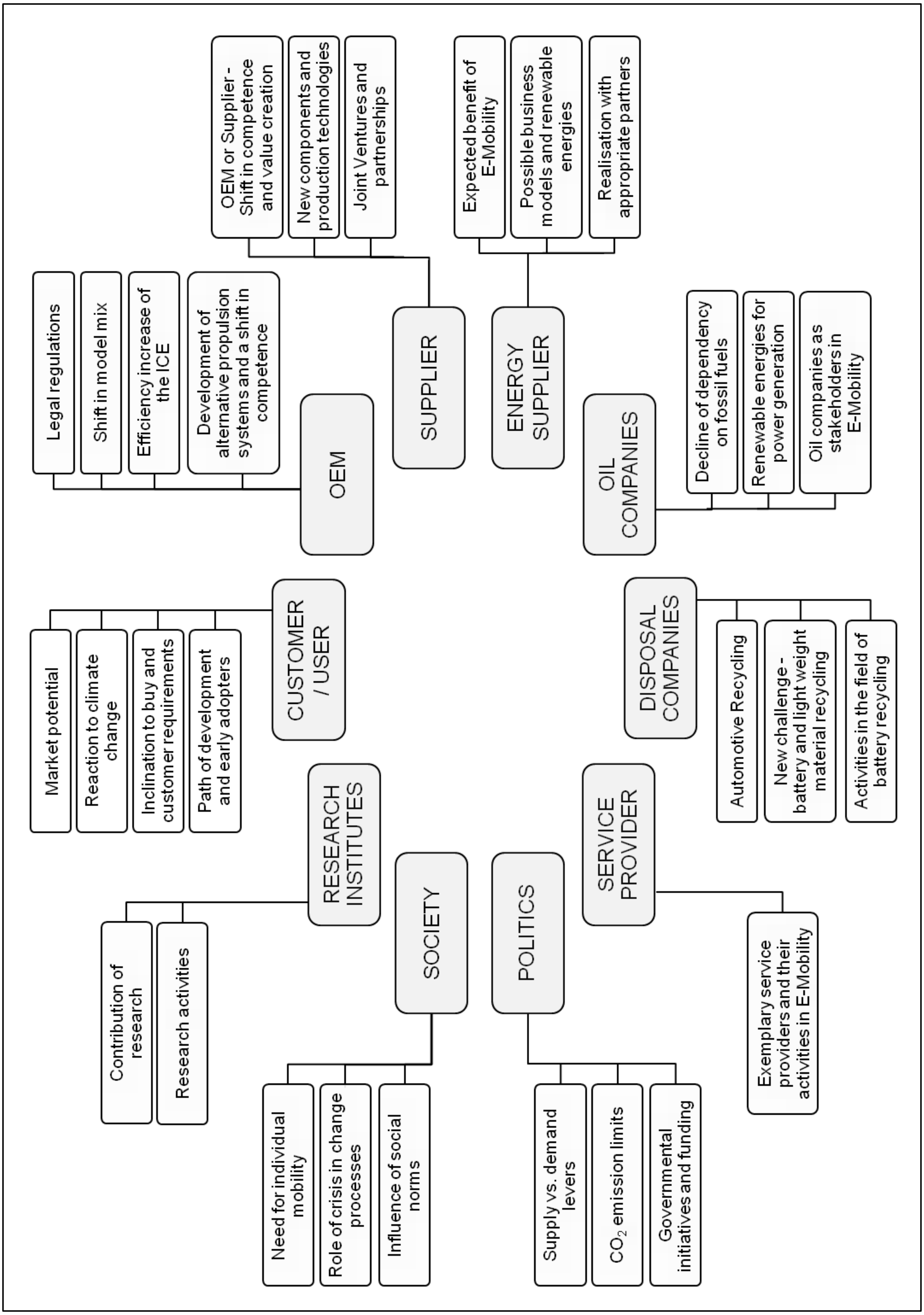

Figure 2.12: Overview of the aspects of the stakeholders in E-Mobility (author's illustration)

3 Analysis of Relevant Aspects of Innovations

With the purpose of clarifying as to what extent E-Mobility can be referred to as an innovation, this chapter discusses some theoretical aspects about innovation, innovation processes and barriers to innovation. To start with, the term innovation is specified, also including the characteristics, dimensions and different types of innovation. Next, the structure of innovation processes is described, covering representative innovation processes and different theoretical perspectives on it. Particularly relevant in regards of E-Mobility, lastly, this chapter also contains a theoretical basis of barriers in innovation with special focus on their characteristics and the overcoming of barriers as a management task.

3.1 Basics of Innovation

In order to understand what is meant by the term ‘Innovation’, an overview about the various definitions of innovation is first given. Further, the characteristics by which an innovation is dominantly determined are discussed. To conclude, the different dimensions of innovation with special emphasis on the types of innovation plus the postindustrial system innovation are covered.

3.1.1 Scope of the Term Innovation

The term innovation is derived from the Latin word “innovatio” which is originally translated as “novelty”.[176] Various authors define innovation in much the same way as it is referred to as a novelty: however, there are distinct formulations and conceptual clarity is an issue.[177] Table 3.1 shows an extract of the manifold definitions.

[176] Cf. VAHS, D.; BURMESTER, R. (2005), p. 45
[177] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 3

Schumpeter, J. A.	“innovation, that is the process of finding economic application for the inventions”
Barnett, H. G.	“An innovation is [...] any thought, behavior or thing that is new because it is qualitatively different from existing forms.”
Thompson, V. A.	“By innovation is meant the generation, acceptance, and implementation of new ideas, processes, products or services.”
Rogers, E. M.	“An innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption. It matters little, so far as human behavior is concerned, whether or not an idea is “objectively” new [...]. The perceived newness of the idea for the individual determines his or her reaction to it. If the idea seems new to the individual, it is an innovation.”
Zaltman, G./Duncan, R./ Holbek, J.	“[...] we consider as an innovation any idea, practice, or material artifact perceived to be new by the relevant unit of adoption. The adopting unit can vary from a single individual to a business firm, a city, or a state legislature.”
Mirow, C.	Innovation is the process from the idea generation up to the implication on the market of any good perceived to be new.

Table 3.1: Extract of definitions of innovation[178]

Beyond that, innovation is clearly distinguished from invention as well as from imitation, which are defined by SCHUMPETER as follows:[179]

- Invention is “the obvious first step toward any new product or process”.
- Imitation is “the process by which innovation is diffused throughout the industry or the economy”.

Joseph A. SCHUMPETER exerted significant influence on the research of economic theory and devised basic scientific considerations about innovation as a critical dimension of economic change in his book “The Theory of Economic Development” which was first published in 1911. According to SCHUMPETER, five cases of innovation can be distinguished:[180]

[178] SCHUMPETER, J. A. (1942), as cited in: RAY, G. F. (1969), p. 40; BARNETT, H. G. (1953), p. 7; THOMPSON, V. A. (1965) p. 2; ZALTMAN, G.; DUNCAN, R.; HOLBEK, J. (1984), p. 10; ROGERS, E. M. (2003), p. 12; cf. MIROW, C. (2010), p. 9

[179] SCHUMPETER, J. A. (1942), as cited in: RAY, G.F. (1969), p. 40

[180] SCHUMPETER, J. A. (2008), p. 66

1. "Introduction of a new good - that is one with which consumers are not yet familiar - or a new quality of a good."
2. "Introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially."
3. "The opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before."
4. "The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created."
5. "The carrying out of a new organization of any industry, like the creation of a monopoly position [...] or the breaking up of a monopoly position."

3.1.2 Characteristics of Innovation

An innovation is basically determined by four dominant characteristics, i.e. the degree of novelty, uncertainty / risk, complexity and the potential for conflicts, as described in the following paragraphs.[181]

- *Degree of novelty:* The degree of novelty is the essentially determining characteristic of an innovation. It is often related to the aspect of a progress, i.e. an improvement compared to the initial situation. Depending on the degree of novelty, innovations cause varying degrees of changes within the company or the peripheral system and therefore require variable substantial investments.
- *Uncertainty / Risk:* The degree of novelty inevitably involves the risk of failure of the new idea, which is eventually caused by a lack of experience. Specifically, the risk lies in the fact that a planned result may not occur in time or even at all. The failure can be expressed by a financial loss, a loss of prestige, a loss of a market position, just to name a few.
- *Complexity:* The complexity describes the presence of diverse interdependencies. Innovations are no isolated actions, but rather a series of various partial activities.

[181] Cf. THOM, N. (1980), pp. 23

- *Potential for conflicts:* Due to the considerations about the degree of novelty, uncertainty and risk and the complexity, innovations hold great potential for conflicts. In this respect various dimensions can be distinguished, i.e. the objective-intellectual, the socio-emotional and the value-culture dimension. Consequently, innovation management faces unique and challenging requirements.

The dependencies of the four typical characteristics of innovation are demonstrated in Figure 3.1.

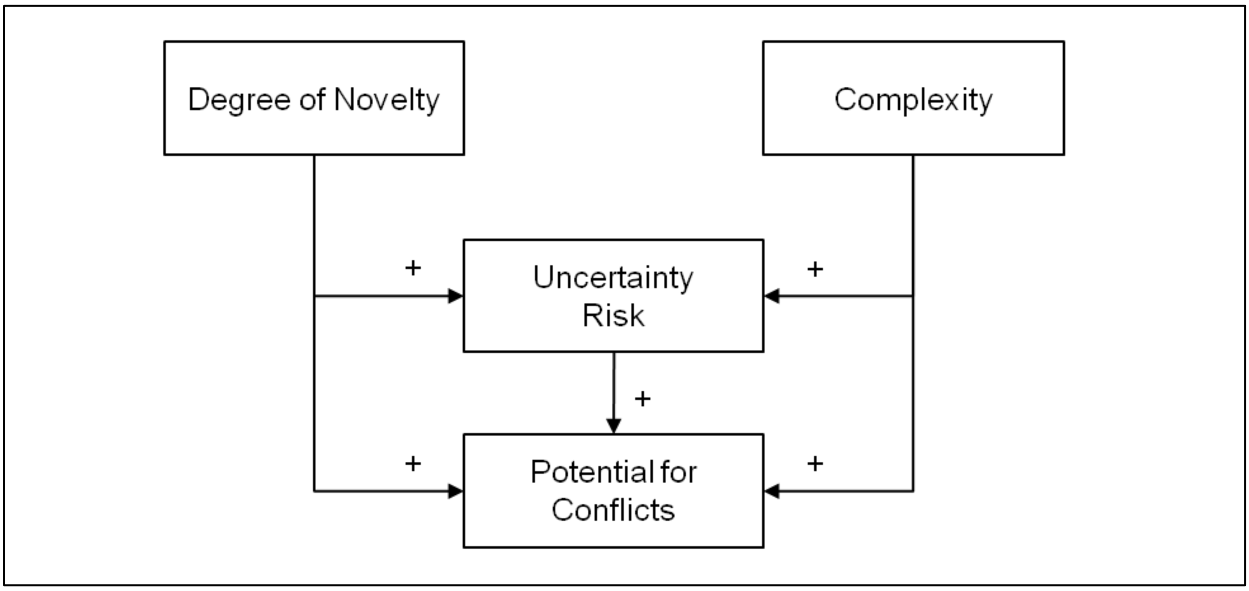

Figure 3.1: Dependencies of the four typical characteristics of innovation[182]

3.1.3 Dimensions of Innovation

The degree of novelty, as a determining characteristic of innovation, is based on the carrying out of new combinations of means and purposes. However, the new combination in and of itself is not sufficient for it to be termed an innovation, since the sale or utilization is the decisive difference between invention and innovation. In order to explicitly define the term innovation, HAUSCHILDT and SALOMO raise the question of the distinct dimensions of an innovation in respect of novelty as follows:[183]

- *Content-based dimension:* What is new?
- *Intensity-based dimension:* How new?
- *Subjective dimension:* New to whom?

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[182] Referring to THOM, N. (1980), p. 31
[183] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 8

- *Procedural dimension:* Where does the novelty start, where does it end?
- *Normative dimension:* Does new equal successful?

Once an issue is determined to be "innovative", it requires a distinct management compared to a routine job in respect of attention, acceptance, processing and economics. Due to that, it is of great importance that according to the defined dimensions it is specified as to whether a problem is referred to as innovative or not. Therefore, the priority need, after all, is the awareness of innovations.[184]

Types of innovation

The following section specifically describes the content based dimension "what is new?" in order to specify the different types of innovation, which are diversely classified by various authors.

According to KNIGHT and THOM, innovations can be assigned to the following classes:[185]

- *Product or service innovation:* "These are the introduction of new products or services which the organization produces, sells, or gives away."
- *Production-process innovations:* "These are the introduction of new elements in the organization's task, decision, and information system or its physical production or service operations, the advances in the technology of the company."
- *Organizational-structure innovation:* "This includes the introduction of altered work assignments, authority relations, communication systems, or formal rewards systems into the organization. This category is in part complementary to category 2", i.e. production-process innovations, "since it includes the formal interactions and authority relations among the participants in the organization that are established to form the production process. In addition, this third category includes the other aspects of formal interaction among the people in the organization."
- *People innovation:* "This is one of two alternatives that produce direct changes in the people within the organization: (a) altering the personnel by dismissing and/or hiring and (b) modifying the behavior or beliefs of the people in organization via techniques such as education or psychoanalysis."

[184] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 29
[185] KNIGHT, K. E. (1967), p. 482; cf. THOM, N. (1980), pp. 32

Although similar in some respect, the following classification established by HAUSCHILDT and SALOMO differs from that given by KNIGHT:[186]

- *Product and process innovation:* The term process innovation refers to an increase in efficiency, while the aim of product innovations is to achieve effectiveness. At first sight, a product innovation seems to be enforced more strictly than a process innovation as it includes the diffusion to the market. Empirical findings argue against it because process innovations are more involved in the overall system and therefore more complicated as well as more difficult to realize. However, the separation of product and process innovation is increasingly questionable since product innovations consistently require process innovations.
- *Innovation of system properties:* The content of an innovation can be extended to a consideration of the innovative product or process elements' connection. Therefore, a system theoretical approach is used, whereas the system can either be determined by innovative components, by innovative systems or by innovative networks between autonomous and innovative systems. Upon closer examination of the respective system, two more variants of innovations can be distinguished, i.e. the modular innovation as the creation of new components within the retained system and its connections, and the architectural innovation which is the creation of new connections between the retained components. On top of this, innovations can be distinguished with regard to the relevance of the system components and connections, i.e. either core/central or peripheral subsystems. This system orientation allows a more distinct classification of innovations.
- *Innovations beyond technology:* SCHUMPETER significantly influenced the understanding of innovation, thus allowing the inclusion of an economic and organizational orientation alongside a purely technical one. As mentioned before, SCHUMPETER determines five cases of new combinations and/or innovations, and therefore establishes a functional classification of innovations such as market, sourcing, logistics, production, financial, personal, social innovation, etc. The key statement of these considerations is that the emphasis is put on an administrative-economic as much as on a technical view.
- *Postindustrial system innovation:* This perception of innovation denies, in the first place, that innovations are specifically a problem of industrial companies and, in the second place, that they are solely internal problems within a company. In

[186] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 9

addition to industrial companies, innovations occur in the service industry, in the financial sector, in the information and communication sectors as well as in politics and public administration, etc. Innovation management has to widen its perspectives as such system innovations involve a network of various co-operation partners from different branches and, therefore, impose additional and distinct requirements.

As postindustrial system innovation differs most, compared to the other types mentioned, it is discussed in more detail in the following paragraphs.

Postindustrial system innovation

GRÜN, HAUSCHILDT and JONASCH conducted further research on system innovations and contributed a specification for what is referred to as such. It is determined to be a system innovation if:[187]

- out of innovation-specific partial activities,
- of legally and economically independent innovators (enablers),
- in an inter-organizational arrangement (governance),
- an innovative combination of purpose and means arises,
- which leads to a sustainable change in behavior.

To an extent, system innovation, which is often referred to as a postindustrial system innovation in order to emphasize the less technical but rather use orientation, differs from “classic” innovations, particularly in respect of the enablers, who act in an inter-organizational network, and the users, who undergo sustainable changes in their behavior.[188]

The interaction of innovators is, in general, considered to be a vertical co-operation along the value chain, i.e. between suppliers and customers. Even so, in regards to system innovation, the innovators also interact in a horizontal co-operation without a hierarchical coordination, except in the case that a dominant partner is appointed.[189] Figure 3.2 demonstrates the inter-organizational co-operation of the enablers' innovation systems.

[187] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 178
[188] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 178
[189] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), pp. 178

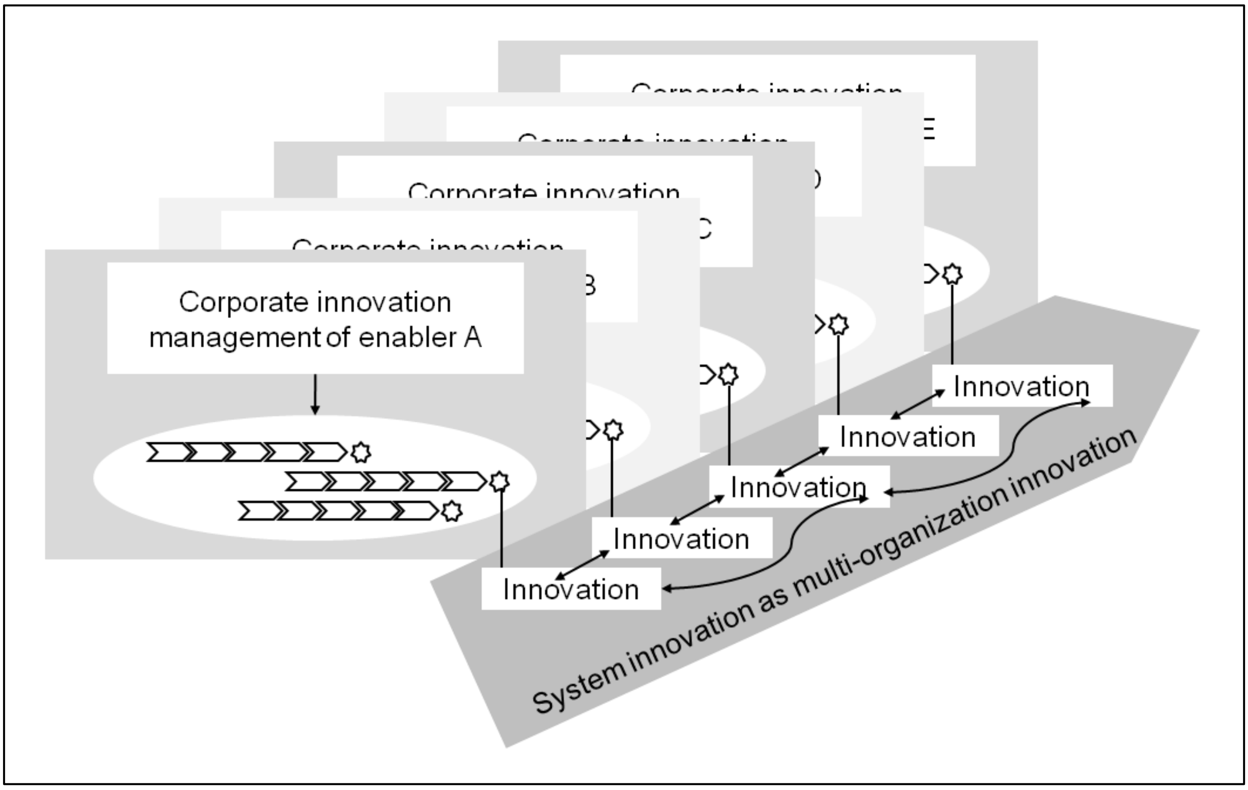

Figure 3.2: Inter-organizational co-operation of the enablers' innovation systems[190]

The user community directs the attention towards adoption and diffusion of a system innovation,[191] whereas diffusion is defined by ROGERS as "the process in which an innovation is communicated through certain channels over time among the members of a social system"[192] and occurs due to adoption of innovation by potential users.[193] The requirements for market penetration are significantly higher since it is more about a paradigm shift in users' behavior than solely about the market shares of a company. In respect of the life cycle of a system innovation, the process from invention through to diffusion is more time consuming, by far, in comparison to classic innovations and, therefore, can even take decades.[194]

Discussion of the different types of innovation

The classification established by KNIGHT and THOM is a rather classical approach, which premises the different types of innovation on specific elements within an organization, i.e. *product or service*, *process*, *organization* and *people*. To some extent,

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[190] Referring to SALOMO, S. (2007), as cited in: GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 179
[191] Cf. PLESCHAK, F.; SABISCH, H. (1996), p. 6
[192] ROGERS, E. M. (2003), p. 5
[193] Cf. PLESCHAK, F.; SABISCH, H. (1996), p. 6
[194] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), pp. 181

the classification by HAUSCHILDT and SALOMO considers the same aspects, such as the *product* and *process innovation*. Moreover, both widen the aspect of what is new beyond a technical view and integrate an organizational, people-related and administrative-economic perspective. Although there is a certain analogy, HAUSCHILD and SALOMO provide an even further extended perspective in terms of what is new. Even the *innovation of system properties* induces a system orientation, and, in the end, *postindustrial system innovation* is not limited to an internal innovation within a company's boundaries, but refers to innovations in a network of various co-operation partners. Therefore, the requirements of the management of a system innovation can differ from "conventional", internal innovations and need to be explicitly taken into account.

3.2 Design of Innovation Processes

The management of innovations is looked upon from two different perspectives; HAUSCHILDT and SALOMO, in any case, distinguish the procedural from the system-theoretical view. According to the procedural approach, the design and the structure of innovation processes is referred to as innovation management. In spite of this, from a system-theoretical point of view, innovation management is extended to the whole innovation system and therefore refers to the institution where the processes occur rather than to the respective process itself.[195]

This section deals with the procedural view on innovation management. Therefore, the innovation process itself is discussed in the narrow as well as in the broader sense. In addition, there are various perspectives on innovation processes, which are then described.

3.2.1 The Innovation Process

In the following paragraphs, the innovation process as a cross-sectional function within a company is discussed before two further well-established representatives of innovation processes are introduced. Lastly, the innovation process is demonstrated in a broader sense as distinguished from the narrow sense.

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[195] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 32

Innovation process as a cross-sectional function according to VAHS/BURMESTER

Innovation management as management of the innovation process is clearly separated from the R&D management;[196] actually, it covers - in addition to fundamental and applied research plus (pre-) development - the whole value chain from R&D over to sourcing, production and distribution up to disposal, including the supporting activities. Beyond that, it is embedded in the company's environment, as for example suppliers, competitors, co-operation partners as well as customers.[197] Figure 3.3 demonstrates those relations.

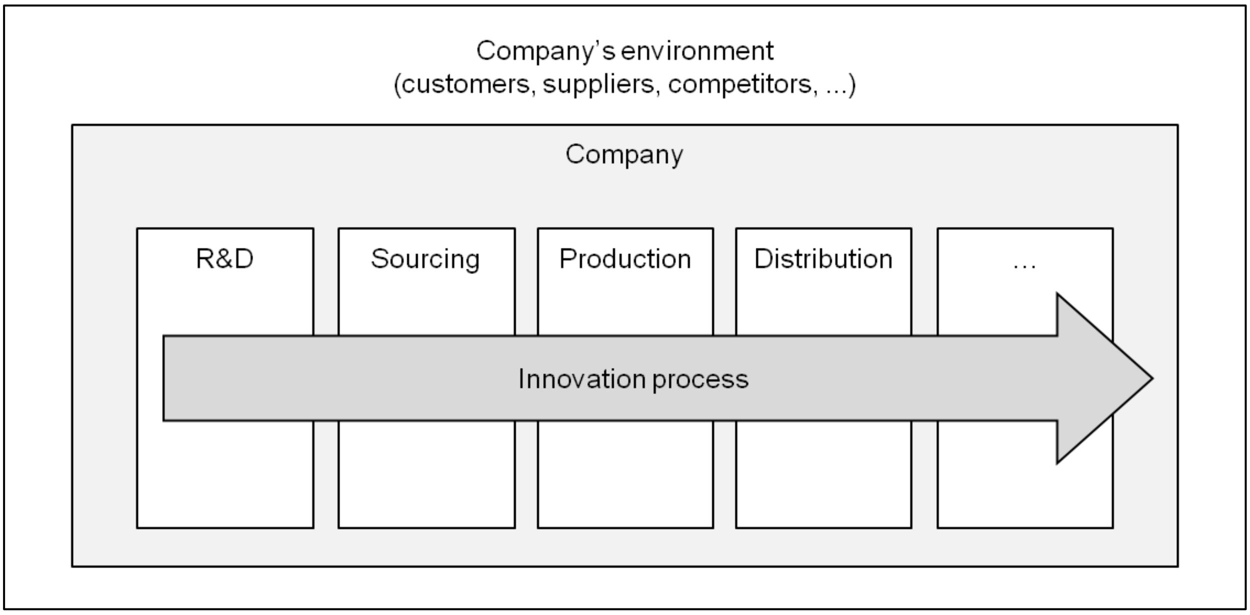

Figure 3.3: Innovation process as cross-sectional function according to VAHS/BURMESTER[198]

Innovation process according to THOM

The innovation process according to THOM, which targets the internal innovation processes within a company, consists of three main phases, as illustrated in Figure 3.4.

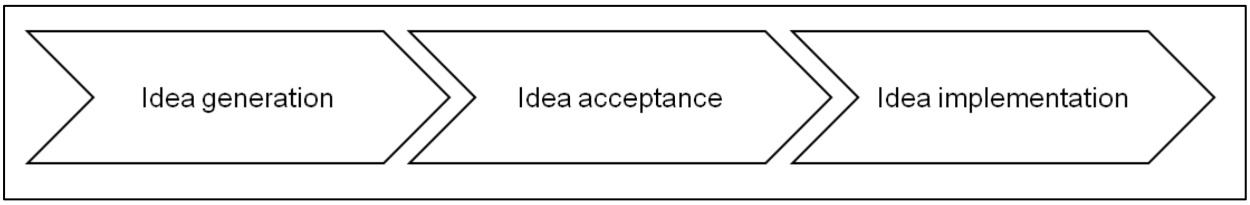

Figure 3.4: Innovation process according to THOM (author's illustration)[199]

[196] Cf. CORSTEN (1989), p. 6
[197] Cf. PLESCHAK, F.; SABISCH, H. (1996), pp. 6
[198] Referring to VAHS, D.; BURMESTER, R. (2005), p. 53; referring to PLESCHAK, F.; SABISCH, H. (1996), p. 7

Each main phase consists of several specific activities. The idea generation phase includes the identification of the search field, the finding of the idea itself and its proposal. The second phase, i.e. the idea acceptance, starts with the evaluation of the ideas, via the creation of a business plan and reaches through to the decision making process. The final and third phase of idea implementation covers the concrete realization, the market launch plus an acceptance control of the idea.

Innovation process according to COOPER

Another well-established process, with its focus also on the internal innovation process, was introduced by COOPER, who separated the innovation process into specific parts, known as *stages* - each consisting of determined, cross-sectional and parallel activities. Before each respective stage, there are stop-or-go decision-making points for a process and quality control called *gates*. As a consequence of this structure, as demonstrated in Figure 3.5, this innovation process is called the stage-gate process.[200]

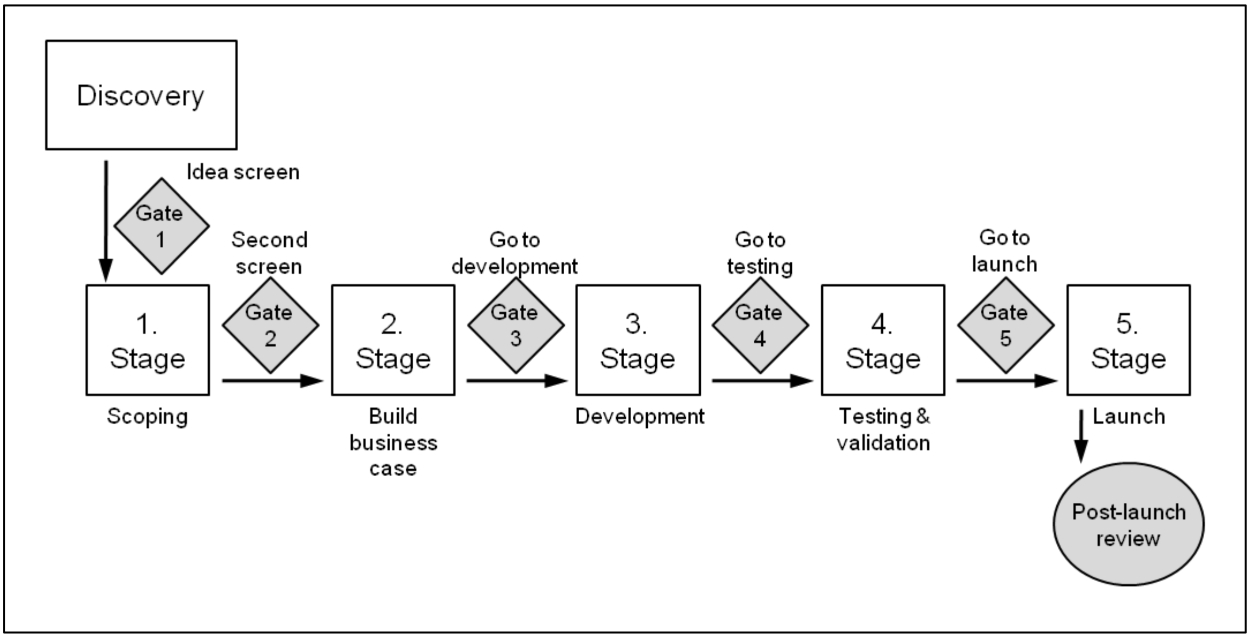

Figure 3.5: Innovation process according to COOPER[201]

Initially, the trigger for each process is the idea as the substance of innovations. The stage known as *discovery* includes idea generation, fundamental technical research, co-operation with lead users in order to explore their requirements and needs, as well as strategic planning. The first gate after the *discovery stage* is referred to as *idea screen,* covering must-meet and should-meet criteria which are, in general, related to

[199] Referring to THOM, N. (1980), p. 53
[200] Cf. COOPER, R. G. (2001), pp. 130
[201] COOPER, R. G. (2001), p. 130

strategic alignment, feasibility of the project, market attractiveness, opportunities, etc. and usually excludes financial aspects. Once past the first gate, the process continues with *scoping* in the first stage, which involves preliminary market and technical assessment, however, with limited resources on a somewhat superficial level. Not until the second gate is passed, where the project - with the additional information gathered in stage one - is again evaluated under similar criteria as in the first gate, the project enters the second stage inducing an increase in resource efforts. This stage, referred to as *building business case,* consists of determining the product characteristics, specifications and requirements, plus a market analysis and a product concept. Therefore it is a critical stage in order to ensure the project's success later on. Gate three, *go to development*, which is the final gate before entering the development stage, is the last stop-or-go point for canceling the project without incurring massive costs. In the third stage, referred to as *development,* the development plan is actually implemented and the physical product is developed. The fourth gate, *go to testing,* serves as a control gate for the proceedings and for the retention of the attractiveness of the product and process. This gate is followed by stage *testing & validation,* which covers the viability of the whole project including the product itself, the production process, the acceptance of the customer as well as financial aspects. The fifth and last gate, *go to launch*, which refers to the results of the testing & validation stage, is the last opportunity to stop the project before production and commercialization in the fifth stage *launch* start. The post-launch review is considered the very last evaluation point for summing up the results along with the success of the project in retrospect. In short, the innovation project team is split up and it is decided whether or not the product is taken over in the "standard" product line.[202]

Innovation process in the broader sense according to BROCKHOFF

The innovation processes according to THOM and COOPER both focus on internal innovation processes within a company, and, therefore, concludes with the market launch. However, a distinct approach is given by BROCKHOFF, who defines - besides innovation in the narrow sense – the innovation process in the broader sense, which is an extended view that also includes the diffusion and the imitation as illustrated in Figure 3.6.[203]

[202] Cf. COOPER, R. G. (2001), pp. 133
[203] Cf. BROCKHOFF, K. (1992), pp. 28

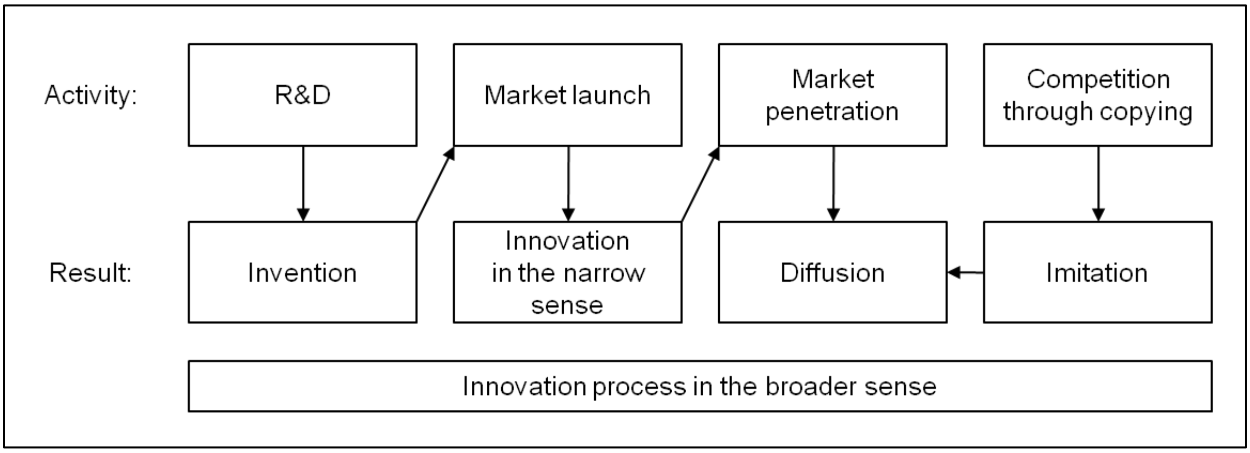

Figure 3.6: Innovation process in the broader sense according to BROCKHOFF[204]

BROCKHOFF states that the extension of the innovation process in the broader sense is not explicitly determined in literature and shows a lack of clarity. It is not necessary that the respective activities occur exclusively within the company, and, what is more, the respective stages are not identically defined.[205] However, BROCKHOFF defines an innovation process in the broader sense which proceeds – after the market launch – with market penetration leading to diffusion of an innovation and even includes the company's environment in terms of competition through imitation.[206]

3.2.2 Different Theoretical Perspectives on Innovation Processes

The management of innovation processes is a task which can be considered from three distinct perspectives:[207]

- *Managerial-based view:* The innovation process is determined as a decision and enforcement process or, in a technical respect, as a development and realization process. The critical issues are the complexity in decision making, the barriers of enforcement and additionally that the decision making and the enforcement cannot distinctly be separated from each other.
- *Resource-based view:* From this view, the innovation process is the specific combination of production factors. Therefore, it demands both resources, as available production factors, and potentials, as the abilities of innovators to gather those resources and combine them in a new way. However, the emphasis is put on the abilities, also referred to as human resources.

[204] Referring to BROCKHOFF, K. (1992), p. 30
[205] Cf. BROCKHOFF, K. (1992), pp. 29
[206] Cf. PLESCHAK, F.; SABISCH, H. (1996), p. 6
[207] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 40

- *Diffusion-based view:* This view considers the innovation process as an exploitation process within and beyond the established value chain. Seeing as inventions only become innovations if they succeed on the market, the internal perspective must be supplemented with a market based view, at least for product- rather than process innovations. This view, in general, concerns the next partners in the value chain, whereas the diffusion to the first customer is considered to be the most difficult one to realize and is therefore emphasized through what is known as the "lead user".

