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A persona-centered approach to understanding adoption barriers of electric vehicles

Human Factors and Engineering Psychology:

Bachelor Thesis

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Abstract

The charging process and –requirements of electric vehicles (EV) pose major barriers for adoption among the majority of prospective users. In order to estimate whether EV charging is a factual or rather a perceived barrier for adoption among the early and late majority of users, semi-structured interviews with eight prospective EV users were conducted, which contained an information update about the current state of the art charging technology. The persona technique by Acuna et al. (2012) was applied to ascertain user-requirements towards the charging process and –environment in order to minimize charging-related barriers and facilitate widespread EV adoption in the future. Two user personas were synthesized which represent different mobility needs, levels of charging-related knowledge, perceived charging inconvenience, other perceived barriers and EV purchase intentions. By updating user's knowledge about charging, the perceived inconvenience of charging decreased while purchase intentions remained unchanged. Possible user-centered design solutions like cost-conversion apps or strategically placed information presentation to further decrease perceived inconvenience and facilitate EV adoption among prospective users are presented in the discussion.

Samenvatting

Het laadproces en laadeisen van elektrische voertuigen (EV) maken sommige belangrijke barrières voor de adoptie van EV onder de meerderheid van toekomstige gebruikers uit. Om in te schatten of het opladen een feitelijk- of meer een waargenomen barrière voor adoptie onder gebruikers is, werden semigestructureerd interviews met acht potentiële EV-gebruikers uitgevoerd waar hen over de huidige stand van laadprocessen en laadvoorwaarden werd verteld. Er werd gebruik gemaakt van de persona techniek van Acuna et al. (2012) om gebruiker-eisen achter tegenover het opladen achter te halen die in het context van laadprocessen en laadomstandigheden belangrijk zijn. Als resultaat zijn er wee gebruiker persona's ontstaan die verschillende mobiliteitsbehoeften, niveaus van EV-gerelateerde kennis, door opladen veroorzaakt ongemak, en andere ervaren barrières vertegenwoordigen die EV-adoptie remmen. Door updaten van kennis van de gebruikers over het opladen is het waargenomen ongemak van het opladen verminderd terwijl de aankoop intenties ongewijzigd bleven. Mogelijke user-gecentreerde design-oplossingen voor het bevorderen van EV-adoptie zoals kosten-conversie apps of strategisch geplaatste informatie, die aan de afname van waargenomen ongemak kunnen bijdragen, worden in de discussie uitgelegd.

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1 Introduction

Since the late 19th century the internal combustion engine has become the predominant propulsion method in automobiles. Over time this method has continually been improved and the mobility enabled by combustion engine vehicles (CEVs) has gradually formed one of the cornerstones of human society (Høyer, 2008). But due to the severe impact of CEVs on the worlds climate, more sustainable solutions for mobility like electric vehicles (EVs) are currently being refined. Although the electric motor was invented before the combustion engine, it has not found as much acceptance among the general population until the 21st century. Due to the environmental friendliness, EVs represent a sustainable solution for humanities growing mobility needs in the future while minimizing the impact on the worlds climate (Høyer, 2008). Most automobile manufacturers currently offer at least one EV model in their product range, and the pre-order numbers of the Tesla Model 3 as well as overall EV sales-number foreshadow that EVs might become the predominant mode of transport in the future (Wietschel, Plötz, Kühn & Gnann, 2013; Tesla, 2016; Foley et al., 2015). But EVs impose different requirements on users than contemporary CEVs do, which currently demand an adaptation by the users. Because these user-adaptations and varying requirements inhibit the widespread adoption of environmentally friendly EV-technology, it is necessary to understand how the wide variety of different users perceive EV-technology from a user-centered design point of view. In order to facilitate EV adoption, designers and engineers need to incorporate the user's requirements towards the product, as well as their motivations and perceived barriers for adoption.

1.1 Requirements for EV adoption

The necessary user-adaptations for EV adoption currently include the recharging process of the EVs batteries, which requires more time than the refueling of a CEV, and the installation of a home-charging system. Also, the availability of public charging stations is markedly below the availability of gas stations. This means that EV users currently need to adapt to the new type of vehicle and give up some of the conveniences which are given for CEV users, because EVs do not provide the same level of convenience and usability which CEVs do (Egbue & Long, 2012). But for the success of sustainable innovations such as the EV, the adoption of the consumers is critical, and not every user is equally (or at all) willing to adapt to the new technology (Noppers, Keizer, Bolderdijk, & Steg, 2014). Therefore, in order to enable EV adoption for the majority of the population, the product, environment and the available information must also be adjusted to accommodate the requirements of a wide variety of different users (Wickens, Lee, & Becker, 2004). Because each user has different mobility needs, different motivations for adaptation and

perceives different factors as barriers, EV designers and engineers need to provide a product which is easy to use, which users will want to use, as well as an environment in which the user will want to use the product. Additionally, it needs to be ensured that the information about the product as well as the environment suit the users, in order for users to accept and adopt the new technology (Wickens et al., 2004).

According to Rogers Diffusion of Innovation Theory (1995), the choice to accept or reject an innovation such as the EV is not a spontaneous decision made by an individual alone, but rather a social process that contains five different stages and develops over time: The first stage of the process is *knowledge* – gaining information about a new technology, followed by *persuasion* – being persuaded in a positive or negative way in regard to the innovation, *decision* – deciding for or against adoption, *implementation* – starting to use the innovative technology, and *confirmation* – deciding to continue using the innovation or to averting it. In each of these steps the adopter reduces uncertainty about the innovation by gaining information about it in different ways. Current users of EVs are the innovators and early adopters of this new technology, according to Rogers, while the majority of users has not yet adopted them (Rogers, 1995). This means that, in order to make EVs more attractive to the early and late majority of users, additional barriers for adoption must be eliminated.

1.2 Adoption barriers

A number of studies have been dedicated to the barriers of widespread EV adoption. While the battery capacity of contemporary EVs is a barrier in the product itself, the problems related to the charging process pose some of the main barriers in the use-environment. These charging-related problems include the charging time, charging infrastructure and the charging costs (Carley, Krause, Lane, & Graham, 2016). The requirements of EV charging currently either demand users to change their habits, which have developed over time by using CEVs, or constrain them in their mobility. While refueling of a CEV can be completed within minutes, a full battery charge may take several hours to complete depending on the charging mode. This means that the mobility needs of users which are dependent on quick refueling times (e.g. long-distance drivers) are not met. But also the short-distance use of EVs is often complicated by the rudimentary charging network in many areas (Carley et al., 2016). Many users are used to and dependent on the dense network of gas stations, which are incorporated in the road network and infrastructure. In order to assure a comparable usability environment for EV users, public chargers might need to be installed in greater quantities in key locations and be as well-signposted as gas stations are. Additionally, charging requires the users to convert from

accustomed units, e.g. liters per 100 kilometers or the cost per liter of gasoline, to new units such as kilowatt hours per 100 km or the cost per kWh of electricity. This can make the calculation of charging costs complicated for some users, and therefore also pose a barrier for adoption. A study by Sovacool & Hirsh (2009) found that users do not properly evaluate the savings from fuel-efficient vehicles, and do not incorporate this information into their decision making process of buying a new vehicle. For those consumers who do calculate the running costs of both vehicles, Steiner (2003) as well as Geller & Attali (2005) found that buyers expect vehicle efficiency improvements to pay for themselves much faster than they do in reality. This means that confusion is caused among prospective users, either through insufficient, wrong or unsuitable information about the running costs of an EV.

Factual and perceived barriers

However, it is not certain whether these differing circumstances, costs and user requirements for EV charging are real barriers, or whether they are also barriers of a psychological nature. A study by Franke & Krems (2013) has shown that users perceptions about the inconvenience of EVs range can be changed through exposure. Letting participants use an EV for a period of time changed the user's perceptions about how the use of an EV and its comparatively lower range was an impairment in their daily lives. Therefore, if EV range is rather a psychological than a factual barrier and it could be minimized through exposure, then the problems related to EV charging could also be of a psychological nature or contain some psychological components. This notion is supported by the findings of further studies. The study by Carley et al. (2016) found that "the interest in plug-in EVs is primarily shaped by consumers perceptions of EVs disadvantages", and Lane & Potter (2007) found that "car buyers have a poor knowledge of cleaner car technologies, as well as the environmental impacts of road transport and car ownership costs", and that "(this) level of knowledge can be a powerful predictor of behavioral intentions". Furthermore, Graham-rowe et al. (2012) discovered that "personal mobility needs were prioritized over environmental benefits" within their sample, and Noppers et al. (2014) conclude that "the consensus is that instrumental shortcomings of sustainable innovations inhibit their adoption". This suggests that the prospective user's level of knowledge about EVs is rather low, that the inconvenience of EVs is perceived as high, that this perceived inconvenience inhibits adoption. Because this lack of knowledge and the high perceived inconvenience are rather psychological instead of factual barriers, it is also necessary to understand and include these components when attempting to facilitate widespread EV adoption.

1.3 Research goal

Since Franke and Krems (2013) were able to show that the perceived inconvenience of EV range decreased after exposing users to the unfamiliar technology, the inconvenience of charging could possibly be reduced in a similar manner. Because the study of Lane and Potter (2007) showed that the general knowledge about EV technology is low, it is possible that the perceived inconvenience of charging could also be reduced by properly informing prospective users about the unfamiliar technology, instead of exposing them to it.

In order to assess the individual requirements of different users for EV adoption, as well as their perceived barriers and shortcomings, semi-structured interviews with prospective EV buyers were conducted and the enhanced Persona Technique by Acuna, Castro, & Juristo (2012) was applied. The Persona Technique was used to assess what the different prospective users are like in order to draw conclusions for more user-friendly EV design and engineering, as well as a more user-friendly environment for EV use. Because users were expected to differ in knowledge about charging, information brochures were provided during the interviews in order to assess user's thoughts and opinions about the current state of charging technology. Ultimately the goal of this study was to make user-centered implications on how to make electric mobility more attractive for the majority of prospective users, and create conditions under which users will want to use the new technology.

2 Methods

2.1 Participants

In order to answer the research question, a semi-structured interview was conducted with 8 participants from Germany in May of 2016. Seven were of German nationality and one was a United States expat, with 3 female and 5 male participants. The majority of participants were part of the working population with no background in higher education. One participant was a former engineering student, and another a current health science student. The age ranged between 23 to 60 years (M = 33, SD = 14,18) with 37,5% female participation. All respondents were selected based on the inclusion criteria of (1) being in possession of a valid EU-drivers license and (2) being the owner of at least one personal vehicle, that is used on a daily basis. These inclusion criteria were chosen to ensure that the participants had experience with acquiring costs, as well as the running costs of a car. Moreover, participants that are owners of a personal vehicle were expected to be aware of their driving habits and mobility needs, which were considered important factors for projecting one's thoughts in an EV user's perspective.

Furthermore, it was chosen to include a broad sample of young, middle-aged and older adults, as different demographic groups may have varying standpoints and arguments relevant to the adoption of EVs.

2.2 Materials

The data for the current research were collected in form of a semi-structured interview (Appendix D), which focused on the adoption barrier charging, as well as several related topics and specific sub-questions. The individual topics were formulated broadly with example questions to give the interviewer the freedom of adjusting formulation and changing the order of questions during the interview. The questions and topics were based on the researcher's theoretical overview of the topic.

The first part of the interview contained questions about the participant's general knowledge, associations, opinions and purchasing intentions of an EV in the future. These questions were based on the review of scientific articles which showed that users differ in knowledge and opinions about EV's, and that those factors in turn have an influence on perception of EV's as well as purchasing intention (Egbue & Long, 2012). The questions were included to estimate how participants viewed EVs beforehand, since this has a proven impact on the adoption process of electric vehicles (e.g. Rezvani, Jansson, & Bodin, 2015). Moreover, this part gave an indication about the thought process of individual participants in regard to their answers on the open questions without a clear lead, as these questions showed which information was already present, how sure participants were about their standpoints as well as how relevant the different topics were to them.

The second part of the interview contained questions about the specific aspects of electric vehicles and charging. These were specified due to the researcher's findings of the literature review, as articles about barriers for the adoption of electric vehicles frequently mentioned charging-related barriers as the main barriers for EV adoption (Zhang, Yu, & Zou, 2011; Roma, Momber, & Abbad, 2011; Skippon & Garwood, 2011). In this part, the interview was designed to yield specific and detailed information about the participant's knowledge of the topics, as well as to connect their knowledge with their regular use-environment, habits and most significant mobility needs.

After the conclusion of part two, the interviewer presented information brochures about the previously discussed topics to the participant in order to update their knowledge about the current charging circumstances and requirements (Appendix E, F). The brochures were included as an information update on the current state of charging technology, based on the

findings of Franke and Krems (2013) who found that exposure to EV technology could improve the subject's perception of the new technologies usability, and Lane & Potter (2007) who stated that user's knowledge of cleaner car technologies is low. The aim of the information update was to get respondents to an equal level of knowledge about charging, since the level of charging-related knowledge was expected to differ across respondents. Furthermore, the goal was to find out how the current charging circumstances are perceived, and how current charging technology can be adjusted and enhanced to facilitate adoption. The latest information about EV charging was presented in form of a brochure (Appendix F). The brochure contained information about the charging network density in Europe, Germany and the Netherlands, as well as charging-time and charging-cost related information and a preview of a charger-finding smartphone app. After the information was provided, some previously asked questions were revisited to assess whether the interviewees opinion about the current state of charging technology and the current charging environment was different from their previous opinion. A further set of questions regarding purchasing intentions in the present and future were also added to yield information about a possible change in adoption behavior based on the latest information provided.

2.3 Procedure

The participants were recruited through personal contacts of the researcher, as well as through the social media network Facebook. They were subsequently approached by standardized email to participate in the current research (Appendix A). No financial or material incentive was offered, other than gaining insight into the research topic. Afterwards, individual appointments for the interview were arranged with all interested participants. The semi-structured interviews were conducted at the participant's home in a quiet room in all cases, and recorded with a smart phone. Beforehand the researcher conducted a pilot interview to test the interview scheme and procedure, detect possible shortcomings or mistakes and allow the interviewer to identify possible pitfalls. Due to this pilot interview, some minor changes were made to the interview scheme in regard to formulation of questions and sub-questions in order to facilitate the interviewees understanding.

Before the interview started the researcher explained the procedure of the interview and informed the participant that the interview would be recorded and used anonymously for further analyses. Participants were asked to read and sign the informed consent form (Appendix B). The researcher then introduced the participant to the general topic of the study and answered open procedural questions if necessary. Participants were asked to fill in a short questionnaire

about demographic information and important background information regarding the interview topic, such as driving habits and mobility needs (Appendix C). The conduction of the interview was started subsequently. The interviews consisted of six phases, and each phase was briefly introduced to clarify the context and purpose, and to have a smooth transition between topics.

Concluding the interview, the participants had the chance to ask remaining questions and give feedback to the interviewer. All interviews were conducted personally and held in German (native language of the interviewees). One participant was given the freedom to use English technical terms whenever necessary, since German was not the native language. The interviews had an average length of 42 minutes (SD = 5,3).

2.4 Data analysis

In order to process and analyze the data yielded from the semi-structured interviews the activities 1 - 7 of the enhanced Persona Technique from Acuna, Castro, & Juristo (2012) were applied. The remaining activities are beyond the scope of this study and were therefore not carried out. 'Activity 1.1: Identify possible personas' consisted of stating preliminary expectations of the personas to be created, based on variables on which they were expected to differ (Table 1). These variables were based on the findings of the researcher's literature review.

Table 1: *Persona Hypotheses*

Hypothesis 1:	There are different personas representing different states of knowledge, perceived inconvenience and purchase intentions
Hypothesis 2:	Personas differ in knowledge about EV charging network, charging technology, as well as charging cost and time
Hypothesis 3:	Personas differ in willingness to adopt new habits and incorporate EV charging into their routines
Hypothesis 4:	Perceived inconvenience of EV charging is lower after information update
Hypothesis 5:	Purchase intentions are higher after information update

'Activity 1.2: Hold ethnographic interviews' consisted of interviewing the participants and transcribing the audio recording thereof using Microsoft Word 2015 and VLC 2.2.4. 'Activity

2.1: Synthesize Interview Responses' was carried out by synthesizing a number of behavioral variables on which the participants resembled or differed from each other. The analysis of interview responses was carried out by one researcher and 25% of the responses were re-coded by an independent rater to ensure inter-rater reliability ($\kappa = 0{,}39$). In 'Activity 2.2: List Behavioral Variables' these variables were later listed in tabular form by scanning the transcribed interviews in ATLAS.ti 7.0. Based on reoccurring subject matters in the interviews, a coding scheme (Appendix G) was constructed in order to label the quotes. The behavioral variables were chosen to allow a range of manifestations along a scale with two opposite extremes according to Acuna, Castro, & Juristo (2012).

While performing 'Activity 3.1: Identify the Ranges of Behavioral Variable Values' the two extremes as well as interim values were specified for all behavioral variables. In 'Activity 3.2: Map Interview Subjects to Behavioral Variables' the interviewees answers were grouped together with respect to the values of the behavioral variables, which were synthesized in Activity 2. Each participant's answers were placed on the range of possible behaviors, which showed the distribution of answers across the sample for each behavioral variable. During 'Activity 4: Identify Significant Behavior Patterns' groupings of interviewees responses across more than one range or variable were analyzed in order to find bigger behavioral patterns and clustering of answers across the sample. Through this, percentages for the frequencies of answers across the sample could be determined (Appendix J) as well as some significant behavioral patterns, which were used as a basis for the following step. During 'Activity 5: Synthesize Characteristics and Relevant Goals' these patterns were used as a foundation to draw conclusions about the personas personalities, characteristics and their relevant goals. This step yielded the foundation document for the creation of the different personas (Appendix H).

