SMART
COMMERCIAL
BUILDING

Consortium Study

Smart Parking & Charging Campus

A Consortium Study of the Center Smart Commercial Building at RWTH Aachen Campus

fir at RWTH Aachen University

Content

Acknowledgements

We would like to take this opportunity to thank you for your cooperation in the context of this consortium study.

In virtual workshops as well as on-site meetings, we were able to conduct exciting discussions and discuss valuable content together. The exchange among each other, whether virtually or on-site, in the workshop formats or accompanying lectures have enriched this study.

In the future, we will also be at your disposal for any new innovation projects and look forward to hearing from you..

In particular, the Living Lab in the form of the intelligently connected charging infrastructure as part of a holistic building platform is available on request for demonstration purposes of any kind.

Introduction

Motivation

Electromobility is gaining increasing attention and acceptance among the population in Germany. Automobile manufacturers have recognized this and have been launching various new models with increasing driving ranges in different price segments. Along with users' desire for a vehicle with a long range and a low price, the need exists to secure access to charging infrastructure. Currently, the vast majority of charging events still takes place at private locations. These include private homes, underground garages and company parking lots. Increasing environmental awareness among companies and their employees, as well as government subsidies for electric mobility, are increasing the pressure to expand the charging infrastructure. Integrated, cross-company solutions are currently only available in exceptional cases. Therefore, this study marks the start of an innovative project at the RWTH Aachen Campus to make it as easy as possible for companies to get started with electromobility while at the same time steering into the „post-app era".

Living Lab
Smart Parking & Charging Campus

Within the framework of this consortium study, a dedicated charging infrastructure was established and operated as part of our Living Lab. Various charging technologies for electric vehicles were installed on the RWTH Campus Melaten and made available for testing purposes. In doing so, we are addressing a variety of challenges:

- Early expansion and early testing of state-of-the-art charging infrastructure
- Successive expansion of digital services and their testing within our holistic building platform
- Increasing convenience and contributing to intelligent mobility on campus
- If interested, integration and live operation of novel business models

Objective of the Study

The objective of the study is to provide a detailed access to knowledge on the topic of Smart Parking & Charging. The following topics have been examined in depth and developed with the consortium through integrative workshop formats and processed results:

- Development of a methodology focused on user experience and intuitive customer journey to apply a holistic parking management system and to implement partial aspects of the company-specific industry with a focus on existing and relevant stakeholders
- Benchmarking of currently available technologies and future trends
- Development of overarching business models and market opportunities based on a user survey and trend analysis of the Smart Parking and Charging environment.

Partners and Implementing Institutions

This study is led by the following institutions and was carried out in cooperation with the consortium partners.
Metropolitan Cities MC GmbH (MC), a spin-off and subsidiary of the Institute of Industrial Management at RWTH Aachen University (FIR at RWTH Aachen University), is leading this study together with the FIR at RWTH Aachen University. Thus, there is a seamless link between scientifically based research and practice combined with a user-centered orientation.

The corresponding center, whose thematic focus encompasses the subject of the study, is the Center Smart Commercial Building, which is an acknowledged point of contact for the real estate industry and for equipment suppliers, service providers, and software companies operating in this sector. The Center makes a significant contribution to enabling these companies to exploit the opportunities of digital transformation for themselves and to increase the value of real estate. The smart commercial building of the future will become uncompromisingly sustainable through digitization.

Buildings are taking on a new significance in future urban systems and must be redesigned in terms of their potential use cases and the productivity that can be achieved. This is equally important to the relevant stakeholders from investors and architects to technology suppliers and end users.

The motivation for founding the Smart Commercial Building Center is based on the fact that in the future, a building's potential use cases and productivity will be defined by its software and

no longer just by its design and location. Artificial intelligence will enable the “learning building” and communication and interaction with the user will be placed on a new technological footing. The Smart Commercial Building Center intends to think ahead and develop prototypes in these areas in order to eventually arrive at marketable solutions.

To this end, institutes of the RWTH Aachen University and enrolled companies conduct interdisciplinary research and design the real estate of the future. Demonstrators support the transition to scalable solutions. The center is also responsible for testing the function and interoperability of Building IoT (Internet of Things), preparing technology reports and promoting standardization.

The Smart Commercial Building Center serves as a unique focal point for the knowledge required to design future usage models for commercial real estate. This also includes the use of AI and new possibilities for human-machine interaction. The Center defines the necessary foundations and standards and imparts the relevant application knowledge.

This consortium study is being carried out in collaboration with the Business Transformation department of FIR at RWTH Aachen University. To empower organizational change, the Business Transformation team aims at enabling organizations to position themselves in a digital economy and gain the required skillset to succeed in such an environment. In an increasingly digitalized world, the ability to innovate and change are key success factors. To achieve this, they must learn new skills regarding the use of data and new forms of collaboration within platform economies. Practice shows that these skills are still under-developed and numerous innovation and transformation projects fail. Against this backdrop, the Business Transformation area addresses the question of which principles companies must adapt to shape the process of change in their digital transformation.

Thus, the concrete added value of the interdisciplinary management of the study can be seen from the points above. Jointly with an interdisciplinary consortium, the study addresses relevant questions on the topic of Smart Parking and Charging and develops a guideline for intelligent parking management with the integration of a smart charging infrastructure.

Procedure and Methodology of the Consortium Study

The consortium project ran for about 8 months and included five one-day meetings as well as individual associated workshops. In three phases, the main findings regarding user experience, technology benchmarking and business models were developed.

Phase 1 – User Experience:
The requirements of the consortium partners in terms of business models, technologies and user experience are recorded and a common objective is developed. MC identifies the customer journey and user experiences for the individual stakeholder groups (e.g. retailers, car parks, districts, etc.). For this purpose, actual and target user experiences are developed and compared with the requirements and the target image (focus on deriving personas).

Phase 2 – Technology:
In this phase, a benchmark of the currently available technologies from the field of Smart Parking & Charging and the comparison with the findings from the ongoing developments at the Living Lab was carried out.

Phase 3 – Business Model:
Based on the findings, overarching business models were developed for the existing stakeholder groups and prepared for possible transfer into practice.

Over the course of the consortium's initial meeting, various questions were discussed as guiding principles of the study. Below is an overview of these questions and their priority within the study.

Overview of the Identified Issues

What can the **customer journey** of the parking and charging process be described and which user groups are involved?

How should an overarching **parking management system** be designed and how can it be integrated into the digital infrastructure? **8** **Tech**	How can **charging infrastructure** efficiently be retrofitted in parking garages? **4** **Tech**
Which **safety requirements** must be taken into account when installing and operating charging infrastructure – especially regarding fire protection? **4** **Tech**	How can the **status of parking spaces be** monitored and reliably prepared for a consumer? **5** **UX**
How should a **fully automated billing process for EV** charging be designed? **6** **GeMo**	Which digital optimization potential can be capitalized for the connection of charging infrastructure to the power grid? **4** **GeMo**

Figure 1: Overview of questions

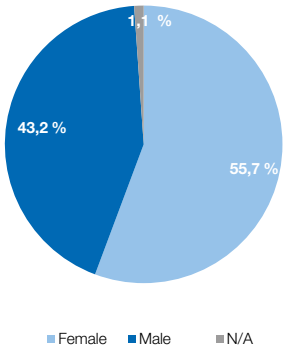
User Group and Survey Results

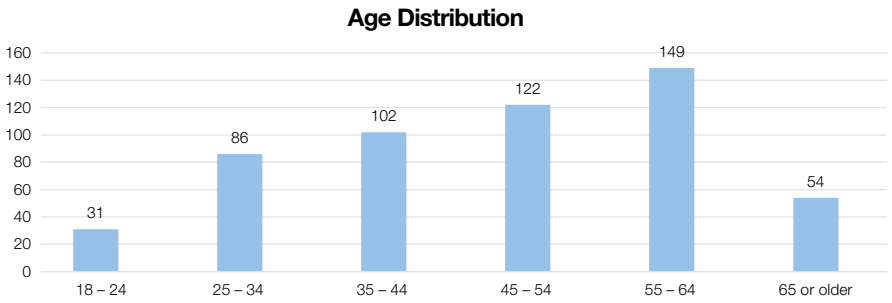
Evaluation of the Survey

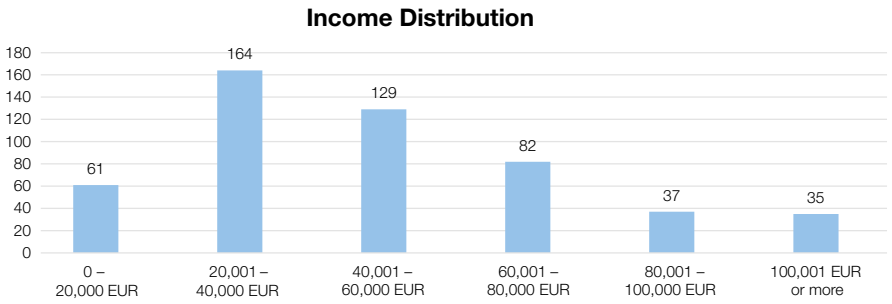
In the following section, important graphics relating to the evaluation of the survey conducted as part of the consortium study are listed, explained and placed in a holistic context. The individual graphics are provided with key takeaway boxes.

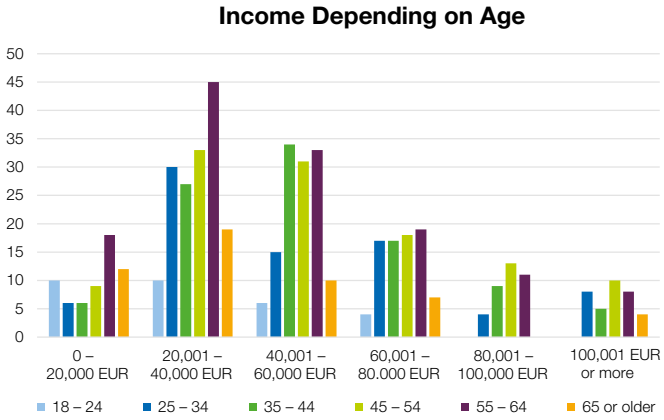
Additional text modules enable a comprehensive understanding of the evaluations and serve as a basis for the resulting recommendations for action.