In contrast to the managerial and resource-based view, which both focus on internal i.e. intra-company problems, the diffusion-based view clearly refers to the interaction between the partners on the market; thus, it is an inter-company issue. Therefore, the hierarchical principle is not appropriate but rather other principles such as pricing and negotiation apply.[208]

Discussion of different innovation processes

The different perspectives on innovation processes correlate with certain process models. The innovation processes, according to THOM and COOPER, are designed for internal innovation management and therefore can be associated more toward the managerial- and resource-based view. In contrast, the innovation process in a broader sense, according to BROCKHOFF, decidedly relates to an internal plus an external perspective, including the organization as well as the interaction with its environment and the market. As a result, the diffusion based view is best suited for interpreting the innovation process in a broader sense. However, the respective steps are described in a very generic way. As to this, the innovation process as a cross-sectional function, according to VAHS/BURMESTER, represents an innovation process in the narrow sense, yet, the process within the company's boundaries is depicted in its embedded environment, i.e. customers, suppliers, competitors, etc. Additionally, the internal process specified therein is described in more detail as it is the case in BROCKHOFF's process model.

Apparently, there is a lack of the combination of the managerial- and resource based view, covering the internal management process in more detail, and the diffusion-based view, referring to the interaction with other partners. As to this, it is conceivable to incorporate two process models in order to combine the distinct views.

[208] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 46

3.3 Barriers in Innovation Processes

If in doubt, innovations are not welcome. Although crucial for a company to survive on the market, innovations imply serious changes and are, therefore, perceived as disturbances, irritations or even senseless turbulence.[209] This is not only valid for outdated companies; however, SCHUMPETER indicated that "even the most up-to-date firm has a persistent resistance to change"[210]. Moreover, MARCH and SIMON stated that "individuals and organizations give preferred treatment to alternatives that present continuation of present programs over those that represent change."[211]

In the following section, the scope of barriers to innovation defines what is commonly referred to as a barrier to innovation, to then describe its key characteristics and eventually the overcoming of barriers to innovation as a management task.

3.3.1 Scope of Barriers to Innovation

According to WITTE, a barrier to innovation does not represent a fixed obstacle which is open or closed, surmountable or not. It is a gradual resistance which, is also to be overcome gradually.[212] HAUSCHILDT and SALOMO define a barrier to innovation as a hindering, yet conquerable obstacle.[213]

Despite the fact that barriers to innovation are generally determined to have primarily negative influence on innovations,[214] HAUSCHILDT emphasizes the positive assessments since constructive opposition tries to change the result of an innovation in a positive way.[215] This is also supported by the definition established by MIROW, HÖLZLE and GEMÜNDEN, specifying that a barrier to innovation is an influencing factor on a company's innovation process that blocks, retards or modifies an innovation.[216] A blockage is the strongest form of the three effects and completely stops an innovation, while a retardant exerts influence only in terms of time and does not refer to the innovation's content or objective. However, if a blockage or a retardant of an innovation is not wanted or even not possible, the third option is that the innovation is modified. Both variants, retardation and modification of an innovation, can have a positive influence on it. On the one hand - referring to a retardant - the point in time

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209 Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 178
210 SCHUMPETER, J. A. (1912), as cited in: HAUSCHILDT, J. (1999), p. 217
211 MARCH, J. G.; SIMON, H. A. (1958), p. 173
212 Cf. WITTE, E. (1973), p. 6
213 Cf. HAUSCHILDT, J., GEMÜNDEN, H. G. (1998), p. 13
214 See also HADJIMANOLIS, A. (2003), p. 560 and PIATIER, A. (1984), p. 4
215 Cf. HAUSCHILDT, J. (1999), pp. 218
216 Cf. MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 105

when an innovation enters the market and, on the other hand, - in respect of a modification - any adapted or better customized detail can be significantly crucial whether or not an innovation eventually succeeds on the market.[217]

In the context of barriers to innovation, it is often referred to diffusion barriers. As the last phase in the innovation process in the narrow sense, is considered to be the market launch, implying the objective to ensure successful market penetration, the barriers, in particular, opposing this objective can be regarded as diffusion barriers. In concrete terms, all barriers hindering the innovation's diffusion by negatively influencing the overall market potential, the company's individual sales potential and/or the diffusion speed are referred to as diffusion barriers.[218]

3.3.2 Key Characteristics of Barriers to Innovation

Literature points out the multidimensional character of barriers to innovation.[219] Therefore, MIROW has established a comprehensive model in order to meet the complexity of barriers to innovation and, therein, determines the following four integral characteristics for analyzing and describing them:[220]

- *Structure of barriers to innovation:* Barriers to innovation have a complex structure.
- *Level dependency:* Barriers to innovation are influenced by various levels of an organization; therefore, the consideration of one single level is insufficient.
- *Phase dependency:* A phase dependency of barriers to innovation – although presumed - has not yet been definitely confirmed.
- *Perspective dependency:* The perspective on barriers to innovation influences their perception and assessment.

In the following paragraphs, the respective characteristics are described in more detail.

Structure of Barriers to Innovation

Barriers to innovation can emerge in a variety of ways; they often overlap and are interdependent. Therefore, it is appropriate that barriers to innovation are structured into

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[217] Cf. MIROW, C. (2010), p. 29
[218] Cf. TALKE, K.; SALOMO, S.; TROMMSDORFF, V. (2007), p. 126
[219] See also HAUSCHILDT, J.; SALOMO, S. (2007), p. 183; SCHMEISSER, W. (1984), pp. 67; STAUDT, E. (1985), pp. 355; COOPER, R. G. (1975), p. 316
[220] Cf. MIROW, C. (2010), p. 17, p. 26

visible symptoms and latent causes in literature.[221] Figure 3.7 shows the causal relation between cause and symptom as the structure of barriers to innovation.

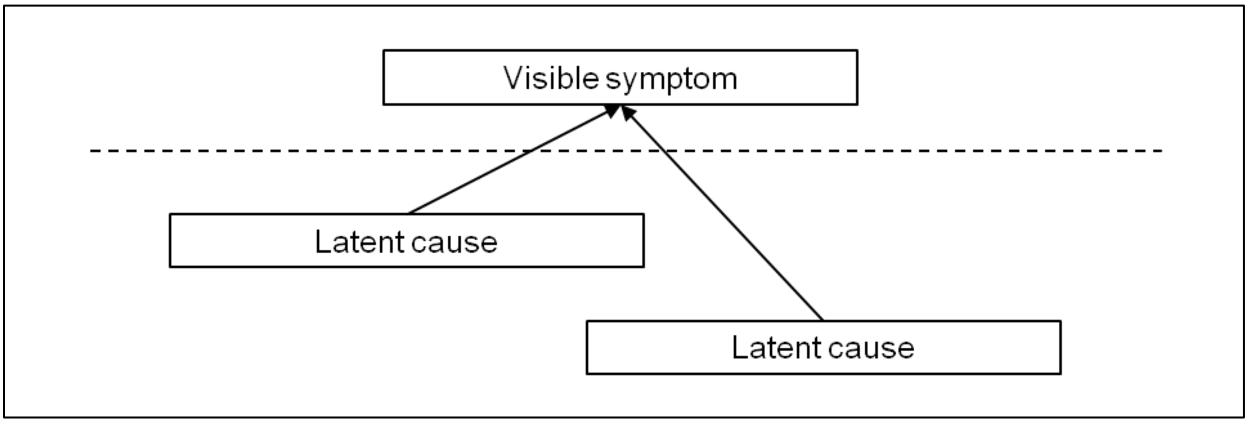

Figure 3.7: Structure of barriers to innovation[222]

The well recognizable symptom can be expressed through arguments against the innovation.[223] Table 3.2 describes various established classifications of arguments, also referred to as fields of causes or types of barriers.

BITZER, B./POPPE, P.	WOHINZ, J. W./MOOR, M.	HAUSCHILDT, J./SALOMO, S.
Types of barriers: • personal • organizational • technical • financial	*Fields of causes:* • technical • economic • legislative • organizational • socio-psychological	*Arguments:* • technological • marketing • financial • ecological

Table 3.2: Classification of symptoms of barriers to innovation[224]

Beneath the surface there are various latent causes which induce the rational arguments and symptoms, which are characterized as follows:[225]

- Barriers of unwillingness, i.e. barriers due to a lack of will
- Barriers of ignorance, i.e. barriers due to a lack of competence

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[221] Cf. MIROW, C. (2010), pp. 17
[222] Referring to MIROW, C. (2010), p. 19
[223] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 183
[224] Cf. BITZER, B.; POPPE, P. (1993), p. 317; cf. WOHINZ, J. W.; MOOR, M. (1989), pp. 199; HAUSCHILDT, J.; SALOMO, S. (2007), pp. 183
[225] Cf. HAUSCHILDT, J. (1999), p. 218

WITTE defined barriers of unwillingness as persistence to uphold the status quo as it is uncertain whether or not the new status may cause a loss of any benefits.[226] As PIATIER demonstrates, the list of questions which symbolizes this uncertainty is impressively long.[227]

In contrast, the barriers of ignorance can be explained by the nature of innovation itself. A novelty is unknown in terms of technology as well as in terms of process and usage.[228] The resistance to innovation emerges as the individual concerned is actually incapable of coping with the intellectual requirements.[229]

The combination of cause and symptom leads to a matrix which covers a great number of barriers, such as HÖLZLE demonstrates as shown in Table 3.3.

Symptom / Cause	Deficient internal co-operation	Deficient targets	Lack of resources	Restriction of innovative actions	Deficient external co-operation
Ability restrictions		Unclear decisions			Insufficient management of customer needs
Lack of motiviation	Exchange of ideas not open enough			Hindrance due to habitual thinking	
Strategic restriction	Areas are not close enough		Projects are insufficiently resourced		
Operational restrictions	Insufficient co-operation within the project	No space for new ideas	Innovation is blocked by time, costs and quality	No space for innovative thinking	

Table 3.3: Relation between cause and symptom[230]

Level dependency

Innovation barriers emerge on different levels from a micro-perspective, which refers to an individual as the driving force for or against an innovation, up to a macro-perspective, whereas the characteristics and the behavior of organizations have a determining influence.[231] The specific levels can be determined as follows:[232]

[226] Cf. WITTE, E. (1973), p. 6
[227] Cf. PIATIER, A (1984), p. 115
[228] Cf. WITTE, E. (1973), p. 8
[229] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 191
[230] Referring to HÖLZLE, K. (2010), p. 11
[231] Cf. MIROW, C. (2019), pp. 19; cf. SLAPPENDEL, C. (1996), pp. 110

- Individual level
- Group level
- Organizational level
- Inter-organizational level
- Regional/national level

However, the last two levels, i.e. the inter-organizational and the regional/national, can also be summed up as the *environmental level* of an organization. Even though, in theory, the levels listed are specified and clearly distinguished, they cannot be separated as easily in practice. For instance, individual behavior is influenced by environmental factors and, in the same way, organizational behavior results from individual behavior.[233]

In the context of level dependency they are often referred to as internal and external barriers, whereas this view relates to the organization's or company's perspective, i.e. internal to the company or external to the company.[234] According to MIROW, HÖLZLE and GEMÜNDEN, internal barriers apply to employees, coworkers, superiors and organizations while barriers of external origin involve institutions and market forces.[235]

Phase dependency

In literature there are several indications that barriers to innovation change according to the phase in the innovation process.[236]

STAUDT conducted research on the dependency of barriers to each phase and empirically confirmed that in the R&D phase the main barriers are primarily time and costs, followed by lack of qualified personnel and know-how. During production the major focus is on the adaption to the production, problems with supplier and lack of acceptance from personnel. The last phase of market launch is significantly determined by the lack of acceptance from customers, but also a late market launch, lack of service and maintenance personnel, pricing, etc. all play a role.[237]

BITZER and POPPE investigated the extent of barriers along the innovation process covering the idea generation, idea acceptance, idea implementation and introduction

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[232] KING, N. (1990), pp. 15; cf. GUPTA, A. K.; TESLUK, P. E.; TAYLOR, M. S. (2007), as cited in: MIROW, C. (2010), p. 21
[233] Cf. MIROW, C. (2010), p. 21
[234] Cf. HADJIMANOLIS, A. (2003), pp. 560
[235] Cf. MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 110
[236] Cf. MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 112
[237] Cf. STAUDT, E. (1985), pp. 353

into operation. As a result of this study, the highest barriers emerge during the idea acceptance.[238]

HAUSCHILDT and SALOMO distinguish between a decision and an enforcement process, whereas in the decision process the emphasis is on a barrier of complexity in contrast to a barrier of interaction, which is assigned to the enforcement process. However, they point out that the processes cannot be clearly separated from each other.[239]

Within a dynamic investigation of the promoter model[240] FOLKERTS determined that in earlier phases of the innovation process the dominant resistance is more that of a technical nature due to a lack of competence compared to the later phase where the primary resistance is caused by a lack of will.[241]

However, MIROW points out some difficulties in the exact allocation of barriers to the respective phases of the innovation process, because some barriers emerge repeatedly in various phases.[242]

Perspective dependency

In terms of the perspective dependency, whether or not barriers to innovation are perceived differently by various individuals is discussed. According to the attribution theory, which was first proposed by HEIDER[243] in “The psychology of interpersonal relations” in 1958, individuals explain the causes of phenomena such as behavior or events differently depending on their specific situation, the social environment as well as their experiences. Therefore, individuals may also interpret barriers to innovation differently, which significantly effects perception and assessment of the barriers as described as follows:[244]

- *Hierarchical level:* Being on a higher hierarchical level implies that individuals have greater insight into the company’s strategies and structures. Therefore, they assess the current market situation better and perceive barriers differently than others in lower hierarchical levels.

[238] Cf. BITZER, B.; POPPE, P. (1993), p. 319
[239] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 41
[240] WITTE, E. (1973)
[241] Cf. FOLKERTS, L. (2001), as cited in: MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 111
[242] Cf. MIROW, C. (2010), p. 24
[243] HEIDER, F. (1958)
[244] Cf. MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), pp. 108

- *Experience:* Individuals who are already experienced in dealing with innovations assess their feasibility differently than non-experienced individuals. Therefore, they also better evaluate the existence and the overcoming of barriers.
- *Commitment:* A strong commitment to an innovation implies that individuals are more enthusiastic and confident regarding the innovation's success. Therefore, they assess barriers to be overcome more easily and do not give up even under adverse conditions.

As a result, eight different categories of perception can be distinguished, which is the operative versus the top management category - in the first instance divided into experienced and inexperienced and each one further subdivided into dedicated and not dedicated categories, as depicted in Figure 3.8.[245]

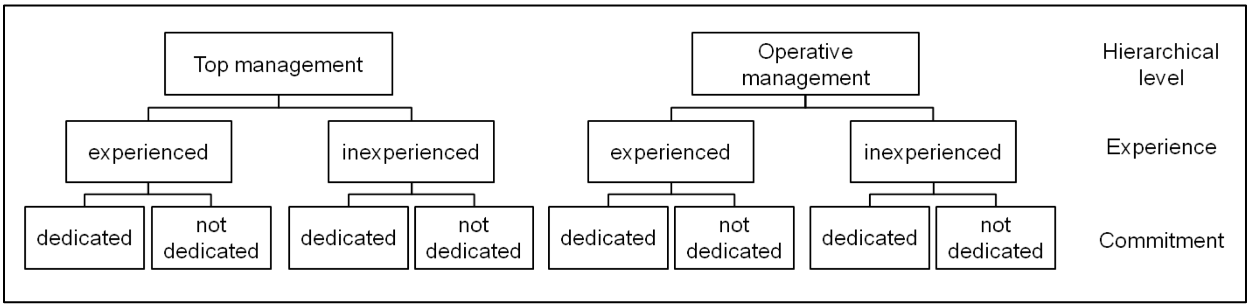

Figure 3.8: Different categories of perception (author's illustration)[246]

Moreover, in order to understand how to overcome barriers to innovation, it is crucial to identify the barriers and their origin. HAUSCHILDT and SALOMO point out that barriers emerge at various sources, which can be divided into the following three different classes:[247]

- *Internal resistance:* This internal resistance against the innovator comes from employees of the innovating company including superiors, coworkers and subordinates.
- *Resistance from the market players:* This external resistance relates to market partners such as customers, suppliers, dealers and competitors.
- *Resistance from the further firm environment:* This - also external - resistance can be attributed to politics, i.e. legislators, governments and local communities, as well as to society such as, for instance, protest groups.

[245] Cf. MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 109
[246] Referring to MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 109, p.113
[247] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 180, cf. TALKE, K.; HULTINK, E. J. (2010), p. 539

Thus, within this approach the barriers considered comprehensively cover diffusion barriers related to employees of the innovating company, customers, players of the external market as well as actors from the further environment.[248]

3.3.3 Overcoming Barriers to Innovation as Management Task

In order to overcome barriers, it is especially emphasized in literature that the perspective should be widened to include all stakeholders even if their effect is more of an indirect nature. Contributions have to be provided by all stakeholders; therefore, in order to manage the barriers, it is of significant importance that such stakeholders interact in a constructive way. It has been empirically proven – from a company's perspective - that only the addressing of barriers at all sources of resistance leads to an overcoming and thus to a market success.[249]

Innovation management refers to a permanent fight with conflicts and it is especially pointed out, that those conflicts are not just based on rational but rather on irrational arguments. Moreover, there is not one perfect way for the decision and enforcement process of innovations. However, three central issues from a management perspective are suggested in order to overcome emerging barriers:[250]

- *Promoters*
- *Co-operation*
- *Process management*

These three core points refer to what is known as "first-stage-thinking" in problem-solving processes introduced by DE BONO[251], where the problem, the goals and the alternatives have to be defined, in short, where the whole situation has yet to be specified, rather than to the "second-stage-thinking", where the focus is on finding and applying the appropriate algorithm. The considerations including the promoters, the market forces and the activities in the innovation process are intentionally assigned to this first stage, as they represent the real challenges of innovations, such as unclear goals, the absence of alternatives and undefined parameters of the situation.[252]

[248] Cf. TALKE, K.; HULTINK, E. J. (2010), p. 539
[249] Cf. TALKE, K.; HULTINK, E. J. (2010), p. 538, p. 550
[250] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 206
[251] DE BONO, E. (1982)
[252] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 207

Promoters

The promoter model was developed by WITTE[253], who first conducted research on a theoretical concept about the presence of promoters, enthusiastic about the innovation and helping to overcome barriers, improving the success of the innovation process. The promoter model contains three core theorems:[254]

1. "each type of resistance has to be overcome by a specific type of energy. The barrier of unwillingness is overcome by *hierarchical potential*, the barrier of ignorance is overcome by the use of *specific knowledge in a certain technical field* (correspondence theorem);"
2. "these types of energy are provided by different people. The *power promoter* contributes resources and hierarchical potential and the *technology promoter* contributes specific technical knowledge to the innovation process (theorem of division of labor);"
3. "the innovation process is successful when the power promoter and technology promoter form a *coalition* and are *well coordinated*, i.e. when they really co-operate (theorem of team-interaction)."

As a consequence of research projects by HAUSCHILDT and CHAKRABARTI[255], WITTE's promoter model was extended to a three-center constellation, also referred to as *troika*, i.e. a *process promoter* was introduced. In order to overcome barriers due to established routine processes, the process promoter's emphasis is on leadership qualities and influencing tactics. Lastly, a further modification was made by WALTER and GEMÜNDEN[256], who introduced the *relationship promoter*, as co-operation with external partners in the value chain becomes increasingly important as requirement for innovations.[257] By establishing connections to the external partners, by supporting communication, resolving motive- or perception conflicts and enhancing social relations, the relationship promoter's contribution is to overcome the following barriers of inter-organizational co-operation:[258]

- *Barrier of "Not knowing of each other":* The external partners are not known and the search is avoided.

[253] WITTE, E. (1973)
[254] HAUSCHILDT, J. (2003), pp. 805
[255] HAUSCHILDT, J.; CHAKRABARTI, A. K. (1988)
[256] GEMÜNDEN, H. G.; WALTER, A. (1995)
[257] Cf. HAUSCHILDT, J. (2003), p. 807
[258] Cf. GELBMANN, U.; VORBACH, S. (2007), pp. 120

- *Barrier of "Cannot co-operate with each other":* There is a significant psychic, social, spatial, linguistic and inter-cultural distance and the effort for overcoming is avoided.
- *Barrier of "Not wanting to co-operate with each other":* There are resistances because of motives and attitudes and the carrying out of this conflict is avoided.
- *Barrier of "Must not co-operate with each other":* There are prohibitions, political, ideological, ethical norms which are affected by the interaction and therefore specific relationships are avoided.

Co-operation

There are a variety of terms in literature, which refer to co-operations and are even used as synonyms, such as strategic alliances, networks, value chain networks, coalitions, collaborative agreement, partnerships, etc., however, they are not clearly and consistently distinguished. Even so, what they all have in common, is that the involved partners pursue a common objective while preserving their legal and (partial) economic independence.[259] VYAS, SHELBURN and ROGERS define a strategic alliance as "an agreement between two or more partners to share knowledge or resources which could be beneficial to all parties involved."[260] Further on, they point out that they range from simple alliances between two partners sharing their technological or marketing resources through to highly complex ones including several companies in different countries. The main reasons alliances are formed are of a technology- or market-related nature or a combination of the two.[261] The determining factors of the alliance's nature and form include the following issues:[262]

- "distribution channels (going around entry barriers);"
- "synergy (to pool resources, increase efficiency, share expertise, reduce costs, increase market share and become more competitive, etc.);"
- "diversification (to reduce/share risk, gain access to new market segments); and"
- "sourcing raw materials."

In order to be more specific about co-operations their characteristics can be referred to as direction, local expansion, intensity, obligation, duration, etc. In regards to the direction of co-operation, which determines the value-added stage and the branch where the co-operation partners interact, there are three types, i.e. the horizontal, the vertical and the diagonal co-operation. If the partners are in the same branch and on

[259] Cf. MORSCHETT, D. (2003), pp. 389; cf. STREBEL, H.; HASLER, A. (2007), p. 349
[260] VYAS, M. N.; SHELBURN, W. L.; ROGERS, D. C. (1995), p. 47
[261] Cf. VYAS, M. N.; SHELBURN, W. L.; ROGERS, D. C. (1995), p. 47
[262] VYAS, M. N.; SHELBURN, W. L.; ROGERS, D. C. (1995), p. 50

the same value-added stage, such as competitors, it is referred to as a horizontal co-operation. It is referred to as vertical co-operation if the partners are in the same branch, but on different value-added stages like, for instance, supplier-client relations. In contrast, diagonal co-operations are those that see partners are in different branches.[263]

Process management

Further, it is pointed out that innovation management can be understood as internal process management within a company. The main emphasis is put, in particular, on the process of initialization, problem definition, generation of alternatives and process control. Further reading on these topics is provided by HAUSCHILDT and SALOMO.[264]

Discussion of possible ways for overcoming barriers

As mentioned above, the literature suggests three central issues for overcoming barriers, i.e. by promoters, co-operations and process management. However, the multidimensional character of barriers to innovation is also highlighted, which, evidently, emphasizes their complexity. In order to cope with barriers to innovation, the question arises as to what extent the proposed possibilities are sufficient or even adequate and whether there is a positive impact to delving deeper regarding the individual itself, the suitability of the respective innovation process model, and last, but not least, the environment, i.e. the innovation system.

3.4 Scope in regards of E-Mobility

The following paragraphs are aimed at setting the scope of the previous chapters 3.1, 3.2 and 3.3 and their relevance in regards to E-Mobility.

Firstly, the extent to which E-Mobility is referred to an innovation is to be clarified, as electric vehicles, as such, have been around for more than a 100 years. Therefore, the invention of the new product itself has already been made. However, as innovation, per definition, includes the “process of finding economic application”[265] and the innovation process in the broader sense[266] also covers diffusion on the market, which represents the current struggle and efforts, E-Mobility can be classified as an innovation. Moreover,

[263] Cf. KILLICH, S. (2007), pp. 18
[264] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), p. 207
[265] SCHUMPETER, J. A. (1942), as cited in: RAY, G. F. (1969), p. 40
[266] According to BROCKHOFF, K. (1992), p. 30

it also implies the four dominant characteristics of an innovation, i.e. the degree of novelty, uncertainty and risk, complexity and eventually the potential for conflicts. Hence, the assessment of E-Mobility as an innovation constitutes the crucial basis for further considerations.

Moreover, the classification into different types of innovations is intended to answer the question “what is new?” in terms of the content-based dimension. The distinct categories suggested by literature show some similarities such as the product and process innovation; however they diverge, particularly as concerns the system orientation which extends the perspective from assessing innovations as intra-company problems more so to inter-company problems involving various co-operation partners. Evidently, E-Mobility implies partial innovations within one company’s boundaries, such as a product or process innovation; yet, there are more stakeholders involved, and each single one has to make certain contributions to eventually achieve the successful market diffusion of electric vehicles. Actually, E-Mobility corresponds to the definition of a system innovation, which is, moreover, supposed to lead to a sustainable change in users’ behavior, and therefore can be referred to as such. As a consequence, it is to be concluded that E-Mobility - as with system innovations, in general, according to literature - imposes specific and additional requirements towards its innovation management than classic innovations do.

In terms of the procedural view on innovation management, literature introduces various designs of innovation processes and different perspectives on them, correlating either to an intra- or an inter-organizational view. As E-Mobility is determined as a system innovation, evidently, a process which refers to an inter-organizational innovation management appears to be most appropriate, such as the innovation process in a broader sense according to BROCKHOFF. This process model correlates to the diffusion-based view; however, the respective steps of this process are depicted in a rather general way. At this point, the innovation process as a cross-sectional function according to VAHS/BURMESTER, provides more detailed steps, and even though it represents an internal perspective, the process depicted considers the company’s environment. For that reason, the incorporation of the innovation process according to VAHS/BURMESTER into the innovation process according to BROCKHOFF seems to be best suitable in E-Mobility systems, as it offers a detailed and specific description of the phases within an organization and, additionally, includes external partners and environment.

Eventually, the theoretical background about barriers to innovation is supposed to build the basis for any further discussion and description of the challenges of the market diffusion of electric vehicles. Within the system innovation E-Mobility, there is a broad range of barriers which can emerge as various arguments or causes of barriers, such as technical, economic, legislative, organizational or socio-psychological ones, at all levels of an organization, at all phases of the innovation process and from all perspectives. Even though the considerations in literature mostly refer to internal barriers within an organization, it is also indicated that barriers can emerge at various origins, i.e. as resistance from other market players or from the further environment. Referring to E-Mobility in the context of a system innovation, the emphasis has to be put rather on the external barriers between the stakeholders than on the internal barriers within one single organization. As the involvement of the various stakeholders basically specifies the special characteristics of the innovation E-Mobility, it is crucial to address all stakeholders in order to overcome the barriers, in particular including the customers who in the end decide whether or not to adopt a product.

4 Theoretical Model for Managing Barriers to Innovation in E-Mobility

The following chapter comprises the theoretical modeling, and therefore, constitutes the main and distinct chapter of this thesis.

4.1 Basic Structure of the Theoretical Model

To start with, the basic structure of the theoretical model is to be discussed. Basically, this chapter is split into two parts, which are:

- ➔ the identification of barriers to innovation in E-Mobility, and
- ➔ the design of the E-Mobility system innovation.

The first part of the identification of barriers is based on an approach provided by the theory of user acceptance of new technologies. Then, the main challenges which are relevant for any further considerations within this thesis are explored and classified.

After identifying the barriers, the second part covers the design of the E-Mobility system innovation, i.e. the management of the barriers to innovation. Therefore, first, the approach is discussed, which distinguishes between the intra- and inter-organizational innovation; the intra-organizational aspect is concerned with each stakeholder individually, whereas the inter-organizational perspective refers to the all stakeholders at large. The latter also includes an approach for the coordination of the E-Mobility system. To conclude, the different aspects are condensed in a framework for managing barriers in E-Mobility.

In this context, it is to be noted that the research design of this thesis intends to establish the theoretical model upon the theory inputs to the extent deemed possible. Further, these considerations are evaluated empirically, which is covered in the subsequent chapter 5.

4.2 Identification of Barriers to Innovation in E-Mobility

The very first step in overcoming the barriers to innovation in E-Mobility is to be aware of them, further to explore and understand them. As a consequence, the chapter of the theoretical model starts with the identification of barriers to innovation in E-Mobility, including the exploration as well as a classification.

4.2.1 Exploration of Barriers to Innovation in E-Mobility

In order to systematically identify the barriers to innovation in E-Mobility, a possible approach is provided by theory. Various models for user acceptance of new technology are meant to explain how and why individuals adopt innovations, i.e. why some of them successfully enter the market, and, why others do not.[267] A commonly applied model is the theory of diffusion of innovation by ROGERS.[268] Thus, the respective aspects of ROGERS' model and their relevance for the exploration of barriers to innovation in E-mobility need to be explained first.

Theory of diffusion of innovation according to ROGERS

In the last phase of an innovation process in the narrow sense, the objective is to lay the foundations for successful market penetration.[269] In this respect, ROGERS identified a number of different variables, which determine the rate of adoption of innovations, defined as "the relative speed with which an innovation is adopted by members of a social system"[270]. The different types of variables contain (1) "the perceived attributes of innovation", followed by the (2) "type of innovation-decision", (3) "the nature of communication channels diffusing the innovation at various states in the innovation-decision process", (4) "the nature of the social system in which the innovation is diffusing" and last (5) "the extent of change agents' promotion efforts in diffusing the innovation".[271] However, the perceived attributes are most relevant in order to explain the rate of adoption of an innovation,[272] and are specified as follows:[273]

- *"Relative advantage* is the degree to which an innovation is perceived as being better than the idea it supersedes."

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[267] Cf. VENKATESH, V. et al. (2003), pp. 425-478.
[268] Cf. PETERS, A. et al. (2011), p. 984
[269] Cf. TALKE, K.; SALOMO, S.; TROMMSDORFF, V. (2007), p. 126
[270] ROGERS, E. M. (2003), p. 221
[271] ROGERS, E. M. (2003), p. 221
[272] Cf. ROGERS, E. M. (2003), p. 221
[273] ROGERS, E. M. (2003), p. 229, p. 240, p. 257, p. 258

- *"Compatibility* is the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters."
- *"Complexity* is the degree to which an innovation is perceived as relatively difficult to understand and use."
- *"Trialability* is the degree to which an innovation may be experimented with on a limited basis."
- *"Observability* is the degree to which the results of an innovation are visible to others."

Aside for complexity, all other perceived attributes are positively related to the rate of adoption. Therefore, the higher the relative advantage of the innovation compared to previous ones, the higher the compatibility with values and needs, the less complex or difficult to handle and understand, the higher trialability and the observability of the innovation's result is, the faster it is adopted by individuals, i.e. on the market.[274]

In addition, ROGERS points out the crucial importance of perception. It is not the objectively classified relative advantage, compatibility, complexity, trialability and observability, as rather the perception of each individual which influences the rate of adoption.[275]

As a consequence of the aforementioned considerations, a nonfulfillment of the factors indicates a retardation, i.e. a negative impact on the rate of an innovations' adoption on the market.[276] In short, this leads straight back to the definition of barriers to innovation, since they are specified as an influencing factor on an innovation process that blocks, retards or modifies an innovation.[277]

Relevant factors for the diffusion of electric vehicles

Based on the considerations of the theory of diffusion of innovation, PETERS et al. investigated the perceived attributes in regards of their influence particularly on the intention to purchase and use an electric vehicle. However, the five attributes are supplemented by the influencing variable of perceived social norms, i.e. an individual's perception that a certain kind of behavior is expected by others. Although that aspect is not covered in ROGERS' model, he still emphasizes the relevance of social norms

[274] Cf. ROGERS, E. M. (2003), p. 223, p. 249, p. 257, p. 258
[275] Cf. ROGERS, E. M. (2003), p. 223
[276] Cf. TALKE, K.; SALOMO, S.; TROMMSDORFF, V. (2007), p. 126
[277] Cf. MIROW, C.; HÖLZLE, K.; GEMÜNDEN, H. G. (2007), p. 105

especially for consumers in a later phase of the diffusion process.[278] Besides, social norms can also be found in other theories of acceptance of new technology.[279]

The research findings of PETERS et al. are illustrated in Figure 4.1, whereas the variable “complexity” is replaced by “ease of use” which creates a positive relation equal to the other variables.

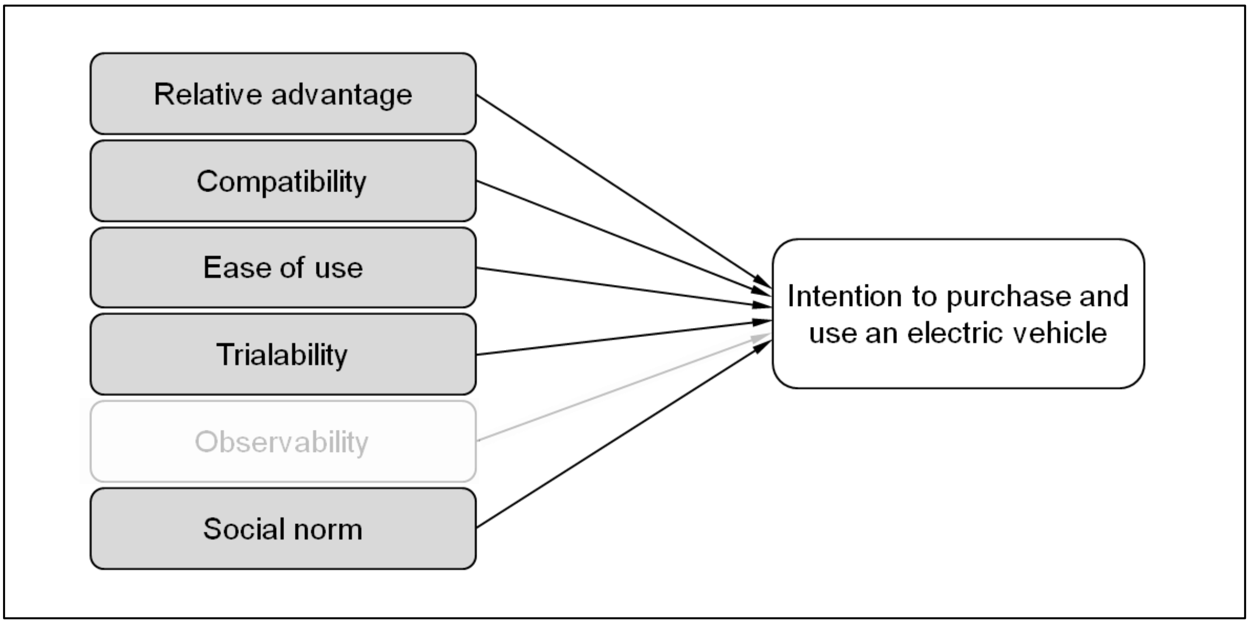

Figure 4.1: Influencing variables on the intention to purchase and use an electric vehicle[280]

Besides compatibility, which has a strong influence on the intention to purchase and use an electric vehicle, the relative advantage is also particularly relevant. Further, the ease of use and social norms are less, but still significantly, decisive. Moreover, the relevance of trialability is emphasized not least because of its influence on other variables such as compatibility, since customers gain experience when testing them as to whether electric vehicles are compatible with their needs. However, the evidence of observability could not be proven within the research findings of PETERS et al. and is, therefore, not examined in more detail for the following considerations.

In a further analysis, the variables mentioned can be specified as relevant factors for the diffusion of electric vehicles. By means of an Ishikawa diagram[281], which investigates the effect of a specific event with its causes, Figure 4.2 illustrates these relations.