The foundation document gave the outline for important characteristics of each persona, as well as some more detailed descriptions which could be retrieved directly from verbatim interview quotes. On this basis, the personas could later be embellished with more detail. Afterwards 'Activity 6: Check for Redundancy and Completeness' was carried out. During this step the researcher examined the main characteristics of the personas for gaps in information, as well as for the thorough definition of all other important aspects. 'Activity 7: Expand the Description of Attitudes and Behaviors' was carried out to embellish the personas with more detail and to give a distinct and more life-like picture. In order to make the personas as realistic and vivid as possible, a third-person narrative of each persona was written, which summarized the demographics, attitudes, needs, knowledge, expectations and perceived barriers of each persona.

3 Results

3.1 Distinguishing variables

In this section the results from 'Activity 2.1: List Behavioral Variables' and 'Activity 2.2: Synthesize Interview Responses' are shown. Eleven behavioral and attitudinal variables emerged from the coding of the interviews, which depict participant's different responses. According to Acuna et al. (2012) these variables must represent a range of possible manifestations between two extreme values to which each participants responses can be assigned. The responses can be categorized accordingly for variables 1 and 2, as well as 4 – 9, while variable 3 'Other barriers to EV adoption' does not represent a range of manifestations. Instead, variable 3 shows reoccurring topics that were not subject to the interview, but were nonetheless mentioned by participants. All additional barriers mentioned during the interviews are summarized under variable 3. The identified variables are displayed in Table 2.

Table 2: *Distinguishing variables and their ranges*

Variable	**Range**
1. Current automobile use	Infrequent use of one vehicle – frequent use of more than one vehicle
2. Perceived inconvenience of charging	Very inconvenient – no inconvenience
3. Other barriers for EV adoption	Range / acquisition cost / running cost / image and emotional components / wear and tear / governmental policies / technical difficulties / safety
4. EV charging knowledge	Trivial knowledge – in depth knowledge
5. Readiness for charging adaptation	Low disposition – high disposition
6. EV Purchase intentions	None – high purchase intentions
7. Change in perceived inconvenience of charging	Very inconvenient – no added inconvenience

8.	Change in readiness for adaptation	Low disposition – high disposition
9.	Change in EV purchase intentions	None – high purchase intentions

3.2 Variable ranges and behavioral patterns

This section shows the results from 'Activity 3.1: Identify the Ranges of Behavioral Variables', 'Activity 3.2: Map Interview Subjects' and 'Activity 4: Identify Significant Behavior Patterns'. The variables and according ranges from Table 2 are defined hereunder and illustrated with translated interview quotes. Variables 1 – 6 indicate the initial behavior and attitude of the personas, while variables 7 – 9 show the attitudinal change on some of the variables after receiving the information brochures. Original German interview quotes and their corresponding translations can be found in Appendix I.

3.2.1 Pre-intervention variables

Variable 1: Automobile use

The personas vary in the frequency of their automobile use, as well as in their dependency on it. Persona Daniel has access to two cars, is a frequent driver and depends heavily on his vehicle. He drives between 50 and 60km per working day, and uses his car for a wide range of activities, which include commuting to work, leisure trips and vacations. Maren also uses her car for her daily commute, but sometimes uses alternative forms of transport such as carpooling or public transport instead. She mostly drives short distances and estimates her automobile use at 10-20km per working day, but she likes the convenience of being able to take longer trips without constraint. Although long trips do not take place on a regular basis, she has become accustomed to being able to travel long distances when necessary.

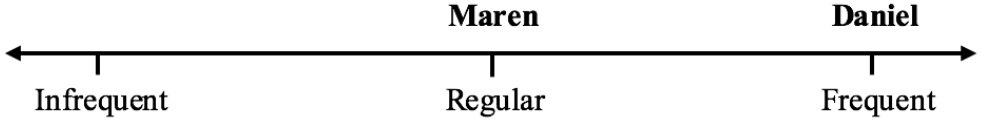

Figure 1: Range of 'automobile use' with persona grouping

Variable 2: Perceived inconvenience of EV charging

The variable 'perceived inconvenience of EV charging' is underpinned by the above variable 'automobile use' and represents the subjective perceived constraint in mobility, due to the current EV charging circumstances. Based on the individual needs and frequency of automobile use, the perceived inconvenience of an EV differs between the personas. Daniel is aware of the different requirements and drawbacks of EVs, as is elaborated in the following sections, but feels that he could adapt to the most requirements with tolerable inconvenience. He perceives the availability of chargers as generally low, but since they are provided at his workplace he could also recharge there during working hours and manage his most important mobility needs nonetheless. The main inconvenience, according to Daniel, are not the requirements of charging itself, but rather the current inability to install a charging system at his home. Therefore, Daniel ranks low on the scale of perceived inconvenience in between 'somewhat inconvenient' and 'no inconvenience', which can be described as little perceived inconvenience. Maren perceives the availability and temporal requirements of EV charging as more inconvenient than Daniel, even though her automobile use is less frequent and covers shorter mean distances. She mainly feels constrained in her long-distance mobility, e.g. her ability to take long distance trips without long and frequent recharging breaks. She describes this as rather inconvenient. Maren admits that she rarely takes long trips with the car and that she could manage most of her daily drives with an EV given the contemporary charging circumstances, but she perceives the difficulties while taking long drives as very inconvenient.

"If, for example, I would want to take a trip to Munich or so, and I would have to take at least two hour-long breaks in between… That would really bother me" (Maren, respondent 1)

"Sure, it's not as convenient as just refueling at a gas station. It takes longer and you have to plan around it somehow. (…) but the main Problem is really that I couldn't charge it at home." (Daniel, respondent 2)

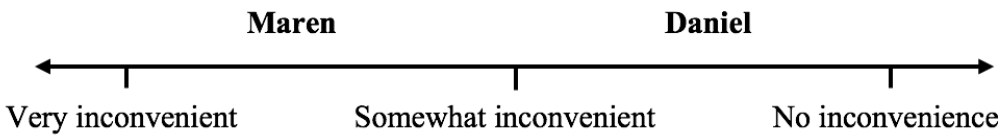

Figure 2: Range of 'perceived inconvenience of EV charging' with persona grouping

Variable 3: Other barriers for EV adoption

The high acquisition costs, uncertainty about running costs as well as the insufficient range of EVs were stated as barriers for adoption by all participants, and are therefore incorporated in both personas. Daniel and Maren also criticized the often futuristic design and overall image of some EVs, and value this as a reduction of desirability. Furthermore, Daniel is also concerned with the safety of EV charging and its widespread use. He thinks that the lack of motor noises could cause more accidents in traffic, because pedestrians are accustomed to hearing cars coming from a distance, and he is insecure about whether public charging is in fact theft-proof. Other barriers include technical difficulties and being overchallenged by the new technology, as well as concerns about the battery lifespan and recycling of old batteries. Another major barrier that persona Daniel is concerned with is the missing governmental policies and incentives to facilitate EV adoption in Germany.

"I think the design is unattractive. For example, with the i3: You can immediately see that it is an EV, and I don't really like that. I wish it would look more like a regular car and not so… spaceship-like" (Persona Maren, respondent 1) (image)

"I think if more people drove EVs we would have to worry about other things as well, especially safety. Because you can't hear EVs coming. Once an EV passed me about 2 meters away and it really startled me. I think most people are not prepared for that. You can hear combustion vehicles coming, but not EVs. I could imagine that lots of people do not recon with that and that accidents may increase" (Persona Daniel, respondent 7) (safety)

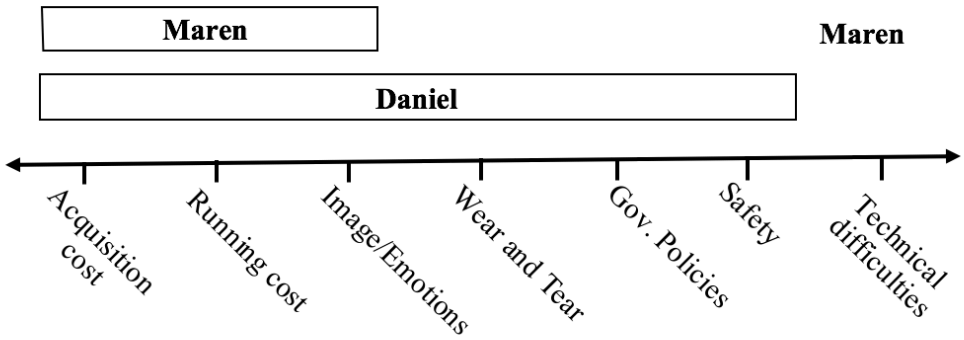

Figure 3: Range of 'other barriers for EV adoption' with persona grouping

Variable 4: Overall charging knowledge

The variable 'Overall charging knowledge' is compiled by the four sub-variables 'knowledge of charging modes', 'knowledge of charging duration', 'knowledge of charging locations' and 'knowledge of charging cost'. In order to compare initial charging knowledge with the post-intervention knowledge, personas are scored both on the variable 'overall knowledge', and the sub-variables for better distinction between the topics of knowledge. Daniel displays mostly detailed and in-depth knowledge about EV charging, while Maren mostly displays trivial and some detailed knowledge. The scores on the sub-variables are shown below.

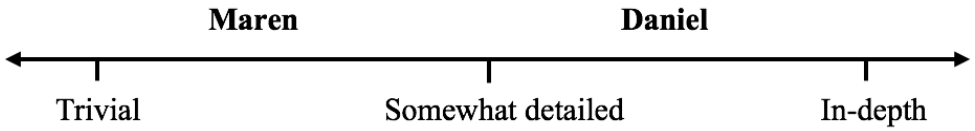

Figure 4: Range of 'overall charging knowledge' with persona grouping

Variable 4.1: Knowledge of charging modes

The duration of the charging process depends on the maximum capacity of the EV battery, as well as the electric current (DC/AC) and voltage (V) of the outlet. These factors contribute to varying charging times and kilowatt-hours (kWh), which are summarized as charging modes. Contemporary EVs can be charged through regular wall-outlets (regular charging; AC; 230V; 3,6 kWh) which can take up to 24 hours for a full charge, through high-voltage charging outlets such as home-charging systems or public charging stations (high-voltage charging; AC; 400V; 20kWh) which take 6 – 8 hours for a full charge, or through direct current charging systems such as Tesla Supercharging stations (supercharging; DC; 90-135 kWh) which enable a quick partial charge within minutes ("The World's Fastest Charging Station", 2016). Each of these processes represent a different charging mode.

Persona Maren has not paid attention to the underlying technical factors of EV charging. She initially thinks that EVs should normally be plugged into the regular wall-outlet in her garage. Although she has made some experience with supercharging while carpooling with colleagues, she did not realize that it was a different charging mode than regular home charging. Her knowledge about charging modes is therefore scored as rather trivial. Daniel has some detailed knowledge about the most prominent charging modes 'full charging', which he recommends should be done over night and at home via a home-charging system, and

supercharging, which is designed for partially recharging in between on long trips. He is aware of the differences in kWh and voltage between charging modes, but knows no precise values thereof. Daniels knowledge of charging modes is scored as in-depth.

"Well I think you just plug it into the normal outlet, don't you?" (Maren, respondent 6)

"There are different charging modes, so it all depends. There's quick-charging, impulse-charging, full charging, and who knows what else. And the plug-ins are usually Poka-Yoke-Systems. Simply plug it in and you're finished. So, everything is fool-proof basically" (Daniel, respondent 2)

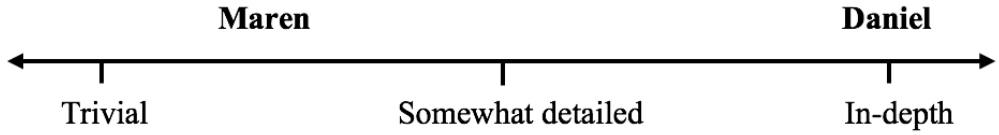

Figure 5: Range of 'knowledge of charging modes' with persona grouping

Variable 4.2: Knowledge of charging duration

Knowledge about the duration of charging is linked to the previous variable, since the charging times are dependent on different charging modes. This variable displays the accuracy and depth of knowledge related to charging times. While Maren is aware that charging consumes more time than the refueling of her current CEV, she has no knowledge about the varying charging durations corresponding to the different modes of charging, even though she has experienced supercharging before while carpooling. She declares that EVs should probably be charged over night due to the long charging time. Her knowledge is therefore categorized as rather trivial. Daniel displays quite detailed knowledge about different charging modes and the corresponding charging times, but miscalculates the duration of state of the art quick-charging stations. He knows, for example, that quick-charging can be accomplished within the average break-time on long trips, but estimates this time at 30-45 minutes instead of 20 minutes. His knowledge of charging durations is therefore categorized as rather in depth.

"(...) I would have to know how long it takes to charge it completely, in order to schedule it. But those are so many factors that I don't know yet" (Maren, respondent 6)

"I think the quick-charging takes about 45 minutes or something like that, so you have to take a little bit longer break than usual" (Daniel, respondent 5)

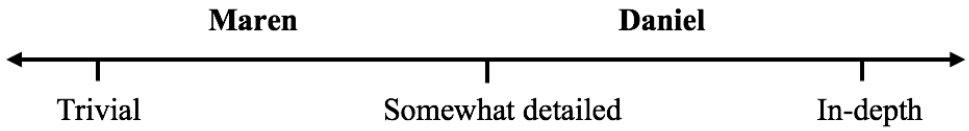

Figure 6: Range of 'knowledge of charging duration' with persona grouping

Variable 4.3: Knowledge of charging locations

This variable includes both knowledge about the possibilities of home charging, and knowledge about the amount and locations of public charging stations in the area of residence. Persona Maren is not familiar with the concept of high voltage home-charging systems, but knows that EVs can be charged at home. She has paid little attention to public EV chargers in her residential area. She is able to name some charging locations in her surrounding area, but underestimates the amount thereof. Daniel is very familiar with home-charging systems and is able to name several public charging locations, which include his workplace, surrounding car parks and some public parking spots.

"I know it can be done at home, but I can imagine it would take forever to charge the car fully. (...) The battery must hold a lot of electricity, and I think that would take very long" (Maren, respondent 4)

"Well, I could charge at work. Some car parks here also offer chargers. Then there's one quite close to here near the (Name) school. (...) and at home of course" (Daniel, respondent 3)

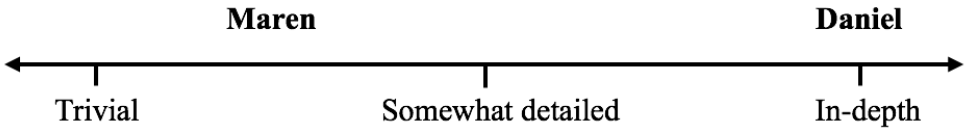

Figure 7: Range of 'knowledge of charging locations' with persona grouping

Variable 4.4: Knowledge of charging cost

Both personas only have trivial knowledge about the costs of EV charging. Neither has made a comparison of charging costs and fuel costs before, and neither have calculated the break-even point of an EV-purchase compared to their contemporary vehicles. Nonetheless, both personas assume that charging cost is significantly below the current refueling cost of their vehicles.

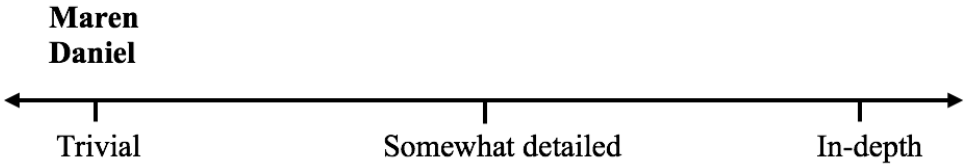

Figure 8: Range of 'knowledge of charging cost' with persona grouping

Variable 5: Readiness for charging adaptation

Currently charging an EV is a quite different process from refueling a car with gasoline. The ratio between charging- and possible driving time is different from CEVs, as well as the available recharging locations. This currently requires some habitual adaptation in order to incorporate EV use into the daily routine. Personas vary strongly on their readiness for these habitual changes and adaptation to charging. Maren admits to being a bit lazy and reluctant to change her habits, especially concerning the longer waiting times during long trips. She says that she would be annoyed if she had to wait for a long time at several stops during long distance trips before being able to continue her journey. As for her everyday use of the car, she says that she would probably forget to plug in the EV in the evenings when she comes home from work, but she thinks she would get used to it and be able to incorporate it into her routine. Daniel reports a very high readiness for adaptation, which is partly due to the availability of chargers at his workplace. For him, the inability to install a home-charging system due to the lack of a personal parking spot, is the knockout argument against purchasing an EV, rather than a lack of willingness to adapt charging into his daily routine.

"I think many people are just to lazy to do that (adapt). I know I am." (Maren, respondent 1)

"The knockout-argument was definitely charging problem at home. Forget it, it's basically impossible (...) without an own parking space" (Daniel, respondent 2)

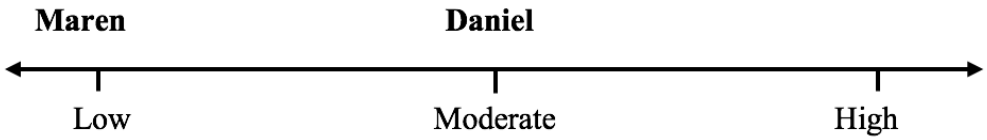

Figure 9: Range of 'readiness for charging adaptation' with persona grouping

Variable 6: EV purchase intentions

This variable indicates the personas strength of purchasing intentions for the future, and therefor also implies the initial attitude towards EVs prior to the intervention. Daniel has already recently contemplated buying an EV as an alternative to his last vehicle, because he likes the concept of environmentally friendly transport, and because his employer provides free charging stations in the company car park. Due to the inability to install a home-charging system, he decided to buy a fuel efficient Diesel car instead for the next years. Nonetheless, he is confident that technology, charger availability and his housing situation will have changed by the time he makes his next car purchase. If that is the case, he wants to buy an EV as his next vehicle. Therefore, Daniels purchase intentions are strong. Maren also likes the idea of noise- and pollutant-free transportation, but states that she wants to wait for more sophisticated technology before purchasing an EV. For her, the inconveniences of EV use still outweigh the benefits and her purchase intentions are only moderate.