General Analyses







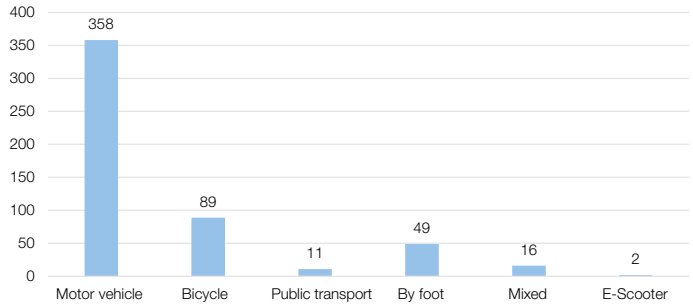


Significant correlation?	**Nein**
Correlation coefficient	**- 0,044**
Significance level	**-**
N	**508**

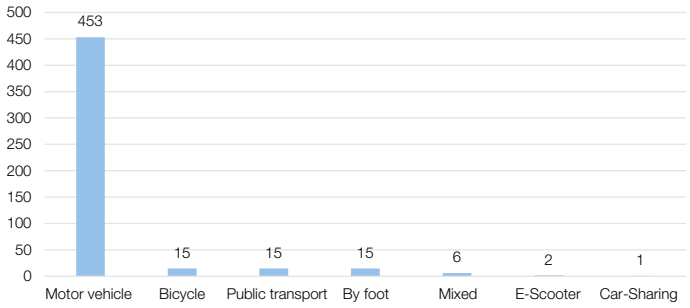
Coefficient negative, since Yes was coded with rank 1 and No was coded with rank 2 (!)

In this survey, there is **no correlation between age and income** for all respondents.

Mobility Type Leisure Routes

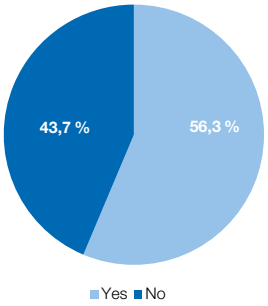


Mobility Type Commuting

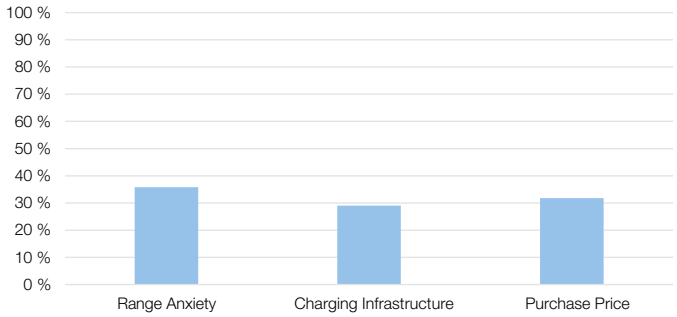


The motor vehicle is the **dominant means of transport** for journeys to work. Leisure journeys are more diversified. In particular, commuters can be targeted to address customer groups.

Basic Interest in an Electric Vehicle?

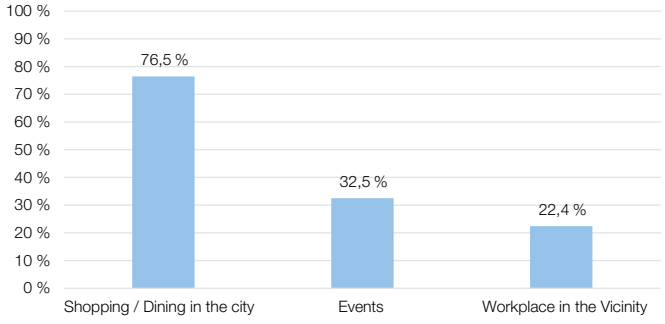


Reasons for Not Considering an Electric Car

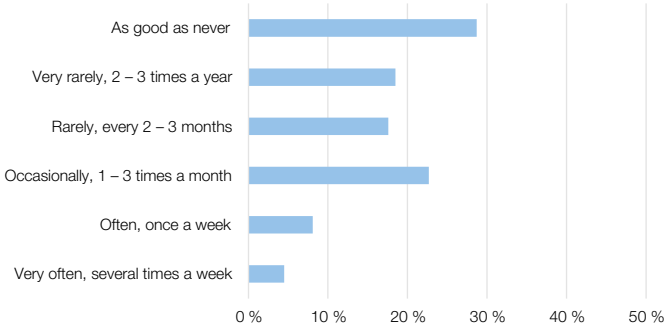


In principle, there seems to be a **slightly increased interest in electromobility.** The generally known reasons speak against electromobility.

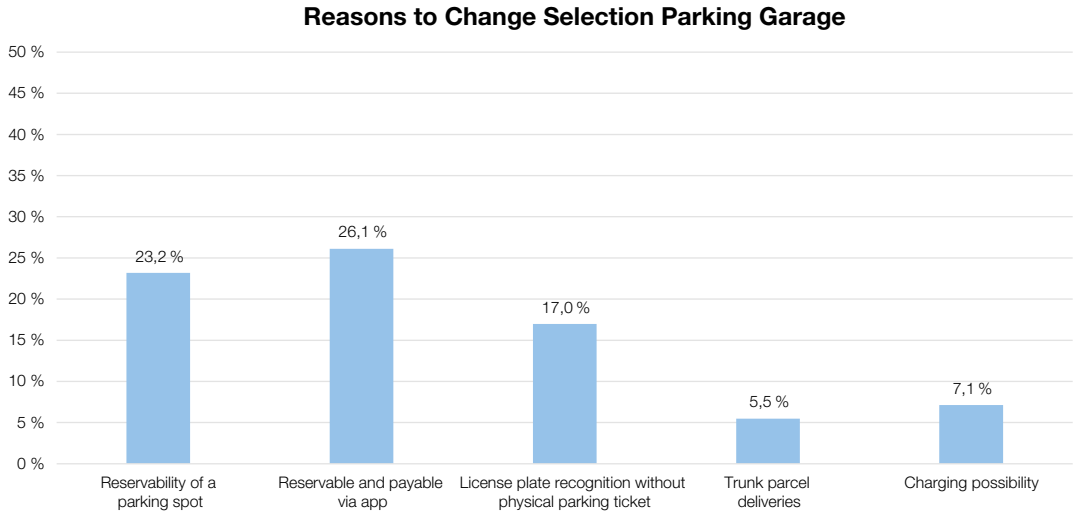
Reasons for Using the Car Park



Frequency of Use of Car Park

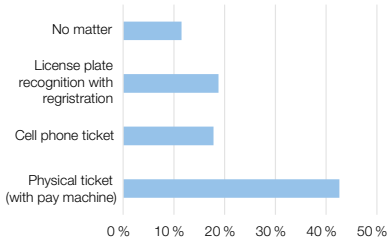


The vast majority seem to **use car parks infrequently.** The reasons for the use of car parks support this. It is possible that use is increasing as the need to bundle transport centrally rises (keyword: hubs).

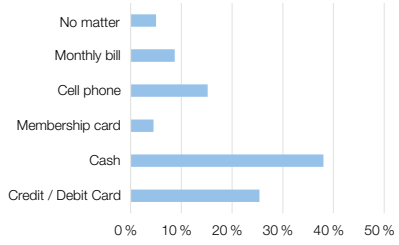


Possible expansion of various services and processes can increase attractiveness. **Technology may currently provide too little real added value for a potential switch.**

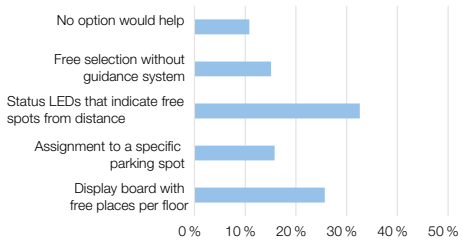
Preferred **Ticketing** for Parking
(frequency of mention as most important criterion)



Preferred **Method of Payment** for Parking
(frequency of mention as most important criterion))

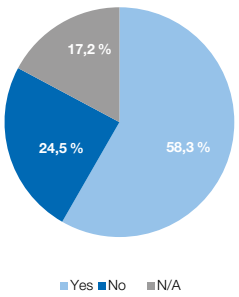


Preferred **Guidance System** in Car Parks
(frequency of mention as most important criterion)

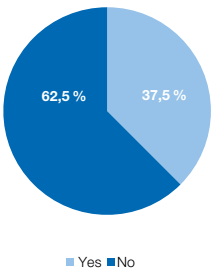


The relevance of existing „conservative“ systems is evident, but more modern solutions appear to have a relatively high level of acceptance. A **successive expansion** appears to make sense in order to bring about a **habituation effect.**

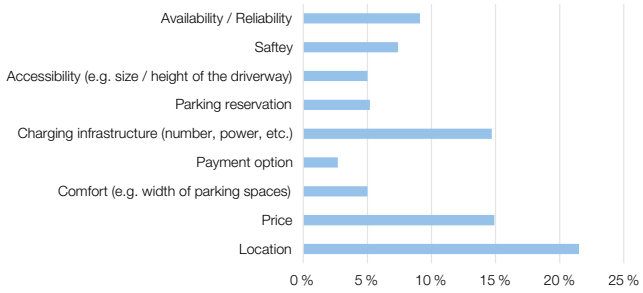
Would Charging Infrastructure Influence the Choice of Car Park?



Willingness to Pay a Premium for the Highest Charging Capacity



Criteria for the **Selection of** a **Parking Garage under the** Assumption That an **E-vehicle** Is Driven (frequency of mention as the most important criterion)



Charging infrastructure and location can be a decisive lever. Possibly, existing charging infrastructure in combination with attractive prices compensates for slight location disadvantages. Surcharges for the highest charging performance are negated. The dynamics of different roaming tariffs on the market can provide information about the willingness to pay.