[278] Cf. PETERS, A. et al. (2011), pp. 984
[279] See also DAVIS, F. D. (1993); FISHBEIN, M.; AJZEN, I. (1975)
[280] Referring to PETERS, A. et al. (2011), pp. 986; referring to ROGERS, E. M. (2003), p. 222
[281] ISHIKAWA, K. (1980); cf. KAMISKE, G. F.; BRAUER, J.-P. (1995), pp. 180

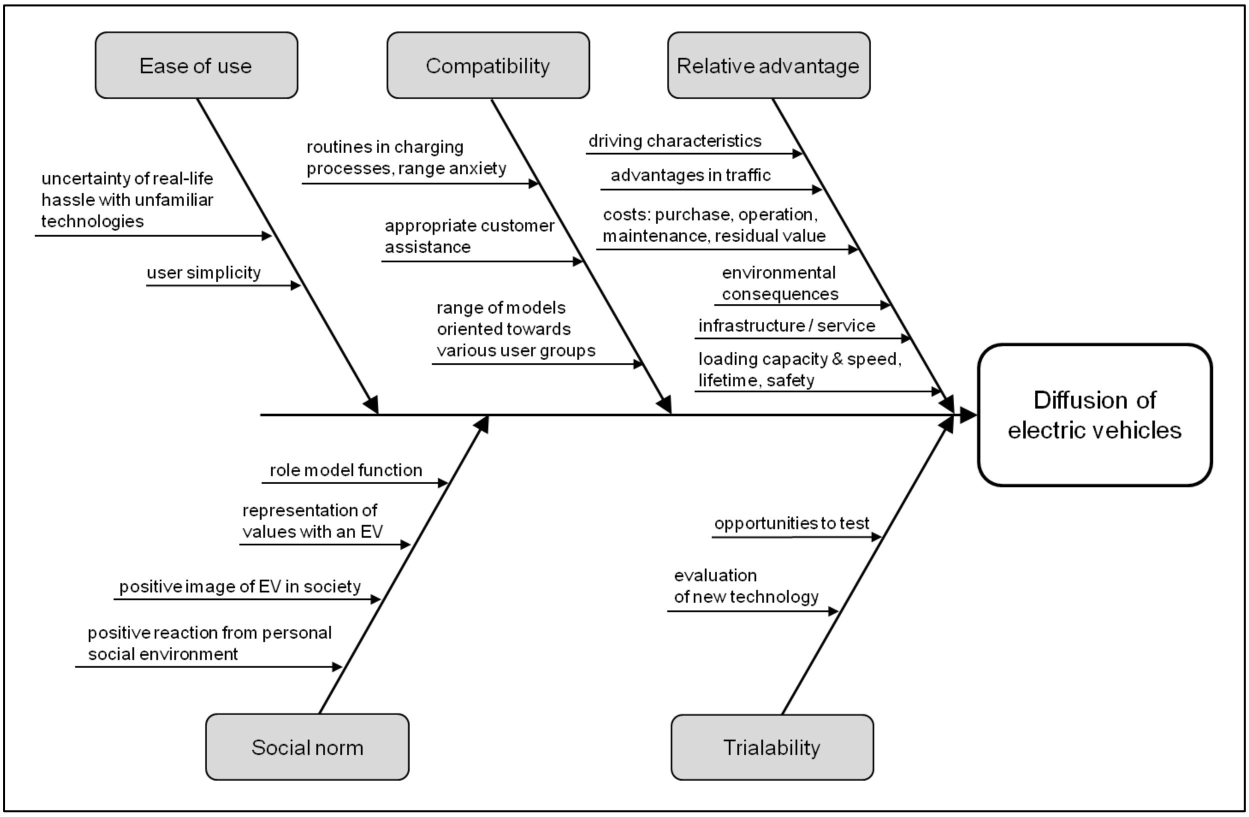

Figure 4.2: Specification of influencing variables into relevant factors for the diffusion of electric vehicles (author's illustration)[282]

The *relative advantage*, as it relates to the diffusion of electric vehicles, can be expressed in terms of better driving characteristics, i.e. driving pleasure, acceleration performance, etc., and, advantages in traffic, such as preferred lanes for electric vehicles, free car parks, etc. Environmental consequences are a crucial issue and should favor electric vehicles, which means decreasing emissions as well as dependency on fossil fuels. Aside for costs of operation, the costs of purchase, maintenance and the residual value are currently a disadvantage compared to conventional cars, just like loading capacity, lifetime and charging speed of batteries associated with range limits and safety issues. Further, concerning the supply network and/or the infrastructure for service and recharging, there is also a disadvantage for electric vehicles. In terms of *compatibility* with individual habits and needs, a crucial issue is routines in recharging processes and dealing with range anxiety, as routines currently exist for conventional cars however they do not exist for electric vehicles. In this respect, appropriate technical devices as support play an important role. Moreover, compatibility can be specified as to whether the range of models, aside from the electric city cars, meets the customer's expectations and appeals to various user groups.

[282] Referring to PETERS, A. et al. (2011), pp. 988; referring to ROGERS, E. M. (2003), p. 222

Concerning the *ease of use,* the uncertainty of dealing with new and unfamiliar technologies confronts the user-simplicity when driving. A relevant factor for the *social norm* is whether the image of electric vehicles in society is positive or not. To be more specific, the social norm also refers to the reaction from the personal social environment, from individuals who are important to the potential customer. Therefore, the values which are represented by an electric vehicle are crucial, as role models and lead users can be significantly influential. The *trialability* refers to testing opportunities of the new technologies, i.e. electric vehicles, allowing the evaluation of whether they are compatible with individual habits and needs, as well as in terms of ease of use and relative advantages such as driving characteristics, or the experience of people's reaction when seeing the electric vehicle.[283]

As the relevant factors influence the diffusion of electric vehicles and can either enhance or reduce the rate of adoption on the market through customers, they provide a profound basis for the classification of barriers to innovation in E-Mobility.

4.2.2 Classification of Barriers to Innovation in E-Mobility

Upon the exploration of the factors, which are relevant for the market diffusion of electric vehicles, how they can be classified into different fields of causes is described. To conclude, an overview of the barriers to innovation in E-Mobility is given.

Classification according to WOHINZ / MOOR

Based on the relevant factors, as explored in Chapter 4.2.1, the barriers to innovation in E-Mobility can be classified into different fields of causes. In this respect, WOHINZ/MOOR provide a distinction between

- technical,
- economic,
- legislative,
- organizational and
- socio-psychological causes of barriers, as described in more detail in Chapter 3.3.2.[284]

[283] Cf. PETERS, A. et al. (2011), pp. 988
[284] Cf. WOHINZ, J. W.; MOOR, M. (1989), pp. 199

Further, the specified factors of the perceived attributes determined by ROGERS can be translated into technical, economic, legislative, organizational and socio-psychological barriers as distinguished by WOHINZ/MOOR.

Figure 4.3 illustrates this correlation in this particular case.

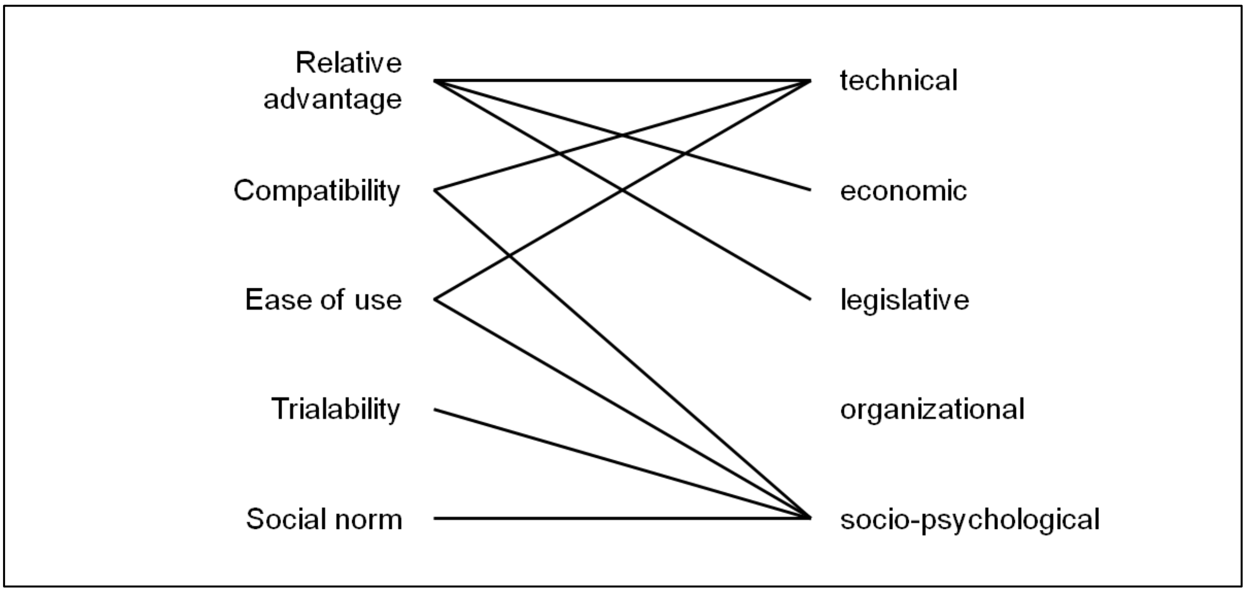

Figure 4.3: Translation of perceived attributes in causes of barriers (author's illustration)[285]

Thus, the translation of the influencing variables on market diffusion of electric vehicles into different causes of barriers implies a N:N relation; however, none of the variables could be assigned to organizational causes. A possible explanation is that organizational barriers occur only as a consequence of the variables mentioned, rather than being perceived by the customer as an obvious attribute.

Overview of the barriers to innovation in E-Mobility

The results of the identification of barriers to innovation in E-Mobility are shown in Table 4.1, which provides an overview that is also supplemented with organizational causes.

[285] Referring to ROGERS, E. M. (2003), p. 222; referring to WOHINZ, J. W.; MOOR, M. (1989), pp. 199

Barriers	1. technical	1.1	driving pleasure
		1.2	emissions, fossil fuels
		1.3	loading capacity & speed, lifetime
		1.4	customer assistance
		1.5	range of models
		1.6	charging infrastructure
		1.7	service, safety
	2. economic	2.1	costs of purchase
		2.2	costs of operation
		2.3	costs of maintenance
		2.4	residual value
	3. legislative	3.1	penalties / incentives supply-sided
		3.2	penalties / incentives demand-sided
	4. socio-psychological	4.1	image, testimonials
		4.2	routines
		4.3	testing, evaluation
	5. organizational	*5.1*	*coordination of activities*

Table 4.1: Overview and classification of barriers to innovation in E-Mobility (author's illustration)[286]

According to this classification, the driving pleasure includes both the driving characteristics plus the user-simplicity. Emissions and dependency on fossil fuels represent environmental consequences, alongside the other technical barriers such as loading capacity plus charging speed and lifetime, appropriate technical assistance for the customer for creating and supporting new routines, the customer oriented range of models, plus a reliable and available infrastructure for charging and service including a safe handling. Further, the costs of purchase, operation, maintenance and residual value are assigned to economic causes of barriers. The cost issue can also be related to legislative causes either supply-sided - such as CO_2-regulations for fleet emissions punished by penalties if they are not met, or R&D incentives for electric vehicle projects - or demand-sided - implying purchase incentives for customers and advantages in traffic for users of an electric vehicle. The next field of causes describes the socio-psychological issues such as the image of electric vehicles including testimonials, which

[286] Based on the considerations of PETERS, A. et al. (2011), pp. 988, and on the classification of fields of causes of barriers according to WOHINZ, J. W.; MOOR, M. (1989), pp. 199

is linked to the representation of values in society. Additionally, routines refer to dealing with individual habits and needs such as range anxiety, charging processes, etc. through communication or technical solutions. In addition, testing and evaluation represent opportunities for gaining experience with the handling of unfamiliar technology. Despite the nonexistent assignment of variables to organizational causes, its importance is still pointed out in literature.[287] Accordingly, the coordination of the large number of activities and the resulting challenge are to be considered as barriers as well.

The identified barriers, as shown in Table 4.1, are used as the basis for further considerations aimed at overcoming them.

4.3 Design of the E-Mobility System Innovation

This section covers how to overcome as well as how to manage the barriers to innovation for a successful market launch of E-Mobility. On that account, the approach for the design of the E-Mobility system innovation is discussed first. Further, the intra-organizational, on the one hand, and the inter-organizational innovation, on the other hand, are addressed. To conclude, a general framework for managing barriers in E-Mobility is demonstrated.

4.3.1 Approach

This part aims at explaining the approach of how to manage the barriers to innovation in E-Mobility. Therefore, the characteristics of the E-Mobility system have to be taken into account in order to understand how, by whom and when the barriers can be overcome. All things considered, what makes the innovation of E-Mobility so particular is the large number of stakeholders who are involved. Thus, it is not than an innovation only occurs inside an organization, but rather various stakeholders contribute to an inter-organizational innovation, as illustrated in Figure 4.4. Such cases can be referred to as a system innovation, which is defined in more detail in chapter 3.1.3.[288]

[287] See also BITZER, B.; POPPE, P. (1993), p. 317; WOHINZ, J. W.; MOOR, M. (1989), pp. 199
[288] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 178

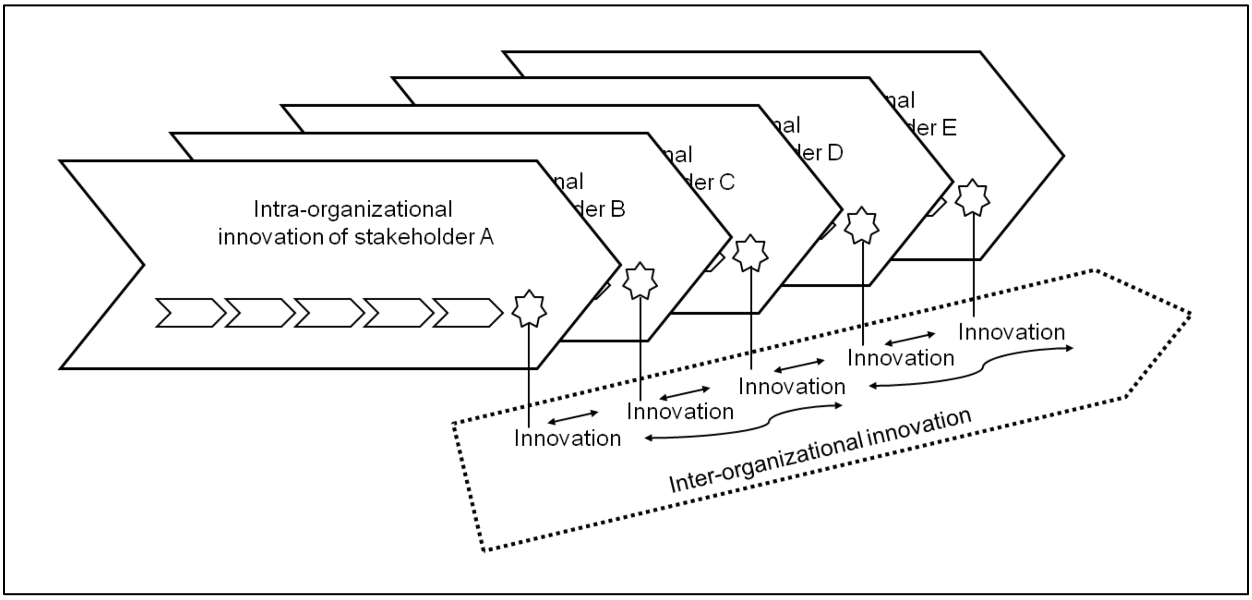

Figure 4.4: System innovation: intra vs. inter organizational innovation[289]

This conjuncture also applies to E-Mobility, as deduced in chapter 3.4. Therefore, the approach for the management of barriers cannot be addressed undifferentiated to the whole E-Mobility system.[290] As pointed out in literature, the internal sources of resistance as well as the external, i.e. from the market players and the further environment, must be incorporated in order to overcome the barriers that emerge.[291]

Thus, the perspective has to be directed, on the one hand, specifically to the intra-organizational view of each specific stakeholder, i.e. each one's contribution, as well as to the inter-organizational view including all stakeholders involved on the other, focusing on their constructive interaction.[292] Lastly, out of the two perspectives a comprehensive framework for managing barriers for a successful market launch of E-Mobility can be deduced, as shown in Figure 4.5.

[289] Referring to SALOMO, S. (2007), as cited in: GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 179

[290] Based on the considerations of GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008); HAUSCHILDT, J.; SALOMO, S. (2007), p. 180; TALKE, K.; HULTINK, E. J. (2010), pp. 538

[291] Cf. TALKE, K.; HULTINK, E. J. (2010), pp. 538

[292] See also SALOMO, S. (2007), as cited in: GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 179; TALKE, K.; HULTINK, E. J. (2010), p. 538, p. 550

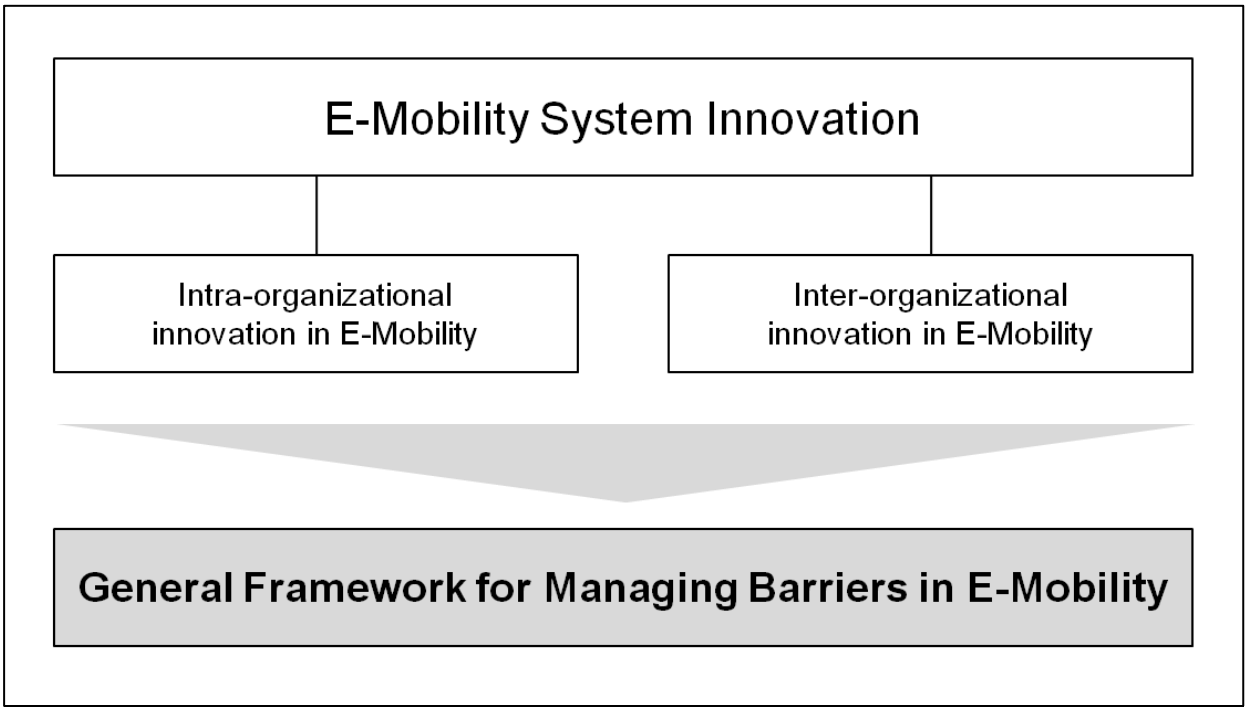

Figure 4.5: Approach for managing barriers in the E-Mobility system innovation (author's illustration)[293]

The considerations of Figure 4.5 specify the structure of the following content, which continues with the intra-organizational innovation, followed by the inter-organizational innovation and eventually concluding with a general framework for managing barriers in E-Mobility.

4.3.2 Intra-Organizational Innovation in E-Mobility

The identified barriers to innovation, which are classified into technical, economic, legislative, socio-psychological and organizational causes as described in detail in chapter 4.2.2, are addressed to the different stakeholders. However, not all of the barriers are equally relevant for each stakeholder, but there are, rather, certain particular issues where each stakeholder is asked to make a contribution. Thus, the interaction between the barriers and the involved stakeholders needs to be clarified. Table 4.2 illustrates this basic principle.

---

[293] Based on the considerations of system innovations. See also GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008); SALOMO, S. (2007)

		Stakeholders									
		Customer / User	OEM	Supplier	Energy Supplier	Oil Companies	Disposal Companies	Service Provider	Politics	Society	Research Institutes
Barriers	1. technical										
	2. economic										
	3. legislative										
	4. socio-psychological										
	5. organizational										

Table 4.2: Basic principle of the interaction analysis (author's illustration)

As a result, the interaction analysis provides an overview as to which barriers are relevant for which stakeholders. But besides the consideration of whether or not a stakeholder is affected by a certain barrier, it seems evident to go further into the question if the barrier can be assigned to a certain phase in the innovation process; as process management, alongside promoters and co-operations, is determined to be a central issue for overcoming barriers.[294] Therefore, the process as shown in Figure 4.6 is to be understood and further, used as a reference innovation process for electric vehicles.

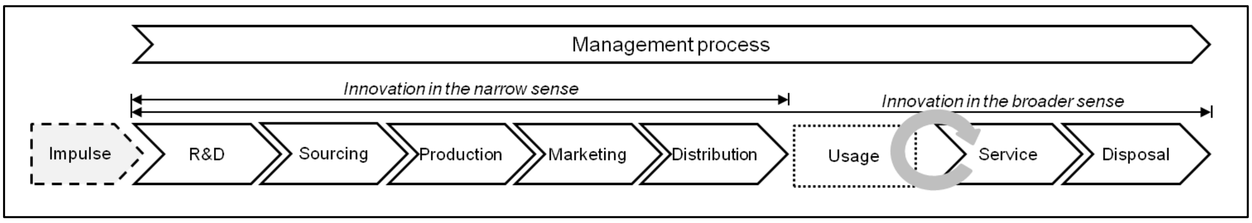

Figure 4.6: Reference innovation process for electric vehicles (author's illustration)[295]

After the impulse, the reference innovation process first covers the phases of R&D, sourcing, production, marketing and distribution. These phases can be associated with

[294] Based on the considerations of HAUSCHILDT, J.; SALOMO, S. (2007), pp. 206.
[295] Referring to VOIGT, K.I. (2008), p. 98; referring to VAHS, D.; BURMESTER, R. (2005), p. 53. For the innovation process in the narrow and broader sense see also BROCKHOFF, K. (1992), p. 30

innovation in the narrow sense, whereas the perspective is focused on the internal innovation processes within companies.[296] Although it includes crucial phases, this view is suited to represent the innovation of E-Mobility only to a limited extent. Firstly, because it ends with distribution, i.e. the market launch of electric vehicles. However, with regard to this particular case, the subsequent phases such as usage of electric vehicles, which is different compared to conventional vehicles, new service requirements and the challenges of the disposal, particularly for batteries and light weight materials,[297] must all be taken into account as well. Secondly, E-Mobility does not affect one single stakeholder but rather many different ones. Therefore, the more suitable approach appears to be the innovation process in a broader sense, which represents an extended understanding of innovation.[298] This diffusion-oriented view is based on the consideration that an innovation can only be referred to as such, if it eventually succeeds on the market. This also involves external partners and is therefore determined to be an inter-organizational problem rather than one that is exclusively within a company.[299] As a consequence, the reference process for electric vehicles, as illustrated in Figure 4.6, represents the phases which have to be gone through on track of the innovation of E-Mobility, however, this process is not to be considered as one designed for and accomplished by just one single company but rather requires all stakeholders involved.

In the following section, the interaction between barriers and stakeholders is described and, based on the descriptions, the barriers are assigned as regards the innovation process for each specific stakeholder.

Customer / User

Even though the large number of barriers to innovation, as demonstrated in Table 4.1, is crucial for the market penetration of electric vehicles and therefore affects the customer, it is not an active but rather passive involvement. As a result, the customer cannot make an active contribution to overcome a specific barrier, besides being open to new technology and not being afraid of change.

OEM

The OEM plays a central role in the power-play of E-Mobility and has an influence on a great number of barriers. Except in the case of the legislative barriers, the OEM can

[296] Cf. THOM, N. (1980), p. 53; cf. BROCKHOFF, K. (1992), pp. 28
[297] Cf. LINDER, E. (2010), p. 54
[298] Cf. BROCKHOFF, K. (1992), p. 30; cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 40
[299] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 40

make a contribution regarding technical, economic, socio-psychological as well as organizational fields of causes of barriers in order to overcome them. Table 4.3 demonstrates the relevant barriers for the OEM.

Barriers	1. technical	1.1	driving pleasure	+
		1.2	emissions, fossil fuels	o
		1.3	loading capacity & speed, lifetime	+
		1.4	customer assistance	+
		1.5	range of models	+
		1.6	charging infrastructure	+
		1.7	service, safety	+
	2. economic	2.1	costs of purchase	+
		2.2	costs of operation	+
		2.3	costs of maintenance	+
		2.4	residual value	+
	3. legislative	3.1	penalties / incentives supply-sided	o
		3.2	penalties / incentives demand-sided	o
	4. socio-psychological	4.1	image, testimonials	+
		4.2	routines	+
		4.3	testing, evaluation	+
	5. organizational	*5.1*	*coordination of activities*	+

Legend: o *… not relevant*; + *… relevant*

Table 4.3: Relevant barriers for the OEM (author's illustration)

The relevance of the identified barriers for the OEM as shown in Table 4.3 can be explained as follows.

- *Driving pleasure (1.1):* Dependent upon the shifts in competence and the value chain, however, OEMs are concerned with the manufacturing of the main components of the electric powertrain, such as the electric motor as well as the power electronics and the battery, which basically determine the driving characteristics. Therefore, OEMs can contribute by improving driving pleasure, acceleration performance, maximum speed and user-simplicity.
- *Loading capacity & speed, lifetime (1.3):* In the course of clarifying the shift in competence, some OEMs insource the manufacturing of batteries. Therefore, a huge effort in resources and R&D has to be made regarding the loading capacity, the charging speed and the lifetime of batteries.

- *Customer assistance (1.4):* Good technical customer assistance with regards to compatibility with familiar routines and habits, such as charging processes, i.e. where and how to charge, plus range anxiety is extremely crucial, particularly for electric vehicles.
- *Range of models (1.5):* There are different customer groups which have diverging requirements whether they prefer sports cars, vans, etc; and there are very many customers who would not respond well to a small, city car. Therefore, the OEM must be aware that the selected models of electric vehicles respond to certain customer groups and, as a consequence, to define and determine its target group. Moreover, in the higher car segment the limited capacity of the battery represents an even greater restriction due to the required performance and maximum speed.
- *Charging infrastructure (1.6):* As the installation of an appropriate charging infrastructure is a major issue in addition the electric vehicle itself, OEMs also need to be concerned with it. Beginning with pilot or testing fleets, where the OEMs aim to offer all-in-one solution including recharging possibilities rather than just the product of an electric vehicle, they can make a valuable contribution toward the development of an adequate charging infrastructure.
- *Service, safety (1.7):* Service and maintenance is a big business field for OEMs; therefore, they have to adapt to the new requirements of E-Mobility also as regards safety issues. As the service and maintenance of electric vehicles differs to that of a conventional vehicle with a combustion engine, employees need to be trained in order to provide readily available and reliable service.
- *Costs of purchase (2.1):* In the end, it is the OEM that sells the electric vehicle; therefore, it has to clarify and determine price positioning. In addition to efforts to increase efficiency in order to produce affordable vehicles - especially as regards batteries - which are mainly responsible for the high purchase price, financing models can also help to make the acquisition of an electric vehicle more attractive.
- *Costs of operation (2.2):* The energy conversion efficiency of the electric powertrain influences energy consumption. Therefore, by improving efficiency, OEMs can contribute to lowering the costs of operation.
- *Costs of maintenance (2.3):* As OEMs are concerned with service and maintenance, which includes the battery in addition to other spare parts, they also influence pricing.
- *Residual value (2.4):* OEMs have to take back end-of-life vehicles; therefore, the reuse and recycling of the electric vehicle is also an issue for them, however the residual value of the battery is a central point.

- *Image, testimonials (4.1):* Within the marketing strategy, the OEM has to create values of an electric vehicle and also communicate them to the customer and society. In this respect, testimonials are also useful for representing the values of E-Mobility.
- *Routines (4.2):* OEMs can develop better technical solutions, provide technical assistance but also make a contribution in terms of communication and explanatory work in order to increase the compatibility with familiar routines.
- *Testing, evaluation (4.3):* As part of the marketing strategy, the opportunities to test and evaluate electric vehicles enable potential customers to gain experience with this new technology. By showing their presence at auto shows and, for example, also offering testing fleets OEMs can increase trialability.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to the intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

For the purpose of a process management, the relevant activities for OEMs can be assigned as regards the innovation process as illustrated in Figure 4.7.

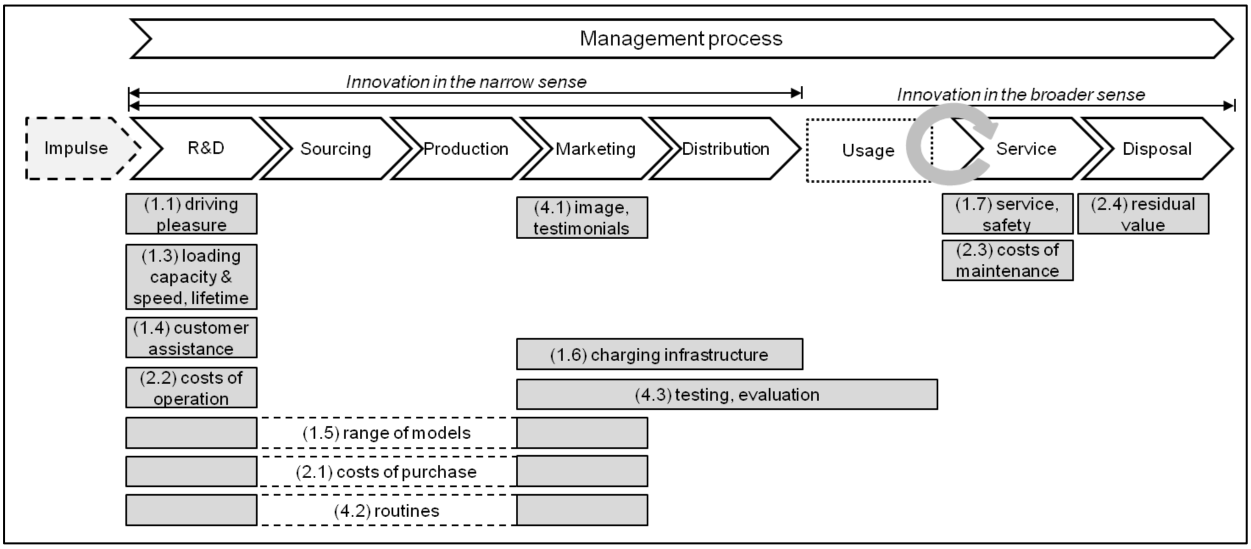

Figure 4.7: Assignment of relevant barriers for the OEM as regards the as regards the innovation process for electric vehicles (author's illustration)

Driving pleasure, i.e. loading capacity, charging speed and lifetime, customer assistance as well as efficiency of the powertrain, which influences the costs of operation, refer to the beginning of the process, i.e. to R&D. Moreover, the costs of purchase, the determination of the model range as well as the handling of routines are issued to R&D and to marketing strategy. Additionally, image creation and the promotion of electric vehicles through testimonials can also be assigned to marketing activities, whereas testing and evaluation – although allocated to marketing - also covers the distribution and usage phase. Further, the aspect of the charging infrastructure, in terms of all-in-one solutions, can be assigned to marketing as well as to the distribution phase. At the back end of the innovation process, service and maintenance are, of course, allocated to the service activities while the problem of the residual value comes into effect at the disposal phase.

Supplier

As shifts occur in the power balance and E-Mobility grants even more importance to the supplier, there are many barriers that the suppliers can make efforts to overcome. Table 4.4 demonstrates the relevant barriers for the supplier.

Barriers	1. technical	1.1	driving pleasure	+
		1.2	emissions, fossil fuels	o
		1.3	loading capacity & speed, lifetime	+
		1.4	customer assistance	o
		1.5	range of models	o
		1.6	charging infrastructure	o
		1.7	service, safety	o
	2. economic	2.1	costs of purchase	+
		2.2	costs of operation	+
		2.3	costs of maintenance	+
		2.4	residual value	+
	3. legislative	3.1	penalties / incentives supply-sided	o
		3.2	penalties / incentives demand-sided	o
	4. socio-psychological	4.1	image, testimonials	o
		4.2	routines	o
		4.3	testing, evaluation	o
	5. organizational	*5.1*	*coordination of activities*	+

Legend: o *… not relevant*
\+ *… relevant*

Table 4.4: Relevant barriers for the supplier (author's illustration)

The following paragraph explains how the marked barriers in Table 4.4 affect the supplier and to what extent he can make efforts in managing them.

- *Driving pleasure (1.1):* As in the case of the OEM, the supplier is highly involved in manufacturing the electric powertrain. Therefore, by improving driving characteristics, such as driving pleasure, acceleration performance, maximum speed and user simplicity, the supplier can make a valuable contribution.

- *Loading capacity & speed, lifetime (1.3):* The loading capacity of the battery, directly coupled with the range of an electric vehicle, charging speed and lifetime are a central point for suppliers. They need to make great efforts in resources and R&D to produce affordable energy storages for a successful market launch of electric vehicles.
- *Costs of purchase (2.1):* Depending on the shift in the value chain, the components provided by the supplier represent a significant part of the electric vehicle. Therefore, especially with regards to the battery, the supplier has a great influence on the costs of purchase of an electric vehicle.
- *Costs of operation (2.2):* As the suppliers are concerned with the manufacturing of the electric powertrain, they can contribute to lowering the costs of operation by improving the efficiency of the energy conversion.
- *Costs of maintenance (2.3):* Mainly referring to the battery, the supplier has a great influence on the costs of maintenance of an electric vehicle by providing affordable spare parts.
- *Residual value (2.4):* The dismantling, recycling and reuse of the electric vehicle also affect the supplier. By developing processes or other opportunities for reusing or recycling the batteries or the lightweight materials, the supplier has an impact on the problem of residual value.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

In order to demonstrate at which phases of the innovation process for electric vehicles the different activities have to be conducted, Figure 4.8 illustrates the assignment.

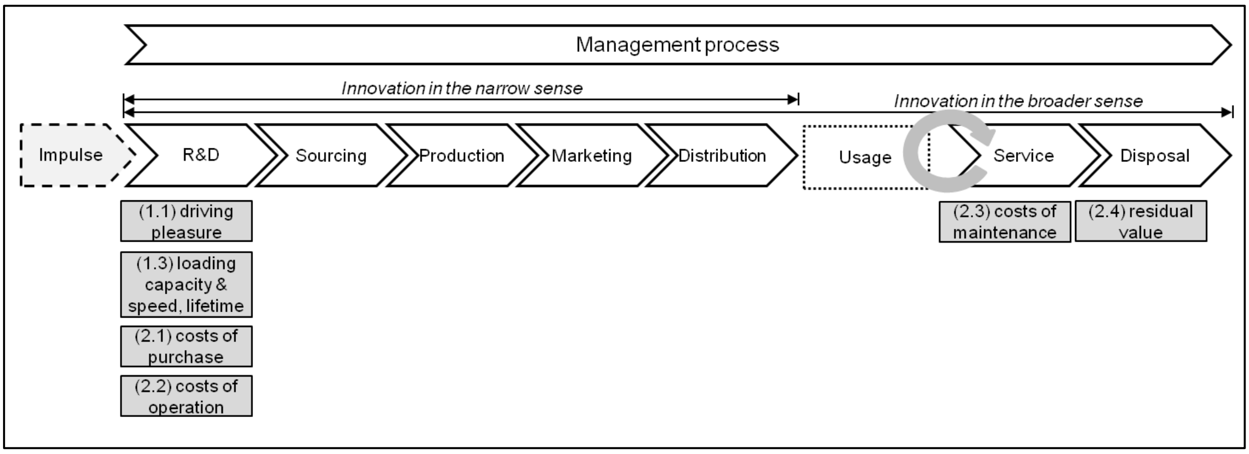

Figure 4.8: Assignment of relevant barriers for the supplier as regards the innovation process for electric vehicles (author's illustration)

The improvement of driving characteristics and efficiency - which are both related to the costs of operation of an electric vehicle - plus increasing the loading capacity and loading speed of the energy storage in line with costs reduction are allocated to R&D. Consequently, the costs of maintenance are, in the first instance, an issue for the service phase and the issue of residual value can be assigned to the last phase of the process, i.e. the disposal.