"Well, until I'm ready to buy my next car some things will have changed, I am sure. (...) The next car will probably be an EV" (Daniel, respondent 2)

"I will probably wait for a couple more years until everything is a little further developed" (Maren, respondent 1)

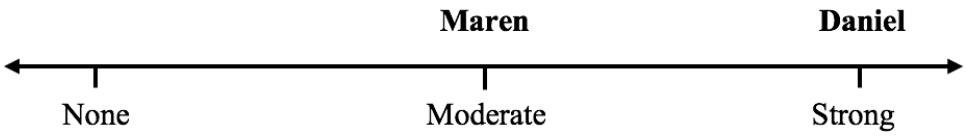

Figure 10: Range of 'EV purchase intentions' with persona grouping

3.2.2 Post-intervention change variables

The following variables indicate the changes in perceived inconvenience, knowledge, readiness for adaptation and purchase intentions of EVs after receiving the information brochure.

Variable 7: Change in perceived inconvenience of EV charging

As shown in Figure 11, both personas have moved toward the less inconvenient end of the spectrum. Both personas perceive EV charging as less inconvenient due to the information presented in the brochure. Daniel mainly perceives EV charging to be less inconvenient because the density of the charging network is higher than he had initially expected. Maren's perceived inconvenience of EVs decreased mainly due to the charger-finding app, which she thinks facilitates charger finding in foreign surroundings significantly, and the current supercharger network of Tesla, which she perceives to facilitate long-distance drives with EVs. She believes that in some time, Tesla's current technology will be affordable for the average car buyer and she perceives Tesla's European supercharger network as very convenient.

"I'm surprised how far and how good everything has developed in these last years. It does make the whole EV thing more attractive for me. It looks like you could really get by with what is already available" (Daniel, respondent 5)

"I really like the search-function where the chargers are located. I think that is a good and sensible idea. And I had no idea such a thing existed" (Maren, respondent 4)

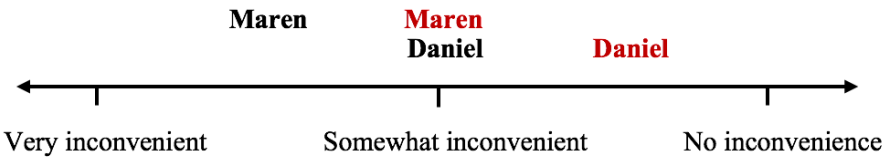

Figure 11: Range of 'change in perceived inconvenience' with persona grouping (red = score after intervention; black = score before intervention)

Variable 8: Change in readiness for charging adaptation

As shown in Figure 12, the readiness for charging adaptation of both personas increased after receiving the latest information in the brochure. Maren then showed moderate readiness for charging adoption because she feels less constrained by the charging network density. She

found the home-charging systems to be more affordable than she had expected, and the convenience of the charger finding smartphone app further increased her readiness to adapt to charging. Daniels readiness to adapt increased slightly, because he also found the density of the charging network less inconvenient than before. Nonetheless, he does not score high on the scale for adoption readiness because he still perceives some barriers, such as his current housing situation and the resulting inability to install a home-charging system, as insurmountable.

"They (home-charging systems) are actually quite affordable. Between 500 and 2000€ seems fair to me. I would have thought that they are much more expensive." (Maren, respondent 6)

"The network is actually denser than I had expected, but there are still quite big regional differences. (...) and it only works well if you charge the EV at home" (Daniel, respondent 7)

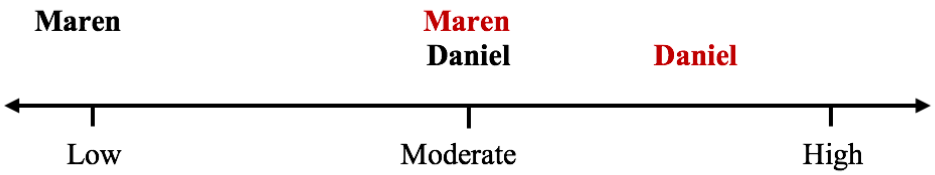

Figure 12: Range of 'change in readiness for charging adaptation' with persona grouping (red = score after intervention; black = score before intervention)

Variable 9: Change in EV purchase intentions

No direct change in purchase intentions took place for the personas. Both Maren and Daniel reported a change in perception and attitude towards EVs as mentioned above, but the purchase intentions remained the same. Persona Daniel stated that although his purchase intentions were already strong previous to the information update, there are still insurmountable barriers which currently inhibit him from purchasing an EV. His purchase intentions have therefore not changed, despite his change in readiness for adaptation and perceived inconvenience. Persona Maren's purchase intentions also remained the same, despite the changes in readiness for adaptation and perceived inconvenience. She stated that the presented information motivated her to more actively inform herself about EVs before her next car purchase, but reported no explicit change in purchase intentions towards EVs. Implications hereof can be found in the discussion below.

"It will take a few more years until I can seriously think about that. I told you what my K.O.-

criteria are… and I won't seriously think about purchasing until that is fixed" (Persona Daniel, respondent 7)

"(Would you rather want to buy an EV now?) I would definitely inform myself better about EVs before buying my next car, in order to see whether an EV would come into question" (Persona Maren, respondent 6)

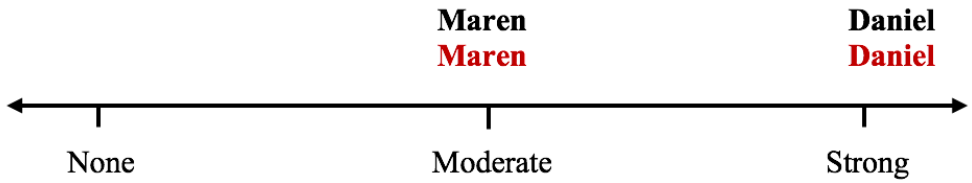

Figure 13: Range of 'change in EV purchase intentions' with persona grouping (red = score after intervention; black = score before intervention)

3.3 Persona synthesis

Presented in this section are the results of Activities 5 through 7 'Synthesize Characteristics and Relevant Goals', 'Check for Redundancy and Completeness' and 'Expand the Description of Attitudes and Behaviors'. Activity 5 'Synthesize Characteristics and Relevant Goals' yielded the foundation document for these personas and can be found in Appendix H. Based on the foundation document, the most relevant characteristics of the personas were elaborated.

Daniel has high initial level of knowledge, a high affinity for electric mobility and has already actively contemplated to purchase an EV. Maren's initial knowledge and attitude towards EVs was not as high in the beginning, but the information aroused more interest in the topic and showed promising results.

The first persona, Daniel, is based on 5 respondents. Their ages range from 24-60 years (M = 32). All respondents are male.

Daniel:

Daniel is 33 years old, has studied Mechanical Engineering and works at an Engineering bureau. He uses his car frequently for the daily commute to work and sometimes for leisure trips on the weekend, which amounts to 60km per day and 15.000km per year. Daniel feels quite dependent on his car. Due to his background in engineering, Daniel attentively follows tech-news of the automobile industry. Therefore, he is very well informed about the state of the art technology, benefits and drawbacks of EVs. He has detailed knowledge about the different charging processes, the availability of charging stations nearby as well as current market developments. Because Daniel works for a large company which is a supplier for the automobile industry and his employer offers EV chargers on the company parking lot, he has previously contemplated buying an EV for his commute. Daniel could cover most of his daily mobility needs with an EV without much compromise and he is willing to adapt to the new requirements of charging. Additionally, his wife owns another compact car which he could use for trips that are not suitable for an EV. Although he is well informed about the requirements and circumstances of EV charging and he is very fond of electric mobility, he recently bought a fuel efficient diesel vehicle instead. His main counterargument for buying an EV was the current inability to install a home charging system, due to the lack of a personal garage. Because Daniel and his family live in a flat in a metropolitan area, they do not have an own spot where they could install a charging system. Although Daniel has no exact information about the costs of EV charging and hasn't compared these to his current fuel costs, he thinks that an EV would be a good and sensible investment.

After informing himself further about the current EV charging circumstances and gaining more in-depth knowledge, he found many details about charging that were previously unknown to him. He found that the charging network in his residential area is denser than he had expected, and he thinks that he could possibly use an EV for more of his mobility needs than he had originally anticipated. Also, he was enthusiastic about the fact that state of the art supercharging can be performed in less time than he had expected. Therefore, Daniel finds that EV charging is even less inconvenient than he had expected, and that he could also manage longer trips with an EV without planning much extra time for in-between charging. Nonetheless, his purchase intentions are unchanged. Daniel is still very fond of EVs, but as long as no alternative solutions for home charging are provided, he cannot purchase one. He is confident that the charging circumstances, his housing situation and the state of the art technology will have changed by the time he buys his next car – which he hopes will be an EV.

Figure 14: Image depicting a Mechanical Engineer [Primary Source]

The second persona, Maren, is based on 3 respondents. The respondents are all female and their ages range from 23 – 50 years (M = 32)

Maren:

Maren is 32 years old, has followed an apprenticeship in physiotherapy and works at the local hospital. She uses her car regularly for her short daily commute to work and occasionally for longer trips, which amounts to 20km per day and approximately 10.000km per year. She drives an old compact car which she has owned for many years. Maren is not particularly interested in cars, has mostly trivial knowledge about the current EV charging technology and has low purchase intentions for a modern EV. Once Maren rode along in a Tesla while carpooling to a seminar with her colleagues. Her knowledge about EVs and the associated charging process are mainly based on this experience, which she still has vivid memory of. She emphasizes that there was only one charger between their starting point and destination, and that this caused for quite some inconvenience, even though the car was partially recharged for the rest of the distance within 30 minutes. She only knows about one public charger in her area, is not familiar with home-charging systems and has little knowledge about varying charging times. She assumes that EV charging is considerably cheaper than refueling, but is not sure. Maren likes the concept of electric mobility but admits to being a bit lazy and reluctant to change her habits in order to adapt to this new mode of transport. She would like to drive an EV in the future, but wants to wait for more sophisticated technology to become available before purchasing one.

By informing herself about the recent developments and state of the art technology, Maren was able to gain a lot of knowledge about EV charging. She discovered that there are more chargers in her area than she had expected, and she found a charger-finding app for her smartphone. Maren is enthusiastic about the progress that the EV manufacturer Tesla has made in refining its supercharging technology and expanding its European network, and she found out that home-charging stations are more affordable than she had expected. Altogether, she discovered that EVs are less inconvenient than expected, and she was motivated to further inform herself about EV charging technology. Although Maren is willing to adapt a bit more to EV charging technology due to the new information she found, her purchase intentions remain unchanged. She is somewhat fond of electric mobility and can imagine driving an EV within the next decade, but wants to wait for the charging network become denser and charging times

to become shorter. After all, EVs are still considerably more expensive to acquire than regular cars, and she doesn't value cars enough to invest much more money just to be able to drive an electric car.

Figure 15: Image depicting a Physiotherapist [Primary Source]

4 Discussion

4.1 Differences in charging barriers between prospective users

This study was designed to make implications on how to make EVs more attractive for the different prospective users, as well as how to create an environment which facilitates EV adoption for the majority of users. Because prospective users differ on a range of important variables, such as EV-related knowledge, mobility needs, and the readiness to change their habits, different factors are perceived as barriers for adoption for each user. In order to make EV technology attractive for the majority, the vehicle as well as the environment need to suit the individual needs of many different types of users. In this study the individual characteristics of eight prospective users were synthesized into two user personas, in order to make specific conclusions about how to facilitate EV adoption.

The user persona Daniel illustrates that many prospective users are quite fond of and well informed about EV technology, but have not yet adopted the EV nevertheless. Users like Daniel are not hard to convince to use the new technology, because their knowledge about EV technology and purchase intentions are already high. This means that the barriers which inhibit users like Daniel from adopting EVs are not necessarily falsely perceived or psychological barriers, but rather factual barriers which demand a more user-friendly solution by EV designers and engineers. In the case of persona Daniel, the main barrier is the inability to install a home-charging system due to the lack of an own garage. This implies that engineers need to bear in mind that not every user has the equal ability to charge their EV at home, and either come up with alternative solutions for home charging or try to decrease charging times in order to enable a quick recharging possibility similar to CEV refueling. A contributing factor to Daniel's low perceived inconvenience of charging and high purchase intentions seemed to be the availability of chargers at his workplace. If larger companies such as Daniel's employer would provide more chargers on their company parking lots, EVs could also be made more attractive for other users. If EV manufacturers provided incentives to large companies to install chargers on their company parking lots, the charging barrier could be reduced for many of their employees, and in turn raise the attractiveness of EVs and create more prospective buyers.

In order to facilitate adoption for users like Maren different solutions need to be found, because she is not particularly interested in cars and her knowledge about EV technology is low. Additionally, since she is not very fond of cars, her readiness to change her habits to accommodate an EV is also much lower. For users like her, there are more factual adoption barriers, and the barriers also have a stronger perceptional component. Her main adoption barriers are the insufficient density of the public charger network, as well as the long charging times. While these factors can definitely be classified as factual adoption barriers, which demand a more user-friendly solution by engineers and policymakers, they also seemed to have a perceptual component. Due to Maren's lower level of knowledge about EVs and charging technology, she underestimates the density of the charging network in her area and overestimates the general inconvenience that EV use would cause her. This manifests itself in a lower readiness to change her habits, because she believes that she will need to give up many of her accustomed conveniences of CEV use, and ultimately in lower purchase intentions. However, these psychological, or perceptional components of Maren's adoption barriers can be removed more easily than the factual barriers. Simply by informing the users whose responses were synthesized into persona Maren about the current state of charging technology, their perceived inconvenience of EV use declined noticeably. This means that it could be possible to make EV use more attractive to some prospective users by (1) providing more information about the current state of EV charging technology (e.g. by specifically directed advertising), and (2) communicating it in a way which is easily understandable and appealing even to those users who have a lower fondness of EVs.

4.2 Reflection on the literature

As is elaborated in this study, the charging-related barriers and the thereby caused inconvenience inhibit the adoption of EVs among prospective users. This is generally in line with the findings of previous studies on the barriers for EV adoption, as is discussed in the following paragraph together with the added implications of this contemporary study. The user personas created in this study perceive the charging process and –circumstances of EVs to be inconvenient in comparison to their current vehicles, which contributes to the inhibition of adoption. This expectedly matches the findings of Carley et al. (2016), who also found that the problems related to the charging process pose some of the main barriers for EV adoption, and of Noppers et al. (2014), who stated that the instrumental shortcomings of EVs inhibit their adoption. This means that in order to make electric mobility more attractive for the majority of users, the charging barriers also need to be understood from a user-centered point of view in

order to be solved to the user's satisfaction. Only by increasing the utility and usability of EVs electric mobility can be made more attractive for the majority of users and compete with current CEV models in terms of practicality. Because many users are quite dependent on their vehicles, as is especially shown in persona Daniel, the personal mobility needs of various users need to be manageable with an EV before user's are willing to make the transition to electric mobility. This also corresponds with the findings of Graham-rowe et al. (2012), who showed that the personal mobility needs of users were prioritized over the EVs environmental benefits. Therefore, it is important to take into account the mobility needs of a wide variety of different users, in order to find more user-friendly solutions for charging and make EVs more practically competitive towards current CEV models. These include the installation of more public chargers in important key-locations (e.g. car parks, public garages, shopping centers, city centers), the facilitation of home-charging for users without personal parking spots (e.g. shared neighborhood-chargers), as well as the reduction of the recharging time during long-distance drives. Because users are generally not inclined to make big sacrifices in respect to their mobility when purchasing a new vehicle, it must be assured that both short- and long-distance mobility is conveniently manageable with an EV in the current usability environment.

Furthermore, it must be better communicated what the current state of the art charging technology and -circumstances are in a manner that is understandable an appealing to all types of prospective users. As is summarized in the user personas of this study, the initial level of knowledge about EVs and charging varied strongly between the prospective users. This is not completely in line with the findings of Lane and Potter (2007), who claimed that the knowledge about cleaner car technologies such as the EV is generally low. While some users had quite profound knowledge about the current state of EV technology, others had paid less, or even very little attention to the new technology. Nonetheless, the level of user's knowledge about EV technology could be an important factor for facilitating adoption. As is shown in the persona Daniel, a high level of knowledge about EV charging was accompanied by a relatively low perceived inconvenience thereof, as well as high purchase intentions. In comparison, the level of initial charging knowledge was substantially lower in the persona Maren. This lower level of knowledge was accompanied by a relatively higher perceived inconvenience caused by charging, as well as lower purchase intentions. Furthermore, all prospective users were able to gain some additional knowledge through the information brochure, which was followed by a reported decrease in perceived inconvenience. This could mean that the perceptional components of charging-related adoption barriers, which play a large role for users such as Maren, could possibly be removed by properly informing users about state of the art charging

technology. This could be done by making little changes to the environment, which motivate the potential users to seek out more information, and presenting the relevant information to them in an interesting manner (e.g. posting QR-codes linked to promotion-videos on public chargers, or distributing them via social media).

Lastly, none of the prospective users interviewed in this study had detailed knowledge about the costs of EV charging, or had made a comparison of the longer-term costs between EV and CEV use. Despite the fact that everyone assumed the charging costs to be substantially lower than the costs of refueling, no one had made the effort to calculate and compare the exact costs to their current vehicle. This matches the findings of Sovacool & Hirsh (2009). Although the use of an EV could possibly be a very sensible investment for some users despite the higher acquisition costs, none of the prospective users were aware of the exact charging costs for calculating the break-even point. A possible explanation therefore could be the conversion from familiar units (e.g. €/liter and liters/100km) to unfamiliar units (e.g. €/kWh and kW/100km). In order to highlight the possible financial attractiveness, automobile manufacturers could advertise their EVs in a manner that is graspable for users who do not want to make the effort to calculate the costs themselves. This could be done by providing and advertising cost-converter apps, or highlighting the current running costs per 100km for the particular vehicle.