The surveyed panel comprised around 540 people while certain questions and clusters may have a lower number of participants. The survey achieved a balanced panel with a slight majority of women. The age structure is evenly distributed with a slight dominance of persons from the age group 55 to 64.

In terms of income, the group from 20,000 to 40,000 euros dominates, but overall more than 50 % of the respondents have a gross income above this level.

No significant correlation was found between age and income. In this respect, the survey we conducted differs from other socio-demographic surveys. However, the surveyed panel was selected by the survey institute according to regular access to a car and thus reflects a car-inclined or car-dependent part of the population. An explanation for the non-significant/insignificant correlation between age and income cannot be clarified in this course.

Based on the applied panel filter with regard to access to a car, the dominance of the car as the modality of choice with regard to commuting is also explained. Even in the area of leisure trips, the car dominates. However, it can be seen that the bicycle and walking have a significantly higher share here than in the case of purely work-related trips.

With regard to the basic interest in e-mobility, there is a slight majority with a positive attitude towards e-mobility. In those with no interest, the three most frequently cited reasons are range anxiety, price and the existing charging infrastructure.

The three most frequently cited reasons for using car parks are shopping or going out to eat, events, and vicinity to the workplace, although only a minority of the people surveyed use car parks regularly in the sense of weekly or even several times a week.

As possible reasons for changing their choice of car park, the respondents primarily mention the ability to reserve a space and, at the same time, the possibility of doing this via app and also paying via app – closely followed in third place is license plate recognition. Charging options and the delivery of parcels to their own boot were cited less frequently.

In addition to ticketing and the corresponding payment option, the guidance system is also an important component of the parking process. In the overall evaluation of the entire panel, most people name the physical parking ticket as their preferred solution. Mobile phone and license plate recognition follow at a clear distance. With regard to the preferred payment option, cash clearly wins ahead of the EC or credit card. Mobile phone or monthly billing also follow at a distance here. In the case of the guidance system, which shows free parking spaces and is intended to signal/guide the way to them, status LEDs that display the occupancy status in red/green logic per parking space are preferred, closely followed by display boards with free spaces per corresponding floor.

Further findings in terms of initial overarching evaluations also include the topic of charging infrastructure in relation to electromobility.

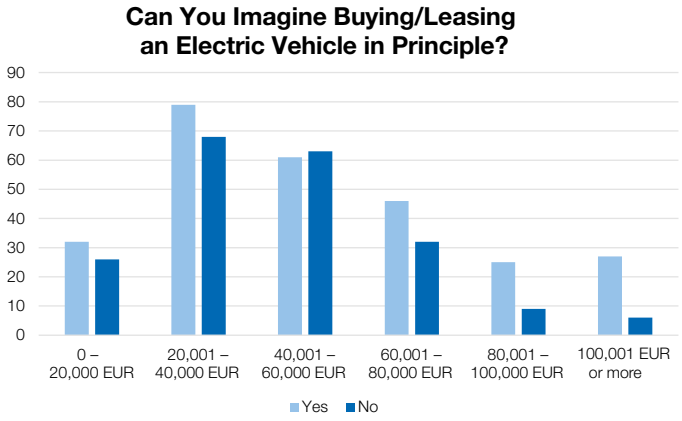
In combination with the topic of parking garages, almost 60 % of respondents say that charging infrastructure would have an influence on their choice of parking garage. Only a quarter deny this, while around 17 % do not specify. At the same time, over 60 % say they would not be willing to pay a premium for maximum charging speed during charging sessions. On the flip side, this means that over a third say they would pay a premium in principle. This figure should be treated with caution and examined more specifically. The choice of car park under the premise that an EV is driven does not differ greatly in terms of the stated criteria from statements without this premise. Location and price dominate. In combination with the premise, the available charging infrastructure plays a decisive role. This response behavior was to be expected.

Overall, there are no major surprises with regard to the initial evaluations, and the answers are expected, particularly with regard to technological and process-related components/ aspects. Only the use of new technologies can be a lever to successively implement innovations, and the potential to monetize maximum charging speeds is an interesting starting point for further analyses.

"Old known systems" dominate but in principle, openness for new technologies is recognizable. These are possibly levers to change the choice of car parks.

Acceptance of Electric Vehicles

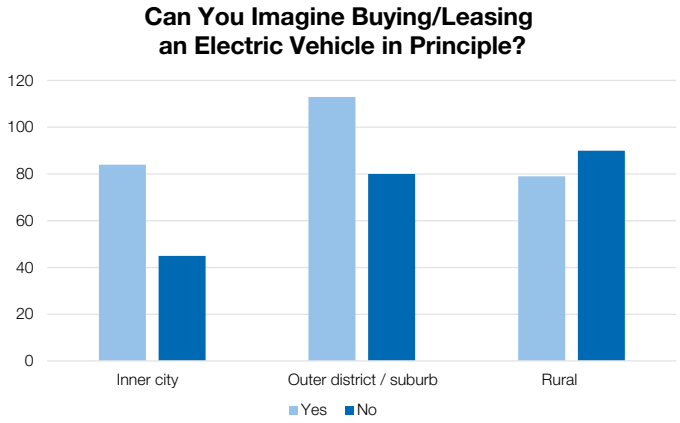
This subsection takes a closer look at the topic of electric vehicles and focuses on the basic acceptance of electric vehicles and correlations between factors such as income, place of residence, and biographical openness.



Sign. Correlation?	**Yes**
Correlation coefficient	**-0,113**
Significance level	**0,01**
N	**508**

Coefficient negative because Yes was coded with rank 1 and No was coded with rank 2 (!).

Rising income means rising interest in EV. This correlation was proven to be significant in the sense of a rank correlation. (Caution: correlation =/= causality!)

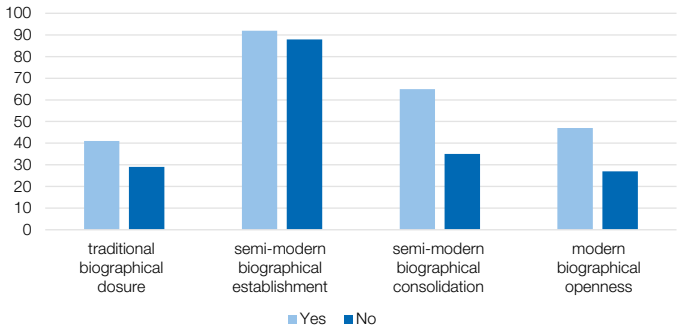


Sign. Correlation?	**Yes**
Correlation coefficient	**0,115**
Significance level	**0,008**
N	**533**

Coefficient negative because Yes was coded with rank 1 and No was coded with rank 2 (!).

The investigation of the place of residence and the basic interest in an EV increases with a shift of the place of residence from a rural to an inner-city area. This correlation could be proven to be significant in the sense of a rank correlation. (Caution: correlation =/= causality!)

Connection of Biographical Openness with the Fundamental Interest in Electric Vehicles



Sign. Correlation?	**Yes**
Correlation coefficient	**- 0,124**
Significance level	**0,008**
N	**453**

Coefficient negative because Yes was coded with rank 1 and No was coded with rank 2 (!).

Increase in the fundamental interest in electric vehicles with increasing biographical openness of the corresponding milieus. This correlation could be proven to be significant in the sense of a rank correlation.
(Caution: correlation =/= causality!)

In the subsection Acceptance of Electric Vehicles, analyses were conducted regarding possible correlations of individual subgroups and clusters of the entire survey panel. In addition to gaining interesting insights, this also served to validate the quality of the entire survey. First, in terms of rank correlation, we investigated whether there was a significant correlation between the basic interest of the respondents and the gross annual income of the respondents. Here, a significant relationship/ correlation was demonstrated. The higher the gross annual income, the greater the indication that there is a basic interest in an electric vehicle.

Also relevant for the deeper assessment of interest in EV is the geographical component, in this case the place of residence. The survey asked where the respondents lived. If this correlation is now analyzed with interest in electric mobility, a correlation emerges. The more rural the place of residence of the respondents, the lower their basic interest in an electric vehicle. Thus, the interest in e-mobility is greatest among people living in inner cities. The reasons for this correlation are hypothetical. Dense traffic, the associated noise, existing or visible charging infrastructure and the tendency towards shorter distances are possible reasons for this correlation.

If all the people surveyed are broken down into different socio-demographic clusters and these are subdivided in terms of biographical openness (see lifestyle types according to Stelzer and Heyse), there is a significant positive correlation between biographical openness and basic interest in electric vehicles. The more open a group of people is on the basis of the characteristics defined by Stelzer and Heyse, the higher this interest. This potentially results in a first target group that needs to be addressed with regard to innovations in the field of smart parking and charging.

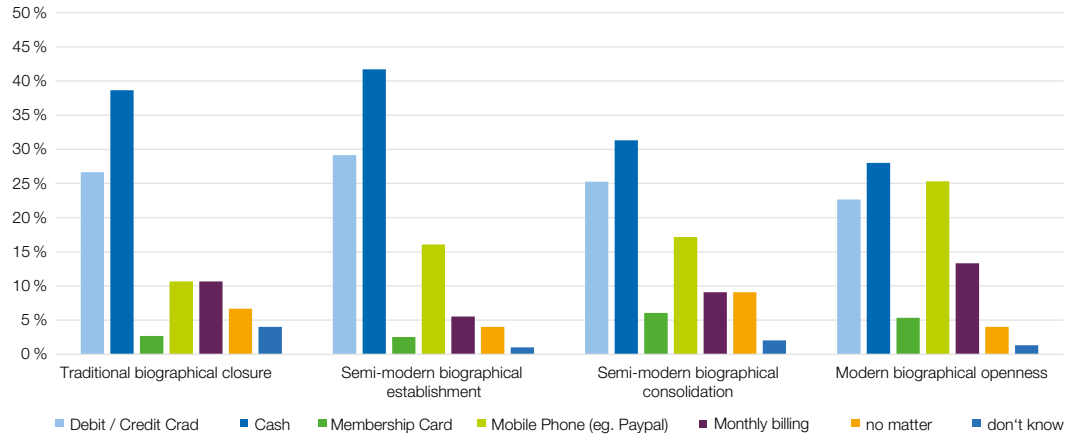
If these three results of a more detailed examination of the entire survey set are considered together, the picture that emerges in summary is that respondents with higher income, inner-city residential location and biographically open milieus primarily show a fundamental interest in e-mobility and represent a solid initial target group for targeted measures.