Energy Suppliers / Oil Companies

In regard to the interaction between stakeholder and barriers, the energy supplier and the oil companies can be considered a unit, as the barriers to which they can make a contribution, according to the identified barriers, actually seem to be the same. An overview of the relevant barriers for energy suppliers and oil companies is demonstrated in Table 4.5.

Barriers	1. technical	1.1	driving pleasure	o	o
		1.2	emissions, fossil fuels	+	+
		1.3	loading capacity & speed, lifetime	o	o
		1.4	customer assistance	o	o
		1.5	range of models	o	o
		1.6	charging infrastructure	+	+
		1.7	service, safety	o	o
	2. economic	2.1	costs of purchase	o	o
		2.2	costs of operation	+	+
		2.3	costs of maintenance	o	o
		2.4	residual value	+	+
	3. legislative	3.1	penalties / incentives supply-sided	o	o
		3.2	penalties / incentives demand-sided	o	o
	4. socio-psychological	4.1	image, testimonial	+	+
		4.2	routines	+	+
		4.3	testing, evaluation	+	+
	5. organizational	*5.1*	*coordination of activities*	+	+

Legend: o *… not relevant*
\+ *… relevant*

Table 4.5: Relevant barriers for energy suppliers and oil companies (author's illustration)

The relevance of the barriers to the energy suppliers and oil companies can be described as follows.

- *Emissions / fossil fuels (1.2):* A crucial precondition for reasonable E-Mobility is the use of electricity from renewable energies in order to reduce emissions and dependency on fossil fuels. It is the energy suppliers and oil companies who are supposed to increase the share of renewable energies; therefore, they have to make significant efforts.
- *Charging infrastructure (1.6):* A core competence of energy suppliers and grid operators is to provide electricity, so it falls within their scope to install a charging infrastructure. Additionally, oil companies are the current gas station operators; therefore, they could also contribute to installing a charging infrastructure for electric vehicles by extending the gas stations with an e-charging spot.
- *Costs of operation (2.2):* It is the oil companies and energy suppliers who sell electricity to the customer. Therefore, as they mainly determine the electricity price, they also have influence on the costs of operation of the electric vehicle.
- *Residual value (2.4):* As the performance of used traction batteries is still around 70 to 80 %, it is also conceivable to reuse them as electricity storage e.g. for solar or wind power plants.[300] In this respect, the energy suppliers and oil companies can contribute by developing options for reusing batteries and thereby addressing the issue of residual value.
- *Image, testimonials (4.1):* For a successful market diffusion of electric vehicles, energy suppliers and oil companies have to consider, within their marketing concepts, the importance of creating value associated with green electricity and green mobility and communicate the benefit of E-Mobility to society.
- *Routines (4.*2): In terms of charging possibilities, energy suppliers and oil companies can contribute by installing a charging infrastructure as mentioned above and also by communicating a new understanding of mobility, including the charging process.
- *Testing, evaluation (4.3):* Beyond internal company fleets, energy suppliers and oil companies can also offer public fleets for testing and evaluating electric vehicles and therefore increase the trialability of E-Mobility.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to the intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

Figure 4.9 demonstrates to which phases the relevant barriers for energy suppliers and oil companies can be assigned.

[300] Cf. LINDER, E. (2010), p. 55

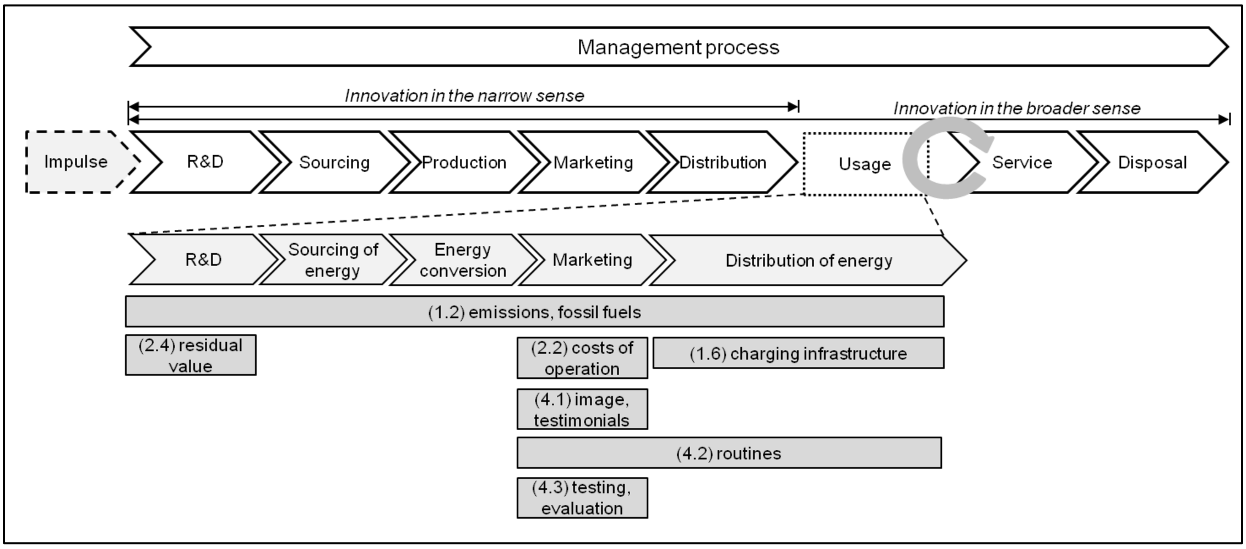

Figure 4.9: : Assignment of relevant barriers for energy suppliers and oil companies as regards the innovation process for electric vehicles (author's illustration)

Almost all barriers come into effect at the usage phase of electric vehicles; it is a crucial issue that the electricity which is used for charging the batteries is generated by renewable energies sources, sold to the customer through an available charging infrastructure at reasonable prices. Further, representing values and increasing the trialability occurs during the use of electric vehicles. However, the efforts required to accomplish those goals need to be made already earlier in the value chain of energy suppliers and oil companies. Therefore, the issue of green electricity extends from R&D to the distribution of energy, while pricing, creation of an image and trialability can be assigned to marketing activities while the charging infrastructure affects the distribution of the energy. The issue of residual value correlates with reuse possibilities and is, therefore, associated with R&D. Dealing with routines is relevant for marketing; however, it is also associated with the installation of a charging infrastructure.

Disposal Companies

In addition to the organizational barrier, there are basically two crucial issues for the disposal companies, as demonstrated in Table 4.6.

Barriers	1. technical	1.1	driving pleasure	o
		1.2	emissions, fossil fuels	o
		1.3	loading capacity & speed, lifetime	o
		1.4	customer assistance	o
		1.5	range of models	o
		1.6	charging infrastructure	o
		1.7	service, safety	+
	2. economic	2.1	costs of purchase	o
		2.2	costs of operation	o
		2.3	costs of maintenance	o
		2.4	residual value	+
	3. legislative	3.1	penalties / incentives supply-sided	o
		3.2	penalties / incentives demand-sided	o
	4. socio-psychological	4.1	image, testimonials	o
		4.2	routines	o
		4.3	testing, evaluation	o
	5. organizational	*5.1*	*coordination of activities*	+
			Legend: o *… not relevant* + *… relevant*	

Table 4.6: Relevant barriers for disposal companies (author's illustration)

The relevant barriers for disposal companies can be explained as follows.

- *Service, safety (1.7):* In general, disposal companies are the ones involved in the handling of hazardous goods. Therefore, they deal with the batteries in the event of service or an emergency.
- *Residual value (2.4):* As regards the issue of residual value, disposal companies focus on research and development of reasonable reuse and recycling opportunities for batteries and lightweight materials.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to the intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

Figure 4.10 illustrates the assignment of the barriers to the reference innovation process for electric vehicles.

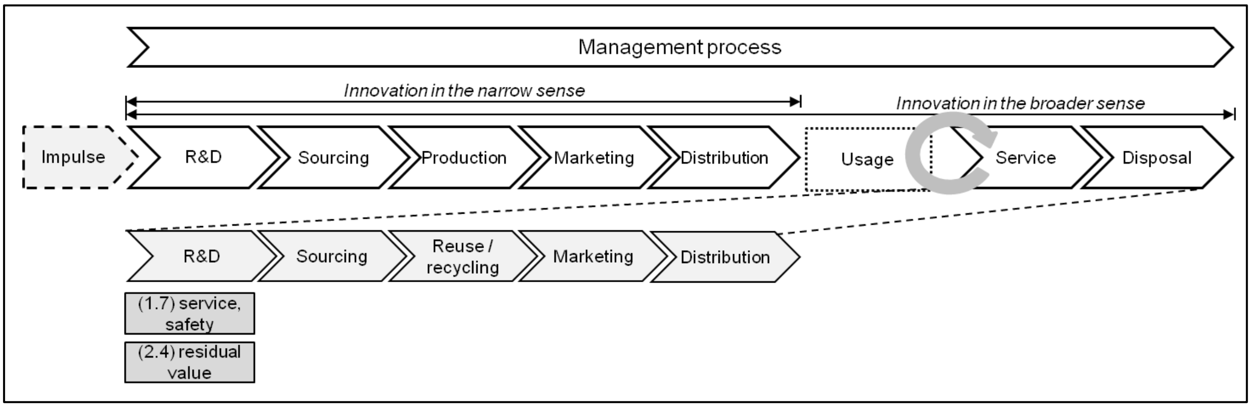

Figure 4.10: Assignment of relevant barriers for disposal companies as regards the innovation process for electric vehicles (author's illustration)

Initially, residual value, service and safety is an issue which is allocated to the service and disposal phases of electric vehicles; however, the main efforts in dealing with batteries as a hazardous good in terms of reuse, recycling and safety have to be made in the R&D phase in the value chain of disposal companies.

Service Provider

For the various service providers in E-Mobility there are a number of fields in which to make contributions for the market launch of electric vehicles. Table 4.7 demonstrates an overview.

Barriers	1. technical	1.1	driving pleasure	o
		1.2	emissions, fossil fuels	o
		1.3	loading capacity & speed, lifetime	o
		1.4	customer assistance	+
		1.5	range of models	o
		1.6	charging infrastructure	+
		1.7	service, safety	+
	2. economic	2.1	costs of purchase	+
		2.2	costs of operation	+
		2.3	costs of maintenance	+
		2.4	residual value	+
	3. legislative	3.1	penalties / incentives for supply	o
		3.2	penalties / incentives for demand	o
	4. socio-psychological	4.1	image, testimonials	+
		4.2	routines	+
		4.3	testing, evaluation	+
	5. organizational	*5.1*	*coordination of activities*	+

Legend: o *… not relevant*; + *… relevant*

Table 4.7: Relevant barriers for service providers (author's illustration)

In the following paragraphs, the extent to which the above tagged barriers are relevant for service providers is explained.

- *Customer assistance (1.4):* As regards the compatibility with familiar routines and habits, service providers can make contributions by offering software solutions for e.g. charging processes and how to deal with range anxiety.
- *Charging infrastructure (1.6):* in addition to developing software solutions for service connected to the recharging of batteries such as billing systems, locating and reserving time at charging spots, the service providers also refer to offering charging spots at car parks and e.g. shopping centers.
- *Service (1.7):* Service and maintenance is not only relevant for OEMs, but also for car repair shops that have to adapt to the requirements of electric vehicles, which differ to the accustomed service for conventional vehicles
- *Costs of purchase, operation, maintenance and residual value (2.1/2.2/2.3/2.4):* In order to offer new options for using rather than owning an electric vehicle, financial service providers and or mobility service providers make a contribution

by developing business models based on the total cost of ownership, such as leasing, mobility packages which include – according to the actual requirements – an electric city car for everyday life, a van for holidays, etc.

- *Image, testimonials (4.1):* In the event that shopping centers offer charging spots for electric vehicles as an add-on service, they may create an image for themselves as an environmentally friendly company that promotes sustainability while, at the same time, increasing the image of E-Mobility. In addition, mobility-, financial- and many other service providers can also make contributions to create an image of E-Mobility.
- *Routines (4.2):* Correlating to technical customer assistance as well as to public charging spots, various service providers can contribute to ease the overcoming of long-established routines.
- *Testing, evaluation (4.3):* Car dealers, railway companies and other mobility service providers can support the trialability of electric vehicles by providing, for example, multi modal mobility and pay per use concepts, so driving an electric vehicle can be easily tested and experienced.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to the intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

The assignment of the barriers to the reference innovation process for electric vehicles is demonstrated in Figure 4.11.

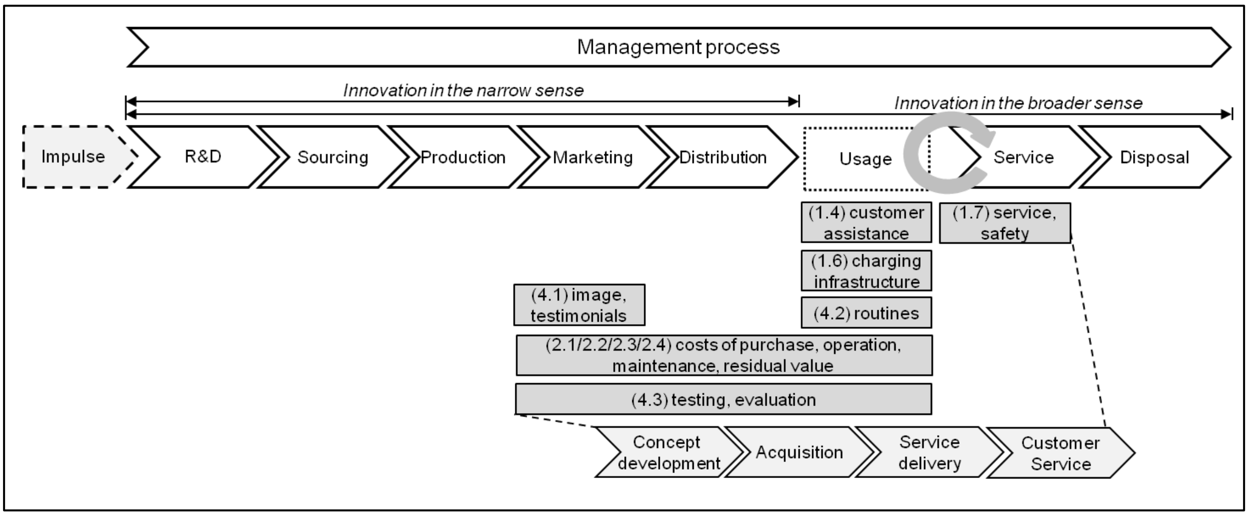

Figure 4.11: Assignment of relevant barriers for the service provider as regards the innovation process for electric vehicles (author's illustration)[301]

[301] For the service value chain see SPIEGEL, T. (2003), p. 35; VOIGT, K. I. (2008), p. 98; ALTOBELLI, C. F.; BOUNCKEN, R. B. (1998), p. 289

The aspects of charging infrastructures, as well as technical support to create new routines and facilitate dealing with electric cars, becomes relevant during the usage phase, while the image creation correlates to marketing. In addition, the costs of purchase, operation, maintenance and residual value affect even the marketing – as the concepts have to be part of the marketing strategy - through to distribution and eventually the usage phase, while the service is, of course, allocated to the back end of the process, i.e. to the service phase. However, the service value chain can be further specified as shown in Figure 4.11.

Politics

In regards to E-Mobility, politics has remarkable levers for enhancing a successful diffusion of electric vehicles on the market. Moreover, politics also has influence on the circumstances, i.e. the environmental consequences, and thus is in charge of developing a reasonable future mobility concept. Table 4.8 gives an overview of the barriers which are particularly relevant for politics.

Barriers	1. technical	1.1	driving pleasure	o
		1.2	emissions, fossil fuels	+
		1.3	loading capacity & speed, lifetime	o
		1.4	customer assistance	o
		1.5	range of models	o
		1.6	charging infrastructure	+
		1.7	service, safety	o
	2. economic	2.1	costs of purchase	+
		2.2	costs of operation	+
		2.3	costs of maintenance	o
		2.4	residual value	o
	3. legislative	3.1	penalties / incentives supply-sided	+
		3.2	penalties / incentives demand-sided	+
	4. socio-psychological	4.1	image, testimonials	+
		4.2	routines	+
		4.3	testing, evaluation	+
	5. organizational	*5.1*	*coordination of activities*	+
			Legend:	o *… not relevant* + *… relevant*

Table 4.8: Relevant barriers for politics (author's illustration)

The following paragraphs describe the relevance of the barriers to politics, plus, to what extent they can make a contribution in order to overcome them.

- *Emissions / fossil fuels (1.2):* Politics has a prime role to play by giving the impetus and even forcing energy suppliers and oil companies to generate electricity from renewable energies by setting up regulations for a renewable energy quota. In fact, that must be a crucial precondition for a reasonable E-Mobility concept.
- *Charging infrastructure (1.6):* A legislative framework, including regulations and incentives, is crucial as a basis to encourage energy suppliers and grid operators to create a public infrastructure.
- *Costs of purchase and operation (2.1/2.2):* With incentives for the purchase of an electric vehicle, tax benefits on electricity and penalties such as CO_2-taxes, higher mineral oil tax, politics can implement powerful levers for making the costs of purchase and operation of an electric vehicle more attractive.

- *Penalties / incentives supply- and demand-sided (3.1/3.2):* By implementing penalties for CO_2-fleet emissions and incentives for R&D projects on alternative propulsion systems, politics gives the impetus for pushing development in the automotive industry towards the electrification of the powertrain. On the other hand, politics can use levers to attract or penalize the customer, as for instance with advantages for electric vehicles in traffic, i.e. free car parks, preferred lanes, or tax benefits, in contrast to CO_2-taxes and higher mineral oil tax. Therefore, it is particularly crucial to set a purposeful scope for bringing E-Mobility on the market.
- *Image, testimonials (4.1):* Politics can make a significant contribution regarding the creation of the image of electric vehicles in society with proper marketing concepts and publicity. What's more, an example and a role model could be set by having an electric vehicle fleet for politicians.
- *Routines (4.2):* By communicating a new understanding of mobility and explanatory work, politics can make a contribution to help overcome long-established routines of the customers.
- *Testing, evaluation (4.3):* In terms of increasing the trialability, there are certain opportunities for politics such as establishing model regions and supporting pilot fleets.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to the intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

Even though, as regards politics, it cannot be called a value chain or innovation process management in the conventional sense, the different barriers come into effect at specific phases and therefore can be assigned as regards the innovation process for electric vehicles, as demonstrated in Figure 4.12.

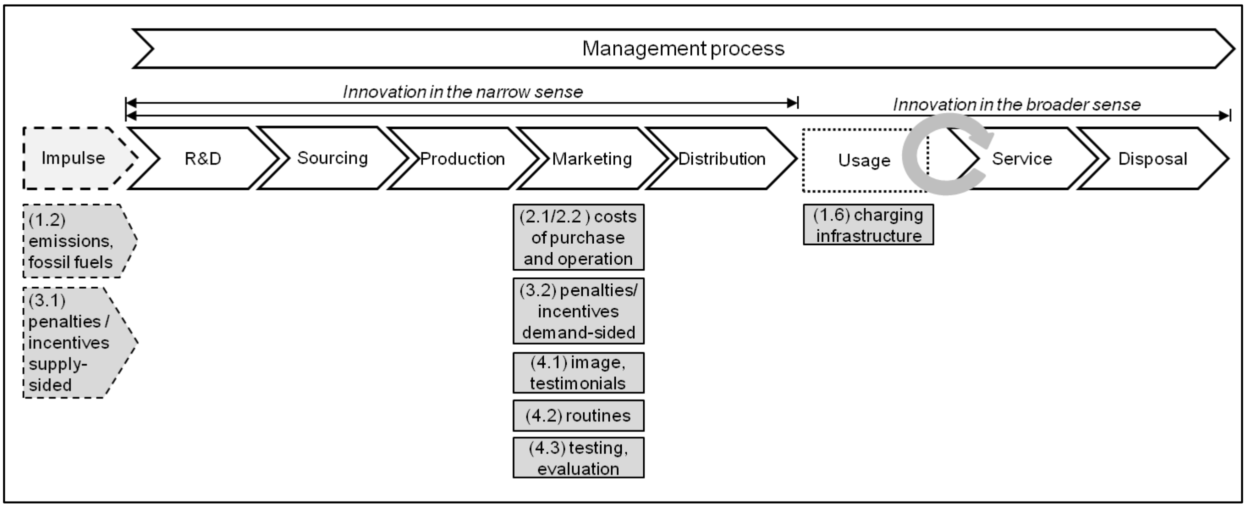

Figure 4.12: Assignment of relevant barriers for politics as regards the innovation process for electric vehicles (author's illustration)

The regulations on CO_2-fleet emissions and a renewable energy quota, as well as the incentives for R&D projects to the automotive industry can be seen as an impetus for the E-Mobility innovation process. The levers to make electric vehicles more attractive, compared to conventional vehicles, i.e. purchase incentives, free car parks, tax benefit and increased CO_2- and mineral oil taxes can be assigned to the marketing activities. Further, also creating an image, facilitate the overcoming of long-established routines and providing opportunities to test and evaluate electric vehicles belong to the marketing phase. As the charging infrastructure is crucial for the usage of electric vehicles, the setting up of adequate framework conditions correlates to the usage phase.

Society

Also for society, there are barriers which are relevant, respectively, where representatives of society can make efforts in order to push E-Mobility forward. Table 4.9 shows an overview of the barriers, which are mainly allocated to socio-psychological causes.

Barriers	1. technical	1.1	driving pleasure	o
		1.2	emissions, fossil fuels	o
		1.3	loading capacity & speed, lifetime	o
		1.4	customer assistance	o
		1.5	range of models	o
		1.6	charging infrastructure	o
		1.7	Service, safety	o
	2. economic	2.1	costs of purchase	o
		2.2	costs of operation	o
		2.3	costs of maintenance	o
		2.4	residual value	o
	3. legislative	3.1	penalties / incentives supply-sided	o
		3.2	penalties / incentives demand-sided	o
	4. socio-psychological	4.1	image, testimonials	+
		4.2	routines	+
		4.3	testing, evaluation	+
	5. organizational	*5.1*	*coordination of activities*	+

Legend: o *… not relevant*; + *… relevant*

Table 4.9: Relevant barriers for the society (author's illustration)

The following paragraphs describe the relevance of the identified barriers for society.

- *Image, testimonials, routines, testing and evaluation (4.1/4.2/4.3):* Certain representatives of society such as media, public opinion leaders, automobile clubs have an impact on creating and communicating specific values and an image of E-Mobility, facilitating the overcoming of long-established routines and increasing the trialability.
- *Coordination of activities (5.1):* This barrier refers more to the inter-organizational than to the intra-organizational innovation; therefore, see chapter 4.3.3 for any further considerations.

As Figure 4.13 demonstrates, the socio-psychological barriers mentioned are particularly relevant for marketing activities within the innovation process for electric vehicles.

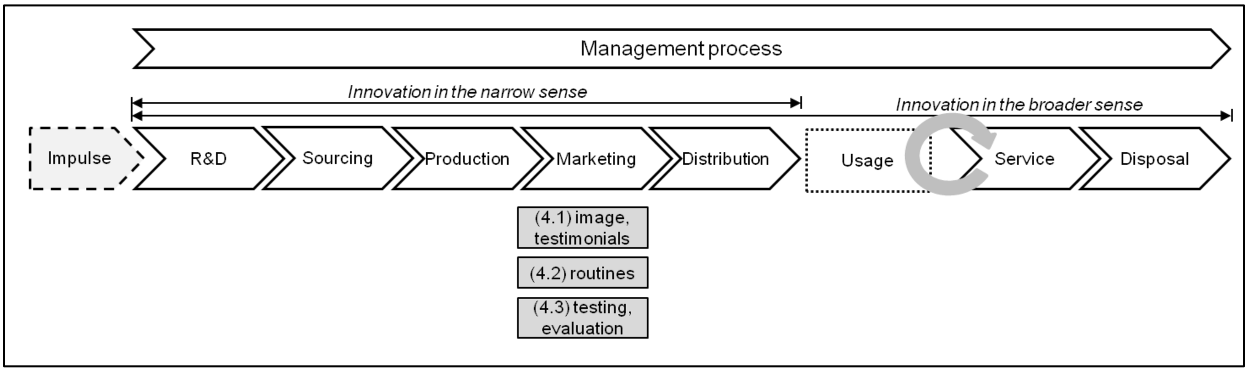

Figure 4.13 Assignment of relevant barriers for society as regards the innovation process for electric vehicles (author's illustration)

Research Institutes

Ultimately, research institutes, although mentioned last, are nonetheless extremely important stakeholders in E-Mobility and can make efforts in most distinct areas; contributions can extend from technical, to economic, legislative over to socio-psychological as well as organizational topics, as demonstrated in Table 4.10.

Barriers	1. technical	1.1	driving pleasure	+
		1.2	emissions, fossil fuels	+
		1.3	loading capacity & speed, lifetime	+
		1.4	customer assistance	+
		1.5	range of models	+
		1.6	charging infrastructure	+
		1.7	service, safety	+
	2. economic	2.1	costs of purchase	+
		2.2	costs of operation	+
		2.3	costs of maintenance	+
		2.4	residual value	+
	3. legislative	3.1	penalties / incentives supply-sided	+
		3.2	penalties / incentives demand-sided	+
	4. socio-psychological	4.1	image, testimonials	+
		4.2	routines	+
		4.3	testing, evaluation	+
	5. organizational	*5.1*	*coordination of activities*	+

Legend: o *… not relevant*; + *… relevant*

Table 4.10: Relevant barriers for the research institutes (author's illustration)

In fact, research institutes can be consulted for any concerns, starting with technical issues such as improvements of energy storage including the capacity, lifetime, loading speed and recycling options, plus the driving characteristics of an electric vehicle and, of course, the major issue of electricity generated with renewable energies, etc. Next, research can assess economic issues such as business models and the customer's willingness to pay, plus the effect and reasonableness of penalties and incentives by politics. Further, research is also asked to contribute when it comes to socio-psychological issues such as, for example, customer's expectation, how to create and communicate values and the impact of testimonials. Ultimately, the organizational and system theoretical aspects as well as holistic approaches which refer to the big picture of E-Mobility can be supported by research. As a result, there are manifold possibilities to consult research all along the reference innovation process for electric vehicles. However, the contributions in regards to basic and applied research in terms of battery technology as a key factor for E-Mobility are particularly valuable.

Résumé of the interaction analysis between Barriers and Stakeholders

Including the relevant barriers and stakeholders in E-Mobility, the overview in Table 4.11 illustrates their interaction, i.e. which barriers are relevant for which stakeholders and where they have to make contributions in order to overcome them.

				Stakeholders									
				Customer / User	OEM	Supplier	Energy Supplier	Oil Companies	Disposal Companies	Service Provider	Politics	Society	Research Institutes
Barriers	1. technical	1.1	driving pleasure	o	+	+	o	o	o	o	o	o	+
		1.2	emissions, fossil fuels	o	o	o	+	+	o	o	+	o	+
		1.3	loading capacity & speed, lifetime	o	+	+	o	o	o	o	o	o	+
		1.4	customer assistance	o	+	o	o	o	o	+	o	o	+
		1.5	range of models	o	+	o	o	o	o	o	o	o	+
		1.6	charging infrastructure	o	+	o	+	+	o	+	+	o	+
		1.7	service, safety	o	+	o	o	o	+	+	o	o	+
	2. economic	2.1	costs of purchase	o	+	+	o	o	o	+	+	+	+
		2.2	costs of operation	o	+	+	+	+	o	+	+	o	+
		2.3	costs of maintenance	o	+	+	o	o	o	+	o	o	+
		2.4	residual value	o	+	+	+	+	+	+	o	o	+
	3. legislative	3.1	penalties / incentives supply-sided	o	o	o	o	o	o	o	+	o	+
		3.2	penalties / incentives demand-sided	o	o	o	o	o	o	o	+	o	+
	4. socio-psychological	4.1	image, testimonials	o	+	o	+	+	o	+	+	+	+
		4.2	routines	o	+	o	+	+	o	+	+	+	+
		4.3	testing, evaluation	o	+	o	+	+	o	+	+	+	+
	5. organizational	*5.1*	*coordination of activities*	o	+	+	+	+	+	+	+	+	+

Legend: o *… not relevant*; + *… relevant*

Table 4.11: Overview of the interaction analysis between barriers and stakeholders in E-Mobility (author's illustration)

As demonstrated, very obviously, in Table 4.11, there are various barriers which are not only relevant for one single stakeholder, but rather for many others who are affected by the issue and, therefore, have to co-operate in dealing with it. In any case, research can be consulted for any concerns and be supportive thereof.

Further on, Figure 4.14 illustrates an overview of the assignment of barriers as regards the innovation process for electric vehicles including all mentioned stakeholders – except the research institutes which can be brought in for any issue and the customers, who cannot make an active contribution in overcoming any barriers. What is particularly noticeable in this respect, is that the barriers are mainly associated with the R&D and marketing phases, followed by the usage phase, which therefore seem evidently to be the critical areas within the innovation of E-Mobility and also most germane to be supported by research. The impulse, even though not emphasized because of the frequency of assignments of barriers, is to be considered as an extremely important phase within the innovation process as it is the very beginning and the initiation of the process in the first place.

Moreover, Figure 4.14 also highlights the need for coordination between the stakeholders in order to manage the great number of challenges. Thus, the coordination of the different activities within the E-Mobility innovation process plays a predominant role that eventually concerns all stakeholders. On the basis of the interaction analysis and the reference innovation process it is clearly pointed out that this aspect is more to be seen as an inter-organizational issue, which is therefore discussed separately in the following chapter 4.3.3.

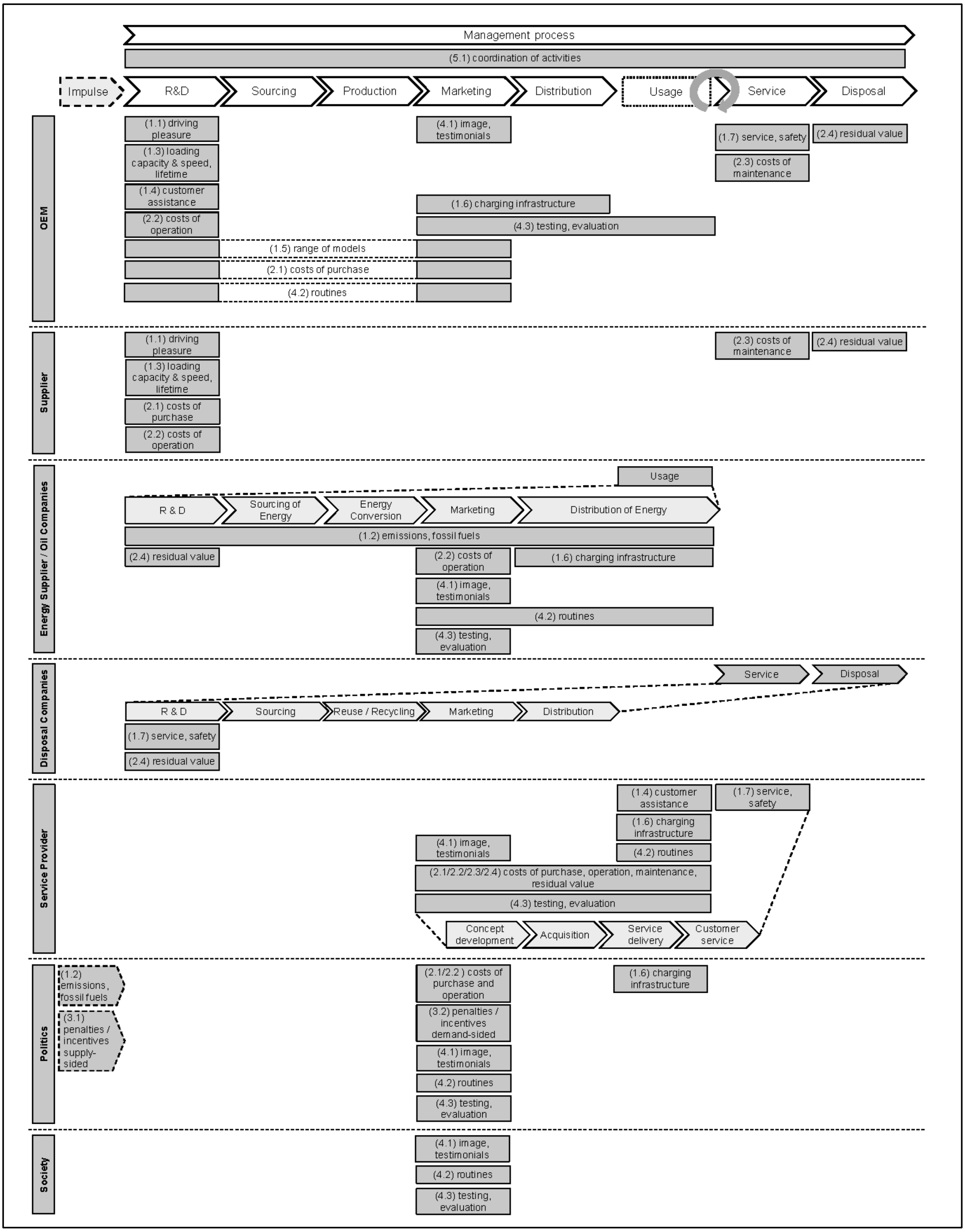

Figure 4.14: Overview of the assigned barriers as regards the innovation process for electric vehicles (author's illustration)

4.3.3 Inter-Organizational Innovation in E-Mobility

Based upon the considerations of the previous chapter, the interaction analysis is not only to be interpreted in such a way as to which barriers are relevant for a certain stakeholder but also which stakeholders interact or, rather, have to co-operate regarding a specific barrier. Moreover, their main topics have to be clarified and an implication for further actions is proposed. As a consequence of the high level of interaction between the stakeholders, the last past of this chapter discusses an approach for the inter-organizational coordination.

Interaction of stakeholders

First of all, the barriers need to be classified as to whether there is any interaction between various stakeholders or if there is none at all; i.e. if one single stakeholder or more than one stakeholder is affected by it.

However, a further distinction can be made, as the impact of the numerous identified barriers on the market penetration of E-Mobility also differs. Thus, there are barriers which are extremely important in comparison to others, which are – although previously identified – not determined as top priority. Accordingly, the barriers can be prioritized as to the impact of each barrier and the affected stakeholders, as illustrated in the portfolio in Figure 4.15. The axis of affected stakeholders is divided into one or more than one stakeholder, which refers to any stakeholder except research institutes, as they can be involved in any issue.