In summary this means that small environmental interventions, such as specifically directed advertising and information presentation, the provision of cost-conversion apps, and the better signposting of public chargers could positively impact how the convenience of EV use is perceived by the majority of prospective users. By actively trying to reduce the uncertainty about the new technology, EVs could soon be made more attractive not only to the innovators and early adopters, but also to the majority of users.

4.3 Strengths and restrictions

The Persona technique by Acuna et al. (2012) proved to be a valuable tool for assessing prospective user's knowledge, perceived barriers and willingness to adapt to EV charging. It was possible to gain insight into the wide variety of user's individual mobility needs and their requirements toward EV charging, which need to be fulfilled before they are willing to adopt the new technology. By providing information at a specific point of the interview, it became clear that some prospective users perceive the inconvenience of EV charging to be unjustifiably high. Although the provision of extra information during the course of an interview is rather uncommon in Persona research, it yielded some interesting insights about user's initial knowledge, perceptions and attitudes towards EV adoption. Additionally, due to the provision

of the latest information, it was possible to assess user's thoughts and opinions about the current state of charging technology, as well as the EV usability environment. By doing so it was possible to make conclusions for designers, engineers, as well as policy makers on how to further facilitate widespread EV adoption in the future.

An unexpected strength of the study was the provision of information about the charging situation in other European countries in the brochures. Because users were able to compare the charging-network density in Germany to that of neighboring countries, such as The Netherlands, many users were encouraged to share their opinions about the roles of policymakers in the adoption of EV technology. Although this unintentionally encouraged some interviewees to start arguments about national politics and the automobile lobby, it also highlighted the importance of a user-friendly environment for EV adoption. It became clear that many users perceive an EV-friendly environment (e.g. a dense charging network, governmental incentives for EV adoption, etc.) to be a premise for adoption. Many of the German interviewees stated that they would find it easier and less inconvenient to use an EV if the German charging infrastructure was as far developed as that of The Netherlands.

The main restriction of the study was the non-saturating sample size of only eight respondents (Mason, 2010). Based on the very different responses and the different emphases which were made during the interviews, it appeared to be possible to synthesize the various responses into more than the two user personas above. Although, in order to create more user personas, it would have been necessary to gather more user's responses to properly support them. Because of this some interesting responses by interviewees could not be included into the user personas of this study.

Another shortcoming of this research was the final interview question about the change of respondent's purchase intentions, after they had received the information brochure. As is shown in variable 9, no change purchase intentions took place in either user persona, despite the change in knowledge and perceived inconvenience. This may be due to the fact that there was not enough time between the update in knowledge and the question in order for a change in purchase intentions to take place. As is incorporated in the description of persona Maren, some respondents stated that they were more motivated to inform themselves about EVs due to the update in information, instead of reporting a direct change in purchase intentions. This could be because respondents were uncertain about how to answer the question at that point.

4.4 Recommendations

Based on the strengths and restrictions stated above, it is recommended to either replicate the study with a larger, and saturating amount of respondents or do further research on user focus groups in the future. Because prospective users vary on many relevant variables for EV adoption, and sometimes have special individual mobility needs, it is necessary to assess the needs of more different types of users (e.g. users living in rural areas, users in metropolitan areas, long-distance commuters, etc.). By including more individual user responses into the persona synthesis, more relevant characteristics can be incorporated into the different personas descriptions. Additionally, more explicit focus should be put on the EV-friendly environment as a premise for adoption, as was hinted at by some respondents in this study. It should prove valuable to understand what adoption incentives prospective users wish for, or expect, from manufacturers and policymakers before being willing to adapt.

Lastly, because it is possible that the questions about a change in purchase intentions followed to quickly after the update in information in order to detect a change, it is recommended to split the interview into two parts in case of a replication of this study. In order for a change in purchase intentions to take place, it could be that the newly acquired information needs to sink in for a while. The recommendation is therefore to first conduct an interview about the initial level of knowledge, perceived inconvenience and purchase intentions of the prospective user. Concluding the first interview, the researchers should present and discuss the information brochures with prospective users and possibly motivate them to do some internet-research on their own. After some time, a follow up interview or survey could be conducted in order to properly understand the role of user's knowledge for EV adoption, and detect whether a change in purchase intentions maybe does take place if users are properly informed about state of the art EV- and charging-technology.

4.5 Conclusion

The present study was able to demonstrate that the EV adoption barrier charging has perceptional components similar to those of the barrier range, which Franke and Krems (2013) implied. This approach highlighted the individual mobility needs as well as levels of knowledge and perceived inconvenience of various users, and how these inhibit adoption behavior. Although some components of the adoption barrier EV-charging seem to be of a more perceptual nature, and may be removed by properly providing relevant information to users, others components of the barrier demand a more user-friendly engineering approach. Barriers such as the inability of some users to install home-charging systems, low availability of public

chargers and long charging times need to be solved by innovative and user-friendly engineering, in order to enable highly motivated users to adopt EVs. In order to facilitate adoption for less motivated users, it is particularly important to make changes to the environment in order to raise interest, and present relevant information in an appealing and convincing manner. By properly informing prospective users about the current state of EV technology, the perceived inconvenience of electric mobility may be reduced significantly.

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Appendix A: First letter to participant

Lieber Teilnehmer,

Danke, dass du dich bereit erklärt hast an unserer Studie teilzunehmen.
Wie abgesprochen werden wir bald ein Interview über das Thema elektrische Autos und deren Anwendbarkeit führen.
Dieses Interview ist Teil meiner Bachelor-Studie, die ich gemeinsam mit meinem Kommilitonen Nik Hanebaum an der Universität Twente durchführe.

Ich möchte gerne einen Termin mit dir absprechen, an dem ich bei dir zuhause vorbeikommen kann. Mein Vorschlag wäre der __.__.____ zwischen __.__ Uhr und __.__ Uhr. Würde dir das passen? Falls nicht, sag mir bitte Bescheid, wann es dir besser passen würde.

Für das Interview brauchen wir nur einen ruhigen Ort, an dem wir uns ungestört an einen Tisch setzen und uns unterhalten können. Sonst brauchst du überhaupt nichts vorbereiten. Deine Daten werden selbstverständlich vertraulich behandelt und in meiner Thesis nur anonymisiert wiedergegeben. Es werden keine Rückschlüsse auf deine Person möglich sein.

Solltest du vor unserem Interview schon mit jemandem sprechen, der bereits an unserer Studie mitgemacht hat, bitte ich dich keine Details der Studie mit dem- bzw. derjenigen zu besprechen. Gleiches gilt selbstverständlich, wenn du nach unserem Interview mit jemandem sprechen solltest, der zu einem späteren Zeitpunkt noch an der Studie teilnehmen will.
Es ist uns sehr wichtig, dass jeder Teilnehmer möglichst unvoreingenommen teilnehmen kann.

Vor und nach dem Interview sollten wir genügend Gelegenheiten haben um eventuelle Fragen zu klären, und ich stehe dir natürlich gerne Rede und Antwort zum Thema.
Solltest du vorab bereits eine Frage haben, kannst du mich jederzeit unter dieser Email-Adresse erreichen.

Mit freundlichen Grüßen,

Christopher

Appendix B: Informed consent

Informed consent / Informierte Einwilligung

Hiermit erkläre ich, dass ich hinreichend über die Durchführung und die Methoden dieser Studie informiert bin. Alle offenen Fragen sind zu meiner Zufriedenheit beantwortet worden und ich stimme freiwillig zu an der Studie über elektrische Fahrzeuge teilzunehmen.

Ich behalte mir das Recht vor, meine Einwilligung jederzeit und ohne die Angabe eines Grundes wieder zurücknehmen zu können und das Interview abzubrechen. Alle bis dahin versammelten Daten werden in diesem Fall vernichtet.

Sollten meine Aussagen in einer wissenschaftlichen Publikation erscheinen, werden sie so anonymisiert, dass kein Rückschluss auf meine Person möglich ist.
Meine persönlichen Daten können nicht ohne ausdrückliche Zustimmung durch Dritte eingesehen werden.

Name, Datum, Unterschrift der Testperson

Hiermit erkläre ich, dass ich das Ziel und den Hintergrund der Studie hinreichend erklärt habe. Des Weiteren bin ich gerne dazu bereit um eventuelle weitere Fragen nach bestem Wissen und Gewissen zu beantworten.

Name, Datum, Unterschrift des Interviewers

Für weitere Informationen über diese Studie können Sie Kontakt aufnehmen mit Christopher O'Connor (+49170-XXXXXXX; xxxxxxxxx@student.utwente.nl) oder Nik Hanebaum (+49170-XXXXXXX, yyyyyyyyy@student.utwente.nl). Für eventuelle Beschwerden über diese Studie oder deren Durchführung können Sie Kontakt aufnehmen mit der Ethikkommission der Fakultät für Verhaltenswissenschaften an der Universität Twente (J. Rademaker, Postbus 2177, 7500AD Enschede; j.rademaker@utwente.nl)

Appendix C: Questionnaire demographics and mobility needs

Vragenlijst rijgedrag / Fragebogen Fahrverhalten

1. Naam / Name:
2. Leeftijd / Alter:
3. Woonplaats / Wohnort:
4. Geslacht / Geschlecht:
5. Opleiding / Ausbildungsstand:
6. Professie / Berufstätigkeit:

7. Hoe lang bent u al in bezit van een rijbewijs?
Wie lange sind Sie schon im Besitz eines Führerscheins?

_____

8. Hoe lang heeft u al een eigen auto? (Hoeveel jaren)
Wie lange sind Sie schon im Besitz eines eigenen Fahrzeuges? (Anzahl der Jahre)

_____

9. Hoe belangrijk is uw auto voor uw alledaagse leven?
Wie wichtig ist Ihnen Ihr Auto im Alltag?

_____

10. Waarvoor gebruikt u uw auto meestal? (Denk bijvoorbeeld aan: boodschappen doen, tot werk komen, etc.)
Wofür benutzen Sie Ihr Auto meistens? (z.B. Einkäufe, an die Arbeit kommen, etc.)

_____

_____

11. Hoeveel kilometer rijt u ongeveer per jaar? Zet een kruisje
Wie viele Kilometer fahren Sie ungefähr pro Jahr? Kreuzen Sie an.

< 5.000 km	
5000 – 15.000 km	
> 15.000 km	

12. Hoeveel kilometer rijt u gemiddeld op een gewone dag? Geef een inschatting
Wie viele Kilometer fahren Sie durchschnittlich an einem normalen Tag? Schätzen Sie.

_____

13. Wat voor een type auto rijdt u momenteel? Voor welke reden?
Was für ein Auto fahren Sie momentan? Aus welchen Gründen?

Appendix D: Interview schema (revised)

Interview schema: Consumer adoption of electric vehicles

1. Voorstelling en Kennismaking

Begroeting en verheldering:
Goedemiddag, bedankt dat u de tijd genomen heeft om dit interview te voeren. Mijn naam is (Chris/Nik) en ik doe met mijn collega (C./N.) op de Universiteit Twente voor ons afstudeeropdracht onderzoek naar elektrische auto's. Wij zijn van plan dit interview ter eigen analyse en voor eigen gebruik op te nemen, bent u daarmee akkoord? Het interview zal ongeveer 45 minuten duren, en er zijn geen goede of foute antwoorden. Het gaat puur om uw mening. Voordat wij beginnen wil ik u graag vragen om een korte vragenlijst over uw rijgedrag in te vullen.
Is dat duidelijk of heeft u nog vragen?

Begrüßung und Erklärung:
Guten Tag, und danke, dass Sie sich die Zeit genommen haben um dieses Interview zu führen. Mein Name ist (Chrishris/Nikik) und ich schreibe zusammen mit meinem Kollegen (Chris/Nik) an der Universität Twente in den Niederlanden meine Bachelorthese über elektrische Autos. Wir wollen dieses Interview zur weiteren Analyse gerne aufnehmen. Sind Sie damit einverstanden? Das Interview sollte insgesamt etwa 45 Minuten dauern. Es gibt keine richtigen oder falschen Antworten, es geht uns ausschließlich um Ihre Meinung. Bevor wir beginnen möchte ich Sie aber noch bitten, diesen kurzen Fragebogen über Ihr Fahrverhalten auszufüllen.
Ist alles deutlich oder haben Sie noch fragen?

2. Bepalen algemene kennisstand en mening over EVs

Het gaat in dit interview om pure elektrische voertuigen, dus niet om Hybriden met nog een conventionele verbrandingsmotor. Voordat wij gaan focussen op bijzondere aspecten van EVs, willen wij graag iets algemener weten wat u over EVs denkt en weet.

Es geht in diesem Interview um reine elektrische Autos, also nicht um Hybriden mit sowohl konventionellem Verbrennungsmotor und Elektroantrieb. Bevor wir uns aber bestimmten Aspekten von elektrischen Autos widmen, möchte ich gern noch etwas allgemeiner erfahren, was Sie über E-Autos denken und wissen.

2.1 Vrije associatie
Waaraan denkt u het eerst als u over elektrische auto's nadenkt? ☐
Woran denken Sie als erstes, wenn Sie über elektrische Autos nachdenken?

2.2 Kennis en ervaring
Heb je al eigen ervaring met EVs gemaakt? ☐
Haben Sie schon eigene Erfahrungen mit EVs gemacht?

Wat weet u tot nu toe alles over de werkwijze EVs? ☐
Was wissen Sie bis jetzt über wie Elektroautos funktionieren?

Heeft u een idee hoe EVs op dit moment verder worden ontwikkeld? ☐
Was denken Sie, wie E-Autos momentan weiterentwickelt werden?
→Heeft u een idee van hoe de batterij in een EV werkt? ☐
Was denken Sie, wie die Batterien in E-Autos funktionieren?
→Heeft u een idee van hoe ver men gemiddeld met een momentele EV zou kunnen rijden? ☐
Was denken Sie, wie weit man im Schnitt mit einem aktuellen E-Auto fahren kann?
→Heeft u een idee hoe het opladen van een EV werkt? ☐
Was wissen Sie darüber, wie das Aufladen von E-Autos funktioniert?

2.3 Mening
Wat is uw mening over EVs? ☐
Wie ist Ihre Meinung über E-Autos?
→ Als u denkt aan Denk daarbij ook aan ttechnische aspecten (Denken Sie dabei an *technische Aspekte?*) ☐
→ Denk daarbij ook aan Als u denkt aan mmilieuaspecten? (Denken Sie dabei an *Umweltaspekte?*) ☐
→ Denk daarbij ook aan Als u denkt aan bbruikbaarheid? (Denken Sie dabei an *Benutzerfreundlichkeit?*) ☐

2.4 Koopintentie
Zou u op basis van wat u nu over EVs weet ook een EV willen kopen? ☐
Würden Sie, basierend auf was Sie so weit über E-Autos wissen, eines kaufen wollen?
Zou u voor uw volgende aankoop van een auto daarover nadenken een EV te kopen? ☐
Würden Sie darüber nachdenken bei Ihrem nächsten Autokauf ein E-Auto zu kaufen?
→ Zo nee: Kunt u voorstellen binnen de volgende tien jaren een EV te kopen? ☐
→ Falls nein: Könnten Sie sich vorstellen innerhalb der nächsten zehn Jahre ein E-Auto zu kaufen?

3. Bepalen kennis over range

Dank u wel. Dit was een iets algemeen deel, maar nu willen wij op enkele bijzondere aspecten van EVs komen te spreken. In het volgende stuk gaat het over de distantie, die men met een EV zou kunnen rijden – in het Engels "range" genoemd. Wij willen in dit stukje niet alleen weten wat u over het onderwerp denkt, maar ook graag uw redenering daarachter. Uw redenering is erbij echter belangrijker dan uw kennis. Wij willen vooral graag weten waarom u zo denkt en in hoeverre dat met uw dagelijks leven en uw behoefden samenhangt.

Danke so weit. Das war nun ein allgemeinerer Teil, aber nun möchte ich gern auf einige spezielle Aspekte von E-Autos eingehen. Im folgenden Teil geht es um die Reichweite, die man mit einem E-Auto erreichen kann – auf englisch 'Range' genannt. Ich möchte in diesem Stück nicht nur wissen was Sie über dieses Thema denken, sondern auch gerne, sofern möglich, warum Sie so denken. Ihre Begründung ist uns dabei wichtiger als ihr tatsächliches Fachwissen. Wir möchten vor allem gerne wissen, wie sich Ihre Meinung auf Ihren Alltag und ihre Mobilitätsbedürfnisse bezieht.

Hoe belangrijk vindt u de range van een auto? ☐
Wie wichtig finden Sie range/Reichweite eines Autos?
Zou het huidige 'state of the art' technologie voldoende zijn om aan uw eisen te voldoen? ☐
Wäre der aktuelle Stand der Technik für Sie ausreichend, um Ihre Anforderungen zu erfüllen?

→ In vergelijking met uw huidige auto? ☐
→Im Vergleich mit Ihrem momentanen Auto?

Denkt u dat de chauffeur de mogelijkheid heeft de range te verbeteren? Zo ja, hoe? ☐
Denken Sie, dass der Fahrer die Möglichkeit hat die Reichweite zu verbessern? Falls ja, wie?

Gezien hoeveel u rijt, hoe veel range heeft u (meestal) nodig? ☐
→ Wat zou u ‚Comfortable range' zijn ☐
Gemessen an wie viel Sie fahren, wie groß müsste die Reichweite für Sie sein?
→ Was wäre für Sie eine komfortable Reichweite

Denkt u dat range bij verschillende temperatuur veranderd? ☐
→Denkt u dat dit hier in Nederland/Duitsland een belangrijke rol zou kunnen spelen?
Denken Sie, dass sich die Reichweite bei unterschiedlichen Temperaturen verändert?
→ Denken Sie, dass das hier in den Niederlanden/Deutschland eine Rolle spielen könnte?

Op basis van u nu weet, zou range van EVs een barrière voor u zijn om uiteindelijk een EV te willen kopen? ☐
Basiert auf was Sie momentan über E-Autos wissen, wäre die Reichweite von E-Autos eine Barriere um letztendlich ein solches Auto kaufen zu wollen?