Income, inner-city residential location and biographical openness correlate significantly with acceptance of electromobility.

Preferred Payment Methods for Parking Transactions

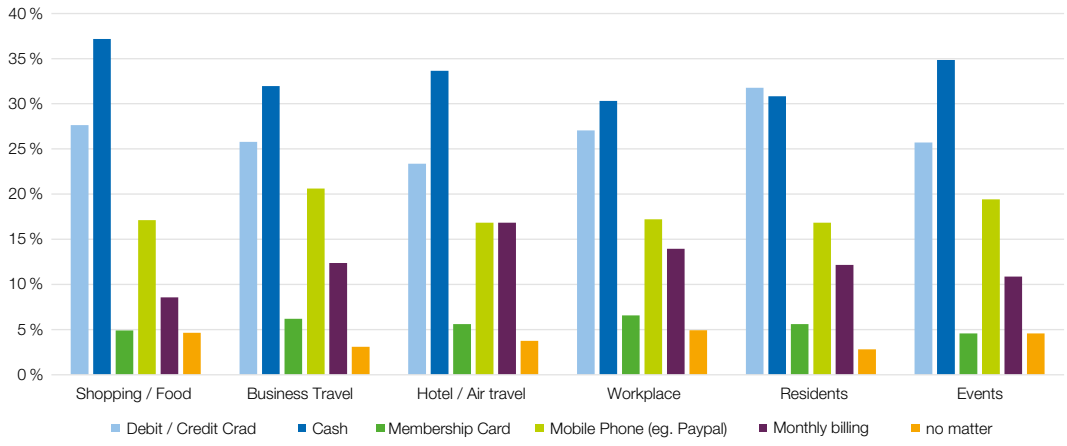
The following is a closer look at the topic of payment options.

Payment Option Parking Transactions
(frequency of mention as the most important criterion) – relative



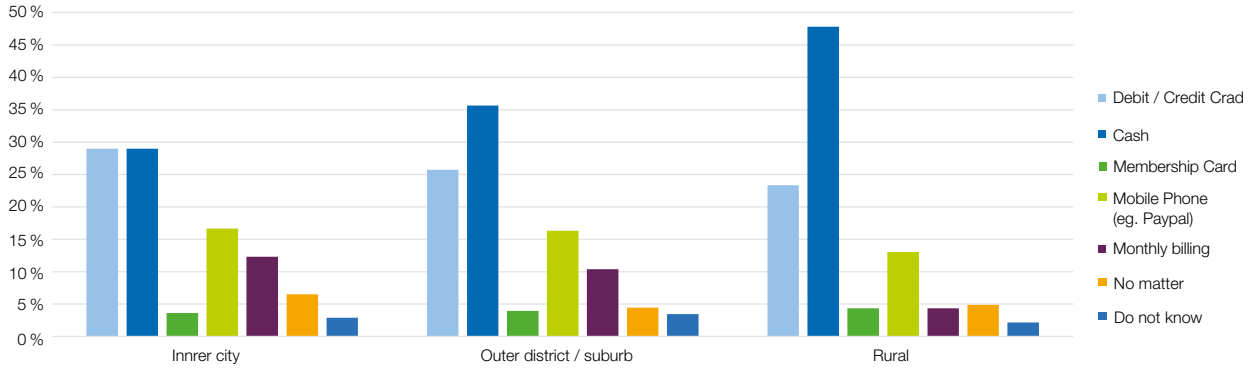
When looking at the relative proportions of preferred payment options, it is noticeable that the preference for alternatives to cash and card payment increases with increasing biographical openness. This can be a lever to deliberately address these biographically more open milieus as early adopters for new and additional services having to do with parking and charging.

Payment Option Parking Transactions
(frequency of mention as the most important criterion)



Individual purposes for the use of parking facilities do not show any clear trends in terms of preferred payment options. Only a slight increase in interest in monthly billing for purposes involving a longer parking period indicates options to evaluate these payment options in the context of business models.

Preferred **Payment Option** for **Parking Transactions**
(frequency of mention as the most important criterion)



Rural areas appear to be more dominated by cash than suburban and inner-city areas in terms of payment preference. The reasons for this are difficult to determine, as there is no correlation in the data set between, for example, age or biographical openness and place of residence. One possible explanation could be the higher parking pressure in urban areas, which in turn could explain the need for payment methods that tend to be faster and more efficient.

If the preferred payment method for parking transactions is subdivided into the four clusters of biographical openness, it is noticeable that cash and card payment dominate as preferred methods. Only in the most biographically open cluster is payment by mobile phone/smartphone named second most frequently, just ahead of card payment, and thus only just behind cash payment.

If the respective purpose of parking is included in the analysis, a similar picture emerges here, regardless of whether it is business trips, events or shopping: cash and card payment dominate. For work-related purposes, monthly billing seems to be more desirable than for other purposes. The payment option via smartphone is named as the third most preferred payment option for every purpose.

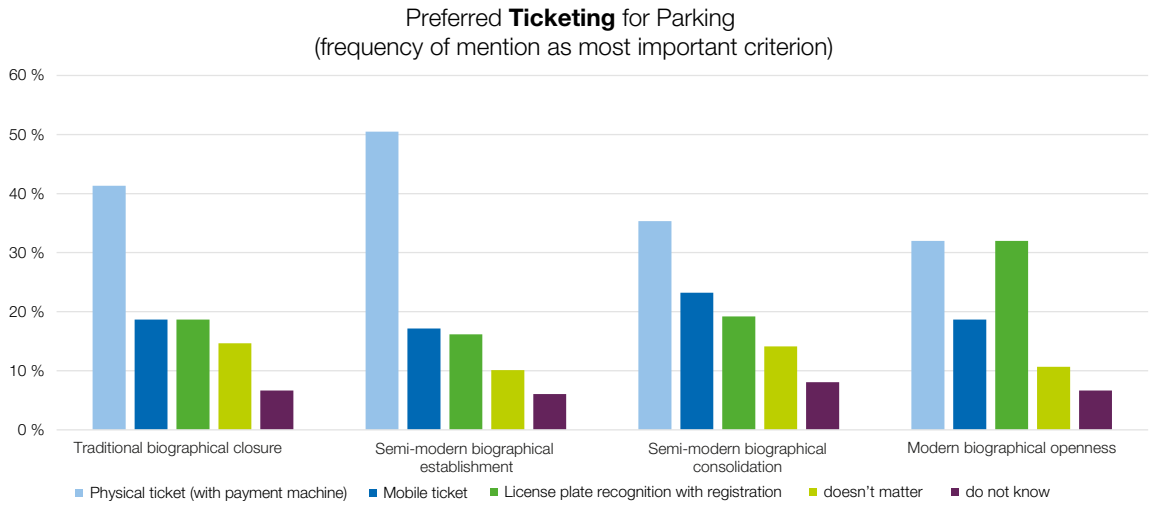
If a distinction is made between places of residence, the information provided by people living in rural areas in particular clearly shows that cash is preferred over other payment methods by a wide margin in this case, while in inner-city residential areas there is almost parity between card and cash payments.

Based on this analysis, inner-city milieus tend to be suitable for testing alternative payment options. At the same time, it appears that a possible lever is the smartphone/mobile phone in particular, as most people always carry theirs with them and it does not further complicate the payment process.

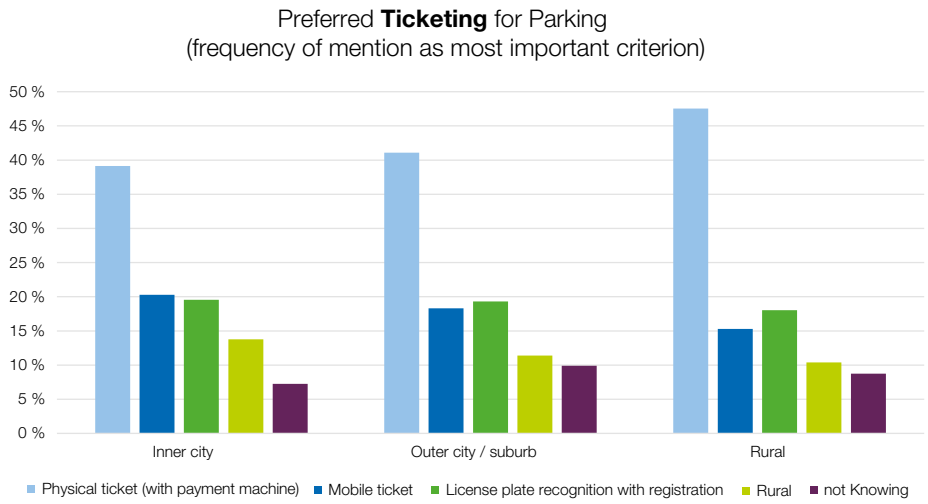
Typical payment options for parking transactions continue to dominate. Milieus with biographical openness relevant as the first target group for new forms of payment. Cash is extremely dominant in rural areas.

Preferred Ticketing and Guidance System

In this section, the topics of ticketing and control system are analyzed in more detail.