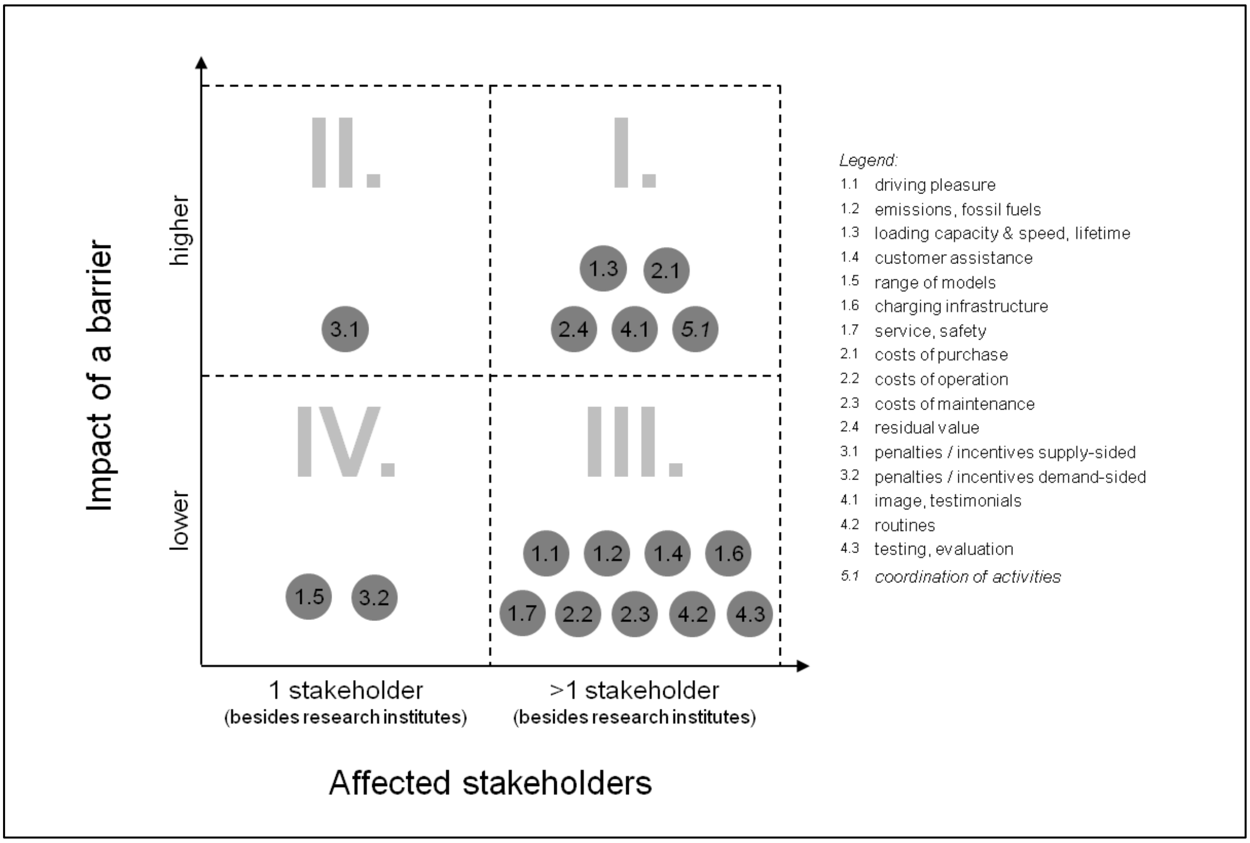

Figure 4.15: Portfolio on the impact of the barrier vs. affected stakeholders (author's illustration)

The spread of the portfolio demonstrates that most of the barriers affect various stakeholders. Moreover, greater importance is given to some selected barriers, i.e. to loading capacity, loading speed and lifetime, costs of purchase and residual value, image supported by testimonials, coordination of activities as a superior task and supply-sided penalties and incentives as an impulse for E-Mobility. However, in the latter case, it is only politics that is involved. As a result, the section with more stakeholders affected plus a high impact of the barrier, followed by section two, which represents a high impact of a barrier with one stakeholder involved, are considered top priority.

According to the portfolio, the paragraphs below describe each section in more detail, whereby the following aspects are considered:

- the barriers of each section,
- the affected stakeholders of each barrier and their main issues,
- and concluding implications for each section.

As to this, the interaction of stakeholders at a specific barrier is referred back to Table 4.11, which illustrates an overview of the interaction analysis. At this point it is mentioned again, that any aspect can be consulted and supported by research institutes.

As first section, the barriers with higher impact and many affected stakeholders are discussed. The following list describes the main issues for the interacting stakeholders induced by a barrier.

- *Loading capacity & speed, lifetime (1.3):* Both OEM and supplier enforce the developments as regards battery technology, particularly the loading capacity, loading speed and lifetime. In this respect, establishing international standards and norms is also extremely crucial. Due to the shift in competence there is no straight separation between the OEM and the supplier, so their co-operation needs to be clarified. Especially when it comes to battery technology, research institutes are asked to make valuable contributions.
- *Costs of purchase (2.1):* In the first place, the OEM and the supplier, in co-operation with research, need to increase efficiency and produce affordable batteries which, currently, essentially determine the costs of purchase of an electric vehicle. Here, politics can implement levers such as incentives for the purchase of an electric vehicle to enhance sales and therefore economies of scale. However, financial and mobility service providers can also make a contribution by offering attractive leasing models and mobility packages.
- *Residual value (2.4):* The lifetime, which is currently still short, and high price of traction batteries along with associated residual value issues affect various stakeholders. Of course, disposal companies are active in the reuse and recycling of used traction batteries. However, OEMs have to take back end-of-life vehicles, so they have to - just as the suppliers do – deal with recycling and reuse of the batteries. Additionally, the energy industry may also provide options for reusing batteries e.g. in solar and wind power plants. Along the lines of research on battery technology, research institutes are also very involved in finding reuse and recycling options. Ultimately, by offering leasing models, the uncertainty of the residual value the customer would have to contend with is assumed by financial- and mobility service providers.
- *Image, testimonials (4.1):* First of all, it is up to OEMs to create values and establish a positive image for electric vehicles. In addition, energy suppliers and oil companies also have to work on communicating the values of green electricity and green mobility, and – moreover, they may also serve as a role model with company fleets. The latter is also relevant for politics, which should set an example by having electric vehicle fleets, besides, of course, publicity work and marketing concepts. Ultimately, some service providers and society

representatives can be supportive in creating an image, for example, with testimonials.

- *Coordination of activities (5.1):* In the end, the great need for coordination involves all stakeholders. This aspect is further discussed in the next part of this chapter "Inter-organizational coordination".

This section is especially relevant as there is not only the high impact of the barriers, but also diverse stakeholders who are involved in finding a solution. Therefore, the following implication can be deduced for section I.

Section I.: >1 affected stakeholders / higher impact
➔ *As section I. has top priority, the affected stakeholders are, first of all, strongly requested to clarify their interaction, i.e. to coordinate their concerns and, as regards technical aspects, to establish standards and norms, and second, to enforce specific and targeted activities. In this case of a very high interaction, the importance of coordination and communication between the involved parties is particularly emphasized for overcoming the barriers.*[302]

Section II. also implies a high impact of the barriers, however, with only one stakeholder – aside for research institutes - who is affected by it. In fact, there is only the aspect of supply-sided penalties and incentives, which falls into this scope. Like the first section, section II. is also highly relevant, but as politics is the only force that can define which activities are set, the deduced implication is as follows.

Section II.: 1 affected stakeholders / higher impact
➔ *As a consequence of the high impact of barriers, section II. also has top priority, so the affected stakeholder is required to push specific and purposeful actions; however, due to the fact that it affects just one stakeholder, there is less need for coordination and communication than for the barriers of section I.*

Most of the barriers are comprised in section III., which is determined to represent a lower impact of the barriers that affect various stakeholders. In the following paragraphs, the main issues for the barriers of section III. are discussed.

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[302] See also TALKE, K.; SALOMO, S.; TROMMSDORFF, V. (2007), pp. 125-156; TALKE, K.; HULTINK, E. J. (2010), pp. 537-553.

- *Driving pleasure (1.1):* As car manufacturers and/or manufacturers of components, it is up to the OEMs and suppliers – aside for research - to work on improving driving characteristics, acceleration performance, maximum speed and user simplicity.
- *Emissions, fossil fuels* (1.2): Pushed by politics, which drives legislation for renewable energy quotas, oil companies and energy suppliers need to provide electricity from renewable energies which builds the basis for a reasonable E-Mobility concept. In the course of this, research institutes can be supportive, for example, by providing concepts with increased efficiency, etc.
- *Customer assistance (1.4):* By ensuring appropriate customer assistance the OEMs, along with certain service providers, can make a major contribution in increasing compatibility with familiar routines and habits, which is particularly relevant for charging processes and range anxiety.
- *Charging infrastructure (1.6):* In the first instance, expectations are that energy suppliers will create a charging infrastructure. Further, oil companies, as current gas station operators, are also in line for building up e-charging spots. However, there can also be other providers of charging spots, such as car parks and shopping centers in addition to service providers who develop software solutions for billing systems, locating and reserving charging spots, etc. Ultimately, the OEM aims to offer system solutions, especially as regards home charging spots for customers of pilot fleets. Moreover, politics is required to set up framework conditions, i.e. regulations and incentives, particularly as regards multi-unit dwellings and public infrastructure in urban areas. Research may contribute starting from providing information as to what extent a public charging infrastructure is needed through to technical concepts. In reference to the reloading of batteries, great importance is attached to international standards and norms for the charging infrastructures.
- *Service, safety (1.7):* The after sales area of OEMs, along with car repair shops, need to establish readily available service for electric vehicles, which requires infrastructure as well as trained personnel with the specific know-how of dealing with batteries in cases of emergency. As to this, disposal companies are supportive in the handling of hazardous goods such as the battery.
- *Costs of operation (2.2):* The operating costs are influenced by various factors. First of all, the energy conversion efficiency of the powertrain is a determining factor, so the OEMs and suppliers need to make efforts. Further, electricity costs are decisive; they are set by the energy suppliers and oil companies, on the one hand, and on the other hand, influenced by politics in the form of taxes. In

addition, service providers can develop attractive business models for leasing and mobility services.

- *Costs of maintenance (2.3):* The costs of maintenance of electric vehicles are determined by the OEMs and suppliers, who provide the spare- and repair parts. Further, financial- and mobility service providers initially assume the costs of maintenance and charge the total cost of ownership to the customer, whose individual user behavior eventually also has an impact, especially on the battery's lifetime, i.e. how the battery is used and charged. Referring to the latter, research is also involved as they are engaged in battery technology.
- *Routines (4.2):* The handling of long-established routines can be facilitated by technical customer assistance, developed by OEMs and/or specific service providers, as well as by communicating a new understanding of mobility and promoting a change in behavior, which can also be supported by the energy industry, representatives of society, i.e. media, etc. and by politics.
- *Testing, evaluation (4.3):* With adequate marketing concepts, pilot fleets, etc. OEMs, along with energy suppliers and oil companies make E-Mobility tangible for the customer and provide opportunities to test electric vehicles and gain experience in dealing with E-Mobility. Plus, it is also up to politics to establish model regions. Further, multimodal mobility and pay-per-use concepts by mobility service providers facilitate access to E-Mobility.

For the barriers assigned to section III. the following implication can be deduced.

Section III.: >1 affected stakeholders / lower impact
➔ *Even though section III. implies a lower impact for the market penetration of electric vehicles and is, therefore, not considered a as top priority, the barriers represent relevant aspects for the customer and need to be addressed. Further, special attention needs to be paid to this section as it affects various stakeholders who have to define their interaction and establish standards and norms. Therefore, coordination and communication is a critical requirement for overcoming the barriers.*

Section IV. covers a lower impact of a barrier in which there is only one stakeholder – aside for research – who is affected. This includes the OEM, as concerns the range of models, and politics, as concerns setting demand-sided incentives or penalties. The following implication can be deduced for section IV.

Section IV.: 1 affected stakeholders / lower impact
➔ *The stakeholder who is affected by a specific barrier needs to focus mainly on addressing intra-organizational activities, as there is just one stakeholder involved. Even though not a top priority, this section includes relevant issues for the market penetration of E-Mobility, and the barriers that need to be addressed by the specific stakeholder.*

Inter-organizational coordination

As elaborated upon in the previous part of this chapter, the handling of the different activities requires a high level of coordination between the stakeholders. The term coordination implies the reconcilement of structures, processes, appointments, objectives and goals, measures, regulations, etc., for the most part in the sense of harmonization. As a result, the objective of coordination is the reduction of the need for coordination.[303]

In the first place, any given stakeholder is clearly responsible and in charge of managing its own innovation process and further is also the problem owner of it. Consequently, the question arises as to how the inter-organizational innovation needs to be managed, whether there is a problem owner who is chiefly interested in the implementation of E-Mobility, and who should take on this task.

At any rate, the inter-organizational coordination of the stakeholders in E-Mobility is extremely crucial. Therefore, it is suggested that the expression and the result of this necessary co-operation be a network between the involved parties, as in literature co-operation in general is determined to be a central issue for overcoming barriers to innovation.[304] The network can therefore be understood as a quasi-firm, i.e. an intermediary form of organization between market and hierarchy, which are the two basic models of economic coordination.[305] Thus, as regards the *market model*, the coordination of the rather loose and volatile relationships between independent parties is effected by means of pricing. In contrast, the coordination within the *hierarchical model* takes place through a central planning or, respectively, through the precise execution of instructions.[306] As illustrated in Figure 4.16, the two basic models

[303] Cf. DICHTL, E.; ISSING, O. (1994), as cited in: STREBEL, H.; HASLER, A. (2007), p. 357
[304] Cf. HAUSCHILDT, J.; SALOMO, S. (2007), pp. 206
[305] Cf. EVERS, M. (1998), pp. 26
[306] Cf. STREBEL, H.; HASLER, A. (2007), p. 353

represent the endpoints, while between them there are all other potential possibilities of co-operation which unite hierarchical, market, co-operative and competitive elements,[307] and are therefore also referred to in literature as *hybrid forms* of organizations.[308] Hence, co-operation means a continuous interaction of organizations in order to accomplish specific tasks in the interest of common objectives.[309]

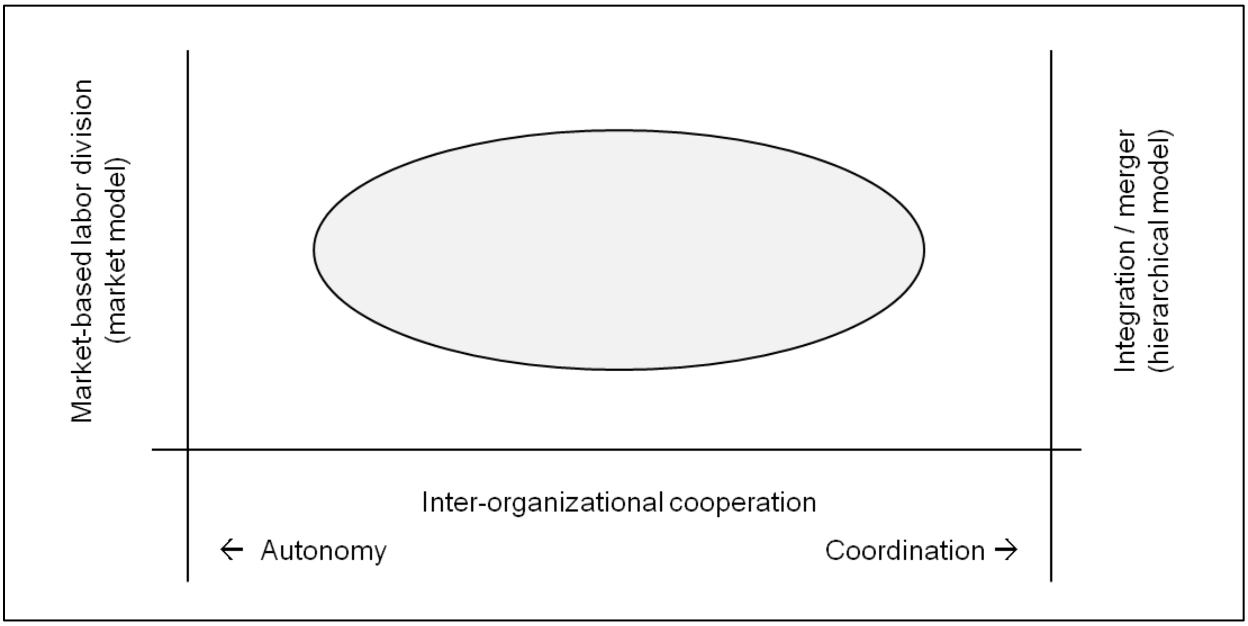

Figure 4.16: Forms of economic coordination[310]

Networks can be distinguished by the degree of centralization of the organizations' coordination.[311] Hence, the centralization of the strategic executive function leads to a strategic network, which implies the reconciliation of the objectives of the involved organizations as well as the coordination of specific activities through a central unit. As a result, the interconnection and co-operation of organizations as strategic networks enhances innovations by means of an information function, a development function and lastly a diffusion function.[312] Additionally, in the case of a high number of parties involved it is particularly advantageous to transfer the inter-organizational coordination task to a specialized central unit in order to reduce the number of relationships and therefore the complexity in the network,[313] as illustrated in Figure 4.17.

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[307] Cf. STREBEL, H.; HASLER, A. (2007), p. 353; see also EVERS, M. (1998); SYDOW, J. (1992)
[308] See also PICOT, A.; REICHWALD, R.; WIGAND, R. T. (2003), p. 54; PICOT, A. et al. (2012), p. 240; EVERS, M. (1998), p. 27; WILLIAMSON, O. (1985)
[309] Cf. STREBEL, H.; HASLER, A. (2007), p. 353
[310] Referring to EVERS, M. (1998), p. 30; referring to STREBEL, H.; HASLER, A. (2007), p. 354
[311] Cf. STREBEL, H.; HASLER, A. (2007), p. 351
[312] Cf. STREBEL, H.; HASLER, A. (2007), pp. 364
[313] Cf. PICOT, A. et al. (2012), p. 269

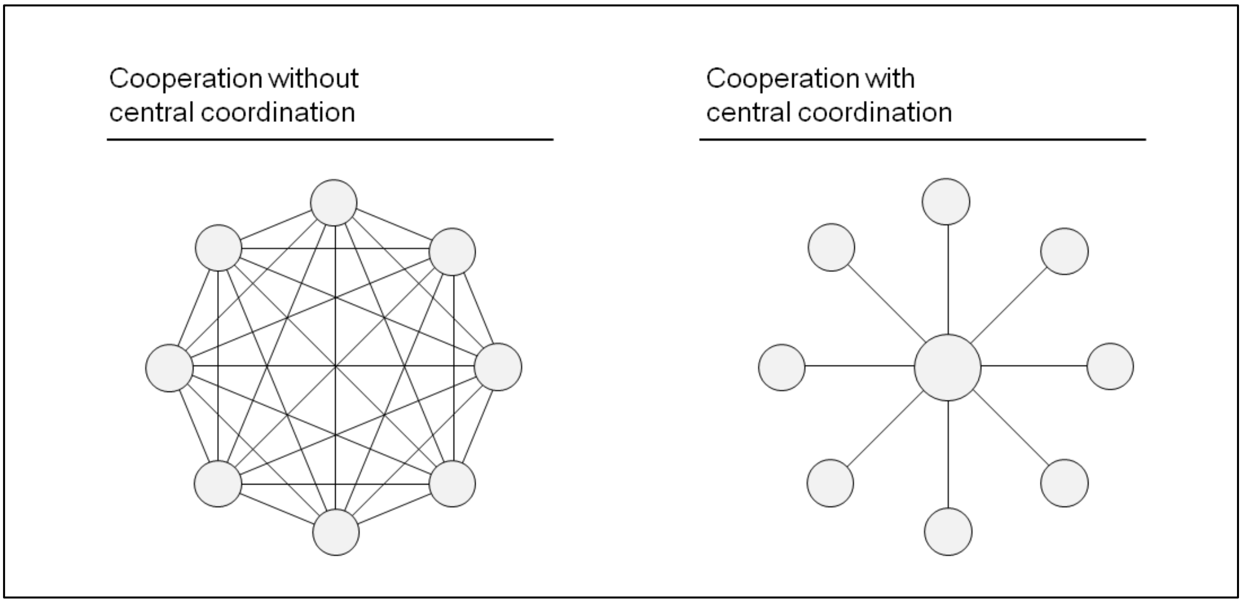

Figure 4.17: Co-operation with and without central coordination[314]

The innovation of E-Mobility also takes place in a system which involves various stakeholders; therefore, these considerations need to be reflected for this particular case. Just to name an example, car manufacturer and companies in the field of battery technology enter into co-operations in order to get access to specific know-how.[315] Ultimately, there are many activities set by different stakeholders, which emphasizes the need for a common coordination. As to co-operations, there is a reference to the importance of the availability of sufficient and adequate complementary products and services to the product itself, i.e. the electric vehicle, because customers apparently only jump on if complements do exist, which eventually activates the added value spiral.[316]

A hierarchical form of the inter-organizational coordination in E-Mobility doesn't constitute an appropriate possibility, because the individual organizations are evidently not willing to give up their market power nor their autonomy. With respect to the market model, the coordination in the sense of a hybrid form, i.e. co-operation and formation of networks, implies considerable advantages, such as reducing and sharing risk, pooling resources, increasing efficiency, sharing expertise, reducing costs, increasing market share, increasing information transfer, etc.[317] Apart from that, the actual definition of co-operations needs to be pointed out, as it refers to the accomplishment of certain tasks,

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[314] Referring to DIETL, H. M. (1993), p. 195
[315] Cf. PICOT, A. et al. (2012), pp. 253
[316] Cf. PICOT, A. et al. (2012), pp. 282
[317] Cf. VYAS, M. N.; SHELBURN, W. L.; ROGERS, D. C. (1995), p. 50; cf. PICOT, A. et al. (2012), pp. 247

and – most important – in the interest of common objectives.[318] In this particular case, this means to eventually establish a reasonable concept of E-Mobility. However, that very concept requires not only single products appearing on the market, but rather includes all other complementary products and services and framework conditions which are crucial for a definite master plan, i.e. as regards the issues of battery technology, battery recycling and reuse, powertrain technology, standardization and norms, electricity from renewable energies, charging infrastructure, etc.

For that reason, special importance is attached to a central coordination in this network, apart from all the other advantages of a central control unit as mentioned above,[319] such as the reduction of complexity within the system and the general enhancement of innovations by means of the information function, the development function and the diffusion function which is ultimately crucial for a successful market penetration.

Figure 4.18 illustrates the inter-organizational coordination in E-Mobility. It aims to demonstrate that regulations, for example as set out by the European Union, can give the necessary impetus for getting things started, but in further consequence it is up to a central unit or even up to the stakeholders to establish a central unit in order to set target-oriented activities within different working clusters.

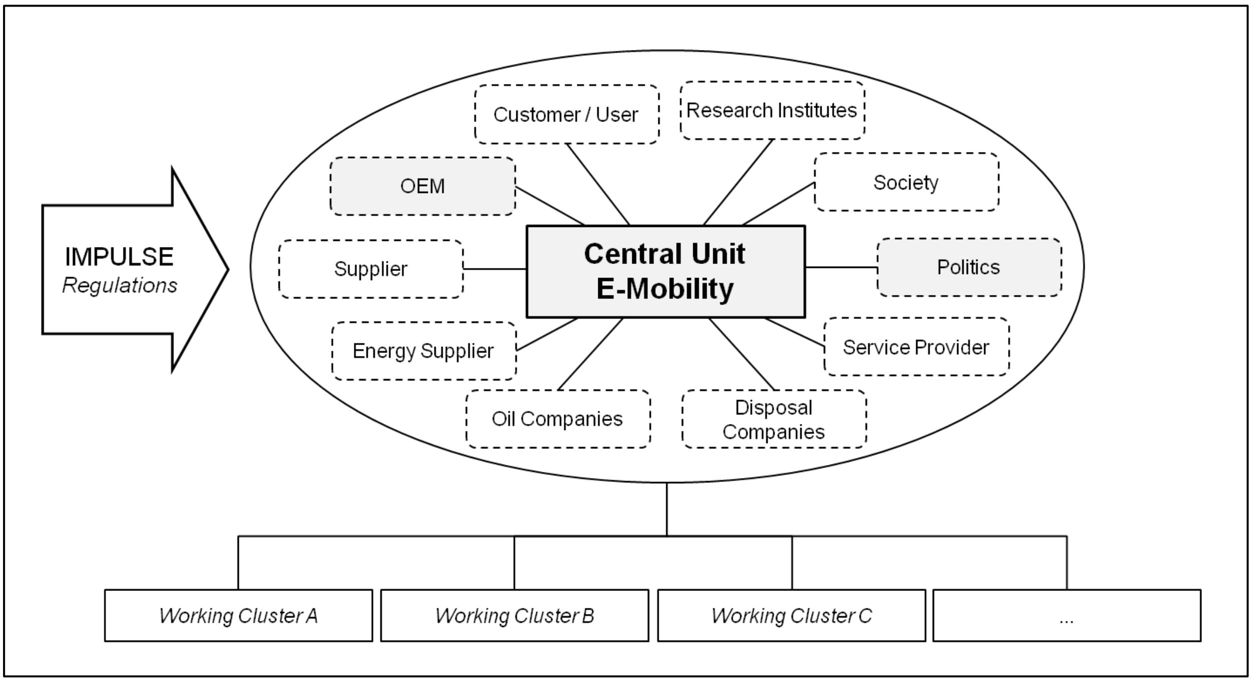

Figure 4.18: Inter-organizational coordination in E-Mobility (author's illustration)

318 Cf. STREBEL, H.; HASLER, A. (2007), p. 353
319 Cf. STREBEL, H.; HASLER, A. (2007), pp. 364; cf. PICOT, A. et al. (2012), p. 269

Among the various stakeholders, greater importance in respect to the central unit is attached to the car manufacturers on the industrial side due to their market power, which they are apparently not willing to give up, along with their knowledge about the automotive market and its customers. On the other hand, politics also gets a central role, because it obviously takes over a certain control function by setting measures, i.e. incentives and penalties, while it also oversees the framework conditions, as for instance renewable energies. However, in regards to politics, the different levels, i.e. international, national, regional and local can be distinguished according to their priority tasks:[320]

- *International level:* regulations, network, standardization, etc.
- *National level:* framework and environmental conditions, funding, marketing, coordination, communication, etc.
- *National / regional / local level:* model regions, benefits for private and public fleets, taxis, commuters, communication, etc.

So, the central unit can be expected to take on the coordination and control, i.e. to take measures in order to stick to the plan, but if necessary also changing partial objectives in the interest of the superior objective.[321] Various working clusters, with a certain thematic focus, can be installed under this central unit, which can include several stakeholders and are further expected to elaborate upon specific solutions.

Ultimately, the aim is to facilitate the market penetration of E-Mobility by the formation of networks and co-operations, which are determined to enhance the diffusion of innovations in multiple ways.[322]

4.3.4 General Framework for Managing Barriers in E-Mobility

This last part of the theoretical modeling aims to conclude the previous considerations of the theoretical model; therefore, a general framework for managing barriers in E-Mobility is introduced covering the basic elements of the approach for a successful market entry of E-Mobility, as illustrated in Figure 4.19.

[320] See also BMVIT (2010), p. 38
[321] Cf. STREBEL, H.; HASLER, A. (2007), p. 351
[322] Cf. STREBEL, H.; HASLER, A. (2007), p. 374

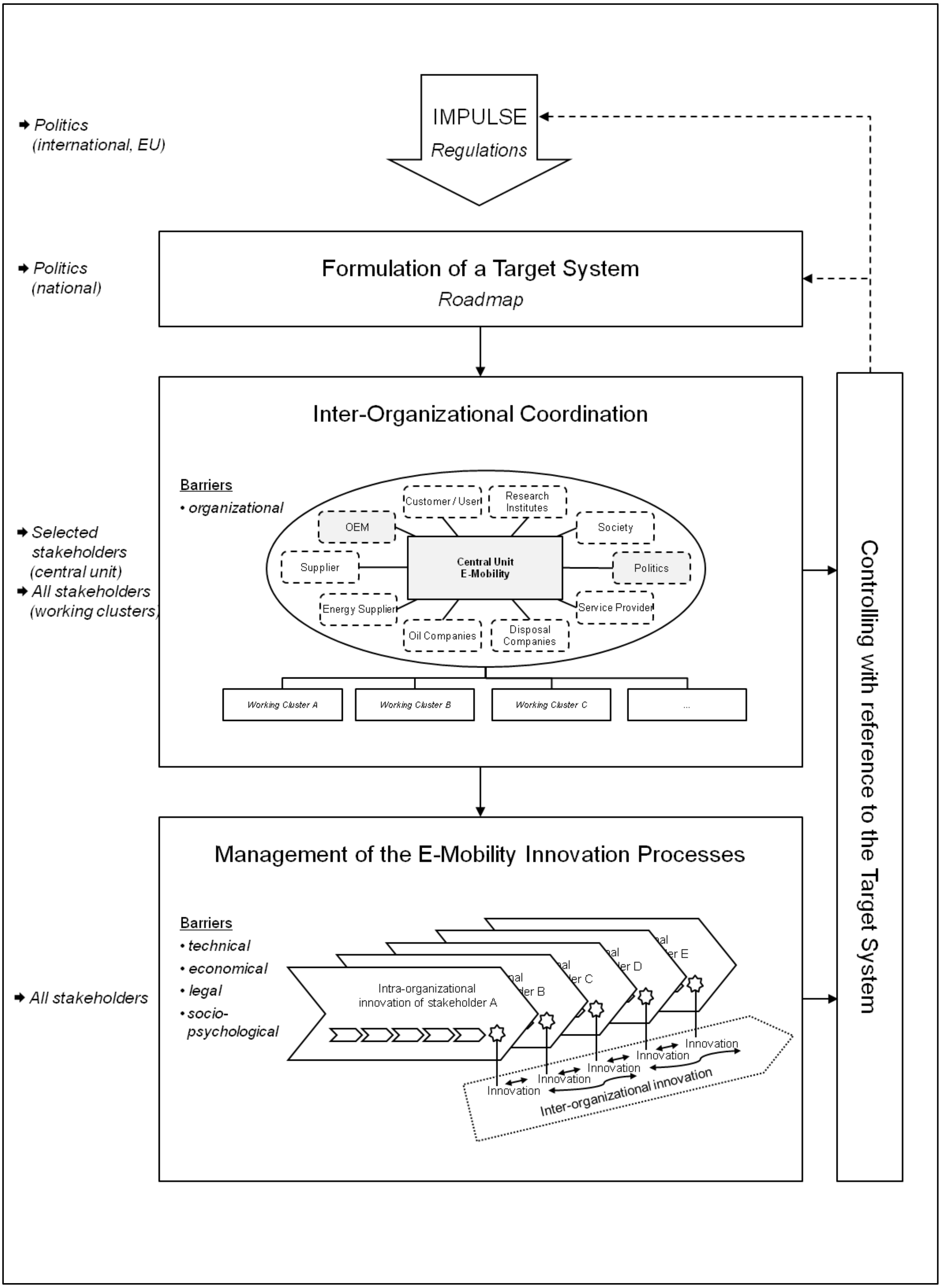

Figure 4.19: General framework for managing barriers in E-Mobility (author's illustration)

Thus, to push the market players towards the electrification of the powertrain, politics has to give an impetus on an international level by setting certain regulations concerning CO_2-emissions, such as the limit of 95 g CO_2/km for Europe in 2020.

Next, it is up to politics to transform those regulations on a national level into a specific target system and lay out a roadmap as well as specific milestones, considering and supporting certain fields of activities such as battery technology, standardization, charging infrastructure and renewable energy, etc.

Furthermore, selected stakeholders - in particular OEMs and politics, as they appear to be the most dominant ones – should take the initiative and build a central unit with the aim of bringing all the necessary stakeholders to a platform in order to coordinate the activities with respect to the target system. On that account, it appears to be advisable to install different working clusters in order to address the respective thematic areas. As to the formation of an inter-organizational coordination, it is primarily the barriers of organizational nature which arise.

An Austrian's answer to that question is “Austrian Mobile Power” founded by Magna, Verbund and Siemens. With the aim of pushing forward the market diffusion of E-Mobility, this open platform comprises various companies engaged in automotive engineering, system development and infrastructure.[323] Some of the partners are KTM, AVL, Fronius, Infineon, Wien Energie, Energie Steiermark, Linz AG, REWE Group, BEKO, ÖAMTC, Schrack, Austrian Institute of Technology, just to name a few, and of course Magna, Verbund and Siemens Österreich as founders.[324]

A German's approach known as the “National Platform for Electric Mobility” was initiated by the German government and consists of representatives of industry, science, politics, labor unions and of society, all organized into seven working groups such as drivetrain technology, battery technology, charging infrastructure and grid integration, standardization and certification, materials and recycling, training and skills and, lastly, the general framework.[325]

This inter-organizational coordination forms the basis for proceeding in a target-oriented way in line with the intra-organizational innovation process of each stakeholder, which is to be aimed at explicitly addressing the technical, economic, legislative and socio-psychological barriers discussed. At this point, the established inter-organizational coordination is of vital significance, as individual activities and partial innovations are

[323] Cf. AUSTRIAN MOBILE POWER (2011b), access date 10.05.2012
[324] Cf. AUSTRIAN MOBILE POWER (2011c), access date 06.09.2012
[325] Cf. BMU (2010), access date 10.05.2012

inadequate to ultimately meet the target system without being coordinated and complemented by contributions of other stakeholders.

The collective result of the intra-organizational innovation processes, and the outcome of the set activities, is ultimately supposed to constitute the inter-organizational innovation, i.e. the E-Mobility system innovation.

Beyond this, controlling with reference to the target system ensures not losing sight of the target ahead even during the formation of the inter-organizational coordination as well as during the E-Mobility innovation processes and to adapt certain actions if necessary. However, the controlling needs to be taken into account not only by the central unit, but also by any given stakeholder.

5 Empirical Evaluation

In the course of scientific research, the research design according to WOHINZ includes an empirical collection of relevant data alongside the theoretical model. In this respect, high relevance is attached to the empirical evaluation particularly as a supplement to the theoretical model, in order to verify the described model and/or the hypothesis.[326] Therefore, the following chapter contains the empirical evaluation of the theoretical model.

The aim of this empirical evaluation is to verify the considerations of the theoretical model as described in chapter 4, as well as to capture the different perspectives of the various stakeholders involved in the E-Mobility system innovation. On that account, qualitative expert interviews are conducted with representatives of the stakeholders.

5.1 Method of the Empirical Evaluation

In order to conduct an empirical evaluation two basic methods need to be distinguished, i.e. quantitative and qualitative methods.[327] Basically, quantitative methods are based on the interpretation of certain circumstances, which results in the description of those circumstances by means of numbers; in short, the characteristics or the frequency of a circumstance are displayed by numbers. In contrast, qualitative methods are based on the interpretation of circumstances, which results in a verbal description of those circumstances.[328]

Since both quantitative and qualitative methods have their advantages and disadvantages, the question of whether one is better than the other cannot be answered in general, but rather must be decided on a case-by-case basis.[329] Thus, the best suited method for an empirical evaluation depends chiefly on its subject and on the

[326] Cf. WOHINZ, J. W. et al. (2008), pp. 4
[327] Cf. WOHINZ, J. W. et al. (2008), p. 7; cf. GLÄSER, J.; LAUDEL, G. (2004), p. 24
[328] Cf. GLÄSER, J.; LAUDEL, G. (2004), p. 24
[329] Cf. WOHINZ, J. W. et al. (2008), p. 9

objectives of the research work.[330] Figure 5.1 illustrates the explanatory approaches and the employment of methods in empirical research.