4. Bepalen kennis over opladen

Dank u wel. Nu dat wij over range hebben gesproken, willen wij nog iets daarover te weten komen wat u over bepaalde aspecten van het opladen van elektrische auto's weet. Ook in dit stukje zijn we heel erg geïnteresseerd aan uw mening, maar ook aan uw redenering daarachter. Uw redenering is erbij echter belangrijker dan uw kennis. Wij willen vooral graag weten waarom u zo denkt en in hoeverre dat met uw dagelijks leven en uw behoefden samenhangt.

Dankeschön. Jetzt wo wir über die Reichweite gesprochen haben, möchte ich nochmal auf einige Aspekte des Aufladens von EV's eingehen. Ich möchte in diesem Stück nicht nur wissen was Sie über dieses Thema denken, sondern auch gerne, sofern möglich, warum Sie so denken. Ihre Begründung ist uns dabei wichtiger als ihr tatsächliches Fachwissen. Wir möchten vor allem gerne wissen, wie sich Ihre Meinung auf Ihren Alltag und ihre Mobilitätsbedürfnisse bezieht.

Heeft u al eens opladers voor EVs gezien? Indien ja, waar? ☐
Haben Sie vorher schon einmal eine Ladestation gesehen? Wenn ja, wo?
Waar denkt u dat men een EV momenteel kan opladen? ☐
Wo denken Sie kann man ein E-Auto momentan überall aufladen?
Hoe denkt u dat het opladen werkt? ☐
Was glauben Sie, wie das Aufladen funktioniert?
Waar zou u uw EV in de toekomst willen kunnen opladen? ☐
Wo würden Sie in der Zukunft gerne ihr E-Auto aufladen können?
→ Denkt u dat er binnenkort meer opladers zullen zijn? ☐
→ Denken Sie, dass es in nächster Zeit mehr Ladestationen geben wird?

→ Zou het opladernetwerk van vandaag, op basis van wat u nu denkt hoe het eruit ziet, voor uw behoefte voldoende zijn? ☐
→ Würde Ihnen das Ladenetzwerk, so wie Sie es sich nun wahrnehmen, ihren Bedürfnissen entsprechen?

Vergeleken met een gewone moderne auto, wat denkt u hoe duur het zal zijn om een EV op te laden? → Goedkoper of duurder? In hoeverre? ☐
Wie viel würde es Sie ihrer Meinung nach, im Vergleich mit einem normalen modernen Auto kosten, um ein E-Auto aufzuladen? -> Eher günstiger oder teurer? In wie fern?

Heeft u al eens een eigen vergelijking van de kosten tussen een EV en een CEV gemaakt? ☐
Haben Sie schon einmal einen solchen Kostenvergleich zwischen E-Auto und herkömmlichem Auto angestellt?

Heeft u al eens van batterijwisselstation, in het Engels 'battery swapping station', gehoord?
→ Indien ja, leg alstublieft uit. ☐
Haben Sie schon einmal etwas von Batteriewechselstationen gehört?
→Falls ja, könnten Sie diese erklären/beschreiben?

Heeft u al eens van een snellaadpaal, in het Engels 'supercharger station', gehoord? ☐
→ Indien ja, leg alstublieft uit. ☐
Haben sie schon einmal von einer sogenannten Schnellladestation (Supercharger) gehört?
→ Falls ja, könnten Sie diese erklären/beschreiben

Wat denkt u hoe lang het zou duren om een EV maximaal op te laden? ☐
→ met een snellaadpaal?
→ met een gewone oplader?
Wie lange denken Sie dauert es ein E-Auto komplett aufzuladen?
→ Mit einem Schnellladegerät?
→ Mit einem normalen Auflader?

Stel dat u een uitstapje naar Amsterdam wilt ondernemen:
Heeft u een idee hoe u het opladen zou moeten zo'n dag inplannen? (time-management) ☐
→ Zo ja, hoe? Zo nee, waarom niet?
Stellen Sie sich vor Sie wollen einen Tagesausflug nach Frankfurt unternehmen:
Haben Sie eine Idee wie Sie das Aufladen auf einer solchen Reise einplanen müssten?
→ Wenn ja, wieso? Ebenso: wenn nein, wieso nicht?

Stel dat u op vakantie naar Spanje wilt rijden:
Heeft u een idee hoe u het opladen op zo'n reis zou moeten inplannen? ☐
→ Zo ja, hoe? Zo nee, waarom niet?
Stellen Sie sich vor Sie wollen nach Spanien reisen:
Haben Sie eine Vorstellung von wie Sie das Aufladen auf einer solchen Reise einplanen müssten?
→ Wenn ja, wieso? Wenn nein, wieso nicht?

Stel dat u vanaf nu voor enkele weken een EV in het alledaagse leven mag gebruiken:
Hoe zou u het opladen inplannen? (habits) ☐
Stellen Sie sich vor Sie würden ab jetzt für einige Wochen ein E-Auto im Alltag benutzen:
Wie würden Sie das Aufladen einplanen?

6. Verandering in perceptie van EVs

Dank u wel. Wij hebben nu zowel over range als ook het opladen gesproken, en ik heb de voor u belangrijkste punten genoteerd. In het volgende stuk wil ik u graag over de net besprokene onderwerpen de nieuwste informatie presenteren. Ik geef u daarvoor nu eerst een informatieblad over de recente ontwikkelingen en het momentele 'state of the art' wat betreft de range. Neemt al de tijd die u nodig heeft om alles door te lezen. Als u vragen heeft, stelt hem alstublieft.
Vielen Dank soweit. Wir haben bis jetzt sowohl über die Reichweite als auch das Aufladen gesprochen und Ich habe mir die wichtigsten Punkte notiert. In dem nächsten Abschnitt möchte Ich Ihnen gerne ein paar neue Informationen präsentieren. Ich werde Ihnen dazu nun erst ein Informationsblatt über aktuellen und neusten Entwicklungen im Bezug zur Reichweite von E-Autos geben. Nehmen Sie sich so viel Zeit wie Sie benötigen um alles gut durchzulesen. Sollten Sie Fragen haben können Sie diese gerne stellen.

→ INTERVENTIE 1: INFORMATIEBLAD RANGE GEVEN ☐

6.1 Range
Was er iets verrassends voor u daarbij? Wat precies?
War da etwas Überraschendes für Sie dabei? Was genau?

Heeft deze informatie uw perceptie over EVs veranderd? ☐
Haben diese Informationen ihre Wahrnehmung von Elektroautos verändert?
→ In hoeverre m.b.t range ☐
→In wie fern im Bezug auf Reichweite

Wat is nu uw mening over de range van EVs? ☐
Wie ist nun ihre Meinung über die Reichweite von E-Autos?

Denkt u dat het huidige state of the art in technologie voor u behoefden voldoende zou zijn? ☐
Denken Sie, dass die derzeitige modernste Technologie ihren Bedürfnissen gerecht werden würde?

Dank u wel. Nu dat we het over range hebben gehad, wil ik u ook nog een informatieblad over het opladen geven. Neemt weer al de tijd die u nodig heeft om alles door te lezen. Als u vragen heeft, stel hem alstublieft.

Vielen Dank soweit. Nachdem wir uns erst über die Reichweite unterhalten haben möchte Ich ihnen jetzt gerne ein Informationsblatt über das Thema Aufladen geben. Nehmen Sie sich so viel Zeit wie Sie benötigen um alles gut durchzulesen. Sollten Sie Fragen haben können Sie diese gerne stellen.

→ INTERVENTIE 2: INFORMATIEBLAD OPLADEN GEVEN ☐

6.2 Opladen
Was er iets verrassends voor u daarbij? Wat precies?
War da etwas Überraschendes für Sie dabei? Was genau?

Wat vindt u daar nu van? Wat denkt u nu over het opladen van EVs? ☐
Was denken Sie nun über das Aufladen von E-Autos?

Wat is nu uw mening over het opladen van EVs? ☐
Was ist nun Ihre Meinung zum Aufladen von Elektroautos?

Denkt u dat het huidige opladernetwerk voor u behoefden voldoende zou zijn? ☐
Denken Sie, dass das heutige Ladenetzwerk ihren Bedürfnissen gerecht werden würde?

Dank u wel. Afsluitend willen wij u nog enkele vragen daarover stellen, in hoeverre u een EV zou willen kopen.
Vielen Dank. Abschließend würde Ich Ihnen gerne noch ein paar Fragen über Ihre Kaufintentionen in Bezug auf E-Autos stellen.

6.3 Koopintenties in de toekomst
Zou u nu voor uw volgende aankoop van een auto daarover nadenken een EV te kopen? ☐
Würden Sie bei nun ihrem folgenden Autokauf ein E-Auto in Erwägung ziehen?

Kunt u zich voorstellen binnen de volgende tien jaren een EV te kopen? ☐
Können Sie sich vorstellen in den kommenden 10 Jahren ein E-Auto zu kaufen?

7. Afsluiting

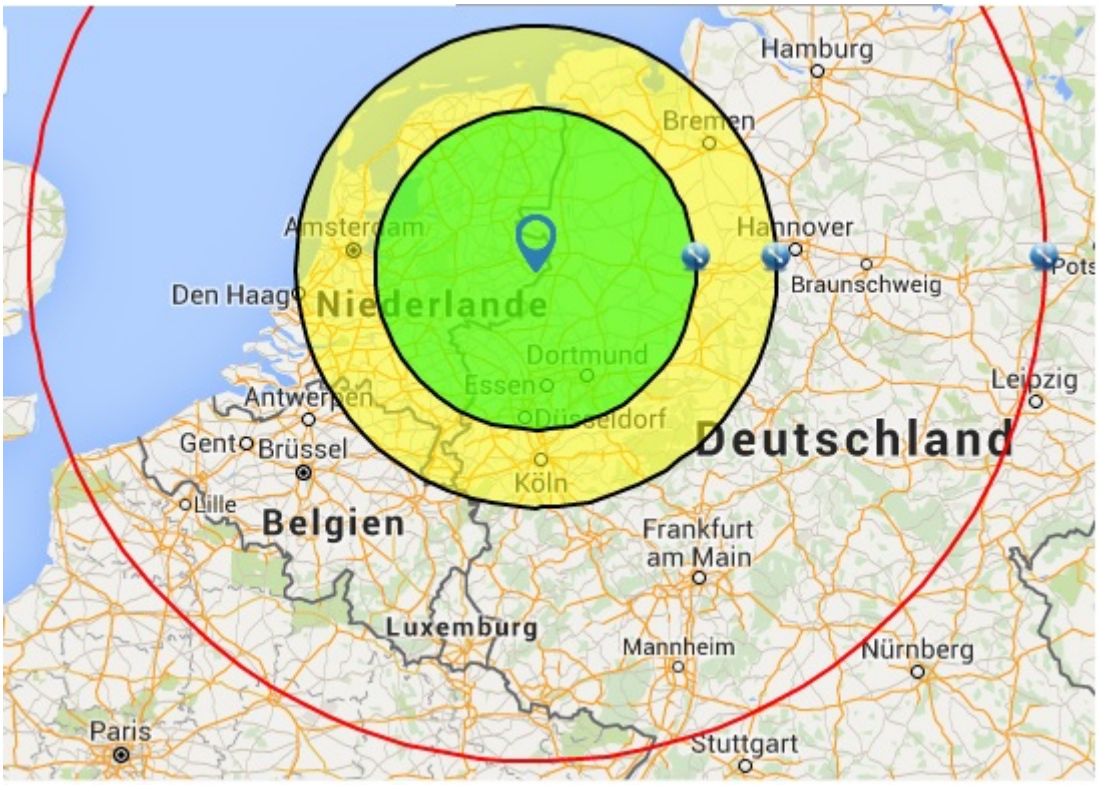
Bedankt dat u de tijd heeft genomen voor dit interview.
Hoe vond u het?
Heeft u misschien nog iets toe te voegen, of heb je misschien vragen aan mij/ons?
Vielen Dank, dass Sie sich die Zeit für diese interview genommen haben.
Wie fanden Sie das Interview?
Haben sie unter Umständen noch etwas hinzuzufügen oder Fragen an mich?

Appendix E: Intervention Range

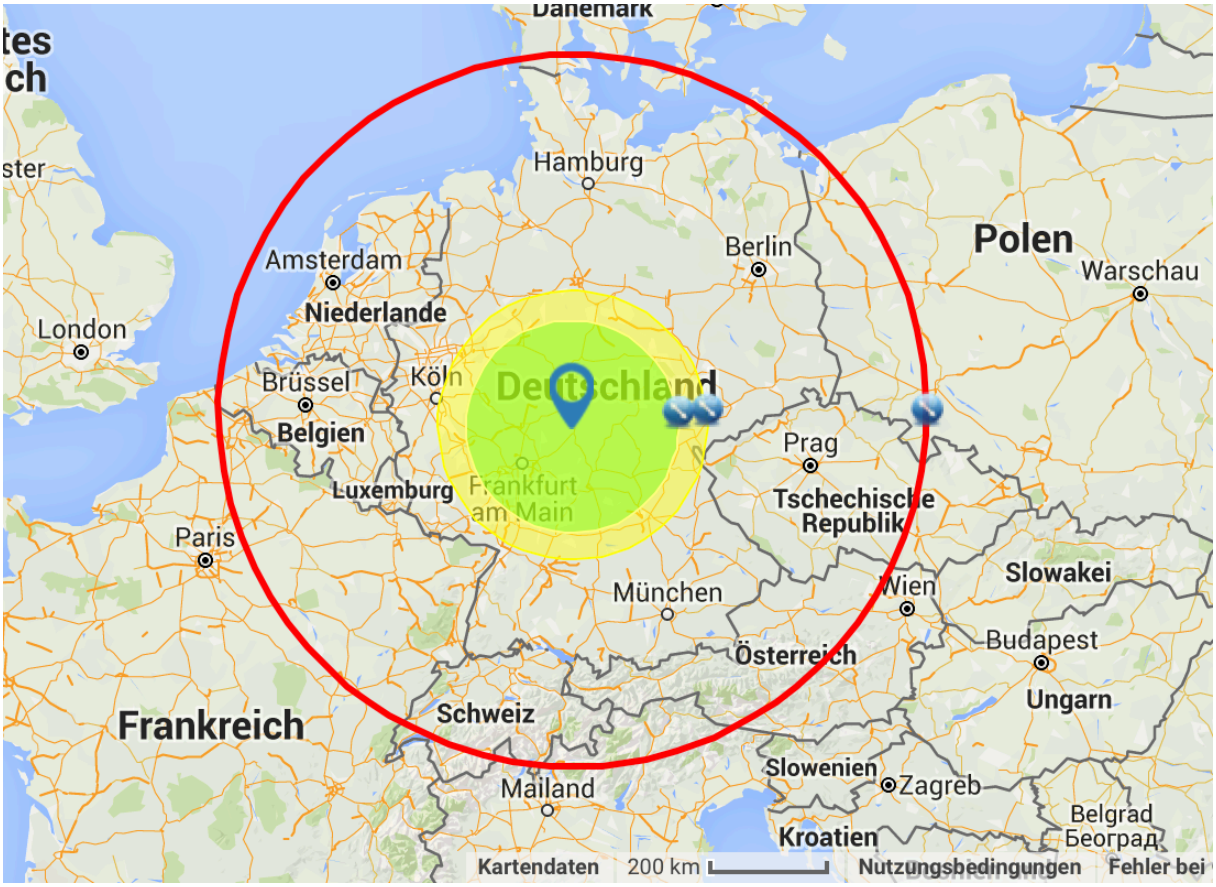
Informationen Reichweite – Deutsch (Revised):

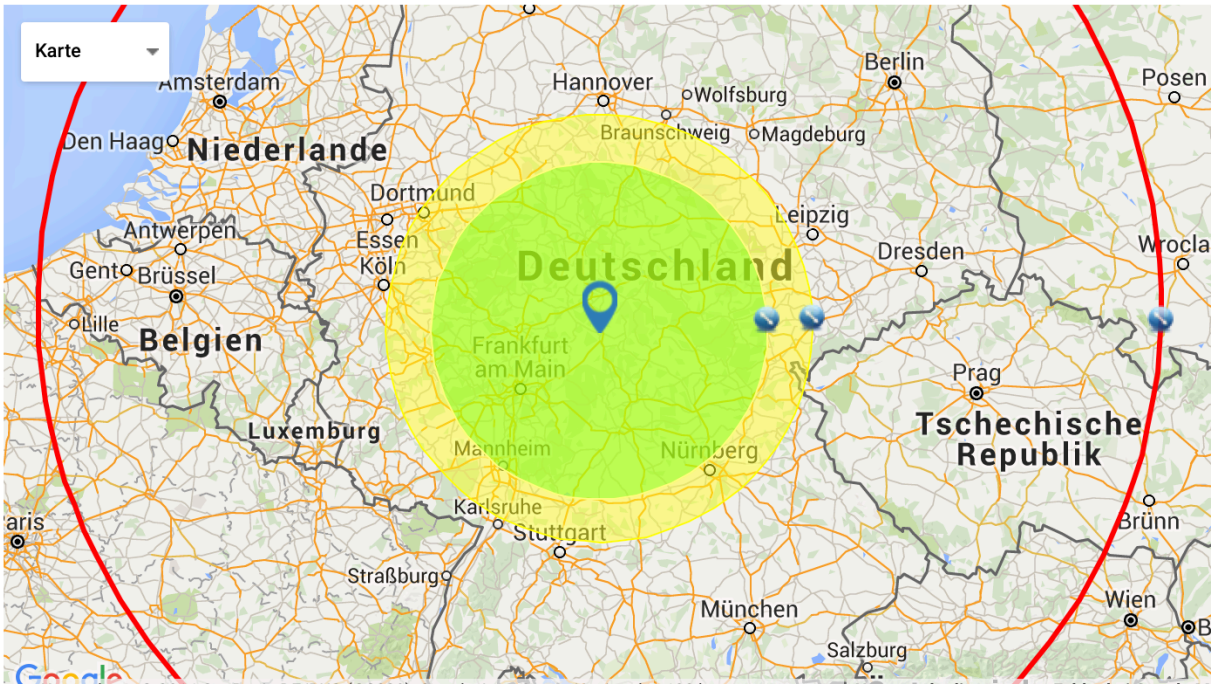
Durchschnittliche Reichweite aktueller E-Autos: 150-210 km (z.B. E-Golf: 190 km)
Modernste Technologie Reichweite: 450-550 km (z.B. Tesla Model S 90D: 550 km)
Reichweite Verlust durch Heizung oder Klimaanlage: 10-20%
Reichweite Verlust bei niedriger Temperatur (-5°C): 15-25%