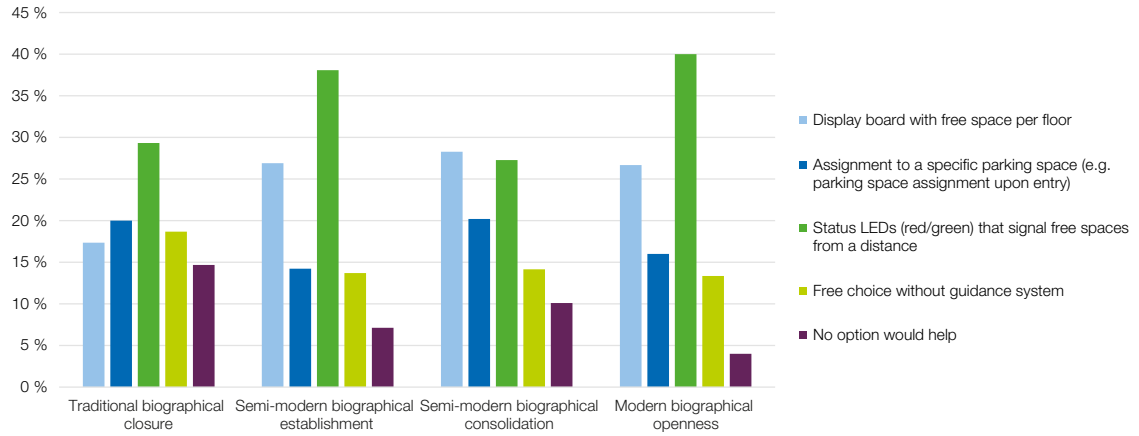


Physical ticketing for parking processes dominates the subjectively weighted priority list. With increasing biographical openness, the preference for license plate recognition as a type of ticketing also increases.



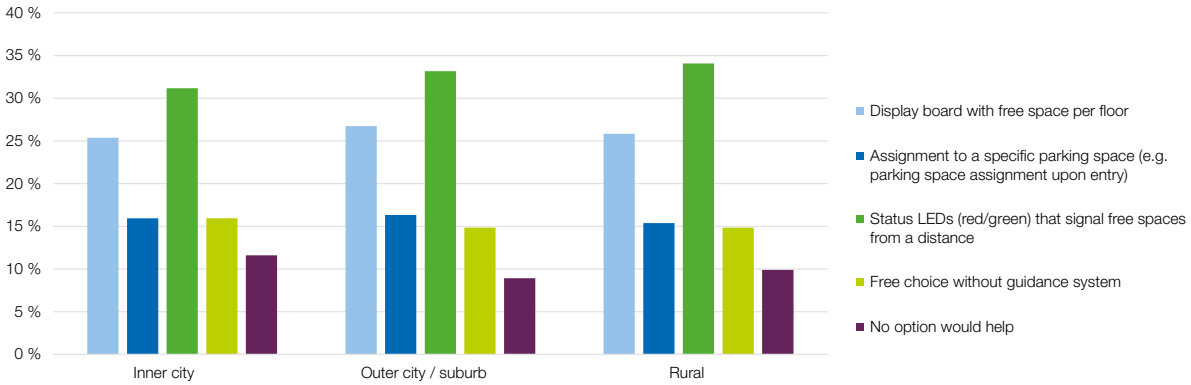
The preferred ticket type in terms of the classic physical parking ticket seems to increase with distance from the inner city to the rural residence.

Preferred **Guidance System** in Car Parks
(frequency of mention as most important criterion)



Status LEDs dominate as a technology building block. Combination with display panels to indicate capacities for floors seems the most obvious configuration of a control system. Surprisingly, the direct allocation of a specific space is also relatively attractive. Here, reservation in combination with charging points can represent an additional service for parking operators.

Preferred **Guidance System** in Car Parks
(frequency of mention as most important criterion)



There are no significant differences in terms of the preferred guidance system between people from different places of residence. The recommendation for action regarding the guidance system for the clusters of biographical openness can be applied here in an equivalent manner.

In order to gain a deeper understanding of the general preferences for the topics of ticketing and guidance systems, the panel was also divided into different clusters for this thematic focus.

When examining the different groups with regard to biographical openness, it is striking that the physical parking ticket dominates in all groups except the most biographically open group. Among the most biographically open milieus, the classic physical parking ticket is equally preferred as the medium of license plate recognition.

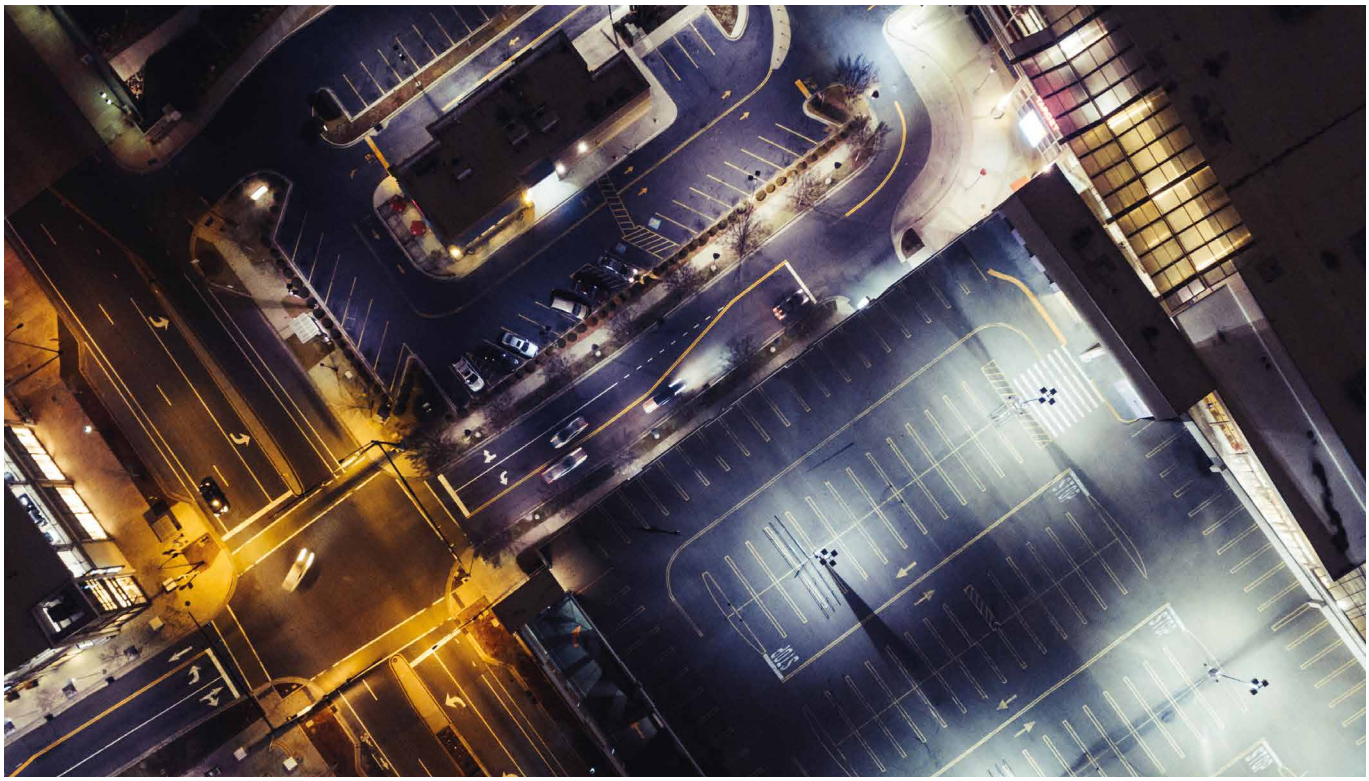
If potential differences are analyzed with regard to place of residence, the physical parking ticket is preferred regardless of whether it is an inner-city or rural place of residence. However, there is a slight increase from city to countryside with regard to the physical ticket. Otherwise, there are no noticeable differences.

If the preferred guidance system is now first examined in the different groups of biographical openness, the solution with red-green status LEDs is preferred in three of the four groups and display boards with free spaces per floor follow in second place. Only in the second most open group is this exactly the opposite. It is interesting to note that a concrete assignment to a specific place is a preferred option for around 15 to 20 % of the respondents in the various groups of biographical openness.

An examination of the different places of residence with regard to a preferred guidance system does not reveal any significant differences compared to other evaluations.

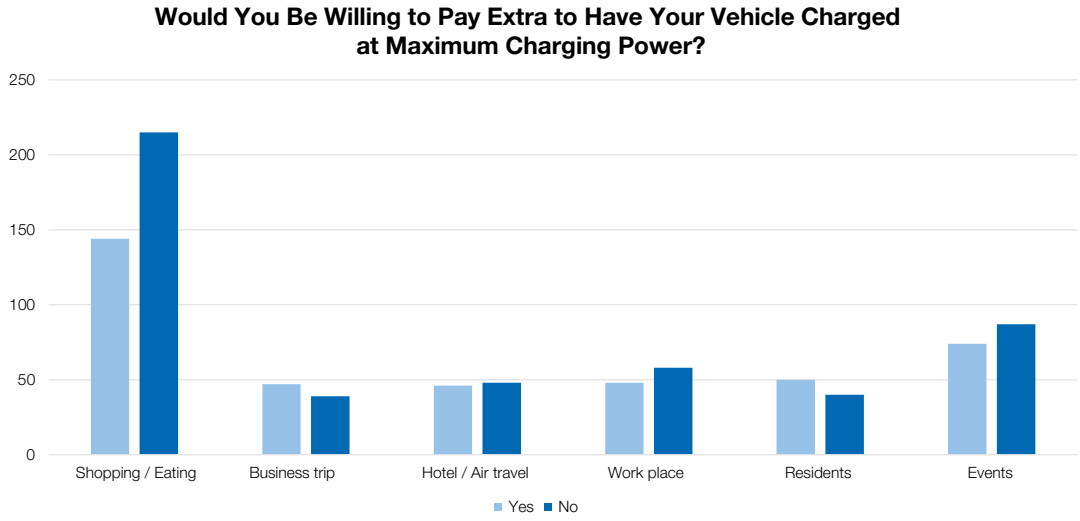
In order to address innovative approaches to the topic of ticketing, such as license plate recognition, the biographically most open group should be addressed first. On the topic of guidance systems, there seems to be a clear dominance of status LEDs. Alternative systems can be tested, but redundancy between the control systems should be maintained.