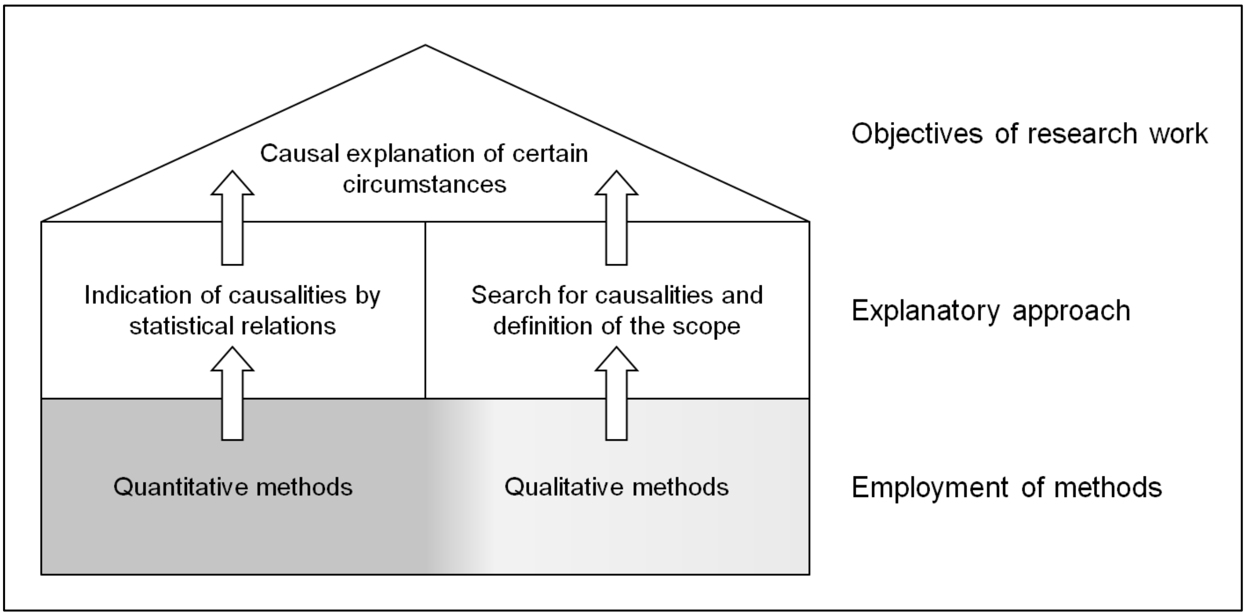

Figure 5.1: Explanatory approaches and employment of methods in empirical research[331]

In general, interviews can be classified according to the degree of standardization; standardized interviews are conducted in quantitative research, while non-standardized interviews are counted as a qualitative method:[332]

- *Standardized interviews:* predefined formulation and sequence of questions, predefined possible answers
- *Non-standardized interviews:* no predefined formulation or sequence of questions, no predefined possible answers, only predefined subject

However, the qualitative mode is to be preferred if it is difficult to make standardizations due to a high degree of abstraction and if research is conducted on complex causalities.[333] As the latter is the case in this thesis, qualitative methods are clearly most suitable and therefore the selected method is a non-standardized interview with a question guideline. That means, with a list of prepared questions, a certain circumstance is aimed at being elaborated upon in such a way, that neither the formulations nor the sequence of the question must be kept. By conducting the

330 Cf. GLÄSER, J.; LAUDEL, G. (2004), p. 24
331 Referring to GLÄSER, J.; LAUDEL, G. (2004), p. 26
332 Cf. GLÄSER, J.; LAUDEL, G. (2004), p. 39
333 Cf. WOHINZ, J. W. et al. (2008), p. 9

interview in the form of a natural conversation, it allows the interviewees to give further explanations to a specific circumstance if necessary.[334]

5.2 Results of the Expert Interviews

Before describing the content of the expert interviews, the sample of the interviewees is demonstrated. Finally, in the last part of this chapter the results are summed up.

5.2.1 Sample for the Expert Interviews

The sample for the empirical research consists of experts who are selected representatives of all stakeholders affected by E-Mobility, as illustrated in Figure 5.2.

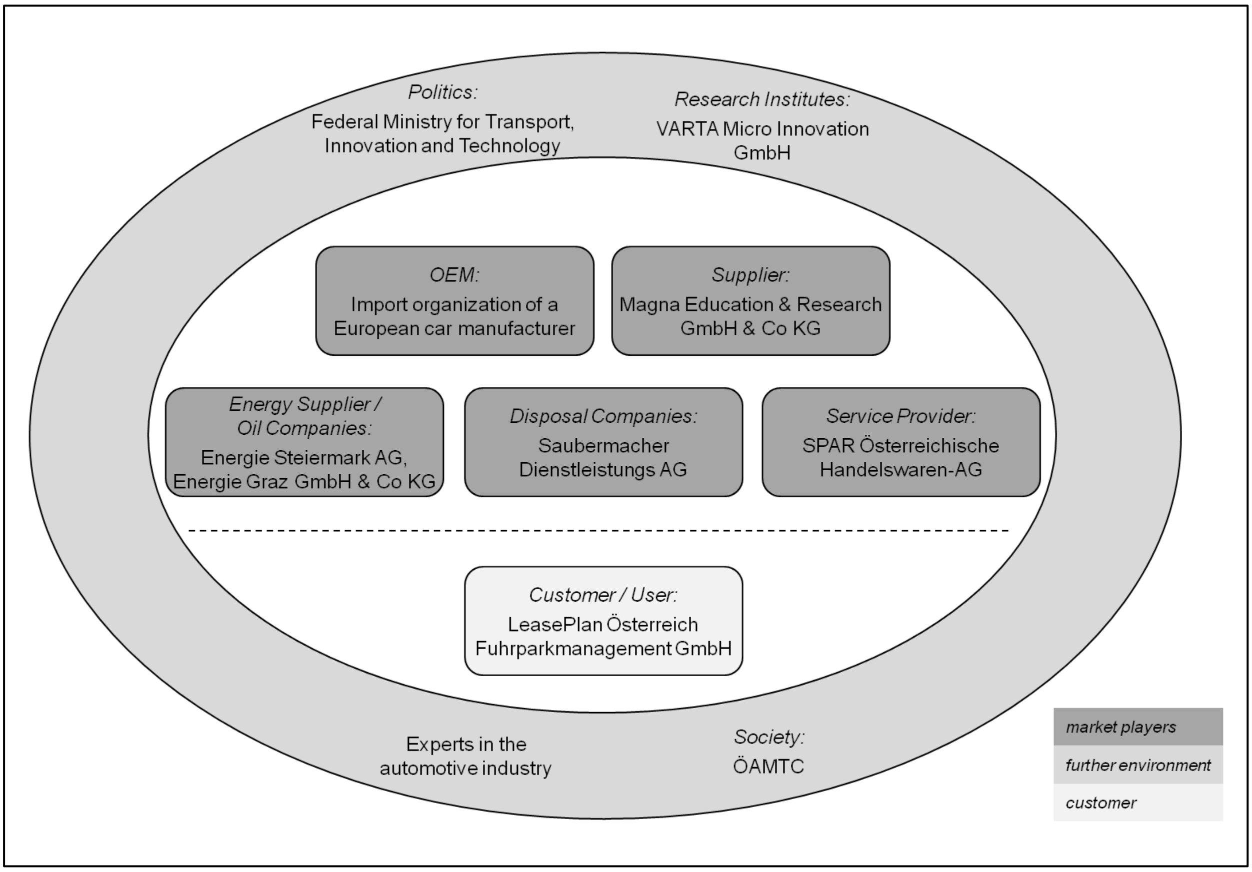

Figure 5.2: Selected representatives of stakeholders in E-Mobility for Austria 2012 (author's illustration)

[334] Cf. GLÄSER, J.; LAUDEL, G. (2004), pp. 39

The following paragraphs are aimed at introducing the respective representatives in order to explain why they were chosen for the empirical evaluation.

- *Experts in the automotive industry:* Prof. Dipl.-Ing. Dr. h.c. Jürgen Stockmar and Dipl.Kfm. Brigitte Kroll-Thaller have been active in most honorable functions in the automotive industry and are therefore highly valuable interview partners.
- *Customer / User:* LeasePlan Österreich Fuhrparkmanagement GmbH is the market leader and the biggest brand-independent company in Austria in the field of fleet management.[335] As LeasePlan works for different companies of all sizes, it represents the commercial customers' perspective on E-Mobility.
- *OEM:* The selected representative of the OEM is not mentioned by name for reasons of anonymity.
- *Supplier:* Magna Education & Research GmbH & Co KG is a subsidiary company of Magna International Europe AG. Magna is the most diversified automotive supplier worldwide and also very active in E-Mobility.[336]
- *Energy supplier / oil companies:* Energie Steiermark AG, a Styrian energy supplier, is the fourth largest energy company in Austria and very actively involved in E-Mobility.[337] Additionally, Energie Graz GmbH & Co KG represents the leading energy service provider in Graz.[338]
- *Disposal companies:* Saubermacher Dienstleistungs AG is one of the largest private waste disposal companies in Austria, and therefore represents the perspective of the disposal industry.[339]
- *Service provider:* SPAR Österreichische Warenhandels-AG is one of the biggest companies on the Austrian food retail market besides REWE[340] and HOFER[341], and, moreover, under full Austrian ownership. SPAR is actively engaged in E-Mobility with respect to sustainability as well as add-on services like charging options for its customers.[342]
- *Politics:* The Federal Ministry for Transport, Innovation and Technology, Austria, supports the developments of E-Mobility, and provides insight into the perspective of politics.[343]

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335 Cf. LeasePlan (2012), access date 31.08.2012
336 Cf. MAGNA (2012), access date 31.08.2012
337 Cf. ENERGIE STEIERMARK (2012), access date 31.08.2012
338 Cf. ENERGIE GRAZ (2012), access date 31.08.2012
339 Cf. SAUBERMACHER (2012), access date 03.09.2012
340 REWE (2012), access date 03.09.2012
341 HOFER (2012), access date 03.09.2012
342 Cf. SPAR (2012), access date 03.09.2012
343 Cf. BMVIT (2012), access date 04.09.2012

- *Society:* Among other Austrian automobile clubs such as ARBÖ[344] and the VCÖ[345], the ÖAMTC[346] also represents and supports road users. Moreover, the ÖAMTC is the club with the largest membership in Austria, and therefore represents the interests of the general public in terms of mobility.
- *Research institutes:* VARTA Micro Innovation GmbH is a partner of VARTA Microbattery GmbH[347] and the Graz University of Technology[348]. The company is active in the field of research on battery technology, particularly speedy charging, heat resistance and performance, and therefore gives insight into the perspective of research institutes.[349]

Table 5.1 shows the sample in more detail, including the function and the name of the interviewee in addition to the organization and the stakeholder category.

[344] ARBÖ (2012), access date 04.09.2012
[345] VCÖ (2012), access date 04.09.2012
[346] Cf. ÖAMTC (2012), access date 04.09.2012
[347] VARTA Microbattery (2012), access date 05.09.2012
[348] TU Graz (2012), access date 05.09.2012
[349] Cf. VARTA Micro Innovation (2012), access date 05.09.2012

Experts in the Automotive Industry	⇨ Prof. Dipl.-Ing. Dr. h.c. Jürgen Stockmar (Lecturer at Vienna University of Technology; Initiator of the Frank Stronach Institute at the Graz University of Technology; former Managing Director at Magna Education & Research GmbH; Executive Vice President of Magna International, AUDI NSU AG, Adam Opel AG and Steyr-Daimler-Puch AG, responsible for R&D and Technologies) ⇨ Dipl.Kfm. Brigitte Kroll-Thaller (Lecturer at Graz University of Technology and Vienna University of Technology; former Director of Marketing Services at General Motors Europe; Managing Director at General Motors Austria)
Customer / User	⇨ LeasePlan Österreich Fuhrparkmanagement GmbH: Dipl.-Ing. Renato Eggner (Prokurist, Operations Director)
OEM	⇨ 2 representatives of an import-organization of a European car manufacturer
Supplier	⇨ Magna Education & Research GmbH & Co KG: Dr. Markus Tomaschitz, MBA (Managing Director)
Energy Supplier / Oil Companies	⇨ Energie Steiermark AG: Dipl.-Ing. Mathias Schaffer (Head of innovations department, Power projects and technical innovations) ⇨ Energie Graz GmbH & Co KG: Dipl.-Ing. Dr. Stefan Altenhofer (Head of Sales)
Disposal Companies	⇨ Saubermacher Dienstleistungs AG: Univ.-Prof. DDr. Horst Pirker (Chief Executive Officer)
Service Provider	⇨ SPAR Österreichische Warenhandels-AG: Dipl.-Ing. Franz Hölzl (Head of Sustainability)
Politics	⇨ Federal Ministry for Transport, Innovation and Technology, Austria: Dipl.-Ing. Heimo Aichmaier (Coordinator E-Mobility, Office of the Secretary General)
Society	⇨ ÖAMTC: Mag. Christoph Mondl (Deputy Secretary General, CFO)
Research Institutes	⇨ VARTA Micro Innovation GmbH: Dipl.-Ing. Dr. Stefan Koller (Chief Executive Officer)

Table 5.1: Sample of experts for the empirical research

Altogether, the thirteen interviews are meant to capture the different perspectives and ultimately give an evaluation of the considerations in the theoretical model.

5.2.2 Expert Interviews

Initially, the guideline for the expert interviews is introduced. Further, the main statements of the interviews are described according to this sequence in the following paragraphs. In the end, the main results of the interviews are summarized.

Interview guideline

The guideline for conducting the interviews covers the following issues and questions:

0. Introduction
    a. Explanation of the aim of the dissertation and the empirical evaluation
    b. Explanation of the role of the interview for the empirical evaluation
    c. Offer for anonymity of the data and information if requested
    d. Consent for tape recording
    e. Offer of a summary of the results of all interviews
1. Stakeholder analysis
    a. Who are the relevant stakeholders in E-Mobility systems?
2. Identification of barriers
    a. What are the barriers for the market penetration of E-Mobility? (technical, economic, legislative, socio-psychological, organizational)
    b. Which of the barriers are of a low / high impact for the market penetration of E-Mobility?
3. Intra-organizational innovation
    a. Which of the barriers are relevant for the respective stakeholder, i.e. at which barrier can a stakeholder make a contribution?
    b. To which phases of an innovation process can those barriers mainly be assigned?
4. Inter-organizational innovation
    a. Who are the interacting stakeholders at each barrier and what are their main issues?
    b. As there is a strong need for an inter-organizational coordination in E-Mobility, how could it best be coordinated?
    c. Who could assume the inter-organizational coordination? Who should be the designated “Problem Owner”?
5. Framework for managing barriers in E-Mobility
    a. To sum up, which general steps must a framework consist of in order to manage barriers for a successful market launch of E-Mobility?

Expert interview with Prof. Dipl.-Ing. Dr. h.c. Jürgen Stockmar (26.04.2012, Vienna)

ad 1. Stakeholder analysis

a) At first, the interviewee mentions the car manufacturers, who definitely need (hybrid-) electric and smaller vehicles as part of their fleet in order to meet the regulations for CO_2-emissions in the future (130 g CO_2/km as of 2015, 95 g CO_2/km as of 2020). As to that, politics is an important stakeholder and also a driving force towards the electrification of the powertrain as they set up the regulations; moreover, politics can also create incentives such as start-up financing to push a new technology. In this regard, the respondent points out, that incentives distort the market and must be handled with caution, as supporting battery research is more decisive than the start-up financing would be, which is only reasonable to a limited extent. At any rate, research plays a crucial role and can make valuable contributions in various fields, i.e. battery technology as well as clever marketing and psychological aspects. Besides, the suppliers are also stakeholders, entering into completely new business segments such as electric motors, batteries, electronic control units, thermal management, etc. Further stakeholders are the energy suppliers, which identify new business fields due to the additional demand of electricity but also as mobility service providers. As to this, the OEMs are also engaged in providing mobility, as for instance MERCEDES with its concept “car2go”. It is often hoped that the customer is a stakeholder as well; however, their influence at this time is still insignificant as there are, as yet, very few.

ad 2. Identification of barriers

a) According to the respondent, the main barriers are price, range and lifetime, which can be all traced back to the battery. Neither the purchase price, nor the total cost of ownership are favorable for the electric vehicle, when the charging efficiency, the residual value, etc. are also taken into consideration. The technical barriers induce psychological barriers, such as “range anxiety”. However, the interviewee points out that there are various approaches which are promising, at first glance, but ultimately not well-conceived; for example, the installation of a public battery charging infrastructure to reduce range anxiety, however, the recharging takes hours and fast-charging reduces the battery’s lifetime; next, the reuse of old batteries as temporary energy storage in houses and also in wind- and solar power plants, whereas neither the failure rate of the cells nor the even high costs of electricity from renewable energies and the concomitant effects on the economy are considered. The responder declares that a well thought-out and holistic master plan is a critical requirement, which is, on the one hand, concerned with the big picture and on the other hand takes even the smallest detail into account. Additionally, the organization of E-Mobility should not be a barrier if the electric vehicle, in its current form, became an economic success. Ultimately, the interviewee emphasizes the winning driving characteristics and the enjoyment of an electric vehicle, and therefore the importance of testing opportunities.

b) According to the interviewee, range, lifetime and price have the highest impact, as well as a political master plan for E-Mobility. In addition, the number of charging spots, the recyclability, green electricity and noise emissions have a lower impact for the market penetration of electric vehicles. Referring to the recyclability, it is only relevant if it significantly influences the price, whereas the environmental aspects are currently not particularly important as the quantity is still very small. Ultimately, whether or not the electricity for the battery is generated from renewable energies does not represent a barrier for customers buying an electric vehicle, as most of them make their decisions based on price rather than the environment.

ad 3. Intra-organizational innovation

a) This question is skipped as the respondent does not represent any given stakeholder but merely gives an overview about E-Mobility system.

b) Price, range and lifetime of the battery correlate to research and development. Further, marketing includes image creation, testimonials as well as testing opportunities in order to increase the positive experiences by customers during the usage phase.

ad 4. Inter-organizational innovation

a) The price, range and lifetime can all be traced back to the battery, i.e. this is where investments are crucial and where research needs to be conducted. As a result, it is up to politics, which is supposed to set a certain focus and conditions for the allocation of funding, as well as battery manufacturers and suppliers, OEMs, university- and non-university research institutes to collaborate. If this barrier is overcome, it will also impact range anxiety, trialability, etc. Still, the energy supplier, the OEMs, the suppliers and again politics are required to make contributions in terms of model regions, pilot fleets, testimonials, etc. Lastly, the interviewee strongly emphasizes that politics is required to establish a well-conceived master plan and set up intelligent framework conditions for the market diffusion of E-Mobility, which ultimately represents the result of a roadmap for implementing a high share of renewable energies.

b) The responder declares the German's "National Platform for Electric Mobility" a purposeful approach, which would be required in Austria as well, in order to bring the different stakeholders together, introduce a master plan, coordinate the different activities and appropriately allocate research funding. At any rate, if there were already a promising business model for E-Mobility and the stakeholders had a serious vested interest, they would collaborate and urge it along as quickly as possible.

c) Politics is in charge of bringing the stakeholders together and arranging the coordination. The OEMs are interested in E-Mobility as, otherwise, they could not meet the CO_2-fleet emission limit. However, the manufacturing of electric vehicles subverts the investments made for conventional vehicles and also for combustion engines. Furthermore, the battery manufacturers have serious interest, alongside some other suppliers and energy suppliers. Even though there are some new co-operations that are planning to produce their own vehicles, the interviewee seriously doubts that the market power of the OEMs will be so easily undermined, as they have the most experience as well as an established and reliable network for after sales, service, marketing, etc.

ad 5. Framework for managing barriers in E-Mobility

a) The interviewee states that developing a reasonably priced battery, with a long lifetime, a large capacity, and a fast (dis-) charging speed should be the first activity. Next, it is crucial to establish a European master plan, targeted at the most intense efforts to increase the share of affordable renewable energy. On top of that, the respondent strongly emphasizes the importance of an intelligent coordination by politics.

Expert interview with Dipl.Kfm. Brigitte Kroll-Thaller (30.04.2012, Vienna)

ad 1. Stakeholder analysis

a) The interviewee names the relevant stakeholders in E-Mobility as, primarily, the automotive industry, including suppliers and research institutes, followed by politics and finally the customers, i.e. commercial and private. Secondly, energy suppliers and other service providers are also affected by E-Mobility.

ad 2. Identification of barriers

a) First, the charging time and loading capacity are mentioned as barriers, however, the respondent points out that range extenders and plug-in hybrids are possible solutions for coping with those issues. Additionally, the high costs of purchase and the residual value both constitute barriers. In order to enhance economies of scale for already existing solutions, framework conditions for implementing new technologies are a critical requirement, such as financial incentives, tax exemptions, use of bus-lanes, etc. for electric vehicles extended to plug-in hybrids and range extenders. Ultimately, the interviewee assesses the most promising concept to be that of the combination of an electric motor and a combustion engine, as it copes with the barrier that customers are not willing to lower their expectations in terms of mobility, reliability and cost-benefit ratio.

b) The respondent assessed the range and costs as the barriers with the highest impact for market penetration of E-Mobility, whereas other aspects, including the installation of an infrastructure and increasing the share of renewable energies in the energy mix are determined to be low impact.

ad 3. Intra-organizational innovation

a) This question is skipped as the interviewee does not represent any given stakeholder but merely offers an overview about E-Mobility system.

b) Alongside the regulations for CO_2-fleet emission limits, the definition of framework conditions for the implementation of E-Mobility is determined as the impulse. The development and improvement of technical solutions in terms of charging speed and loading capacity are allocated to the research and development phase. A further, very important phase is marketing which is designated to lobbying for funding guidelines, pricing, marketing concepts, etc.

ad 4. Inter-organizational innovation

a) In regards to the price situation, on one side technology and efficiency both need to be improved which affects the automotive industry, battery manufacturers and research institutes. In parallel, politics has to contribute in terms of framework conditions, i.e. model regions, tax exemptions, an extension of the definition of E-Mobility to hybrids up to an emission of 50 g CO_2/km and to plug-in hybrids and range extenders, electric vehicle fleets in semi-public organizations, role model function, restrictions on entry in urban areas, etc. This reduces the risk of investment for the automotive industry and, at the same time, enhances economies of scale. The respondent mentions that the first target group is commercial customers and thereafter private customers. Moreover, politics is also required to take measures for an increased share of renewable energies; however, the interviewee states that this is a parallel process.

b) The very first step is a strong and centrally defined vision determined by rigorous regulations and/or restrictions by politics. This induces decentralized approaches and solutions by industry and research in order to meet those regulations. The focus then has to be directed toward one of these possible solutions, for which legislative framework conditions, such as incentives, are set up in order to eventually roll them out in large quantities.

c) As mentioned above, it is up to politics to regulate the process of implementing E-Mobility.

ad 5. Framework for managing barriers in E-Mobility

a) See question 4b.

Expert interview with Dipl.-Ing. Renato Eggner / LeasePlan Österreich Fuhrparkmanagement GmbH (11.05.2012, Vienna)

ad 1. Stakeholder analysis

a) The most relevant stakeholders, according to the interviewee, are the car manufacturers, however, that does not refer only to the well-known manufacturers but also to new companies in the field such as Tesla. On the other hand, there is the customer, yet the responder mentions that it is more so commercial customers than private customers in the first few years. Further, the energy suppliers, together with electronic companies, are active in establishing an infrastructure for recharging batteries. Additionally, he indicates that model regions can also be considered as stakeholders in E-Mobility. Lastly, there are different kinds of service providers which aim to provide complementary products separate from the vehicle, such as a charging infrastructure, electricity, leasing models, etc. to eventually offer an all-in-one solution to the customer.

ad 2. Identification of barriers

a) The interviewee asserts that the first barrier is the high costs of purchase, mainly caused by the battery, moreover, that is why electric vehicles are not yet economically viable. Without any incentives, the total cost of ownership alone is higher than that of conventional vehicles. Therefore, financial support and incentives play a big role. Furthermore, the range limits caused by the loading capacity of the battery is determined to be a barrier. Next, the responder mentions the infrastructure, which might not be a major issue for private customers with their own garages, but is certainly an issue for the on-street parkers in urban areas, for whom E-Mobility is primarily promoted. Moreover, it is not clear how to pay for the substantial investments, particularly for public charging spots. At this point the interviewee notes, that – according to a commercial customer's experience – the total investment for the charging spots was as high as for the car itself, as they also had to consider trainings, etc. A further barrier arises due to risk and uncertainty, basically caused by the residual value and in particular by the battery. In this respect, on the one hand, great importance is attached to nonexistent uniform guarantees on batteries, plus, on the other hand, the current battery technology will most likely be outdated in five years due to development efforts. In contrast, electric vehicles would be principally well-suited for the second hand auto market due to the reduced costs of purchase and the, consequent, broader target group.

b) According to the interviewee, the two issues which are determined to have a high impact on the market penetration of E-Mobility are the costs of purchase and the limited range. The charging infrastructure is relegated in terms of its impact, however perhaps wrongly, because even though it is an issue, customers are not aware of the resultant costs and problems.

ad 3. Intra-organizational innovation

a) The contribution by the customer is basically limited to openness to new technology, which also refers to a certain curiosity about eventually taking the opportunity to test electric vehicles. In terms of properly using and charging the battery, the respondent states that this cannot be expected from the customer and has to be taken over by intelligent technical solutions.

b) In order to increase the understanding, openness and also enthusiasm of customers, it is crucial to co-operate more closely with customers, which comes into play in the marketing and usage phases. Therefore, great importance is attached to the creation of values, the development of a positive image plus, a role model function, which commercial customers can assume for other customers.

ad 4. Inter-organizational innovation

a) Referring to the costs of purchase, it is the OEMs that need to offer affordable vehicles, on the one hand, and to introduce uniform and the longest possible durations- and transparent definitions of battery guarantees, on the other, in order to reduce the risk and uncertainty for the customer. Another possibility for OEMs and certain service providers is to offer all-in-one solutions with a monthly rate, even including charging options. Moreover, the OEM and, particularly, the battery manufacturers and research institutes are concerned with increasing the range and therefore expend great efforts in enhancing battery technology while at the same time offering other solutions such as plug-in hybrids. Further, politics is asked to take certain measures, such as financial incentives, in an early phase to enhance the market diffusion. According to the interviewee, the installation of an infrastructure is primarily up to energy suppliers and electronic companies; however, as OEMs are part of the standardization institutes, they also have to contribute as far as standardized plugs are concerned and politics may incorporate the charging infrastructure in building regulations for multi-unit dwellings.

b) First, by attaching specific conditions for the allocation of incentives a certain control function is assigned to politics. Furthermore, the respondent states that global standards and norms in all aspects of E-Mobility would definitely be very helpful in increasing the efficiency of the investment costs; hence, the OEMs get a primary role.

c) The problem owners of E-Mobility are, according to the interviewee, the OEMs, who made heavy investments, the general public, as their governments made commitments to climate targets, and lastly the energy suppliers, who can develop new business models.

ad 5. Framework for managing barriers in E-Mobility

a) In the first instance, reliable framework conditions to increase the planning security of investments are absolutely crucial; thus, they need to be determined for a long enough period, such as 10 to 20 years. Second, different kinds of incentives need to be provided until the diffusion of E-Mobility reaches a critical mass and economies of scale are achieved. Last, in order to ease the usage, all-in-one solutions need to be offered to the customer, which include all aspects concerning the vehicles plus charging options.

Expert interview with a representative of an import-organization of a European car manufacturer (24.05.2012)

ad 1. Stakeholder analysis

a) First, the respondent mentions politics as a primary stakeholder due to the importance of setting certain framework conditions. As a consequence, the OEMs enhance the electrification of the powertrain in order to eventually reach the targets set in terms of CO_2-fleet emission limits; therefore, they can be considered as a primary stakeholder as well. In addition, environmental protection organizations also have a positive interest. Even though assessed as a secondary stakeholder, E-Mobility is relevant for energy suppliers as it implies further sales potential of electricity.

ad 2. Identification of barriers

a) According to the interviewee, a main barrier is caused by the infrastructure, which needs to be established in such a way, that customers can eventually benefit. This is particularly critical for urban areas where potential customers park on the street as well as for multi-unit dwellings, plus, the issue of how to pay for the investments is not defined. In general, the current price situation is a decisive factor, i.e. at least the total cost of ownership of a conventional vehicle and an electric vehicle should be approximately equivalent, which also depends on the price trend of gasoline and diesel. At this point, the respondent notes the contradiction that buying decisions are often based on emotions rather than on facts and figures. A further barrier to struggle against is, of course, the limited range due to the capacity of the batteries. However, according to the interviewee, the expectations for range and mobility, in general, will change over the next few generations.

b) For the very first customers the purchase price does not have the highest impact, as they consciously decide upon electric vehicles, however, with reference to the mass market, the price is definitely highly decisive. Additionally, the availability of an infrastructure has a very high impact, eventually followed by the range.

ad 3. Intra-organizational innovation

a) In order to bring electric vehicles onto the market faster and in larger quantities, the OEM has influence as far as the costs and range of the vehicle are concerned. All-in-one solutions which include charging possibilities are also relevant.

b) Along with the manufacturing costs of the battery, which mainly influence the high purchase price, the pricing of electric vehicles is also relevant for marketing and distribution, as it has to be determined with which quantities and at what prices to enter the market. Further, increasing the range is, in the first instance, an issue for R&D, however, when it comes to finding alternatives for customers with an infrequent need of a longer range, as for example for holidays, marketing and distribution are also affected.

ad 4. Inter-organizational innovation

a) Local authorities, communities and cities need to be concerned with setting up framework conditions for establishing an infrastructure, whereas the biggest challenge is not single-family houses with their own garage, but multi-unit dwellings in inner-city areas. Together with energy suppliers, who are concerned with the operative execution, it is crucial to find adequate solutions which can be implemented in a timely manner. However, who takes over the investments for the infrastructure needs to be defined. Further, the price situation can be improved by the OEMs mainly in terms of quantities which positively influence the costs per unit. At this point, the interviewee emphasizes that it has to be considered, as to what extent of sold vehicles financial supports are reasonable and affordable for the OEMs themselves as well as for politics. Moreover, the pricing, of course, involves the battery manufacturers who supply the product which represents the greatest cost driver - depending, for example, on the materials used, their cost development at higher demand, and the attractiveness of conditions at increased production capacities. Eventually, it is up to the OEMs and the battery manufacturers to advance the development of battery technology.

b) According to the interviewee, a certain co-ordination always implies criticism that something has been pushed and influenced by those who have a keen interest.

Instead, it seems more advantageous to first establish the market. However, the OEMs are concerned about their market shares and, therefore, have the responsibility to meet the customers' requirements and to provide all-in-one solutions for E-Mobility.

c) In the long term, everyone will be concerned about alternatives to conventional vehicles simply because of the limited availability of fossil fuels; however, as there is still no direct impact, many individuals do not notice. On the contrary, in a short-term perspective, it is politics that makes efforts towards E-Mobility by setting certain framework conditions and regulations. In addition to the regulations, the OEMs are also affected in the sense of a corporate responsibility to reconsider their products and their customers if at a particular time the fossil fuels are used up. According to the interviewee, the bottom line is that the OEMs and politics are interested in the electrification of the powertrain, even though politics is more optimistic compared to what technology can achieve in the end. In this respect, the interviewee points out, that the global manufacturing capacities cannot even provide enough batteries in order to meet the objectives for 2020.

ad 5. Framework for managing barriers in E-Mobility

a) The first impetus is EU regulations such as the CO_2-fleet emission limits for 2020. The most important thing is to come up with a system solution, which also includes all necessary complementary products such as charging possibilities, etc. and not only partial innovations as the electric vehicle itself. Aside from that, the respondent points out, in some cases certain developments proceed very fast and adds that fuel used to be sold in pharmacies in the past.

Expert interview with a representative of an import-organization of a European car manufacturer (09.05.2012)

ad 1. Stakeholder analysis

a) The customer is the first one mentioned as a relevant stakeholder in E-Mobility, on the one hand, and on the other the OEMs with their suppliers, along with associations of the automotive industry, such as ACEA, JAMA, VDA and KAMA. Additionally, E-Mobility also involves legislation on a national and international level. Furthermore, the electricity producers and grid operators are affected in terms of energy supply. Next, as the recycling and the reuse of the battery is an important issue, the disposal companies are also relevant as stakeholders; however, this affects the OEMs as well due to the economic problem of the residual value as well as the regulatory obligation of taking back end-of-life vehicles. Likewise, companies that are engaged in establishing a charging infrastructure and financial service providers who offer financing models can also be considered as stakeholders in E-Mobility.

ad 2. Identification of barriers

a) A major barrier relates to standards and norms, as they are crucial for any economically viable industrial production. Therefore, standards and norms are in place to avoid unsound investments and provide the basis for serial production. Moreover, production on an industrial scale is also a necessary requirement in order to offer attractive prices, which represent a further barrier. As to this, the interviewee points out, that the current costs of purchase are not representative due to financial support by politics and by the OEMs themselves. Expanded to the total cost of ownership, the respondent states that, as regards energy costs, the calculations are predominantly based on the standard consumption of 15-20 kWh and on electricity costs of 0.20 €/kWh, without considering any variations in prices e.g. at public charging spots, not to mention the loss of load between the grid and the battery of approximately 20 %. Besides, the guarantee duration for batteries is currently aimed at five to eight years, resulting in the fact that the battery needs to be replaced at least once during an average lifetime of a vehicle of 16 years. As a result, the investments exceed the expected savings and the total cost of ownership of an electric vehicle is still not competitive at the moment. As a further barrier, the interviewee notes the public infrastructure, i.e. the customer does not know where to charge the battery other than in his/her own garage, which intensifies the range anxiety. Moreover, the potential customers may read about E-Mobility in newspapers, but do not see it in every-day life, which is determined to be a barrier as well. However, there are already installed model regions which are aimed at bringing it mainstream. There is also the importance of an image creation of electric vehicles. From an organizational perspective, platforms such as the Austrian Mobile Power seem to be advantageous, which mainly involves the supplier industry and the energy suppliers. Also the current legislative conditions, e.g. the tax benefits, are advantageous for the market launch of electric vehicles. However, there is a further critical issue; a distribution network needs to be established which requires an infrastructure and that falls to after-sales and service. Therefore, employees need to be trained in sales and in service. In the end, the interviewee refers to the fact, that the current range of models represents the small car segment rather than the medium-class cars, which is maybe also a barrier for convincing potential customers.

b) As barriers with a high impact for the market penetration of electric vehicles the respondent cites norms and standards, the total cost of ownership, the public infrastructure plus the range anxiety, the observability and trialability of electric vehicles and their image. Besides, the legislative aspects such as tax benefits, as well as organizational barriers, the distribution network, the service field, and, in the end, the range of models do have an impact; however, the interviewee determines it to be lower in comparison to those previously mentioned.

ad 3. Intra-organizational innovation

a) With regard to standards and norms, the OEMs can indirectly contribute by their representation in automotive associations; meaning, they have to encourage decisions to establish standards and norms in a timely manner. Further, the OEMs are able to influence the costs of purchase by production on an industrial scale and by placing the electric vehicles on certain markets with particularly favorable conditions such as buying incentives and environmental restrictions. With respect to the distribution network, it is also up to the OEM to define standards for showrooms, service and after sales. In terms of range anxiety, observability and image creation, the electric vehicles need to be placed in showrooms, the salespersons need to be trained, further, it is crucial to demonstrate how easily and safely the batteries can be recharged, and home charging spots need to be optionally offered. In the end, all-in-one solutions with a monthly rate covering the vehicle, the battery, a charging option, the energy costs, etc. gain importance. Another way for the OEM to increase both trialability and observability is to test pre-series vehicles in pilot fleets.

b) Standards and norms are allocated to the R&D phase. Further, the total cost of ownership extends over the whole process chain, whereas the manufacturing costs are determined by R&D, sourcing and production, while the marketing phase is concerned with range anxiety, image, observability and trialability, i.e. model regions and pilot fleets. However, the latter also affects R&D because it provides valuable information in technical terms as well as in regards to customer requirements. The distribution network is obviously allocated to the distribution phase. As discussed earlier, the service phase is relevant in terms of after sales and lastly, the reuse or recycling of the battery is allocated to the disposal phase.

ad 4. Inter-organizational innovation

a) As mentioned above, it is up to the OEMs, the automotive associations and international standardization institutes to enhance standards and norms. At this point legislation is also required to set up certain framework conditions. Referring to the costs of purchase, it is as explained above up to the OEMs and their suppliers to offer attractive prices, however, incentives by politics can also be supportive. Additionally, financial service providers need to develop new financing models. Furthermore, as to the battery costs, the industry exerts pressure on politics in order to ensure the security of resources needed for the batteries, because a volatile price situation of the raw materials influences the costs of the battery and, therefore, of the electric vehicle. In this respect, the EU has already set up strategy programs. As regards the charging infrastructure, the OEM offers the installation of home charging spots at the customer's residence, in co-operation with specific service providers and energy suppliers. In terms of image creation, observability and trialability, the public authorities would need to address the topic. The respondent also mentions driving schools which can familiarize student drivers with alternative drive technologies, alongside the energy suppliers who can promote green mobility and respectively green electricity.

b) Norms and standardizations are mainly driven by the OEMs, but also by politics and energy suppliers, who provide the basis for an international coordination. Further, on a national level it is up to politics to define objectives and framework conditions, to derive measures, to involve all stakeholders and to build working groups in order to implement specific activities. In the end, the interviewee points out, that coordination is crucial; however, it needs to be aimed at being more efficient.

c) The respondent determines politics to be the problem owner of E-Mobility, as they define the framework conditions, i.e. objectives and penalties, such as restrictions for CO_2-emissions in order to achieve the climate objectives.

ad 5. Framework for managing barriers in E-Mobility

a) As explained in the prior questions, the respondent determines frameworks as being critical for successfully bringing electric vehicles onto the market, politics needs to first set up framework conditions; norms and standards can then be established, and, in the end, the best concept prevails in the market. In addition, the interviewee expects plug-in hybrids and range extenders to be the predominant technology compared to pure electric vehicles in the short- and medium-term perspective.