Der grüne Bereich der Karte markiert mögliche Ziele, die mit durchschnittlichen modernen Elektroautos, ohne zwischendurch zu laden, erreichbar sind. Der gelbe Bereich markiert die maximale Reichweite durchschnittlicher Elektroautos. Dieser ist allerdings nicht immer ohne Ladestopp zu erreichen. Mit einer kurzen Pause von maximal 30 Minuten sind allerdings auch diese Ziele ohne Probleme erreichbar. Der rote und größte Radius markiert die Reichweite der Elektroautos mit neuster Technologie von Tesla. Ziele, die in diesem Bereich liegen, sind mit diesen Autos ohne Ladestopp erreichbar. Durchschnittliche Elektroautos (z.B. E-Golf) müssen zwischendurch einmal komplett geladen werden.
Streckenbeispiele: Enschede - Münster 68 km
Enschede - Nijmegen 113km
Enschede - Amsterdam 159 km
Enschede - Hamburg 316 km



(Abb. 1: Reichweite gemessen von der Universität Twente)





(Abb. 2&3: Reichweite gemessen von der Innenstadt Fuldas)

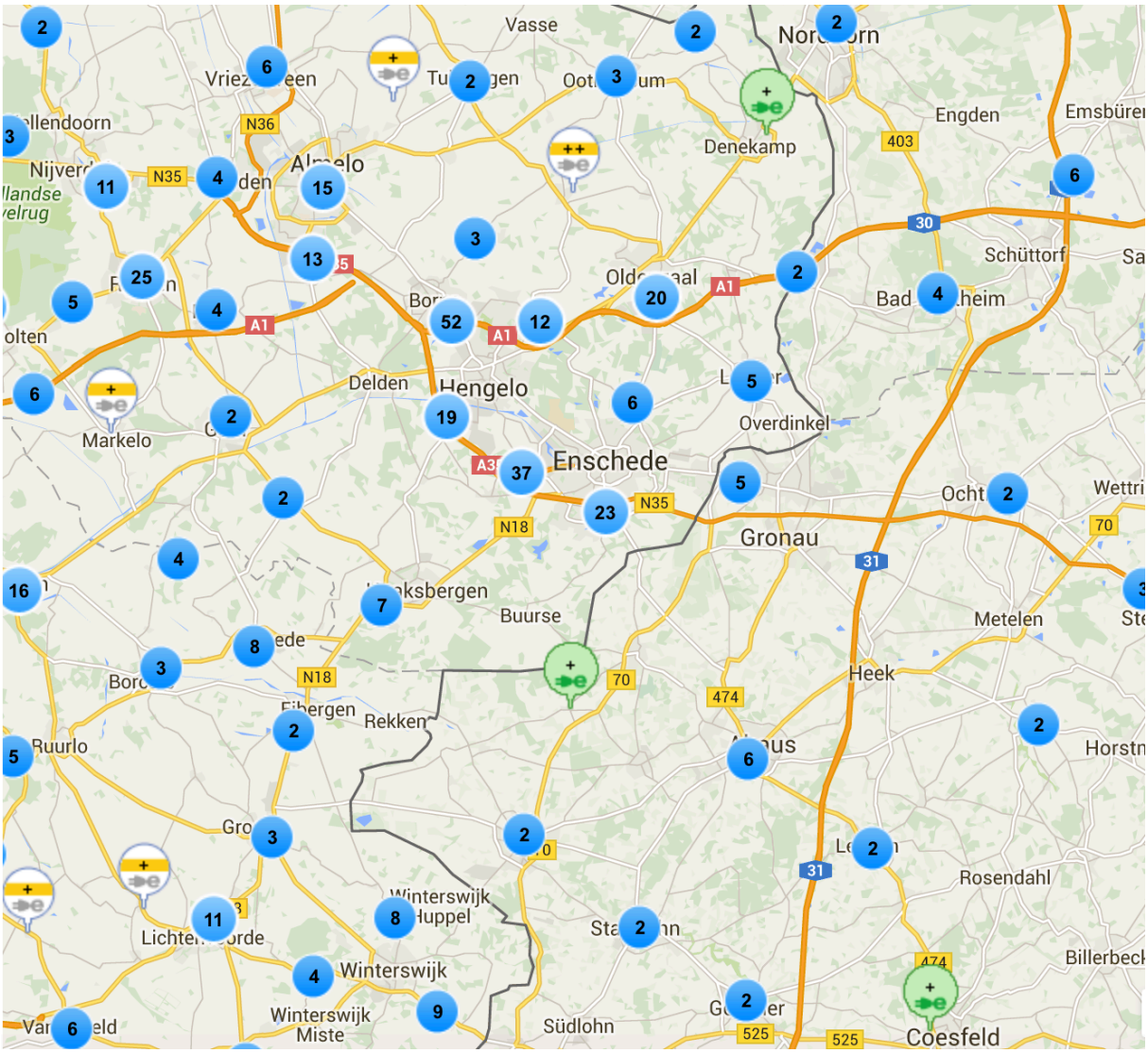
Streckenbeispiele: Fulda – Frankfurt 104km ; Fulda – Mannheim 187km ; Fulda – Nürnberg 207km ; Fulda – Berlin 460km ; Fulda – Amsterdam 494km

Appendix F: Intervention Charging

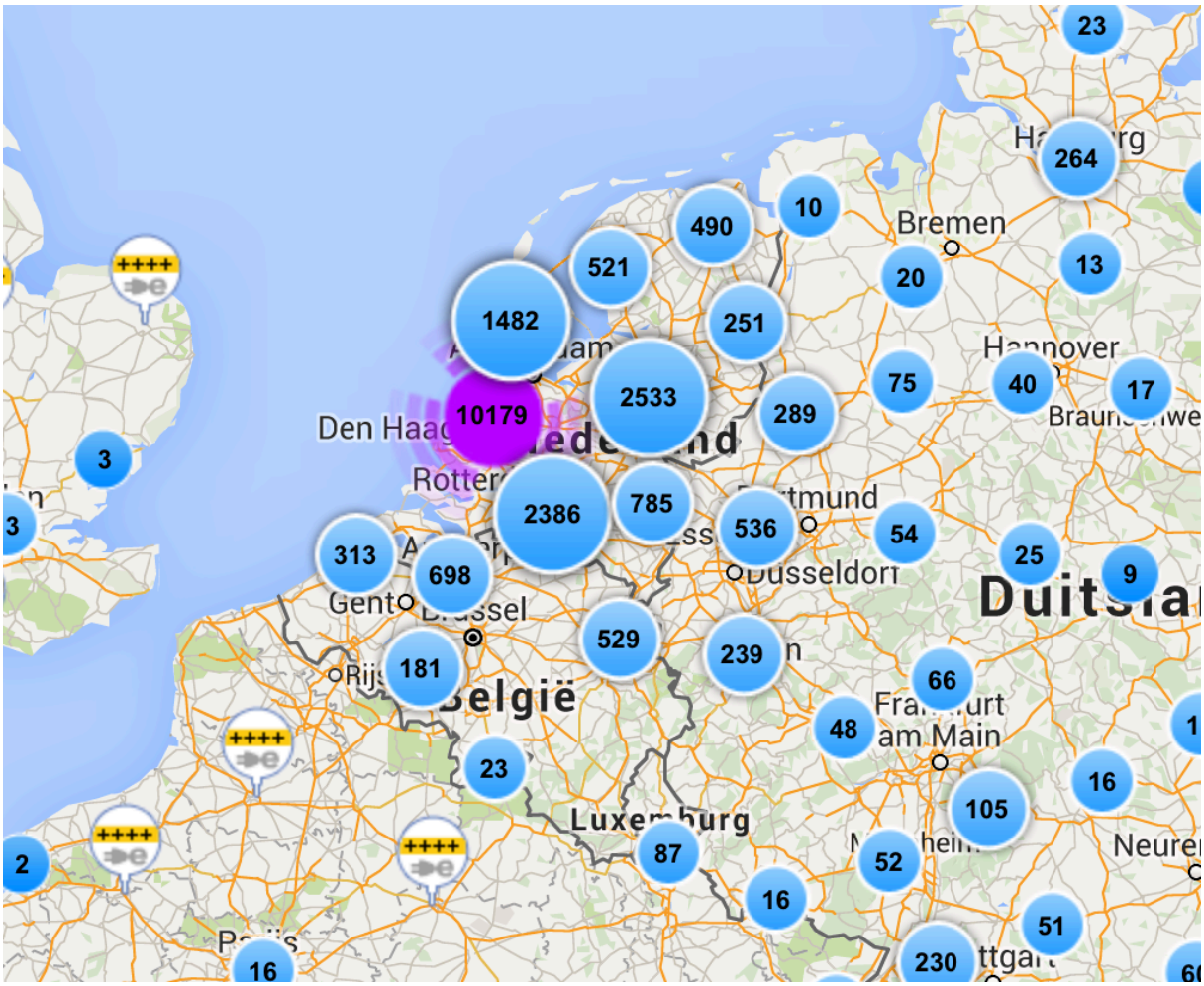
Information Aufladen – Deutsch (revised):

Auf den folgenden Seiten finden Sie einige Informationen zum Auflade-Netzwerk in den Niederlanden, Deutschland und ganz Europa, sowie zu den Kosten und der benötigten Zeit zum Aufladen.

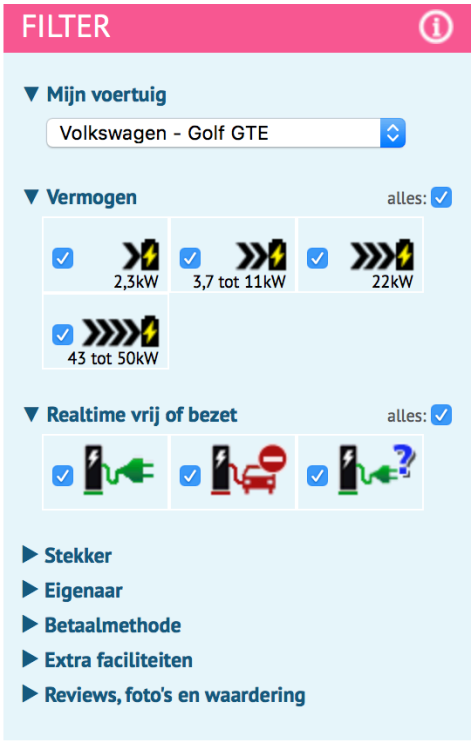
1. Hierunter finden Sie eine Karte mit Auflade-Stationen im Raum Enschede. Die Zahl innerhalb der blauen Punkte gibt an, wie viele Auflader sich im näheren Umkreis befinden. (Entnommen von www.oplaadpalen.nl, einer online Suchmaschine für Auflade-Stationen in Ihrer Nähe)

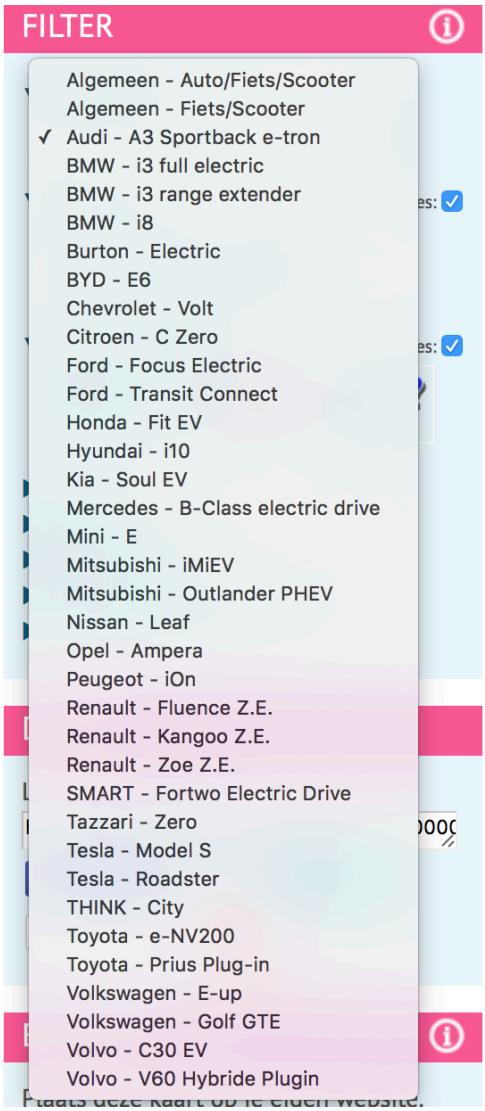


2. Hierunter finden Sie eine Karte mit Auflade-Stationen in den Niederlanden, sowie Belgien und Teilen von Deutschland. Die Zahl innerhalb der blauen und lilafarbenen Punkte gibt an, wie viele Auflader sich in der Region befinden. (www.oplaadpalen.nl)



3. Die Filterfunktion von www.oplaadpalen.nl : Suchen Sie Auflader in Ihrer Nähe, die für Ihr Auto und ihre Bedürfnisse am besten geeignet sind. Zur Auswahl stehen alle gängigen E-Auto Modelle des europäischen Marktes, alle gängigen Stecker-Systeme und Spannungsstärken, sowie eine Echtzeitangabe ob die jeweilige Station frei oder besetzt ist.





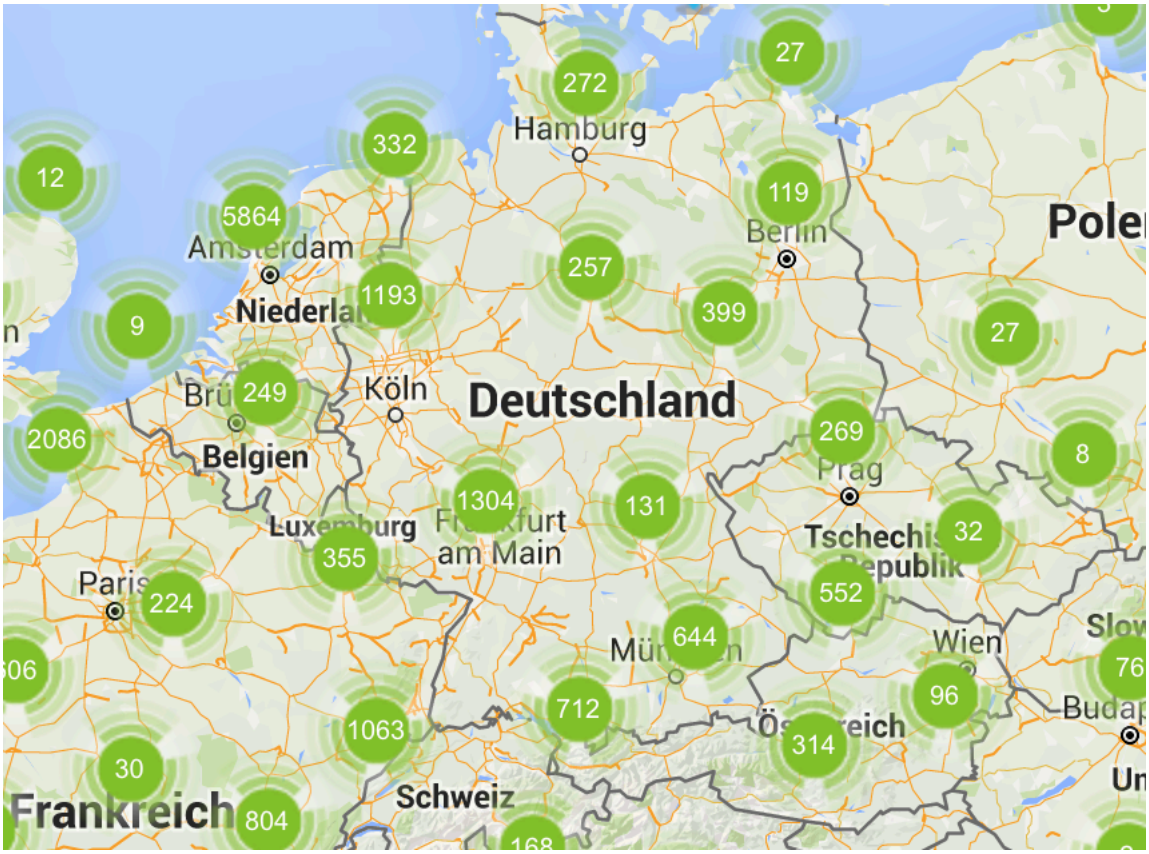
4. Auf dieser Karte finden Sie alle Supercharger-Stationen der Firma Tesla. Supercharger sind spezielle Stromtankstellen des Automobilherstellers Tesla, die für besonders schnelles Aufladen der markeneigenen Autos errichtet wurden. Die Stationen erlauben es, Tesla-Fahrzeuge innerhalb von 20 Minuten (also der durchschnittlichen Pausenzeit auf Langstreckenreisen) das Auto für weitere 200km Strecke aufzuladen.