The physical parking ticket dominates, only in biographically open milieus is license plate recognition very highly weighted. In the case of guidance systems, the combination of status LEDs and display panels with free parking spaces dominates.

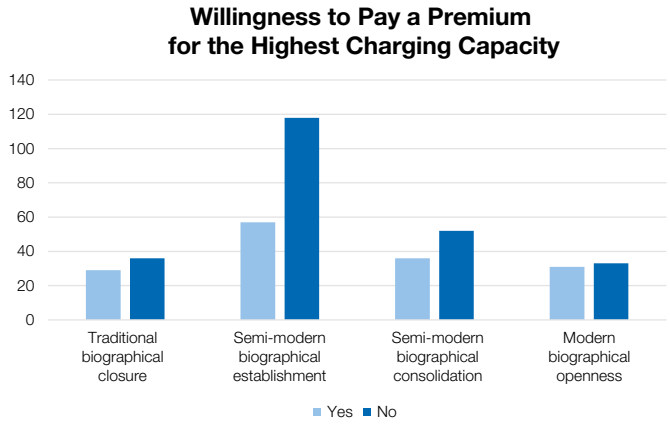


Willingness to Pay Extra for Maximum Charging Power

This section lists the results on the topic of willingness to pay extra and describes related analyses.



Overall, rejection dominates for willingness to pay extra. Dedicated parking can be a lever. Willingness for surcharges seems to be relevant only for range-sensitive areas. Nevertheless, more than one third of the respondents are willing to pay a surcharge.



Sign. Correlation?	**No**
Correlation coefficient	**- 0,050**
Significance level	**-**
N	**392**

Coefficient negative because Yes was coded with rank 1 and No was coded with rank 2 (!).

There is no correlation between biographical openness and willingness to pay extra for maximum charging power. In general, a clear rejection is evident across all data and also here. The most likely cluster to be addressed is the modern biographically open cluster.

In order to examine the topic of charging infrastructure in more detail, a look at possible willingness to pay a surcharge for maximum charging speeds is particularly relevant. In principle, a majority of the respondents indicated that they would not pay a surcharge for maximum charging speeds. However, there is a target group of around one third of respondents who would be willing in principle.

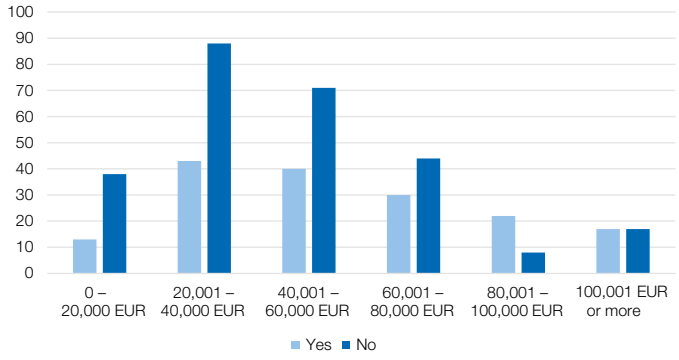
If the willingness to pay surcharges for individual purposes is examined (such as shopping, business trips, etc.), it is noticeable that a majority rejects surcharges for shorter purposes, but for business trips, hotel or air travel and with regard to parking at the workplace, the mood is relatively balanced. With regard to parking for residents, a majority is even prepared to pay surcharges. Possible explanations lie either in the fact that work-related parking transactions can be billed via the company or the range anxiety, especially for residents, that a full electric car should be available in the morning at literally any price. This is also possible at low charging speeds as electric vehicles are parked in residents' areas for several hours.

An examination of groups of different biographical openness and a correlation analysis shows no relationship between biographical openness and willingness to pay extra.

A final analysis on the willingness to pay a premium for maximum charging services reveals a correlation with the topic of income. A correlation analysis showed that the higher the income of the respondents, the less often they say no to surcharges for maximum charging services (caution: correlation =/= causality!). Thus, more individuals indicate they are willing to pay this type of premium, relatively speaking. This is a potential that opens a door for different pricing models taking into account future developments especially with regard to volatile renewable energy generation. However, the result does not allow any conclusions to be drawn as to whether corresponding pricing models would find acceptance or whether a fundamental rejection would promote a negative attitude towards them even in circles that tend to be more open.

Clearly there is some potential to establish different pricing models for charging speeds depending on purpose, and while biographical openness does not allow for inference in this case, income may be a lever.

Willingness to Pay a Premium for the Highest Charging Capacity



The higher the income, the rarer a No to paying premium, or vice versa: higher income, higher willingness to pay a premium for max. charging power. This correlation was proven to be significant in the sense of a rank correlation. (Caution: correlation =/= causality!)

Sign. Correlation?	**Yes**
Correlation coefficient	**- 0,182**
Significance level	**0,01**
N	**431**

Coefficient negative because Yes was coded with rank 1 and No was coded with rank 2 (!).

Paying premium for maximum charging speeds are primarily rejected. About one third can imagine premiums for maximum charging power. Data to be treated with caution.

Electromobility in the Milieus

Derived from the presented survey, we are confident to propose the following hypotheses

Hypotheses as a basis for discussion

- **H1:** The **multitude** of **standards**, charging cards and **processes** is confusing from the customer‘s point of view and promotes **scepticism towards e-mobility.**
- **H2: Intuitive use of** charging infrastructure, along with **pricing**, determines **rapid adoption of** e-mobility.
- **H3: Integration of charging infrastructure** into the **parking area** represents a desirable **added value** from the customer‘s point of view and will enjoy lively demand.

Based on the analysis of the survey in combination with the knowledge generated by the workshops, the hypotheses can be accepted in the broadest sense. They thus provide important impulses for further thinking about and successively investigating the topic of Smart Parking and Charging and for a deeper understanding of the entire subject.

In particular, the individual consideration of each lifestyle type on the basis of sociodemographic characteristics is a core message from the five key takeaways of the analysis. There are lifestyle types in the general population that should first be addressed for the initial testing of innovative solutions before innovations can reach the masses and proclaim a new status quo.

However, these new approaches should be tested and rolled out carefully. Different lifestyle types are one possible way to identify and strategically include specific clusters.

Milieus

Stelzer and Heyse demonstrate a valuable and powerful tool to use socio-demographic data in an aggregate and cluster the population into different milieus and lifestyle types in their publication “The lifestyle typology: milieu diagnosis from 2016”.

Both describe this approach in their publication as follows: “The lifestyle typology is a tool for scientific social structure analysis. The aim is to explore social inequality in population groups with the help of this model. The model is particularly applicable in the field of applied research in social sciences as well as in market and media research. With the help of the present instrument, small-scale as well as comprehensive studies can be set up.”

In addition to this approach of a milieu logic or a milieu approach, there are also the very well-known and widespread Sinus-Milieus, which follow an equivalent approach. The approach of Stelzer and Heyse has the advantage of being publicly accessible and usable together with the battery of questions.

Level of endowment / cultural and economic capital					
	High	Upscale **Conservative** 3,6 %	Status Conscious- **Arrived** 9,0 %	Performance Conscious- **Intellectual** 8,0 %	Reflective **Avant-Garde** 7,9 %
	Medium	Solid **Conventional** 9,7 %	Status oriented- **Civil** 15,2 %	Civic- **Achievement-Oriented** 10,7 %	Expeditious- **Pragmatic** 9,0 %
	Low	Limited- **Traditional** 10,1 %	Defensive- **Disadvantaged** 8,1 %	Consum- **Materialists** 4,0 %	Youth Cultural- **Entertainmentoriented** 4,7 %
	LIFE MANAGEMENT TYPOLOGY	traditional biographical closure	semi-modern biographical establishment	semi-modern biographical consolidation	modern biographical openness
		Modernity / biographical perspective of life management			

Figure 2: Lifestyle types and their proportion of the German population according to Stelzer und Heyse in 2018

In the context of this consortium study, the approach of Stelzer and Heyse is therefore used as a basis for a closer examination of different milieus in Germany in order to derive personas on the basis of the individual characteristics, which include a biographical and an economic and cultural component, and to discuss their behavior and attitudes towards mobility including the parking process.

An important note is that the individual lifestyle types are not perfect self-contained constructs, but overlap can occur between each type.

Milieu-based Recommendations for Action

Based on the analysis and the explanations, the following chapter explains the connection between core results of the survey and the application of a milieu-based approach for the testing and introduction of new products and services.

First of all, in order to understand the approach used in this consortium study, an example of the transfer of a milieu described by Stelzer and Heyse into a typical parking process defined in the context of the study follows. This transfer illustrates the application of relevant lifestyle types in the context of mobility.

Based on the work of Stelzer and Heyse, which also contains a concrete description of each of the twelve milieus, a kind of persona quartet map was developed within the framework of this consortium study on the milieus relevant to the adoption of electromobility, which briefly characterizes the relevant milieu-specific personas and at the same time describes mobility behavior with a focus on the parking process structured by the consortium study.

The figure below shows such a quartet map and includes brief characteristics of a typical person of the expeditive-pragmatic milieu (for the year 2021).

Each of these quartet cards is to be understood as a suggestion of a person in order to obtain a more specific picture of a stakeholder group that is potentially to be addressed. In the context of a workshop specifically set up for each project, the personas then created and their derived characteristics may of course differ in parts from the personas set up in the context of this study. This is based on different questions and topics. In the context of the consortium study, the developed quartet cards serve as a foundation for a customer-centric approach to developing and marketing products and services.

Now, if we take the previous overview of all lifestyle types as a basis and use the fundamental interest in e-mobility determined in the survey to color the lifestyle types, Figure 4 is the result. This serves as the basis for the further transfer to the innovation cycle according to Rodgers as well as recommendations for action.