Expert interview with Dr. Markus Tomaschitz / Magna Education & Research GmbH & Co OG (19.04.2012, Graz)

ad 1. Stakeholder analysis

a) The OEMs are mentioned as relevant stakeholders in E-Mobility in addition to other companies active in the field of electricity such as SIEMENS, BOSCH and GENERAL ELECTRIC. Further, the supplier industry and energy suppliers can also be considered stakeholders. Moreover, the importance of universities and research institutes must not be underestimated according to the interviewee. Customers do not, as yet, exert any pressure; unfortunately, it is more the media which hypes E-Mobility and creates certain expectations.

ad 2. Identification of barriers

a) First, the respondent points out the technical barriers which refer to the battery, particularly to the loading capacity and the loading speed. Next, another barrier is caused by the lack of a charging infrastructure for electric vehicles; however, this issue could be overcome faster and easier than others. According to the interviewee, a very important barrier relates to the customer, as the current models of electric vehicles are comparatively expensive, the design is less appealing, and – most important – neither the understanding, the meaning, i.e. for what reason, nor the value of E-Mobility has been communicated to the customer in an appropriate way. In short, there must be more arguments than just the “green conscience” in order to create a customer benefit. Consequently, customers do not understand why they should invest more money. In addition, there is no adequate reward system or incentives by public authorities, such as, for instance, no toll for electric vehicles, etc., with the aim of changing user behavior. Another point brought out is a financial barrier on the company-side due to the fact that in Europe and the USA companies tried to go it alone in battery technology and vehicle competence in general, whereas Japan, for example, initiated co-operations with universities, suppliers and OEMs at a very early stage. As a result, the financial resources are ending earlier than expected, while in addition, the hype caused expectations that were unrealizable.

b) With regards to its impact on market penetration of electric vehicles, the respondent determines the barrier of first priority to be the increase of customer benefit, which refers to communication, gaining information about its needs, demand-sided incentives and the financial barrier, because a higher customer benefit positively influences the willingness to pay more. The technical barriers are assessed to be second priority, followed by the entering of co-operations. The interviewee deems infrastructure to be the last priority regarding its impact.

ad 3. Intra-organizational innovation

a) The interviewee asserts that suppliers can also make a contribution by gathering customer information, in order to better understand their needs, information which can then be passed on to the OEM. The technical barriers are clearly relevant for the supplier, as great efforts are made to be the first in terms of battery technology, safety, drive train, etc. Additionally, the suppliers can confirm their willingness to enter into co-operations; however, it is up to the OEMs to decide with whom they collaborate in the end.

b) The technical barriers and feasibility are clearly in the purview of R&D, but it also refers to financial barriers as huge efforts are required. Therefore, great importance is attached to co-operations in the R&D phase, because that is where there is the most money to win or lose. Furthermore, the customer benefit, communication, pricing strategy and development of new usage models are assigned to the marketing phase, whereas the latter also pertains to the usage phase.

ad 4. Inter-organizational innovation

a) The interviewee emphasizes, that co-operations are crucial between universities as well as non-university research institutes, which are responsible for bridging the gap between basic research and contract research; further the supplier industry, including conventional suppliers as well as electronic companies, and OEMs, who, in the end, offer the product to the customer. Furthermore, those strategic alliances are aimed at targeting and concentrating financial resources for the intense R&D efforts. Secondly, the OEMs, together with suppliers and media, should collaborate in terms of communication, information and demonstration of benefit to the customer. According to the respondent, a charging infrastructure is the energy suppliers' concern. Moreover, the interviewee stresses the power of the OEMs, the supply industry, the lobbyists and the oil companies in regards to steering legislation in the right direction.

b) Even though co-operations are crucial according to the respondent, they are not entered into by choice. Every company aims at having unique characteristics and a monopoly position; therefore, co-operations only emerge if the benefits outweigh the costs. In many countries there are E-Mobility coordinators who encourage the stakeholders to collaborate. However, the basic characteristic of a market economy is the freedom of contract, so any company can decide, by itself, with which company to enter into co-operation; still, public authorities could create associated financial incentives in order to enhance co-operations. In closing, the responder declares that the market itself is a central control element, because if there is a demand, the companies will supply.

c) As the OEMs decide with whom to co-operate, the interviewee determines that they take the role of the initiator. When all is said and done, it is the OEM who knows the business best as regards their market, customers and, lest we forget, the OEM has an appropriate after sales infrastructure.

ad 5. Framework for managing barriers in E-Mobility

a) The responder stresses that great importance must be attached to the demand pull and, therefore, to communication of the customer benefit, as it is not going to be enough to offer a product to the customer without explaining why to buy it. Nearly simultaneously appropriate co-operations must be established, and on that basis all further activities can be implemented.

Expert interview with Dipl.-Ing. Mathias Schaffer / Energie Steiermark AG (07.05.2012, Graz)

ad 1. Stakeholder analysis

a) The interviewee believes that both customers and users, the OEMs, the automotive trade and mobility service providers, energy suppliers and oil companies, legislation and, lastly, research institutes are all E-Mobility stakeholders.

ad 2. Identification of barriers

a) A critical barrier, according to the interviewee, is socio-psychological barriers which come from the customers' fear of change, range anxiety and the status or image of electric vehicles. Besides, the respondent points out that customers also consider the high purchase price as a barrier. Furthermore, the discussion about the reasonability of E-Mobility due to the reputed insufficient proportion of renewable energy is assessed as a potential barrier by the interviewee. Another barrier relates to the infrastructure in the public sector, as there are currently no attractive business models and no customers to ensure a return of the necessary investments. In closing, the interviewee declares that OEMs underestimate the trend towards E-Mobility and are thinking somewhat linearly while disregarding radical innovation.

b) The barrier of customers' fear of change, i.e. the change in behavior, alongside the discussions encouraged by oil companies which promote the idea that the proportion of renewable energies is not high enough and therefore doubt the reasonability of E-Mobility are, according to the interviewee, of high importance, while all other mentioned barriers are of a lower impact for the market launch of E-Mobility.

ad 3. Intra-organizational innovation

a) Energy suppliers can contribute by using their own company fleets to be role models, which, at the same time, provides testing opportunities for employees. Consequently, communication and explanatory work, as regards the fear of change, range anxiety and image is also an issue for energy suppliers. Furthermore, the interviewee emphasizes that the energy suppliers aim at expanding the proportion of renewable energies in the energy mix. Although this is a long-term process, due to the high investments of the power plants and the long pay-back periods, the interviewee defines the current energy situation in Austria as advantageous and unproblematic in regards to green electricity. Moreover, the offer of mobility service, in order to provide alternative usage models for customers, is relevant for energy suppliers. At this point, the respondent points out the importance of packages combining the vehicle and electricity from renewable energy sources. In terms of charging infrastructure, there is already a market for energy suppliers to install charging spots for private customers, however, as mentioned above, there is, unfortunately, no business model for the public sector. The interviewee emphasizes that co-operations are crucial in regards to E-Mobility and that the energy suppliers should also increase their collaboration with other stakeholders.

b) Aside for the sale of energy, the respondent states that the role of the energy suppliers and, therefore, the share of the value chain in the future is still unclear because there are various opportunities, such as providing mobility services and even selling vehicles. However, the current distribution of energy and the necessary infrastructure correlate with the usage phase of the electric vehicle. Lastly, possibilities for the reuse or a second life of the battery in wind or solar power plants are relevant for R&D, if at all.

ad 4. Inter-organizational innovation

a) The interviewee states that with respect to the fear of change and a change in behavior all stakeholders have to collaborate in order to work out a master plan, however, politics should take the lead. As regards renewable energies, legislators are asked to set up specific objectives and regulations in order to urge the energy suppliers and oil companies to make green electricity a reality; however, it is also up to the customer, who can decide to demand it, whereupon the energy suppliers and oil companies will also increase the proportion of renewable energies. In order to overcome the infrastructural barrier, regulatory authorities would need to set up framework conditions and incentives for grid operators in order to make them invest and finally install an appropriate public infrastructure. Lastly, as to co-operations, OEMs, research institutes, energy suppliers as well as other stakeholders should all enhance their collaboration efforts in order to achieve a common goal.

b) The positive influence of a coordinator is generally doubted by the interviewee. Still, he points to the principle of thinking globally, i.e. legislative regulations, frameworks, incentives, while acting locally, which involves all stakeholders making contributions in a market economy.

c) The interviewee is of the opinion that legislation has the responsibility and is in charge of controlling and coordinating the specific activities in E-Mobility.

ad 5. Framework for managing barriers in E-Mobility

a) A framework for a successful market launch of E-Mobility consists, according to the interviewee, in the first instance of legislative regulations, secondly of national roadmaps and third of actions by all stakeholders. However, the interviewee emphasizes that the third step is the biggest challenge and states, that in order to cope with it, legislation must be even more radical.

Expert interview with Dipl.-Ing. Dr. Stefan Altenhofer / GmbH & Co KG (04.06.2012, Graz)

ad 1. Stakeholder analysis

a) According to the interviewee, the interest groups affected by E-Mobility are, in the first instance, the OEMs, the energy suppliers, public transport services and mobility service provider, but also the telecommunications sector, financial service providers and lastly public authorities. The customers are also stakeholders, even though they are not actively but rather passively involved in E-Mobility.

ad 2. Identification of barriers

a) A very important barrier arises due to a supply-sided economic cause, as there is no player that regards E-Mobility as a promising, future business field. All stakeholders are concerned with E-Mobility; however, no one knows exactly where to go. Actually, it is the OEMs who should mainly drive E-Mobility forward as they account for the greatest part of the value chain; however, in the end, it substitutes their core business. As a consequence, it is the absence of a supply-sided driver with a massive economic interest which is a main barrier. This is far more important than the purchase price of the electric vehicle itself, as customers often base their buying decisions on emotions rather than on facts. Another important barrier on the customer-side is, according to the respondent, caused by the uncertainty about the residual value, as on the one hand, it is unsure whether there is going to be a future market and on the other hand, today’s technology will be outdated and therefore without value. In addition, the interviewee mentions further barriers such as the lack of a public charging infrastructure as there is neither an investor nor a customer, no standardized plug-system, the battery technology in terms of capacity and lifetime and legislative financial incentives serving as an impetus.

b) The absence of an attractive business model and, therefore, of a main driver, as well as the critical issue relating to the residual value are assessed as main barriers with the highest impact for the market penetration of E-Mobility. The further barriers, such as charging infrastructure, standardized plug-system, battery technology and incentives are of a lower impact compared to the first mentioned barriers.

ad 3. Intra-organizational innovation

a) The respondent asserts that the installation of a public and private infrastructure is relevant for the energy suppliers, which, furthermore, also implies the establishing of an attractive business model. Additionally, the energy suppliers can also make a valuable contribution in terms of image creation. As to this, the interviewee points out a certain discrepancy between what is expected by society and/or politics and what is technically feasible, particularly with regards to model regions, which exclusively support pure electric vehicles and do not take plug-in hybrids or any other modification into account. In the end, it is up to the energy suppliers to increase the share of renewable energies in the energy mix in order to provide green electricity for electric vehicles.

b) The energy suppliers are less concerned with the technological development of a charging infrastructure, than they probably are in the connection between infrastructure and telecommunication and apart from this, their activities relate to the installation of the infrastructure. The image creation is relevant for the marketing phase and the efforts towards renewable energies extend over the whole value chain.

ad 4. Inter-organizational innovation

a) In regards to the establishment of a business model, the interviewee declares that it is primarily up to the automotive industry to be more committed. As to this, the battery suppliers also take on an important role as a certain level, in terms of range, is definitely required; however, the same convenience that conventional cars boast is unlikely to be achieved as, even with a range three times higher, the recharging will definitely take longer. Moreover, the public transport services could make a real contribution to the establishment of business models, as there already are short-term possibilities for combining public transport and E-Mobility. With regards to the uncertainty of the residual value, the OEMs and financial service providers could minimize the risk by offering financing models such as leasing of the battery, a standardized duration of guarantee, etc. As mentioned above, the charging infrastructure, in terms of installation, is relevant for energy suppliers, together with electronic companies engaged in the technological development as well as regulatory authorities which are supposed to set up framework conditions. Furthermore, standards and norms also come under the bailiwick of politics; however, it is crucial that the OEMs also exert pressure on the standardization institutes. Advancing battery technology is basically up to battery suppliers in co-operation with OEMs and research institutes. As previously mentioned, the generation of green electricity correlates to the energy suppliers; while in this case, it is again politics that is in charge of specifying a clear framework.

b) The respondent doubts the expediency of an enforced coordination of processes, and declares that it would be much more effective if there were a driver with vested interests. Still, the current initiatives aimed at coordinating the different stakeholders and activities are assessed as positive by the interviewee.

c) The particular stakeholder with vested interests in E-Mobility would also be best in coordinating the necessary activities for complementary products. The interviewee assesses the OEMs as the main driver, as the lion's share of the value chain falls to them.

ad 5. Framework for managing barriers in E-Mobility

a) As an impulse and process accelerator, serious financial incentives could be helpful in order to set things in motion; however, the conditions should be more flexible and not just focus on pure electric vehicles but, rather, include plug-in hybrids as well. The interviewee then goes on to emphasize the importance of a player on the supply-side with greater interest who drives and coordinates the further process.

Expert interview with Univ.-Prof. DDr. Horst Pirker / Saubermacher Dienstleistungs AG (05.06.2012, Graz)

ad 1. Stakeholder analysis

a) In the first instance, customers, i.e. anybody with a mobility need, as well as society, represented by politics and/or non-governmental organizations (NGOs) are the relevant stakeholders in E-Mobility systems. Further stakeholders are the suppliers and their business environment that want to provide E-Mobility, including new potential suppliers, but also the conventional OEMs, battery suppliers, and companies engaged in the handling of hazardous goods such as disposal companies. According to the interviewee, competitors as the oil industry and manufacturers of combustion engines can be considered stakeholders. Public transport services and the energy industry are also involved in E-Mobility. The interviewee points out that behind the stakeholders mentioned there are additional companies involved as business partners and/or suppliers.

ad 2. Identification of barriers

a) The current price situation is defined as a barrier by the interviewee, along with limited range, charging time, weight and size of the battery, the absence of a charging infrastructure and adequate billing systems. An additional issue is pointed out by the respondent concerning the handling of hazardous goods such as the battery, particularly in cases of service and emergency. The sound generation of electric vehicles is also assessed as a barrier, as people are afraid they might not hear an approaching vehicle. Lastly, the interviewee mentions the multi-dimensional involvement of politics, i.e. the interest in environmental issues and the weight of the mineral oil tax for public sector financing. Consequently, the question arises as to how to compensate for this lack of revenues. In general, funding should be focused on supply-sided research in order to develop marketable solutions and increase competitiveness, rather than on customer-sided incentives which eliminate the market forces.

b) The interviewee cites price, range and the charging times as barriers with high impact. In addition, billing systems and a charging infrastructure is indispensable; however, it can be solved more easily. The same goes for the handling of hazardous goods, which is of course an issue that needs to be elaborated upon thoroughly and in earnest, though it is not an insuperable barrier and therefore of lower impact. Moreover, the mineral oil tax is of lower impact as it is also resolvable as is the issue of sound generation.

ad 3. Intra-organizational innovation

a) The disposal companies can make great contributions in terms of the handling of hazardous goods such as the battery, which includes the dismantling of its components and then the recycling in reasonable material cycles, but also, as mentioned above, as regards safety in cases of service and emergency.

b) The current involvement in the handling of the battery as a hazardous good corresponds to the R&D phase. The interviewee points out that there are already ongoing projects; however, there is still no market at the moment.

ad 4. Inter-organizational innovation

a) The interviewee states that economies of scale and R&D, in terms of improving efficiency, would be most powerful in reducing the price while R&D of the battery technology itself would have a lower impact. Consequently, the drivers for OEMs could probably be the strategic advantage in being the first mover, have an outstanding market position and therefore forego margins at the very beginning. Legislative incentives could also increase economies of scale. Furthermore, the battery suppliers - driven by the OEMs - are in charge of improving battery technology. The charging infrastructure and billing systems are the purview of energy suppliers, on the one hand, and the oil industry as gas station operators on the other, as there is already an infrastructure including shops, etc. and in addition, they probably get more attractive purchase prices for electricity than private households due to the huge volumes they buy. In terms of the handling of hazardous goods, the disposal companies are involved, which have the experience and also the required authorizations, plus the OEMs; however, the interviewee mentions that their involvement is still in an early stage, as their priority is to bring the vehicles onto the market. Moreover, different suppliers are also involved in that issue. Further, the sound generation concerns, in the first instance, the customers who enjoy it, secondly it is relevant in terms of safety and the noise protection plays an important role. Therefore, the OEMs are involved, together with politics, who are expected to set up certain standards. Lastly, the mineral oil tax is an issue for politics and consideration must be given as to what is affordable as well as how and where to compensate for a certain lack of revenues.

b) In general, state interventions are skeptically received by the interviewee, however, in some cases they can be reasonable in supporting processes and developments which do not proceed fast enough by themselves. As a regulator, incentives addressing the root, i.e. R&D for advancing powerful technological development and restrictions addressing the periphery, i.e. exhaust emissions, are useful and reasonable. However, the key issue for successful market diffusion remains the technological development according to the respondent.

c) The interviewee points out that it is not entirely clear whether the problem owner of E-Mobility is the automotive industry or politics; however, an essential role is attached to global warming and its consequences caused by emissions such as CO_2 partly due to vehicular traffic. As a result, world politics has determined to set up restrictions. The automotive industry has to meet these requirements which, moreover, imply an additional market potential. The market, with the OEMs as dominant players, has a certain self-regulation force, which is not enough to attain an overall optimum and therefore requires an associated legislation.

ad 5. Framework for managing barriers in E-Mobility

a) The interviewee declares E-Mobility - in combination with green electricity - as one possible answer for reducing CO_2-emissions in traffic and thereby addressing the global warming issue. As a consequence, it is a preferable and necessary circumstance. However, there are also stakeholders with negative interests and therefore a certain intervention is required. This intervention serves as an impetus and contains incentives and penalties along with regulations. Furthermore, the competition within the market proceeds, whereas an associated legislation is advisable as mentioned above.

Expert interview with Dipl.-Ing. Franz Hölzl / SPAR Österreichische Warenhandels-AG (16.05.2012, Salzburg)

ad 1. Stakeholder analysis

a) The most important stakeholders are, according to the interviewee, the customers, who need to be convinced that E-Mobility is a substantial advance. Additionally, car manufacturers and car dealers, car park operators as alternative to gas stations for conventional vehicles, automobile clubs, energy suppliers and politics, in particular in the initial phase, play a major role as stakeholders in E-Mobility.

ad 2. Identification of barriers

a) Most importantly, the concept of E-Mobility requires a new understanding of mobility in general, as it does not entail more liberty for individual mobility as, for example, the mobile phone did. In addition, the costs of purchase, the total cost of ownership and the limited range are also relevant. Another aspect concerns the public discussions about the reasonability of E-Mobility, as there are still doubts with respect to the requirements of additional electricity and raw materials for the battery. At any rate, the interviewee states that there are alternatives for electricity generation of electric vehicles, which is not the case for conventional vehicles. Increasing the share of renewable energies is a decisive issue for E-Mobility.

b) The new understanding of mobility correlates with the limited range and is defined, by the interviewee, as a barrier with a high impact, likewise the public discussions about green electricity and raw materials, and the increased share of renewable energies is also assessed as highly relevant.

ad 3. Intra-organizational innovation

a) The respondent emphasizes that shopping centers and trade in general always has to take reachability and transport connections into consideration. They aim to ensure that customers with electric vehicles also have the additional possibility of recharging their battery while shopping, and therefore they are engaged in installing charging spots. However, the interviewee points out that they are not concerned with billing systems or additional sales potential, and therefore enter into co-operations with energy suppliers. Secondly, the respondent states that they also make contributions in terms of communication and a new understanding of mobility. As to that, they also have electric vehicles in their own fleet, on the one hand, in order to gain experience as a customer – just in case legislators sets up stronger restrictions in urban areas with respect to emissions and noise – and, on the other hand, to act as a role model.

b) The reachability for customers with electric vehicles and the add-on service of charging spots is relevant in the usage phase; however, it also concerns representing an individual company as innovative and sustainable and therefore also involves marketing. Additionally, the creation of a new understanding of mobility correlates with marketing, the same as being a customer itself and acting as a role model.

ad 4. Inter-organizational innovation

a) As regards the new understanding of mobility it would be up to politics, specifically up to traffic and urban planning, alongside car manufacturers, even though the respondent questions their actual commitment. Considering the vehicle itself, i.e. the costs and the range, it is the car manufacturers and their suppliers that are required to provide adequate solutions. As to this, maybe politics can make a contribution by means of start-up financing but only in the short-term. The reasonability and the public discussion about increasing acceptance is a topic for politics, but also includes automobile clubs and OEMs. Lastly, the engagement in green electricity refers, initially, to politics as they have to set up specific conditions and then to energy suppliers.

b) With respect to the coordination, car manufacturing is the core business of the OEMs, and therefore the interviewee notes that they are probably not willing to give up their core competence. As a result, OEMs play the most central role on the industrial side and coordinate all required activities, according to the respondent. Additionally, great importance is attached to politics, which sets up the framework, i.e. regulations, incentives and penalties. As to this, the interviewee declares that the power of the electors is not to be underestimated, so if it fails to create an understanding for E-Mobility in society, it is questionable how politics will react.

c) As mentioned above, the interviewee sees the OEMs and politics as playing central roles in terms of coordination.

ad 5. Framework for managing barriers in E-Mobility

a) The EU regulation for CO_2-emissions is considered a crucial starting point according to the respondent. In further consequence, national politics and traffic planning, in particular, is required to be concerned with integrating E-Mobility in daily-life, as it will not completely substitute the convenience of conventional cars. At the same time, great efforts need to be made to communicate both the new understanding of mobility and the reasonability of E-Mobility to the customer. Eventually, the competition on the market will effect an affordable concepts.

Expert interview with Dipl.-Ing. Heimo Aichmaier / Federal Ministry for Transport, Innovation and Technology, Austria (21.05.2012, Vienna)

ad 1. Stakeholder analysis

a) As stakeholders of E-Mobility the interviewee first mentions universities which conduct basic research as well as big industrial players, i.e. the OEMs and the supplier, plus non-university research institutes in the automotive sector. However, also small and medium-sized businesses or start-ups are involved by providing new concepts in different fields. Up next, the demand of electricity affects the energy suppliers, which are currently figuring out a possible business model. Another stakeholder is of course politics and administration. Eventually, the recycling and disposal industry is definitely relevant according to the interviewee, even though at the moment rather for R&D as the specific quantity is yet very small.

ad 2. Identification of barriers

a) As an important barrier, the interviewee emphasizes an adequate range of models, which should meet the mobility need in terms of range, lifetime of the battery and charging times, as well as equipment level, number of seats, trunk size and finally image, prestige and status. Additionally, the respondent points out that in regard to corporate fleets - including a private use for a monthly fee - it is difficult for employees to decide in favor of an electric vehicle from the current available model range as, with the same budget, they get cars of higher classes. As a result, the fleet managers need to handle the image problem plus the risk of the residual value. Second, an intelligent, clear and transparent incentive system is crucial in coping with the disadvantages.

b) The range of models which is offered to the customer is assessed as high impact by the interviewee. Moreover, the intelligent incentive system is of secondary importance. However, the interviewee points out that the very challenge in E-Mobility is that there are many fields of activities and it is never an either-or decision, as all aspects have to be considered to achieve a change in the system.

ad 3. Intra-organizational innovation

a) The interviewee stresses the importance of clear and transparent framework conditions. As to this, politics can communicate a vision and administration needs to develop an intelligent incentive system. Further, measures need to be taken which promote innovations in order to make the market more attractive and promote economies of scales. A further field of action is to create platforms in order to enhance communication and coordination between federal and regional politics. However, the respondent mentions that the measures to be taken must be considered carefully in order to conform with the law, particularly with the competition law in the EU, and not to distort the market. Another consideration is what is affordable up to which quantity of electric vehicles and how to compensate for the lack of revenues as well as the expenses. At this point, the interviewee shows, as an example, the use of bus lanes as a privilege for electric vehicles and questions why individual mobility should hinder public transportation, as this measure would be contra productive compared to traffic management which aims at increasing the attractiveness of public transportation. Another measure is, for instance, an adaption of the building regulation in order to facilitate a charging infrastructure in multi-unit dwellings. With regards to bringing as many vehicles as possible to the market, clearly incentives, to the extent possible, are the best way to go; however, this constitutes setting precedents and consideration must be given to how to abolish such measures at a later date and how much displeasure that would create.

b) The research funding which promotes basic research up to demonstration is an impetus for the developments towards E-Mobility. However, the smallest and/or small-scale series as well as the gap between R&D and the market cannot be supported by public funds due to the competition law. Nevertheless, it is possible to assign incentives for the purchase of specific vehicle categories which meet certain conditions such as eco-friendliness.

ad 4. Inter-organizational innovation

a) In terms of model range, the car manufacturers, together with the supplier industry and research institutes, are in charge of developing and offering customized products. Additionally, other parties such as trade, car park operators and real estate developers of multi-unit dwellings can make valuable contributions by offering recharging possibilities as an add-on service. As mentioned above, the intelligent incentive system is left up to federal and regional politics as well as administration.

b) According to the interviewee, communication is most crucial for the inter-organizational coordination. The more the different stakeholders from different branches communicate, the better their interaction is, i.e. to be aware of their actual requirements and expectations in order to fulfill them. Moreover, this detection is important for knowing which framework conditions need to be adapted, where need for action is and with whom to enter into co-operation. As to this, platforms such as Austrian Mobile Power make a significant contribution in creating an understanding for other branches and facilitating communication and co-operations.

c) First, the respondent points out, that E-Mobility is not a problem but rather more of a chance or even a solution. At any rate, due to the emissions and the consumption of resources in traffic the problem owner is the government, particularly the ministers for environment, transport, and economy, required to ensure the needed energy supply while still protecting the environment. Therefore, E-Mobility is considered one solution among other alternatives and is clearly an increase of efficiency over conventional vehicles. Furthermore, federal politics and administration can enhance the communication and interaction, but other political levels such as regional politics and even the EU alongside the key industry players can also make a valuable contribution. In fact, E-Mobility should be relevant for society in general as a sociopolitical necessity i.e. being careful and responsible in dealing with resources, as well as creating new markets and know-how. The interviewee declares that it is not about central coordination but about inter-organizational co-operation as regards E-Mobility.

ad 5. Framework for managing barriers in E-Mobility

a) To start with, a strong and clear vision is crucial, followed by an analysis about resources and strengths within a country. Target measures need to be set up and consequently implemented within a timely manner. As to this, politics and administration, as well as the industry, are required to make contributions in order to reach the common goal.

Expert interview with Mag. Christoph Mondl / ÖAMTC (22.05.2012, Vienna)

ad 1. Stakeholder analysis

a) The interviewee first mentions battery manufacturers as relevant stakeholders, researchers in the field of battery technology and car manufacturers followed by energy suppliers and oil companies. The ministers of finance have also been named as indirect stakeholders, as they will need to compensate for the mineral oil tax. The customer does not become a stakeholder until the electric vehicle is ready for the mass market in terms of security and usability, which is, according to the interviewee, not the case at the moment.

ad 2. Identification of barriers

a) In respect to barriers, the interviewee points out that there has been a communication error, as E-Mobility has been pushed to euphorically, which created the impression that there is much about nothing. Secondly, things have not been cleared up for the clients sufficiently in the sense of “KISS – keep it simple, stupid!”. A further barrier concerns all aspects regarding battery recharging, i.e. the uncertainty about where and how to charge. Therefore, the lack of a charging infrastructure and the uncertainty about the quick-charging mode are mentioned as barriers to the market penetration of electric vehicles. In the matter of uncertainty, there is also a lack of transparency for the customer regarding the diversity of different technologies such as the pure electric vehicle, the plug-in hybrid, range extender, full hybrid, mild hybrid, fuel cell, etc. which causes a barrier. Next, the purchase price and the range of models are cited as barriers followed by the battery, particularly the range limits. Lastly, the safety issue is highly relevant for the service field, emergency assistance, and in the end for the customer.

b) The respondent assesses the explanatory work as highly decisive, which refers back to the trialability and role model function as well. Moreover, the battery and the costs of purchase also have a high impact for the market penetration of electric vehicles. In addition, all issues concerning the charging infrastructure are medium important, while the range of models offered and service represent a low impact.

ad 3. Intra-organizational innovation

a) Referring to the question of whether the customer can make any contribution to ease the path for a new technology, the interviewee disagrees and is of the opinion that the customer is basically market-driven. However, the ÖAMTC, as an automobile club, can make valuable contributions in terms of explanatory work and communication, i.e. what technologies are available, where and how to charge, and eventually in dealing with the electric vehicle and its usability. Basically, they test things out in order to gain experience and pass on simplified information with the aim of reducing complexity and increasing transparency for the customer. Next, possibilities for testing can be installed, e.g. at ÖAMTC training centers or exhibitions, to increase the trialability. Further, the ÖAMTC has a certain role model function as they integrate electric vehicles into their own vehicle fleet. However, the interviewee emphasizes that they cannot solve the technical and economic barriers.

b) The contribution of automobile clubs is restricted to marketing support, therefore, the issues cited such as explanatory work and communication, their role model function and the trialability at training centers and exhibitions can be assigned primarily to the marketing phase of the E-Mobility innovation process correlating with the usage of the electric vehicle.

ad 4. Inter-organizational innovation

a) In respect of the explanatory work and communication, the interviewee sees - alongside the OEMs - representatives of society and customers, such as the ÖAMTC, as mainly in charge of increasing transparency and reducing complexity, and emphasizes the importance of not raising false expectations which eventually cannot be kept. Further, energy suppliers need to be concerned about the charging infrastructure in order to increase transparency and availability of charging spots and to ease handling. Next, the European Union and federal governments can offer financial incentives to reduce the costs of purchase for an electric vehicle in order to facilitate market entry, while OEMs and battery suppliers are responsible for reducing the manufacturing costs. However, the question arises as to what extent politics wants to intervene in bringing an uneconomical product onto the market further distorting competition; plus, politics will need to compensate for the financial incentives. At this point, the aim of reducing dependency on fossil fuels plays an important role according to the interviewee. Further, the respondent emphasizes the importance of a uniform and standardized guarantee duration for batteries. As regards the battery, i.e. loading capacity, charging cycles and lifetime, it is up to the OEMs and the battery suppliers to make significant efforts in R&D. Moreover, the OEM is asked to increase the range of models in order to address more customers. Lastly, the interviewee states that it is also the OEM who is basically involved in service issues, hence in education and training for service and emergency assistance.

b) According to the respondent, the coordination of the stakeholders in E-Mobility is a difficult issue, as there are diverse market interests. It is stressed, that various OEMs and battery manufacturers are clearly not going to co-operate with each other, as they do not want to share their knowledge and expertise with their competitors. However, co-operations are entered into by each respective OEM with its suppliers.

c) In the interviewee's opinion, the problem owner of E-Mobility is the automotive industry, i.e. primarily the OEM, who is in charge of developing new solutions together with its suppliers and research, and therefore represents the main driving force. All other stakeholders will follow automatically if there is enough demand. Pointing at what is actually behind the hype of E-Mobility, the interviewee does not believe that environmental protection is explanatory enough and demonstrates this with some statements: first of all, only a small portion of the CO_2-emissions is even caused by humans; moreover, the emissions caused by passenger cars only represent a truly small portion compared to international shipping; further, the calculations of the reduced CO_2-emissions with an electric vehicle compared to a conventional one have to be based on the respective national energy mix; and in the end, the manufacturing of batteries also requires electricity. Hence, the actual strategic benefit derives from the reduction of the dependence on fossil fuels.

ad 5. Framework for managing barriers in E-Mobility

a) In order to reach mass market, the industry needs to offer an electric vehicle which is easy to handle and does not cause disadvantages compared to the conventional vehicle. As long as this is not the case in the short- and medium-term, E-Mobility requires a new usage of mobility which includes car sharing, multi-modal concepts, etc.

However, political regulations enforced by financial penalties are just not going to be sufficient. Good prospects can be ascribed to the plug-in hybrids and range extenders in the short- and medium-term perspective.