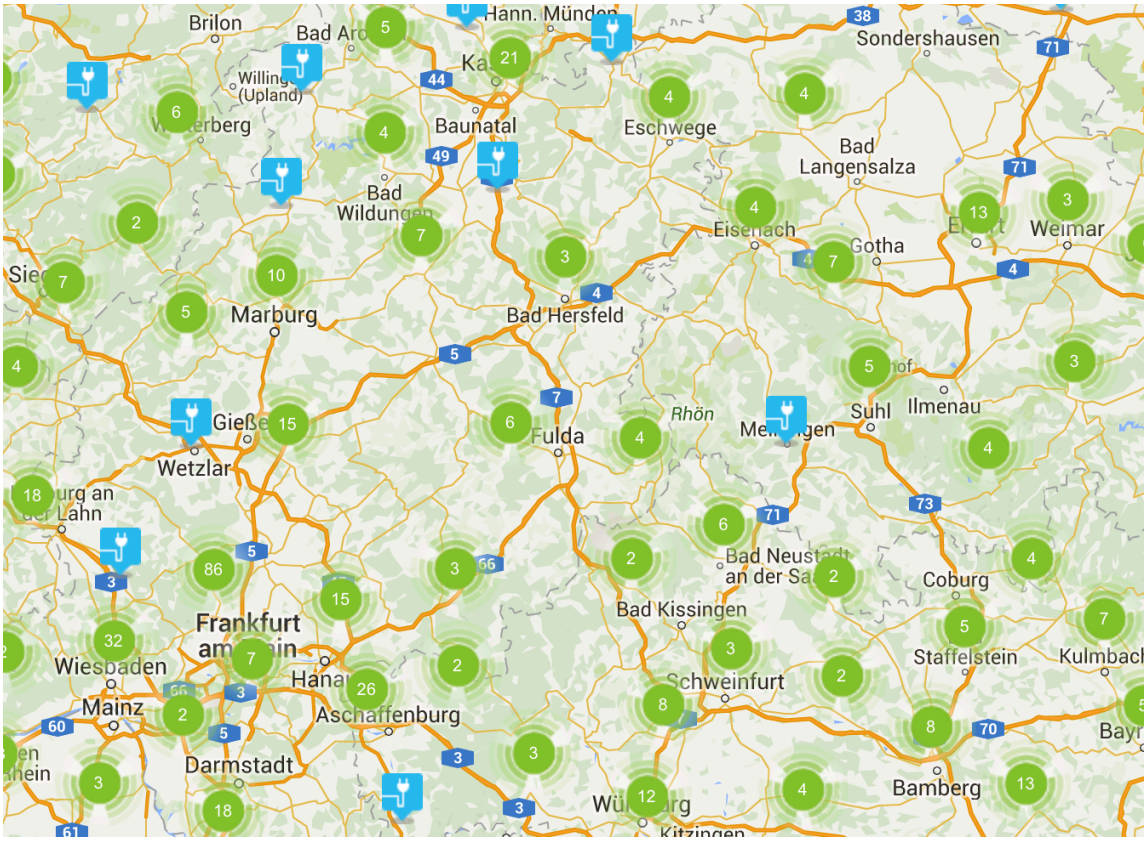
Tesla betreibt europaweit ca. 550 Ladestationen (Stand Ende 2015).
Die Benutzung aller Supercharger Stationen ist für Nutzer von Tesla Fahrzeugen kostenlos. Das kostenlose Aufladen an allen verfügbaren Supercharger Stationen wird für die Lebensdauer des Fahrzeuges mitverkauft.

5. <u>Auflade-Dauer, Infrastruktur und Kosten:</u>

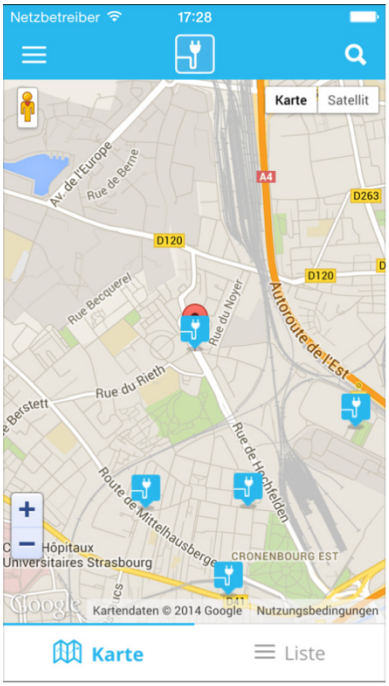
Sowohl die Leistungsfähigkeit der Ladestation als auch die technische Auslegung des jeweiligen Fahrzeuges haben Einfluss auf die Ladedauer. Unter optimalen Bedingungen können moderne Akkus innerhalb von etwa einer halben Stunde zu 80% aufgeladen werden (Schnellladung), wohingegen das hundertprozentige Aufladen deutlich mehr Zeit in Anspruch nehmen kann. Auch bei schnellladefähigen Autos kann das Aufladen unter Umständen sehr lange dauern, wenn die Stromspannung der Ladestation gering ist.
Grundsätzlich wird unterschieden zwischen dem Aufladen aus gewöhnlicher Steckdosenspannung (230V; 2,5-3,6 kWh), dem Aufladen aus Hochspannungsladern mit Starkstrom (400V; 20 kWh), und Gleichstromladesystemen wie den Tesla Supercharger Stationen (30 kWh).
Viele deutsche Elektroautos werden noch mit einem internen Ladegerät (Bordlader) mit einer Kapazität von 3,6 kWh gebaut, was zu Ladedauern von 6 bis 8 Stunden führen kann.
Neunzig Prozent dieser Ladevorgänge finden zurzeit zuhause oder am Arbeitsplatz statt. Nur etwa 10% der Auflade-Vorgänge entfallen daher auf öffentliche Stationen.
Das Installieren einer Ladestation in der eigenen Garage kostet momentan zwischen 500€ und 2000€

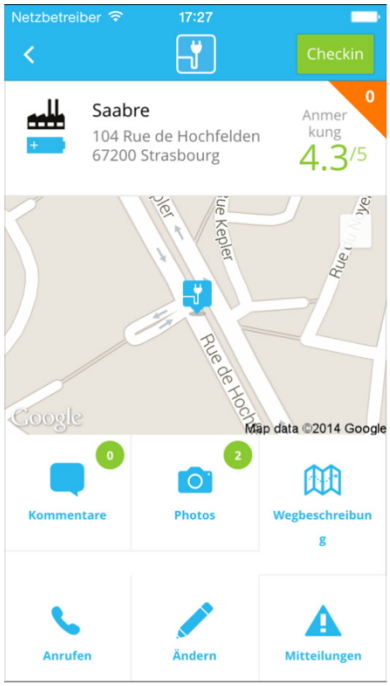
6. Zum Vergleich sehen Sie hier die Dichte des Aufladenetzwerkes in ganz Deutschland, sowie angrenzenden Ländern. Darunter finden Sie die Anzahl der Auflader in Fulda und näherer Umgebung. (Grafiken entnommen von: [www.chargemap.com)](http://www.chargemap.com)

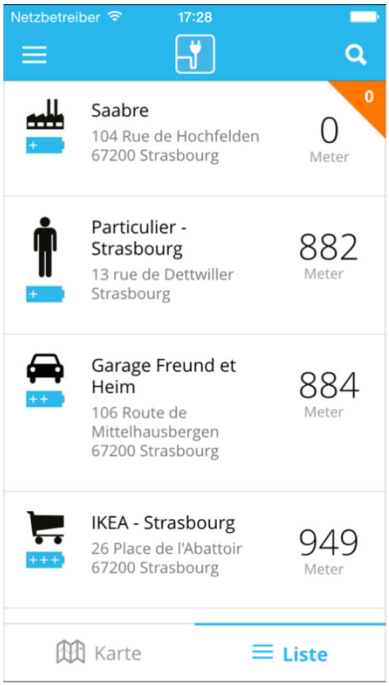


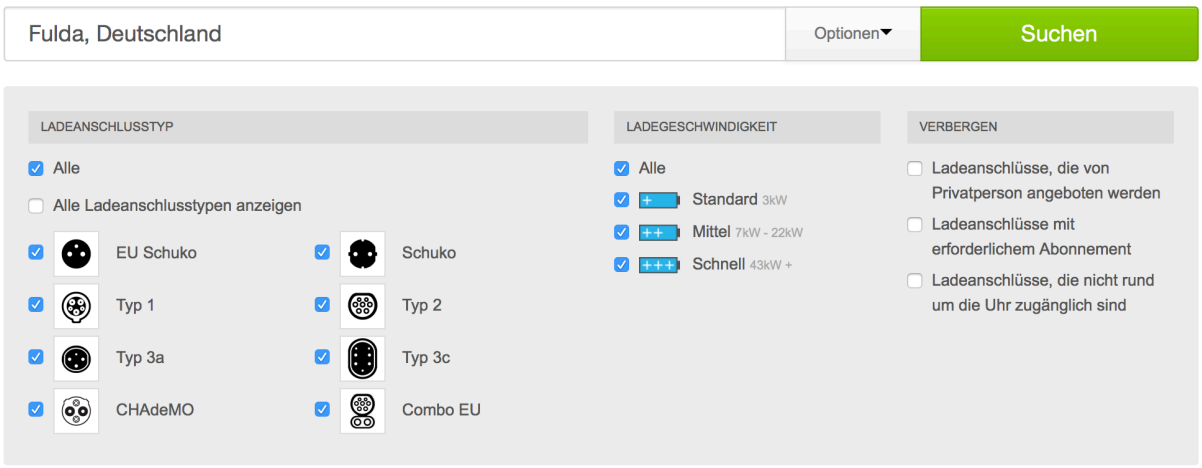


7. Hier sehen Sie Auszüge der iPhone-App sowie der Website von www.chargemap.com, die eine Übersicht über das weltweite Ladenetzwerk geben kann.









Appendix G: Coding Schema

Codes and ranges	Exemplary Topics
1. Current automobile use	
1.1 Infrequent use	Irregular use; not daily; only needs the car for certain activities
1.2 Regular use	Use of one car on a daily basis; mostly short distances
1.3 Frequent/heavy use	Long distances; vacation; leisure activities; commuting; use of two cars for different purposes
2. Perceived inconvenience of charging	
2.1 Very inconvenient	Feels very constrained by rudimentary charging network and increased charging time; feels strong loss in mobility and flexibility
2.2 Somewhat inconvenient	Is aware of drawbacks (e.g. insufficient charging network, higher time demand), but could adapt to them if necessary
2.3 No added inconvenience	EV charging is perceived as no more inconvenient than refueling; charging network is sufficient
3. Other perceived barriers for EV adoption	
3.1 Acquisition costs	Higher costs in relation to comparable CEV; contemporary EVs too expensive; not affordable with current salary; too expensive as an environmentally friendly second car
3.2 Running costs	Battery leasing costs; rising charging costs over time; concerned about supply and demand in electricity
3.3 Image and emotional components	Doesn't like the design; misses the sound of combustion engine; low desirability; doesn't want everyone to know that it is an EV
3.4 Wear and tear	Concerned about battery lifespan; What to do with the old batteries
3.5 Governmental policies	Oil- and automobile lobby are slowing down process intentionally; too many jobs in jeopardy if transition to electric mobility is undertaken; Differences in countries' policies and EV friendliness (NL-GER)
3.6 Technical difficulties	Couldn't repair anything alone; overchallenged by completely digital cockpit
3.7 Safety	Used to cars making noise and hearing them in traffic; bothered by too quiet EVs
4. Overall charging knowledge	
4.0.1 Trivial knowledge	Knows only about basic differences between charging and refueling; knows no charging locations

4.0.2 Somewhat detailed	Knows approximate time and cost difference between charging and refueling; knows some charging locations
4.0.3 In depth knowledge	Knows about different Plug-ins and electric currents; knows different charging times; knows details about different charging modes; knows many charger locations

4.1. Knowledge of charging durations

4.1.1 Trivial knowledge	Knows that charging and refueling times differ
4.1.2 Somewhat detailed	Knows that the charging time depends on different factors; knows some of those factors
4.1.3 In depth knowledge	Knows about different charging times dependent on voltage, ampere and charging mode

4.2. Knowledge of charging modes

4.2.1 Trivial knowledge	Doesn't know different charging modes exist or are in development; Thinks that chargers all use universal connections
4.2.2 Somewhat detailed	Knows different charging modes exist or are in development; knows about supercharging and/or battery swapping
4.2.3 In depth knowledge	Knows differences between different charging modes; Knows benefits and limitations of different charging modes

4.3. Knowledge of charging locations

4.3.1 Trivial knowledge	Knows about possibility of home charging; Knows that public chargers exist but hasn't seen one before
4.3.2 Somewhat detailed	Knows about some charging locations
4.3.3 In depth knowledge	Knows about different charging locations; Knows about superchargers alongside the motorway; Knows about some future developments; Knows about charging locator app/web-service

4.4 Knowledge of charging costs

4.4.1 Trivial knowledge	Knows little/nothing about costs of charging; Assumes that it is more/less expensive; Has no knowledge of how much more/less
4.4.2 Somewhat detailed	Knows how much it would cost to recharge a certain EV model
4.4.3 In depth knowledge	Has made a comparison of costs before; Has made a long-term comparison before

5. Readiness for charging adaptation (habitual changes)

5.1 Low disposition	Does not want to change habits or give up comfort; wants an EVs to be rechargeable as quickly as a CEV can be refueled

5.2 Moderate disposition	Would install a home charging system, but can't; somewhat reluctant to change habits; Waiting for better public charging network
5.3 High disposition	Would gladly install a home charging system and is able to do so; Is ready to change driving habits for the greater good

6. Purchase intentions

6.1 No intentions	Does not want to buy an EV in the distant future; does not want an EV at all
6.2 Moderate intentions	Is open to switching to an EV; could imagine buying an EV within next 10 years
6.3 Strong intentions	Wants to buy an EV soon; Wants to buy an EV as next car; has thought of purchasing EV in the past

7. Change in perceived inconvenience of charging

7.1 Very inconvenient	Feels very constrained by rudimentary charging network and increased charging time; feels strong loss in mobility and flexibility
7.2 Somewhat inconvenient	Is aware of drawbacks (e.g. insufficient charging network, higher time demand), but could adapt to them if necessary
7.3 No added inconvenience	EV charging is perceived as no more inconvenient than refueling; charging network is sufficient

8. Change in overall charging knowledge

8.1 Trivial knowledge	Knows only about basic differences between charging and refueling; knows no charging locations
8.2 Somewhat detailed knowledge	Knows approximate time and cost difference between charging and refueling; knows some charging locations
8.3 In-depth knowledge	Knows about different Plug-ins and electric currents; knows exact charging times; knows details about different charging modes; knows many charger locations

9. Change in readiness for charging adaptation

9.1 Low disposition	Does not want to change habits or give up comfort; wants an EVs to be rechargeable as quickly as a CEV can be refueled
9.2 Moderate disposition	Would install a home charging system, but can't; somewhat reluctant to change habits; Waiting for better public charging network
9.3 High disposition	Would gladly install a home charging system and is able to do so; Is ready to change driving habits for the greater good

10. Change in purchase intentions

10.1 No intentions	Does not want to buy an EV in the distant future; does not want an EV at all
10.2 Moderate intentions	Is open to switching to an EV; could imagine buying an EV within next 10 years
10.3 Strong intentions	Wants to buy an EV soon; Wants to buy an EV as next car; has thought of purchasing EV in the past

Appendix H: Preliminary personas and overview respondents per persona

Persona 1 – Daniel

- Based on 5 respondents (number 2, 3, 5, 7 & 8)
- Age ranges from 24 – 60 years (M = 33)
- All male
- Uses car rather heavily (> 15.000km p.a.) on a daily basis and for a range of leisure activities
- Educational background: Higher degree in Engineering, Telecommunications
- Believes that EVs are the future of mobility, is ready to somewhat change his habits
- Has examined public charging stations first-hand, but never drove an EV before
- Is very well informed about (electric) automobile market and follows tech-news
- Is aware of the politics connected to widespread EV adoption
- Has a very positive opinion about electric mobility, but is also very aware of its drawbacks
- Could probably handle daily commute with current range, but no chargers provided at workplace
- Feels somewhat constrained by rudimentary charging network
- Would gladly install home charging system (bus has no garage to install it in)
- Would currently like to have an EV as a second car for daily commuting, but thinks EV price is still too high for it to be "just a second car"
- Drives about 50-60km per working day, but also regularly drives somewhat longer distances
- Estimates comfortable range at 500-600km
- Has been in possession of a personally owned vehicle since he was 18, but has acquired at least two new(er) cars since then
- Has access to more than one vehicle, but only personally owns one.
- Perceives his car somewhat as an 'extension of his personality'
- Feels a strong emotional component towards his car (identifies strongly with the type of car that he drives)
- Could admittedly afford an electric vehicle at this time and certainly wants to buy one within the next 10 years, but is still waiting for more matured (better engineered) technology
- Doesn't want to give up the freedom of 'nearly unlimited range', which CEVs have
- Anticipates more governmental/political incentives before "making that step"

1. Current automobile use: heavy/frequent
2. Perceived inconvenience of charging: somewhat inconvenient
3. Other barriers: Acquisition cost, running cost, image and emotional components, wear and tear, safety, policy and politics
4. EV charging knowledge: in depth
5. EV charging experience: first hand
6. Readiness for adaptation (habitual changes): moderate
7. Purchase intentions: high intentions
8. Change in perceived inconvenience: remains somewhat inconvenient
9. Change in EV charging knowledge: remains in-depth (some added knowledge)
10. Change in readiness for adaptation: remains moderate (due to housing situation)
11. Change in purchase intentions: remain high

Change of attitude after intervention: Unchanged. Still very positive opinion. Wants to buy an EV within the next 10 years. Now possibly sooner than expected.