Customer Journey Parking Process – Quartet Card Stereotype: Expeditive-Pragmatic

Characteristics Stereotype:

- Young professional (27 years old)
- IT profession and therefore IT affinity
- Middle income, yet price conscious
- Short commute daily (30 km total)
- Buys electric small car for everyday life
- Uses sharing models for long distances

Characteristics of the Customer Journey

Selection: ■ On-Street Free ■ Paid parking only in case of emergency	**Directions:** ■ Digital navigation ■ Uses 80 % of the same parking facilities.	**Driveway:** ■ Free entry
Quest: ■ “Creature of habit”	**Parking:** ■ All day at the workplace ■ Home with resident parking	**Charge:** ■ At work/at home ■ Low to medium charging power
Pay: ■ billing on the basis of consumption ■ Monthly billing (SEPA)	**Exit:** ■ Free exit	**Other:** /

Figure 3: Example of a quartet card of lifestyle types

Level of endowment / cultural and economic capital					
	High	Upscale **Conservative** 7,7 % ↑	Status Conscious-**Arrived** 16,5 % ↑	Performance Conscious-**Intellectual** 13,9 % ↑	Reflective **Avant-Garde** 9,7 % ↑
	Medium	Solide **Conventional** 6,2 % ↓	Status oriented **Civil** 24,0 % ↑	Civic-**Achievement-Oriented** 7,9 % ↓	Expeditious-**Pragmatic** 5,5 % ↓
	Low	Limited-**Traditional** 2,6 % ↓	Defensive-**Disadvantaged** 3,7 % ↓	Consumer **Materialists** 0,9 % ↓	Youth Cultural-**Entertainment-oriented** 1,3 % ↓
	LIFE MANAGEMENT TYPOLOGY	traditional biographical closure	semi-modern biographical establishment	semi-modern biographical consolidation	modern biographical openness
		Modernity / biographical perspective of life management			

■ Interest in electromobility <45% ■ Interest in electromobility 45% - 55% ■ Interest in electromobility >45%

Figure 4: Lifestyle types and their proportion of our field of participants in the context of this study

Within the framework of the evaluation, about 450 persons could be assigned to milieus (the missing persons did not answer at least one of the 14 questions according to Stelzer and Heyse and could not be assigned).

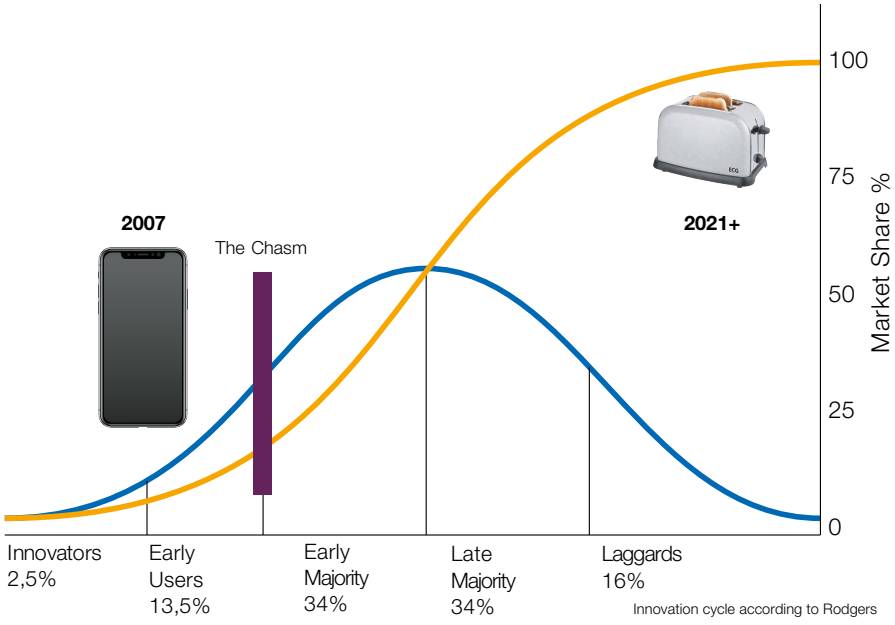
The breakdown of the milieus shows differences compared to the overall German picture of the evaluation according to Stelzer and Heyse. In particular, the filter question for selecting the panel with a focus on regular access to a car can explain this deviation. However, it should not be interpreted negatively in this sense, since the survey was intended to interview a car-inclined panel and achieved this goal.

In order to be able to derive the affinity towards electromobility, we determined for each milieu how many people have expressed a fundamental interest in electromobility. Milieus that are colored purple show an interest of less than 45 %. Milieus colored in orange show an interest in e-mobility of between 45 % and 55 %, and milieus colored in green show an interest of over 55 %. No borderline case occurred in any of the twelve milieus. The smallest gap between two differently colored milieus is just under 5 percentage points.

This traffic light logic serves as a basis for deriving statements from the survey and for deducing a fundamental logic of the overall social interest and its development in e-mobility.

In order to gain an understanding of the influence of individual clusters within the 12 lifestyle types, it is necessary to take a look at the innovation cycle according to Rodgers. After this classification, the aforementioned development with regard to interest in e-mobility can then be shown across all 12 lifestyle types.

Rodgers' innovation cycle broadly describes the adoption of an innovation and divides it into five phases that add up to a potential market share of 100 %. These five phases



are divided into the so-called innovators, early adopters, the early majority, the late majority and the laggards. Moore has added to this innovation cycle the so-called Chasm (the gap) that innovations have to overcome before they find acceptance in the broad market.

Using the example of Apple's iPhone, which was introduced in 2007 and ushered in the real phase of smartphones, it is clear how within a few years the iPhone and the world of smartphones have transcended their status as an innovation and product for a few innovators and early adopters and in 2019 have been equated with a toaster[2]. A quasi 100 % market saturation seems to have been achieved.

A similar example from the past few years is Apple's wireless Bluetooth headphones called AirPods. These were introduced at the end of 2016 and were initially ridiculed. In the months that followed, isolated individuals on the street were eyed critically with the white, small earpieces in their ears. A minority of innovators and early adopters rejoiced in the new benefits of these wireless headphones. Aggressive marketing by well-known wireless carriers and electronics wholesalers with discount promotions for contract renewals and promotions to buy new smartphones bridged the gap in the market and reached an early majority of potential users. This campaign allowed for a new, broad market for this type of headphone to be created and for other mass manufacturers such as Samsung, Bose, Huawei and many Chinese derivatives to almost flood the market with similar products. This recent example further illustrates how an innovation can go through different stages of the innovation cycle. Similarly, this is the case in other fields as well. The innovation cycle and the identification of certain milieus is essential in order to introduce product or service innovations in the field of smart parking and charging into the market and to place them in the long term.

If we look at the overview of milieus colored in the traffic light logic described above, we can basically identify two clusters. First, a look at four green-colored milieus in the upper right corner. Achievement-minded Intellectuals, Reflective Avant-gardists, Expeditive-Pragmatists, and Civic Achievement-minded. According to the logic described, these milieus are open to electromobility. Corresponding behaviors with regard to mobility are deposited in the quartet cards. According to Rodgers' innovation cycle, these four milieus can be described as innovators, early adopters and, in some cases, as an early majority with regard to electromobility. In terms of mobility behavior, this even applies to other innovations in the area of smart parking and charging.

The lowest four milieus in terms of the level of economic and cultural income (from Limited-Traditional to Youth-Cultural-Entertainment-oriented) can be described as laggards in the sense of the innovation cycle.

If this finding from the survey is transferred in combination with elements of the innovation cycle, this first assessment serves as a basis for deriving a possible adoption of electromobility-related and parking-related innovations over time.

A potential development over time with regard to the twelve milieus and their affinity towards the use of e-mobility and electromobility-related topics is acquired from the findings derived above together with the clusters described. This graph

Level of endowment / cultural and economic capital					
	Upmarket	Upscale- **Conservative** 3,6 %	**Status Conscious-Arrived** 9,0 %	Performance Conscious- **Intellectual** 8,0 %	Reflective **Avant-Garde** 7,9 %
	Medium	Solid **Conventional** 9,7 %	Status oriented **Civil** 15,2 %	Civic- **Achievement-Oriented** 10,7 %	Expeditious- **Pragmatic** 9,0 %
	Low	**Limited-Traditional** 10,1 %	Defensive- **Disadvantaged** 8,1 %	Consumer- **Materialists** 4,0 %	Youth Cultural- **Entertainment-oriented** 4,7 %
2021	LIFE MANAGEMENT TYPOLOGY	Traditional biographical closure	Semi-modern biographical establishment	Semi-modern biographical consolidation	Modern biographical openness
		Modernity / biographical perspective of life management			

■ Interest in electromobility <45% ■ Interest in electromobility 45% - 55% ■ Interest in electromobility >45%

Figure 5: Affinity towards electromobility for 2021

[1] Schrader, 2019 (Zeit Online) : https://www.zeit.de/digital/mobil/2019-09/iphone-11-apple-keynote-vorstellung-smartphone