Expert interview with Dipl.-Ing. Dr. Stefan Koller / VARTA Micro Innovation GmbH (21.05.2012, Graz)

ad 1. Stakeholder analysis

a) As relevant stakeholders in E-Mobility, the interviewee cites the OEMs, alongside the obvious, the battery manufacturers, particularly those which have been active on the lithium ion battery market, such as Panasonic and Sanyo, etc. Further stakeholders are research institutes; however, the respondent mentions that there has hardly been any battery research conducted at European universities and the establishment of educational institutions aimed at improving and extending the know-how is rather time-consuming. Further, the energy suppliers are involved in E-Mobility in terms of additional sales potential. In the case of vehicle to grid, the respondent points out that the charging cycles are limited within a battery's lifetime and it is questionable as to whether customers are approving of their batteries being used as temporary storage for electricity. In spite of this, it is worth taking a closer look at used traction batteries as energy storage in their second life. Another stakeholder is the disposal industry for battery recycling and disposal; however, the interviewee states that in addition to lithium great importance is attached to other materials such as copper, aluminum and cobalt, nickel, manganese and also rare earths, which are mainly found in Asia, South America and Africa. So, just like with fossil fuels, dependencies also arise from the battery; however, the major difference is that the resources are not consumed as fossil fuels are but can be made available in a country by recycling them.

ad 2. Identification of barriers

a) The most important barrier is, according to the interviewee, economically caused as the use of batteries as energy storage in vehicles is not competitively viable. Correlating to this barrier, the respondent mentions the limited loading capacity and lifetime of the battery. Upon this, a further barrier arises due to restricted customer acceptance. If the range anxiety could be taken away, if an image could be created, thereby creating a decisive advantage within a certain price category, customer acceptance would be much higher and consequently, there would be more potential customers. As to the image creation, the automotive industry has expended great effort over time in order to establish the car as a status symbol, and this trend can hardly be reversed overnight. In terms of legislative barriers, the interviewee points out regulations and restrictions as well as financial incentives for research.

b) The interviewee assesses the range and the lifetime of the battery as well as the economic viability as barriers with the highest impact, while the other mentioned barriers have a lower impact on the market penetration of E-Mobility.

ad 3. Intra-organizational innovation

a) The respondent stresses the importance of the connection between research institutes engaged in basic research and battery manufacturers with a focus on production, as many problems at implementation can be solved even before they occur. As a result, the interviewee mentions that the company serves as a development partner and knowledge carrier for the automotive industry in regards to increasing the range and the lifetime of the battery, and additionally, they are also engaged in the development of new technologies. In the end, improved battery technology and more effective production have an impact on the costs.

b) According to the interviewee, their engagement corresponds to the R&D phase and also the production phase, as regards the implementation in serial production.

ad 4. Inter-organizational innovation

a) The involved stakeholders for the development of battery technology and the price situation are the legal policymakers, university and non-university institutes, the automotive industry and battery manufacturers. Incentives and support by politics need to be set with a special focus, particularly on batteries and their integration into the vehicle, in order to enable universities to conduct research; however, it is not easy to recruit qualified personal, as in industry there are only a few experts who do not want to share their know-how with other organizations, and in addition, industry has a different financial background from universities. Even so, the aim is to enter into co-operations in order to cope with the financial situation. Interestingly, the car manufacturers, who know the customers best and have the financial means, already collaborate with battery manufacturers for a know-how exchange with the focus on adapting the tried and tested system to usage in the vehicle rather than developing a new battery. As regards the latter, it would be up to university research to get involved. Further, referring to customer assistance, incentives for purchase and regulations such as environmental zones in urban areas would be adequate measures which need to be set up by politics.

b) There are different ways to coordinate the activities; however, the main players have to agree on one. It is conceivable, that a platform which involves the important stakeholders is well suited to enhance communication and the exchange of information.

c) According to the interviewee, OEMs and politics have to take over a certain coordination task, as universities and small to medium-sized companies just do not have the necessary power to be drivers for E-Mobility. The respondent mentions that a certain importance is also attached to the energy suppliers which are involved in terms of additional electricity demand generated by renewable energies. Further, OEMs are a problem owner of E-Mobility as the electrification of the powertrain was considered a possible way out of the crisis. However, today there is no longer any crisis and making electric vehicles a market success is not as easy as expected. The battery and its integration into the vehicle accounts for approximately one third of the added value, and OEMs obviously do not want to lose this share while battery manufacturers and their suppliers clearly have great interest. Society, in general, is also a problem owner of E-Mobility because it desires individual mobility. Increasing the efficiency of conventional vehicles is a possibility to retard the run out of fossil fuels; however, in the long term the technology has to be replaced by an alternative which does not depend on fossil fuels. As to this, the interviewee points out that the European policy is already active in those issues.

ad 5. Framework for managing barriers in E-Mobility

a) The very first and most important step is to develop a technologically reasonable product, which is, in the end, marketable without any incentives. Secondly, marketing, but also incentives and regulations make a valuable contribution in bringing this product successfully on the market. The interviewee stresses that incentives are only reasonable at the initial phase to stimulate the market. The respondent assesses plug-in hybrids and range extenders most likely as marketable products within the next few years.

5.2.3 Conclusion of the expert interviews

In order to provide an overview of the empirical evaluation, the main statements of the interviews are summarized in Table 5.2, Table 5.3 and Table 5.4.

1. Stakeholder analysis	*a) Who are the relevant stakeholders in E-Mobility systems?* • Most commonly mentioned: OEMs, energy industry, politics and administration • Sometimes mentioned: customer, supplier and battery manufacturers, service providers in different fields (mobility, financial service, charging infrastructure, public transport), research institutes • Occasionally mentioned: oil companies, disposal companies, environmental organizations, NGOs, media, automobile clubs, society

Table 5.2: Main results of the expert interviews of question 1

2. Identification of barriers	*a) What are the barriers for the market penetration of E-Mobility?* • Most commonly mentioned: costs of purchase, residual value, battery technology, charging infrastructure • Sometimes mentioned: TCO, incentives, explanatory work and dealing with range anxiety (coping with long-established routines) • Further barriers only occasionally mentioned *b) Which of the barriers are of a low / high impact for the market penetration of E-Mobility?* • Most commonly assessed as higher impact: battery technology, costs of purchase, residual value, TCO, customer benefit, fear of change, no attractive business model, public discussion about the reasonability of E-Mobility, holistic master plan • Most commonly assessed as lower impact: charging infrastructure, green electricity, service and safety, incentives, distribution network, linear thinking of OEMs, noise generation • Divergent: range of models, explanatory work and dealing with range anxiety, image and role models, testing possibilities, standards and norms, coordination and co-operation
3. Intra-organizational innovation	*a) Which of the barriers are relevant for the respective stakeholder, i.e. at which barrier can a stakeholder make a contribution?* *b) To which phases of an innovation process can those barriers be mainly assigned?* • Customer: basically market driven, contribution limited to openness for a new technology; close co-operation to the customer during marketing and usage phase • Representatives of society: explanatory work, communication, testing possibilities, role model; contributions limited to marketing support • OEM: standards and norms, costs and pricing, battery technology, all-in-one solutions, distribution network, service, range anxiety, image, trialability; R&D, sourcing, production, marketing, distribution, service, disposal • Supplier: battery technology, drive train, safety, gaining information about customers' needs; R&D, marketing, usage phase • Energy supplier: role model, testing opportunities, explanatory work, image, green energy, mobility service, charging infrastructure, co-operation; R&D, marketing, usage phase • Disposal companies: handling of hazardous goods, safety, service; current involvement limited to R&D • Representative of a service provider: charging infrastructure, communication, testing, role model; marketing, usage phase • Politics: master plan, framework conditions, communication, coordination, incentives; impetus, marketing support • Representative of research institutes: battery technology, basic research and connection to production, costs; R&D, production

Table 5.3: Main results of the expert interviews of question 2-3

4. Inter-organizational innovation	*a) Who are the interacting stakeholders at each barrier and what are their main issues?* • Most barriers affect various stakeholders *b) As there is a strong need for an inter-organizational coordination in E-Mobility, how could it best be coordinated?* • A market-based coordination is most commonly favored • A hierarchical principal is highly doubted • Assessed as dominant players: politics, OEMs *c) Who could assume the inter-organizational coordination? Who should be the designated problem owner?* • Most commonly mentioned: politics, OEM • Occasionally mentioned: energy suppliers, society in general, key industry player, battery manufacturer
5. Framework for managing barriers in E-Mobility	*a) To sum it up, of which general steps must a framework for managing barriers for a successful market launch of E-Mobility consist of?* • Most common statements: strong and clear vision, European master plan, reliable and transparent framework conditions • Various other occasionally mentioned statements

Table 5.4: Main results of the expert interviews of question 4-5

The thirteen expert interviews represent different perspectives from the various stakeholders. The automotive industry including OEMs and suppliers, the energy industry, trade with add-on services for E-Mobility, further service providers, for example for mobility and financial concepts, representatives of society such as automobile clubs and the disposal industry are brought together on the E-Mobility platform in order to develop and offer an all-in-one solution which is more favorable for the customer than conventional vehicles are.

It is highly interesting to debate and discuss the individual positions which coincide in some cases, but on the other side diverge at times and consequently point out certain discrepancies. Therefore, in the following chapter the results of the empirical evaluation are discussed in more detail and are compared with theory in order to answer the research questions.

6 Discussion and Implications

This chapter aims at incorporating the theoretical considerations with the results of the expert interviews in order to answer and discuss the research questions. Thereupon, implications for management practice, on the one hand, and on the other hand for further research are deduced.

6.1 Discussion and Answers to the Research Questions

In the following paragraphs, the theoretical and empirical findings are discussed according to the sequence of the research questions.

Research Question 1: How can the E-Mobility system be defined?

The E-Mobility system can be defined by its stakeholders, which are described in the following paragraphs.

- ⇨ Who are the relevant stakeholders?
- ⇨ What part do they play in regards to E-Mobility?

According to theory, the following stakeholders can be identified, which are then further classified into three categories, i.e. customers, market players and further environment. This research question is also discussed in Chapter 2.2.

- Customer / User
- Market players:
    - OEM
    - Supplier
    - Energy supplier
    - Oil companies
    - Disposal companies
    - Service Provider

- Further environment:
  - Politics
  - Society
  - Research Institutes

The empirical findings confirmed the aforementioned stakeholders, whereas some of them can clearly be considered as more relevant than others. Figure 6.1 depicts a stakeholder map of E-Mobility in accordance with the relevance of the mentioned stakeholders.

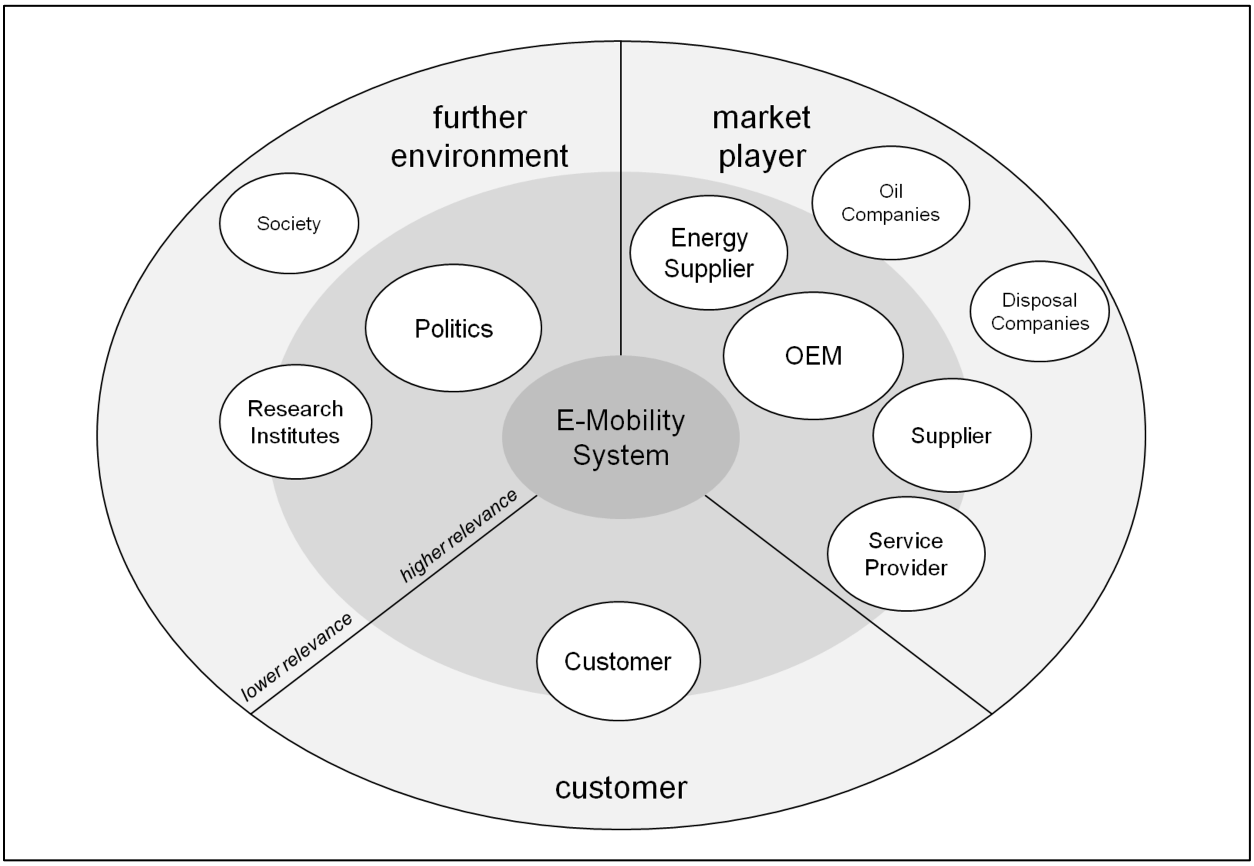

Figure 6.1: Stakeholder map of E-Mobility systems due to empirical findings (author's illustration)

The automotive industry including car manufacturers, suppliers and also battery manufacturers is defined as very relevant. OEMs, in particular, are mentioned most often, as, first of all, car manufacturing is their core business, plus they have the most customer experience, market power and a well and long established network for service, sales, marketing, etc. Also, new players as well as small to medium-sized companies and start ups in this field are noted; however, more so for providing innovative concepts than for producing and selling vehicles to the customer. As to this, certain concerns are expressed as to whether the power and the standing of OEMs are undermined so easily. Moreover, associations of the automotive industry are determined as particularly relevant for standardization and norms.

The energy industry is definitely confirmed as a relevant stakeholder, particularly the energy suppliers and grid operators. Moreover, it is understood that the power of the oil companies is not to underestimate, as they hold seats in most supervisory boards of the OEMs.

A certain importance is attached to various service providers in the fields of mobility service, financial service, charging infrastructure and public transport.

Within the category of market players, disposal companies are declared as stakeholders least often, even though both recycling and the handling of hazardous goods are determined to be a crucial issue. However, they come into effect in the back end of the value chain.

Considering the further environment, politics and administration clearly play a crucial role, followed by research institutes. As to the latter, the contribution by universities in basic research and by non-university institutes in applied research is determined as very necessary and decisive especially in regards to battery technology. However, it is also pointed out that there has hardly been any battery research conducted at European universities. Alongside, certain representatives of society such as NGOs, environmental protection organizations, media and automobile clubs are confirmed, however, just by very few interviewees.

Ultimately, the discussion about the customer is particularly interesting. The opinions as to whether or not the customer can be referred to as a stakeholder vary, as its influence and involvement is determined as passive and yet insignificant. At any rate, it is pointed out that a distinction needs to be made between private and commercial customers.

Research Question 2: What barriers to innovation, with regards to E-Mobility, can be identified?

- ⇨ How can the barriers to innovation be explored?
- ⇨ How can the barriers to innovation be categorized?

The exploration of the barriers to innovation is based on the theoretical model of the diffusion of innovation by ROGERS. This model relates to the theory of user acceptance of new technologies, which aims at explaining why some succeed on the market and others do not. Moreover, different barriers are deduced which are further allocated to classifications according to WOHINZ/MOOR into technical, economic, legislative, socio-psychological and organizational causes. Chapter 4.2 covers those considerations.

The identified barriers are backed up by the empirical evaluation. The results confirm certain barriers, while others are less often- and in one exceptional case not even mentioned at all. In addition, some further crucial issues are pointed out.

- Commonly confirmed barriers:
  - Costs of purchase / residual value
  - Loading capacity, loading speed, lifetime of the battery
  - Charging infrastructure
- Partially confirmed barriers:
  - Total cost of ownership
  - Penalties / incentives supply-sided
  - Penalties / incentives demand-sided
  - Routines
- Rarely confirmed barriers:
  - Range of models
  - Image, testimonials
  - Testing, evaluation
- Very rarely confirmed barriers:
  - Driving pleasure
  - Emissions, fossil fuels
  - Safety, service
  - Coordination of activities
- Unconfirmed barriers:
  - Customer assistance

The additional issues include the missing standards and norms for higher effectiveness and reduced risk of investments, the customer benefit which actually correlates to the price, the range and even the image, non-established distribution networks, the linear thinking of OEMs, the negligence of radical innovations, the noise generation, the fear of change, the public discussion about the reasonability of E-Mobility, that there is no attractive business model and no stakeholder with a serious economic interest, and in the end, the nonexistent holistic and well-conceived master plan and intelligent framework conditions.

Moreover, some highly interesting remarks to the mentioned barriers are made by the interviewees.

ad total cost of ownership: If being precise, the total cost of ownership would need to include the investment costs for the charging spots. Even referring to public infrastructure, the costs will be invoiced to the customer in some way as they are not paid back through the electricity sales. Yet, the increasing gasoline prices have to be considered as well. Furthermore, there is a high uncertainty about the residual value, as the battery technology will probably be outdated in just a few years and, additionally, there are no uniform battery guarantees.

ad public infrastructure: In contrast to home charging spots – as mentioned previously - there are no direct customers for a public infrastructure who would pay for the investment costs. Therefore, the installation of a public infrastructure is not yet economically viable for grid operators and energy suppliers.

ad supply and demand-sided incentives: Incentives for research and development are approved by most interviewees, as they have a long-term effect in terms of technology and national competitiveness. In contrast, demand-sided incentives lose their impact as soon as they are stopped. Moreover, politics will need to compensate the additional expenses and the lack of revenues in the long term. It is emphasized that a demand-sided funding is only reasonable as a short-term start-up financing to push a new technology.

ad driving pleasure: Driving pleasure is not assessed as a barrier but rather as an advantage of electric vehicles due to its performance curve and the high starting torque.

ad emissions, fossil fuels: Even though pure electric vehicles do not have any tank-to-wheel emissions, the well-to-tank emissions nonetheless depend on the source of energy for electricity generation. However, according to many interviewees, the customers are not expected to consider the aspect of green electricity or dependency on fossil fuels during the purchase of a car. Even though it may be relevant for some early adopters or from a theoretical point of view, it is not determined as a barrier for the end customer. In addition, it is also mentioned that the share of renewable energies is increasing, and that Austria compares favorably to other countries. Moreover, the discussions about the reasonability of substituting the dependency on fossil fuels with the dependency on raw materials for the battery are commented in so far as the big difference is that the resources for batteries can be made available in a country by recycling them, while fossil fuels are finally consumed and therefore cannot. Lastly, it is extremely interesting that the ecological reasonability of E-Mobility, which definitely requires green electricity, is not assessed as a barrier according to the empirical findings, whereas literature determines ecological customer requirements as one of the drivers towards E-Mobility, as described in chapter 1.1.

ad customer assistance: Obviously, customer assistance for supporting the handling of an electric vehicle is not determined as a barrier. However, appropriate technical support for customers, particularly, the driving at low remaining range or for charging processes could have an impact on facilitating the handling and coping with certain insecurities such as range anxiety, etc.

ad coordination of activities: In order to reduce the financial barrier for the high investments and research efforts, the importance of co-operations is emphasized. Further considerations relating to the coordination are discussed at research question 3.

The assessed impact of the confirmed barriers by the respondents is depicted in Figure 6.2. In regards to the additionally mentioned barriers, the fear of change, the customer benefit, the absence of an attractive business model, the public discussions about the reasonability of E-Mobility and the nonexistent holistic and well-conceived master plan are cited as being highly important.

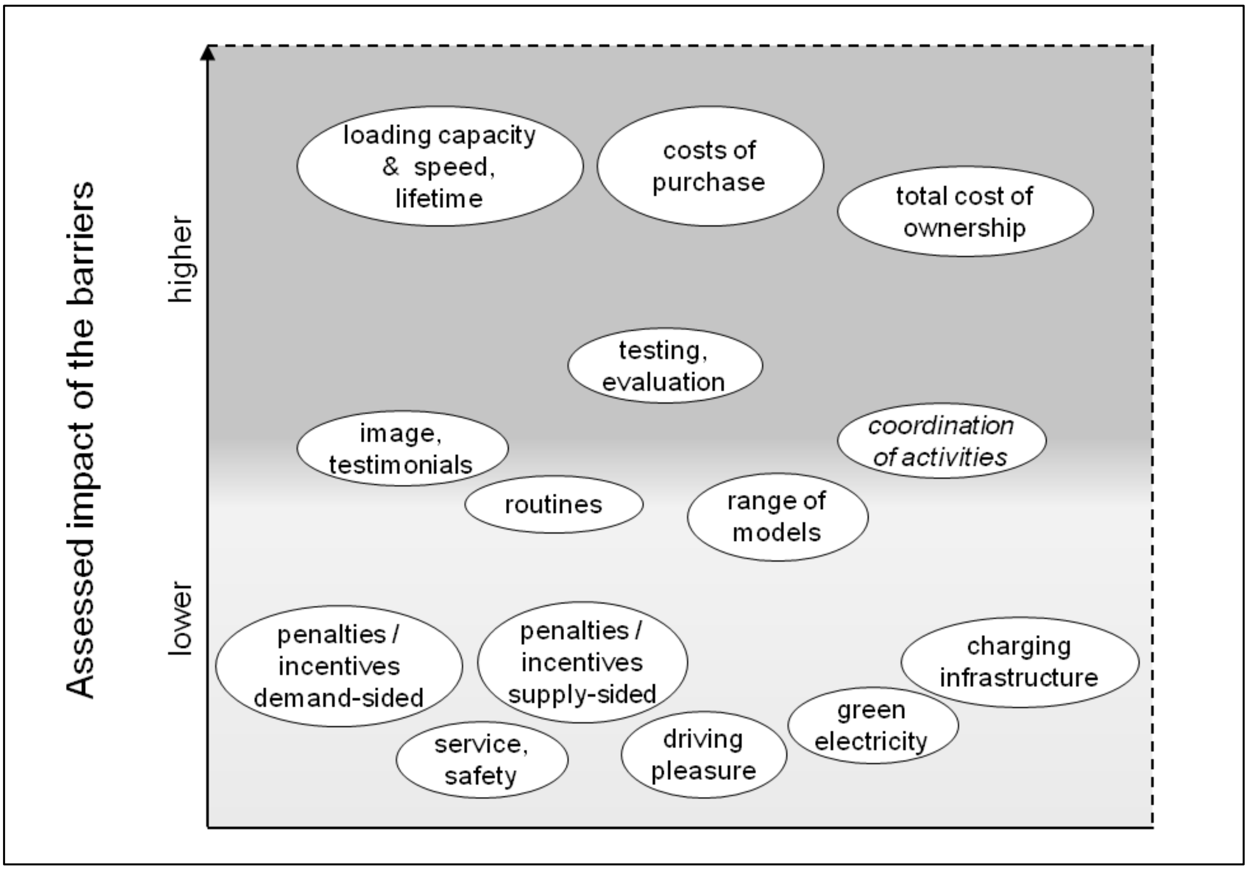

Figure 6.2: Assessed impact of the barriers according to empirical findings (author's illustration)

Research Question 3: How can the barriers to innovation, with regards to E-Mobility, be overcome?

⇨ What approach is purposefully applied in order to manage the barriers to innovation in the E-Mobility system?

The approach for managing the barriers to innovation in E-Mobility is based on the its characteristics, of E-Mobility, which can be described by a system innovation, i.e.:[350]

- out of innovation-specific partial activities,
- of legally and economically independent innovators,
- in an inter-organizational arrangement,
- an innovative combination of purpose and means arises,
- which leads to a sustainable change in behavior.

Therefore, two perspectives are considered, i.e. in the first instance the intra-organizational view relating to each stakeholder and their individual contribution, and secondly the intra-organizational focusing on the interaction between all stakeholders involved. This research question is answered in chapter 4.3.1.

⇨ What implications can be deduced for the relevant stakeholders for managing the barriers in E-Mobility?

The intra-organizational perspective of this research question is elaborated upon in chapter 4.3.2. Further, the interaction of the stakeholders is discussed in the course of the intra-organizational considerations in chapter 4.3.3. Then, a general framework for managing barriers in E-Mobility is suggested in chapter 4.3.4.

The empirical findings confirmed the following contributions and interactions:

- *Driving pleasure:* Contributions need to be made by the OEMs, the suppliers and research.
- *Emissions, fossil fuels:* This issue relates to energy suppliers and the oil industry in terms of increasing the share of renewable energies; however, politics is required to set up framework conditions.
- *Loading capacity & speed, lifetime:* The interviewees unequivocally confirmed the relevance of this barrier for OEMs, suppliers, especially in the field of battery technology and university as well as non-university research institutes, particularly in terms of new battery technologies and effective production. As to

[350] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), p. 178

this, politics has been mentioned as well, which should set a specific focus for allocating funding.

- *Range of models:* This topic involves in the first instance the OEMs and research; however, suppliers are also mentioned. As to this, the major question is whether the mobility offer meets the mobility needs of the customer in regards of vehicle configuration, equipment level, number of seats, trunk size, and, of major relevance, image.
- *Charging infrastructure:* The energy suppliers are primarily considered to be in charge of installing an infrastructure. As to that, oil companies as current gas station operators are also mentioned. In addition, the installation of a charging infrastructure opens new business fields for various service providers, such as trade with add-on service, car parks, real estate developers, and also service providers for the installation itself. In this regard the OEMs are pointed out, which aim for offering all-in-one solutions and therefore might be inclined to be active in charging spots. Moreover, politics is defined as highly crucial for setting up framework conditions, particularly for the public sector in urban areas in regards to building regulations, the support of business models, for example, by incentives for grid operators, but also in terms of norms and standardization.
- *Service, safety:* The service, the handling of hazardous goods and the emergency assistance affects not only the OEMs and the suppliers but also the disposal industry.
- *Costs of purchase / total cost of ownership:* This price issue refers specifically to the OEMs in terms of market positioning, economies of scale, efficient production and battery technology, which also involves the suppliers and research institutes. Further, politics is determined to be highly crucial for financial incentives. As to total cost of ownership, mobility and financial service providers are pointed out, also including energy suppliers. Clearly, the costs of the reacquisition of a battery are decisive, whereas again the OEMs, the suppliers, research and politics are affected. The residual value, moreover, includes the disposal companies in terms of dismantling and recycling in reasonable material cycles.
- *Supply and demand-sided penalties / incentives:* This issue is definitely up to politics and administration. In general, supply-sided incentives are determined as crucial with a clear focus on research funding, whereas demand-sided incentives are assessed as critical. The central issue is defining what is reasonable, what is affordable, how to compensate for it, and then setting up clear and transparent framework conditions.
- *Image, testimonials / routines / testing, evaluation:* As to creating an image, coping with long-established routines either technically or psychologically, and

providing possibilities to gain experience with electric vehicles, the OEMs are involved, as well as suppliers, energy suppliers, various service provider, representatives of society, and of particular importance also politics.

- *Coordination of activities:* All stakeholders except the customer, the disposal companies and representatives of society are mentioned. Further considerations are discussed later on.

The opinions of the respective stakeholder themselves, in regards to their contributions in specific fields of activities, coincide for the most part with the opinions of the other stakeholders.

The contributions of university and non-university research institutes are emphasized as particularly required for battery technology, i.e. capacity, charging speed and lifetime, and cost-efficient battery production. However, they are also valuable in other fields, such as clever marketing as well as in regards to psychological aspects.

Even though certain barriers are allocated to other phases in the reference innovation process for electric vehicles, such as production, distribution, usage, service and after sales and also disposal, the following phases can be confirmed as critical, namely the impetus, the R&D and marketing, as most of the barriers correlate to them.

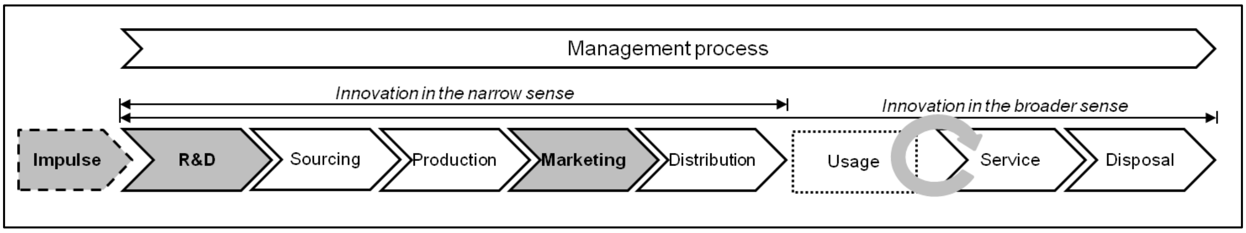

Figure 6.3: Critical phases in the reference innovation process for electric vehicles according to empirical findings (author's illustration)

As a result of the previous considerations, which suggest a high degree of interaction, a special focus needs to be laid on the coordination of the partial innovations and different activities by the distinct stakeholders. The need of coordination is broadly confirmed by the interviewees. It is likewise confirmed by literature,[351] that the interaction in a system innovation takes place without a hierarchical coordination - with the only exception being that there is a dominant partner - the empirical findings, too, cast doubt on the applicability of a hierarchical principle and argue in favor of a market-based coordination. It is particularly emphasized, that a free market economy implies the freedom of contract, i.e. with which partner to enter into co-operation. Even though the market itself has a certain control function, there are still dominant partners among the

[351] Cf. GRÜN, O.; HAUSCHILDT, J.; JONASCH, M. (2008), pp. 178

different stakeholders, namely the OEMs, who have the market power, and politics, which is required to define a vision and thereafter legislative regulations. The energy suppliers have also rarely been mentioned. At any rate, communication and co-operation between the stakeholders is determined as crucial. As a result, a hybrid form of coordination, i.e. co-operation and formation of networks, is suggested by literature as there are considerable advantages, such as sharing risks, resources and know-how, increasing the efficiency and the market share, reducing the costs, etc. and moreover this is also confirmed by the empirical findings to be recommendable for the E-Mobility system.

Furthermore, the following problem owners of E-Mobility, who are supposed to assume the inter-organizational coordination, are mostly mentioned due to the reasons stated:

- *OEM:* CO_2-emission limits, massive investments, long-term strategy, way out of crisis, greatest portion of the value chain, market power, decides with whom to co-operate
- *Politics:* ensure needed energy supply, climate protection, framework conditions, legislative regulation of the market

However rarely, other stakeholders are also mentioned as problem owners as well as:

- *Energy suppliers:* new business models, additional electricity sales
- *Society in general:* careful and responsible way of dealing with resources, ensure individual mobility when fossil fuels are used up
- *Key industry players*
- *Battery manufacturers:* great interest due to high market potential

Therefore, the opinions of the empirical findings differ and the question of the problem owner cannot be clearly answered. Even though the OEMs and politics are clearly regarded as dominant players, there are also doubts in regards to the engagement of the OEMs, as the manufacturing of electric vehicles subverts their core business and the investments made for conventional vehicles. However, they are forced towards the electrification of the powertrain due to CO_2-emission limits, plus they would have the market power, the know-how as well as the distribution and after sales network, which hardly makes it probable for new companies, start-ups or small to medium-sized businesses to be the driver towards E-Mobility. Also, in regards to politics, critical issues arise due to the question of what is affordable and how to compensate for the additional expenses and the lack of revenues.

Lastly, the implications for overcoming barriers and finally for enhancing a successful market launch of E-Mobility conclude with a general framework, which is described in chapter 4.3.4. The main steps, which are accompanied by a controlling with reference to the target system, are as follows:

- Impulse / regulations
- Formulation of a target system
- Inter-organizational coordination
- Management of E-Mobility innovation processes

The empirical findings confirmed the high importance of a strong and clear vision and an impulse specified through reliable, transparent and clear framework conditions over a long period of time. However, other priority topics are then mentioned, such as follows:

- Communication of customer benefit / marketing
- Development of a technologically reasonable product which is marketable without incentives
- Battery: reasonably priced, long lifetime, large capacity, fast (dis-) charging speed
- European master plan
- Intense efforts to increase the share of renewable energies
- Development of new usage of mobility
- Complementary products alongside the vehicle itself
- Standards and norms
- Co-operations / targeted measures
- Massive incentives
- Market competition
- Players with vested interests
- Analysis about individual resources and strengths

The stakeholders are then required to set specific actions and consequently, the best concept prevails.

The opinions in regards to the specific steps of a general framework, i.e. which steps are most important in order to implement E-Mobility, obviously also differ, which, in the end, emphasizes the difficulties for a common approach. The resulting implications are described in the following chapter.

6.2 Implications for Management Practice

This research work aims at developing an approach for coping with the barriers to innovation in E-Mobility with a perspective on the whole system rather than just on the vehicle itself. For this reason, the involved stakeholders are identified and analyzed in the first instance. Secondly, the various barriers which hinder a successful market penetration of E-Mobility are explored, and then each stakeholder's contribution and their interaction is elaborated upon. As a result, the following paragraphs highlight the derived implications which are relevant for practical implementation.

Assessed future prospects

This research work shows up many barriers on the path towards a reasonable concept of E-Mobility. In the very near future, it is very unlikely that all obstacles can be removed.

According to the empirical findings, the barriers related to battery technology, i.e. capacity, charging speed, lifetime, costs, have the highest impact on the market diffusion of electric vehicles. Moreover, it is emphasized that a marketable vehicle concept is crucial, one that does not depend on massive demand-sided financial incentives. As a result, the degree of electrification plays an important role. In the near future, lower degrees of electrification are determined as most promising to prevail on the mass market, as the advantages of both the combustion engine and the electric motor complement each other. The plug-in hybrids, including the range extenders, seem to represent a mid-term solution, as this concept circumvents substantial barriers while retaining advantages of electrification. Yet, in the short-term, the pure electric vehicle can be interesting in niche markets, where its product characteristics are sufficient. Consequently, the experience gained with early adopters would provide valuable information for further developments.

Communication and co-operation

The successful market penetration of E-Mobility requires various activities by different stakeholders. The coordination of those contributions is of special importance and, moreover, as a hierarchical principle is not applicable in this particular case of a system innovation, it can be assessed as critical. Hence, aligning the involved stakeholders to a common goal, communication and co-operation is still suggested to be decisive and absolutely crucial.

Lack of clarity about the problem owner

Yet, the question regarding the problem owner of E-Mobility could not be answered clearly. The empirical findings confirm a special importance of the car manufacturers on the industrial side. On the contrary, it is emphasized that it is up to politics to create clear, transparent and long-term framework conditions as well as to develop a well-conceived master plan for a reasonable concept of E-Mobility, which considers both the big picture and details. However, doubts are expressed with respect to the actual engagement of either. Even so, that only suggests the conclusion that there is evidently no primary driver with a massive interest in E-Mobility.

Need for a well-conceived master plan

The proper interest behind E-Mobility represents a development which is, in general, to be regarded positively, i.e. to offer an environmentally friendly solution for individual mobility without being dependent on fossil fuels and to increase the share of renewable energy sources in traffic. For this reason, it is absolutely crucial to take all relevant aspects into consideration, i.e. to develop a master plan including electricity generation, availability of resources, disposal and recycling, impact on other industrial sectors as well as on market competitiveness, and much more. Instead, partial solutions will not achieve the actual purpose of E-Mobility.

6.3 Implications for Further Research

In the course of the analysis of the relevant theoretical basis and, additionally, due to the findings within this thesis, there arises needs for further research in certain fields, which are discussed in the following paragraphs.

Stakeholder identification

Due to the discussion as to whether or not customers can be determined as a stakeholder in E-Mobility systems, the need for the clarification of the definition of a stakeholder is strongly emphasized.

Barriers in system innovation

Although there are some contributions for barriers to innovation from an intra-organizational perspective, the literature review ascertains a research gaps in the field of inter-organizational as well as external barriers with other partners involved due to the effects of the interactions.

Phase dependency of barriers

Within this thesis, the attempt has been made to associate the barriers to specific phases of the innovation process, even though literature implies certain difficulties for an exact allocation. Therefore, the phase dependency of barriers in general, and particularly the analysis of critical phases of the E-Mobility innovation process indicate a need for further research.

Innovation processes for system innovation

The literature review of innovation processes offers certain well-established innovation processes in a narrow sense for intra-organizational innovations. Further research could focus on the analysis as well as the design of inter-organizational innovation processes for system innovations.

Coordination of system innovations

Literature suggests that neither the hierarchical principle is applicable in system innovations, nor is a partial innovation by a single stakeholder sufficient. This leads to the conclusion, that a certain form of coordination is required. The attempt to answer the question of the coordination of E-Mobility systems and the lack of clarity about the problem owner emphasize the special characteristics and requirements and, therefore, expressly underline the need for further research of coordination in system innovations.

Impact of an extended scope of E-Mobility

This thesis delimitates the term E-Mobility to passenger cars, particularly battery electric vehicles and plug-in hybrids. Further research could investigate as to what extent the considerations of this thesis are suitable for an extended scope, i.e. including utility vehicles, one-track vehicles, etc. and whether the results would differ.

Applicability to other system innovations

The approach in this thesis for a successful market launch of E-Mobility is based on a system-oriented stakeholder analysis, the identification of barriers due to a theoretical model for acceptance of new technologies, an interaction analysis and inter-organizational coordination in system innovations. The applicability of this approach should be worth considering for research works of other system innovations in different fields.

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Abbreviations

BEV	Battery electric vehicle
PHEV	Plug-in hybrid electric vehicle
ICE	Internal combustion engine
OEM	Original Equipment Manufacturer
TCO	Total cost of ownership
EVI	Electric vehicle index
NGO	Non-governmental organization
kW	Kilowatt
kWh	Kilowatt hour