Persona 2 – Maren

- Based on 3 respondents (number 1, 4 & 6)
- Age ranges from 23 – 50 years (M = 32)
- All female
- Educational background: Apprenticeship in Nursing, Physiotherapy or higher education in Health Sciences
- Is not particularly interested in technical aspects of cars, has rather superficial knowledge
- Once rode along in an EV while carpooling, has some first-hand experience
- Primary source of information about cars is a family member
- Likes the idea of electric mobility, but wishes that EVs looked 'more like regular cars and not like spaceships' (image)
- Could easily handle her daily commute with current EV range, but is waiting for more sophisticated charging network
- Would charge EV primarily at home, and could imagine installing a home charging system in the future (has an own garage or parking spot)
- Would be ready to change some of her habits
- Uses car regularly (between 5.000km and 15.000km p.a.) but not necessarily on a daily basis; also sometimes uses other forms of transport (carpooling, public transport, bike)
- Drives about 10-20km per working day, only occasionally longer distances.
- Has been in possession of a personally owned vehicle since she was 18, has owned that vehicle ever since (or uses her vehicles for a long time; very infrequently purchases a different or new model)
- Has access to one vehicle
- Would enjoy some of the benefits of driving an EV (privileged parking spots, free charging at some stations, tax-exemption)
-
- Current automobile use: regular
- Perceived inconvenience of charging: very inconvenient
- Other barriers: Acquisition cost, running cost, image and emotional components, technical difficulties
- EV charging knowledge: trivial
- EV charging experience: first hand
- Readiness for adaptation (habitual changes): low disposition
- Purchase intentions: moderate
- Change in perceived inconvenience: somewhat inconvenient (increase)
- Change in EV charging knowledge: somewhat detailed (did not remember 100% of the facts) (increase)
- Change in readiness for adaptation: moderate disposition (increase)
- Change in purchase intentions: remains moderate

- Post intervention change: Positively surprised by information presented. More positive than before: But could only barely afford an EV, and doesn't value it enough to make such an investment at this time

Appendix I: Original and translated interview quotes

Variable	Original German quote	Translated English quote
2	"Ja aber, wenn ich dann halt doch mal einen Ausflug nach München oder so machen will und ich müsste da zwischendurch ständig anhalten und warten bis das Auto wieder voll ist… Das würde mich schon echt aufregen. Da hätte ich keinen Bock drauf"	*"If, for example, I would want to take a trip to Munich or so, and I would have to take at least two hour-long breaks in between… That would really bother me"*
	"Naja, ist klar. Es ist geht halt alles nicht so schnell wie an der Tanke. Es ist halt ein Akku. Irgendwie muss man das dann einplanen, aber ich denke das geht schon klar. Ich könnte ja locker an der Arbeit auftanken. Das Hauptproblem ist wirklich, dass ich mir zuhause nicht so ein Ding einbauen kann."	*"Sure, it's not as convenient as just refueling at a gas station. It takes longer and you have to plan around it somehow. (…) but the main Problem is really that I couldn't charge it at home."*
3	"Ich finde halt auch das Design oft echt nicht so geil. Zum Beispiel der i3… Man kann halt gleich sehen, dass das ein Elektroauto ist. Ich finde die sehen einfach zu spacig aus. Ich würde mir wünschen, dass die einfach wie ganz normale Autos aussehen würden und nicht jeder gleich sehen würde: 'oh guck mal, die fährt ein Elektroauto'"	*"I think the design is unattractive. For example, with the i3: You can immediately see that it is an EV, and I don't really like that. I wish it would look more like a regular car and not so… spaceship-like"*
	"Ich glaube halt auch, dass wenn mehr Leute Elektroautos fahren würden, dann müsste man sich über ganz andere Sachen Sorgen machen. Zum Beispiel das mit den Fahrgeräuschen. Ich erinnere mich, dass mal ein Elektroauto direkt neben mir vorbeigefahren ist und da hat man nix gehört. Ich hab das nur durch den Windstoß mitbekommen und mich echt mega erschrocken. Ich glaub die meisten Leute rechnen da auch überhaupt nicht mit, weißt du? Seit über einem Jahrhundert hört man Autos auch akustisch kommen und die Leute sind doch einfach gewöhnt daran. Also ich kann mir vorstellen, dass das auch	*"I think if more people drove EVs we would have to worry about other things as well, especially safety. Because you can't hear EVs coming. Once an EV passed me about 2 meters away and it really startled me. I think most people are not prepared for that. You can hear combustion vehicles coming, but not EVs. I could imagine that lots of people do not recon with that and that accidents may increase"*

	zu mehr Unfällen führen wird, weil die Leute das einfach noch nicht auf dem Schirm haben.“	
4.1	„Ich dachte jetzt, man steckert es einfach in die Steckdose, oder?“	*Well I think you just plug it into the normal outlet, don't you?*
	„Ach, da gibt's ganz verschiedene Sachen. Es gibt Schnellladen, Impuls-Laden wie beim Handy gibt's auch schon... Voll aufladen natürlich. Das macht man am Besten zu hause. ... Ja und die Anschlüsse sind eigentlich idiotensicher. Da kannst du nix verkehrt machen. Das sind alles diese Poka-Yoke Systeme von Toyota, wenn ich mich richtig erinnere.“	*“There are different charging modes, so it all depends. There's quick-charging, impulse-charging, full charging, and who knows what else. And the plug-ins are usually Poka-Yoke-Systems. Simply plug it in and you're finished. So, everything is fool-proof basically*
4.2	„Ja um die Frage zu beantworten müsste ich jetzt wissen wie lange so eine komplette Ladung dauert. Das sind einfach zu viele Faktoren, die ich noch nicht kenne“	*“(...) I would have to know how long it takes to charge it completely, in order to schedule it. But those are so many factors that I don't know yet”*
	„Ich glaub das Schnellladen dauert nur so 45 Minuten oder so was. Es geht auf jeden Fall schnell. Sollte nicht länger dauern als eine Pause auf einer längeren Strecke... Also ein bisschen länger dauert es schon, aber ich denke 45 Minuten sind verschmerzbar“	*“I think the quick-charging takes about 45 minutes or something like that, so you have to take a little bit longer break than usual”*
4.3	„Naja zuhause geht es auf jeden Fall, aber von was ich da von dem einen Kollegen gehört habe dauert das wohl ewig. Der hat den Tesla da abends an die Steckdose gehangen und als der morgens losfahren wollte... Das war wohl einfach lachhaft wie viel Strom der nur aufgeladen hatte. Also es dauert wohl mega lange um das Auto komplett vollzuladen“	*“I know it can be done at home, but I can imagine it would take forever to charge the car fully. (...) The battery must hold a lot of electricity, and I think that would take very long”*
	„Naja an der Arbeit geht's halt. Ich glaube manche Parkhäuser in (Heimatstadt) bieten das auch schon an. ... Ja und dann ist noch einer hier in der Nähe. Direkt an der (Name) Schule ist noch einer. Gut, und zuhause natürlich, wenn das geht“	*“Well, I could charge at work. Some car parks here also offer chargers. Then there's one quite close to here near the (Name) school. (...) and at home of course”*

5	„Ich glaube da sind viele Leute einfach zu faul für. Ich wäre es auf jeden Fall“	*“I think many people are just to lazy to do that (adapt). I know I am.”*
	„Ja, Totschlagargument ist halt wie gesagt das mit der Ladestation zuhause. Ohne das Ding kannste das komplett knicken“	*“The knockout-argument was definitely charging problem at home. Forget it, it’s basically impossible (…) without an own parking space”*
6	„Ja, also ich denk schon. Bis ich mir dann mal wieder ein Auto kaufe wird sich mit Sicherheit auch einiges getan haben. Die haben ja jetzt schon große Fortschritte mit der Reichweite gemacht und wenn ich mir die 380km von dem neuen Tesla angucke... Also wenn das bald massentauglich ist und die anderen Hersteller mitziehen, dann wird das nächste Auto wahrscheinlich schon ein Elektroauto“	*“Well, until I’m ready to buy my next car some things will have changed, I am sure. (…) The next car will probably be an EV”*
	„Also es hat mich eher darin bestätigt, dass ich noch ein paar Jahre warten sollte bis sich die Technik noch ein bisschen weiterentwickelt hat“	*“I will probably wait for a couple more years until everything is a little further developed”*
7	„Ich bin echt überrascht wie gut ausgebaut das alles jetzt schon ist und wie weit sich die Technik entwickelt hat. Macht die ganze Sache ehrlich gesagt nochmal eine ganze Ecke attraktiver. Sieht so aus als könnte man in den Niederlanden schon gut mit einem Elektroauto auskommen, und ich denke mal das wird in Deutschland auch nicht mehr lange dauern können.“	*“I’m surprised how far and how good everything has developed in these last years. It does make the whole EV thing more attractive for me. It looks like you could really get by with what is already available”*
	„Am Besten hat mir diese Suchfunktion gefallen. Das finde ich echt ne richtig gute Idee... Und ich hatte keine Ahnung, dass es so was überhaupt gibt. Aber finde ich prima“	*“I really like the search-function where the chargers are located. I think that is a good and sensible idea. And I had no idea such a thing existed”*
8	„Die Dinger sind ja doch recht erschwinglich. Ich hätte mit mehr gerechnet um ehrlich zu sein. Aber zwischen 500€ und 2000€ finde ich echt fair.“	*“They are actually quite affordable. Between 500 and 2000€ seems fair to me. I would have thought that they are much more expensive.”*
	„Das Netz ist sogar jetzt schon dichter als ich dachte... Aber man sieht schon krasse regionale Unterschiede. In den	*“The network is actually denser than I had expected, but there are still quite big regional differences. (…) and it*

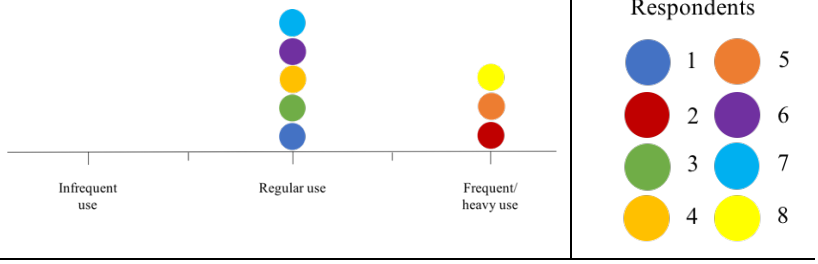
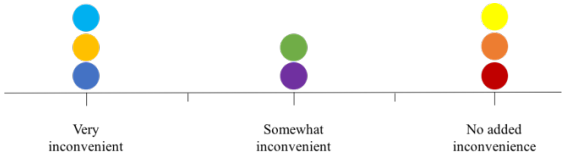
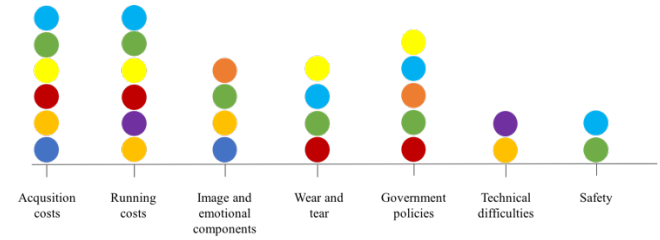
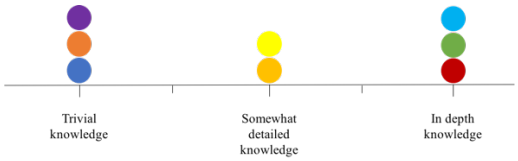
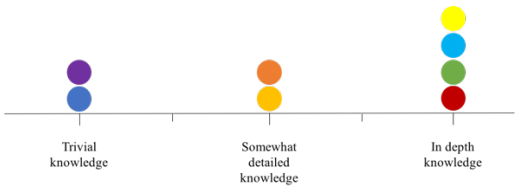
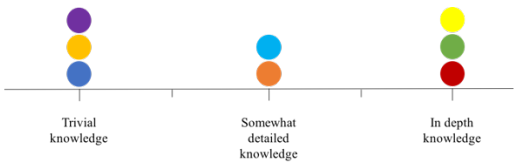
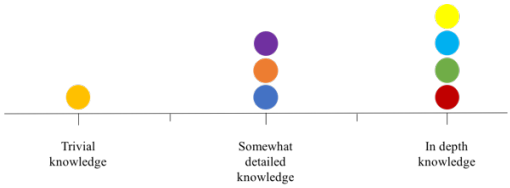
	Niederlanden kommt man ja prima mit einem Elektroauto aus, so wie das aussieht. Hier in (Heimatstadt) sieht das schon ein bisschen anders aus. Da kannst du das nur machen, wenn du das Ding ausschließlich zuhause auflädst... Aber zuhause aufladen musst du wahrscheinlich immer.“	*only works well if you charge the EV at home”*
9	„Das dauert noch ein paar Jahre, bis ich darüber mal nachdenke. Ich hab dir ja gesagt, was da für mich die K.O.-Kriterien sind, und bis die behoben sind, werde ich da auch nicht ernsthaft drüber nachdenken.“	*“It will take a few more years until I can seriously think about that. I told you what my K.O.-criteria are… and I won’t seriously think about purchasing until that is fixed”*
	„(Würdest du bei deinem folgenden Autokauf darüber nachdenken ein Elektroauto zu kaufen?) Ich würde mich jetzt auch noch mal vor dem nächsten Autokauf definitiv noch mal ein bisschen genauer informieren und gucken in wie fern da ein Elektroauto in Frage kommt.“	*“(Would you rather want to buy an EV now?) I would definitely inform myself better about EVs before buying my next car, in order to see whether an EV would come into question”*

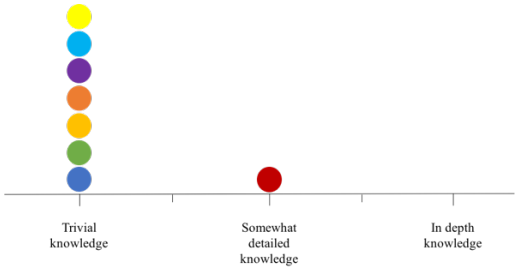
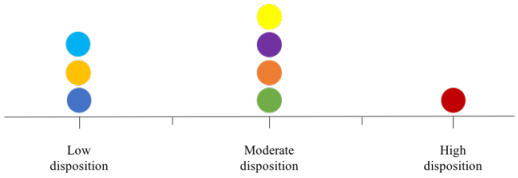
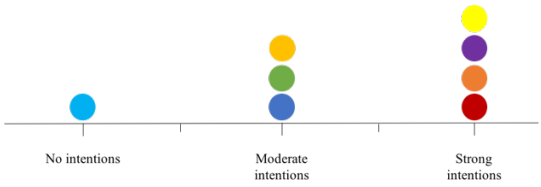
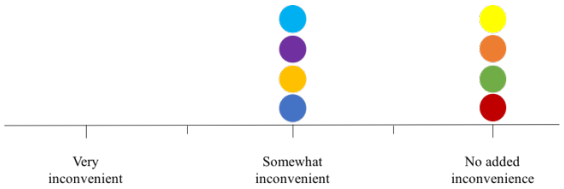
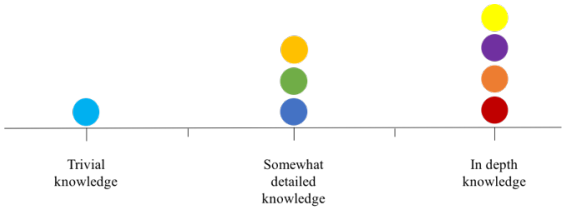
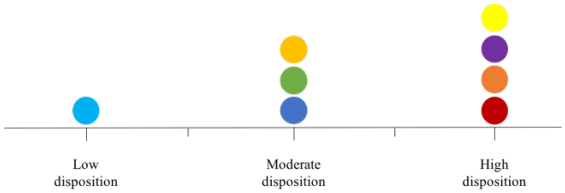
Appendix J: Percentages of respondents sharing variables

Variable	Range	Percentage
1. Current automobile use	Infrequent use	0 %
	Regular use	62,5 %
	Frequent/heavy use	37,5 %
2. Perceived inconvenience of charging	Very inconvenient	37,5 %
	Somewhat inconvenient	25 %
	No added inconvenience	37,5 %
3. Other perceived barriers of EV adoption	Acquisition costs	75 %
	Running costs	75 %
	Image and emotional components	50 %
	Wear and tear	50 %
	Government policies	62,5 %
	Technical difficulties	25 %
	Safety	25 %
4.0 Overall charging knowledge	Trivial knowledge	37,5 %
	Somewhat detailed knowledge	25 %
	In depth knowledge	37,5 %
4.1 Knowledge of charging durations	Trivial knowledge	25 %
	Somewhat detailed knowledge	25%
	In depth knowledge	50%
4.2 Knowledge of charging modes	Trivial knowledge	37,5 %
	Somewhat detailed knowledge	25 %
	In depth knowledge	37,5 %
4.3 Knowledge of charging locations	Trivial knowledge	12,5 %
	Somewhat detailed knowledge	37,5 %
	In depth knowledge	50 %
4.4 Knowledge of charging costs	Trivial knowledge	87,5 %
	Somewhat detailed knowledge	12,5 %
	In depth knowledge	0 %
5. Readiness for charging adaptation (habitual changes)	Low disposition	37,5 %
	Moderate disposition	50 %
	High disposition	12,5 %
6. Purchase intentions	No intentions	12,5 %
	Moderate intentions	37,5 %
	Strong intentions	50 %
7. Change in perceived inconvenience of charging	Very inconvenient	0 %
	Somewhat inconvenient	50 %
	No added inconvenience	50 %
8. Change in readiness for charging adaptation	Low disposition	12,5 %
	Moderate disposition	37,5 %

	High disposition	50 %
9. Change in purchase intentions	No intentions	12,5 %
	Moderate intentions	37,5 %
	Strong intentions	50 %

Appendix K: Mapping of the respondents on the distinguishing variables

Variable	Mapping of the respondents
1. Current automobile use	
2. Perceived inconvenience of charging	
3. Other perceived barriers of EV adoption	
4.0 Overall charging knowledge	
4.1 Knowledge of charging durations	
4.2 Knowledge of charging modes	
4.3 Knowledge of charging locations	

4.4 Knowledge of charging costs	
5. Readiness for charging adaptation (habitual changes)	
6. Purchase intentions	
7. Change in perceived inconvenience of charging	
8. Change in overall charging knowledge	
9. Change in readiness for charging adaptation	
10. Change in purchase intentions