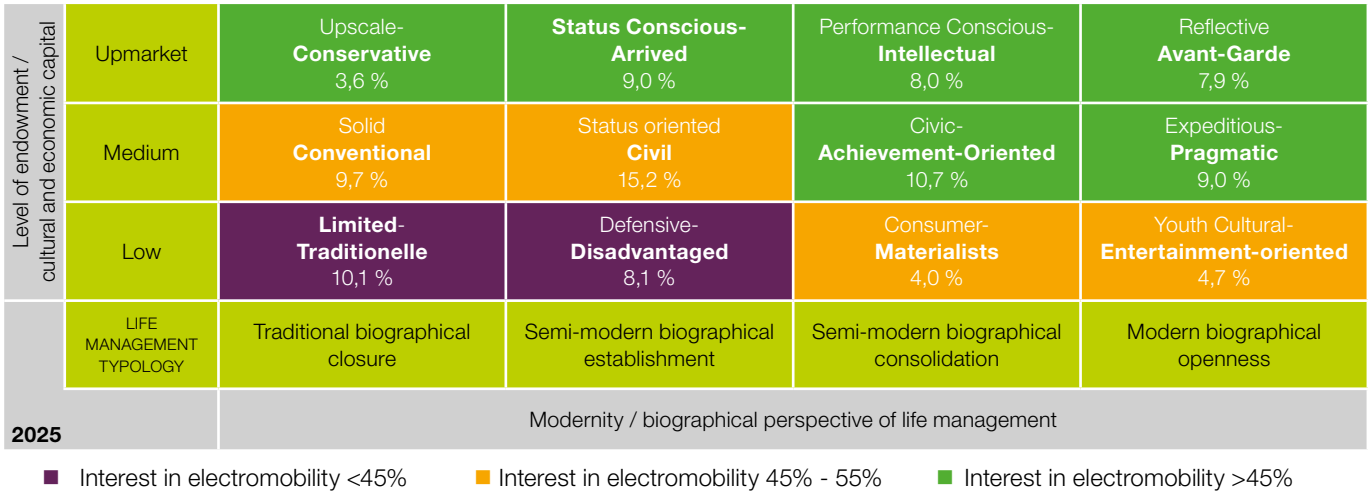


Figure 6: Forecast affinity towards electromobility for 2025

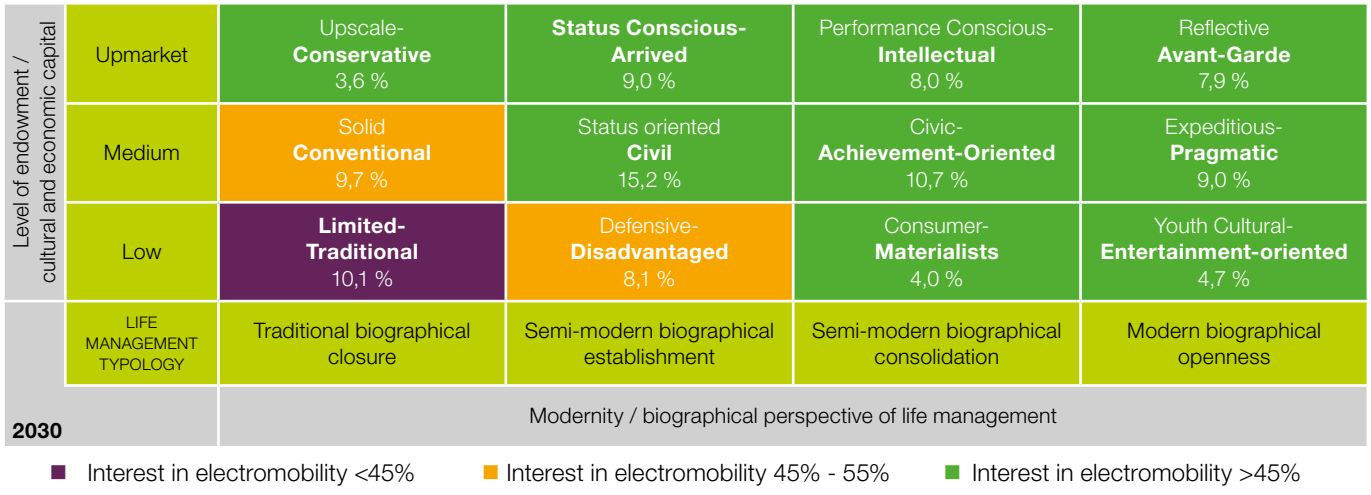


Figure 7: Forecast affinity towards electromobility for 2030

of potential development is to be understood as a forecast of a trend in order to be able to derive strategic considerations from it and to address milieus in a targeted manner for product or service innovations in the context of electromobility.

The said development is mapped for the year 2021, over the year 2025 to the year 2030 and outlines a potential development. The forecast also takes into account that the survey results show that income is an important factor and can partially compensate for biographical openness in terms of interest/affinity. Accordingly, the economically upscale lifestyle type “upscale-conservative” was already colored yellow in 2021, although the biographical openness would tend to indicate skepticism.

Across society, a majority in the green-colored milieus have an affinity for electromobility-related topics, products, and services. This development is steady and is accelerated by strong subsidies from the federal government and ever new, longer-range and cheaper electric vehicles. As early as 2025, based on our trend analysis, it can be assumed that a majority of the milieus represented in Germany will have a positive attitude towards e-mobility topics. In 2030, we forecast a clear majority and only three undecided to rather closed milieus.

In line with this potential development, measures and targeted launches of products and services are to be implemented or tested.

The entire range of electromobility-related topics, including intelligent parking solutions, are already of great importance for companies and municipal and urban stakeholders in order to prepare the infrastructure for this change. We recommend that measures be initiated today and that initial pilots be launched in terms of hardware, software and infrastructure so that scalable implementation can be completed in parts by 2025 at the latest and so that it is possible to react to market dynamics as quickly as possible.

User Experience

The user experience generated the smallest area of interest in the requirements workshop of the study and was therefore considered primarily via user groups and milieus as part of an extensive survey. For the development of the necessary technologies, a reference parking process was therefore outlined and personas were identified and described in order to be able to design a customer-friendly technology.

Parking Process

The parking process was created as a reference for the user experience of parking and charging processes. Based on the Service Blueprint, the reference parking process consists of the following activities

1. Approach
2. Entry
3. Search
4. Parking
5. Charging
6. Pay
7. Exit.

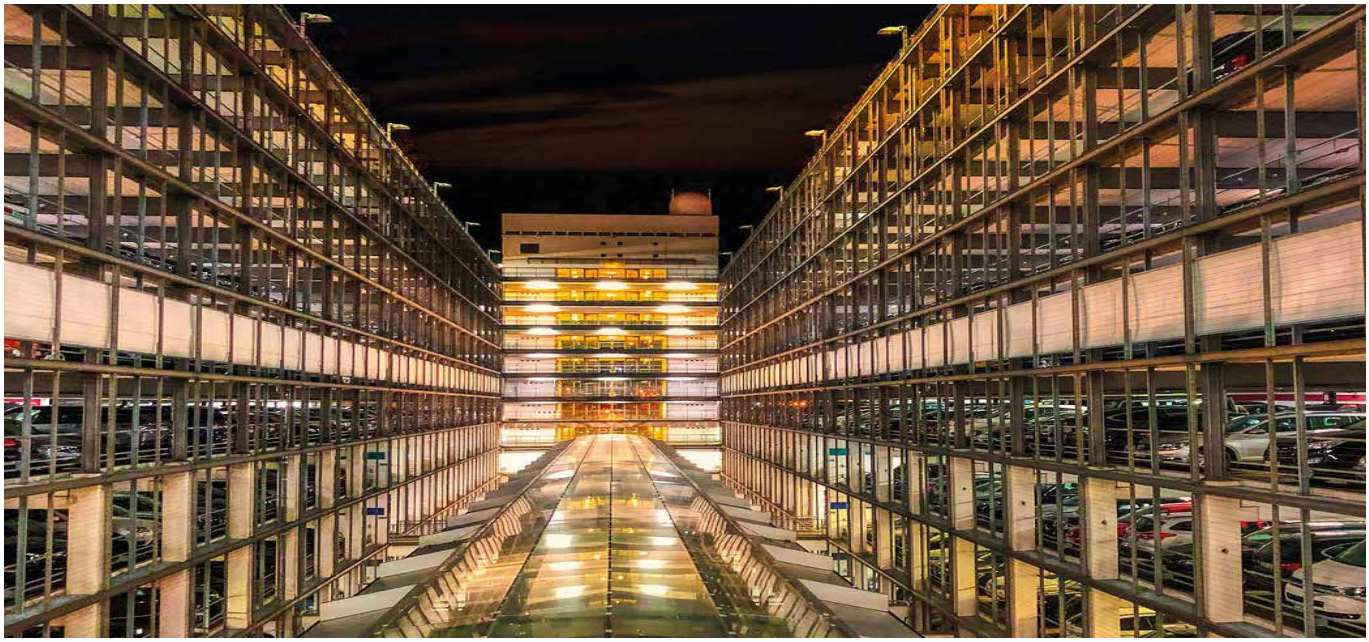
The approach is understood as the selection of the parking option and navigation in the vehicle. The aim here is to find out how the user experience turned out on the way to the parking facility. Entry describes the process of driving up to the parking facility and the corresponding authentication or identification measures, e.g. (light) barriers or ticket machines. The search describes the selection of a free parking space and, if applicable, charging possibility in the parking garage. For this purpose, technical options can enable improved navigation and thus improve the user experience. Parking then describes the pure parking process in a free parking space. Charging includes the optional possibility to fill up one's electric vehicle with electricity and the charging infrastructure required for this. Payment describes the process of the money transaction for the service received and can be triggered by automated activities, for example, or by classic payment machines. Finally, the exit describes the process of leaving the parking facility.

This parking process was used within the study as a starting point for a variety of methods and the concept development of the parking management system and can be found, for example, in the structure of the questionnaire of the survey. On this basis, personas were identified whose user experience can be used for further developments.

Personas

The section Milieus in the chapter of the survey evaluation describes the basic procedure of using certain described criteria of twelve different types from lifestyle types according to Stelzer and Heyse in order to create personas.

The procedure uses these criteria as a basis for the derivation and detailing of various character traits, which in turn form the basis for personas and their mobility reference. The results of this study are the quartet maps of the various milieus described above in relation to a typical parking process. With this basis, further analysis and derivation of specific needs and preferences are possible and were applied in the context of this study. The complete analysis can be found in the appendix of this report.



Technology

Parking Management System

In the context of the Smart Parking and Charging study, a focus was placed on the integration of various technical components within an overarching parking management system. Against this background, the question “How should an overarching parking management system be designed and how can it be integrated into the digital infrastructure?” achieved the highest rating and was considered in a focused manner. In the context of this study, the parking management system (PMS) is understood as the technical system that connects all technical components necessary to fulfil the performance of parking and charging in the car park. The PMS thus connects the local technical and structural infrastructure with an overarching (charging) platform or the user and their vehicle.

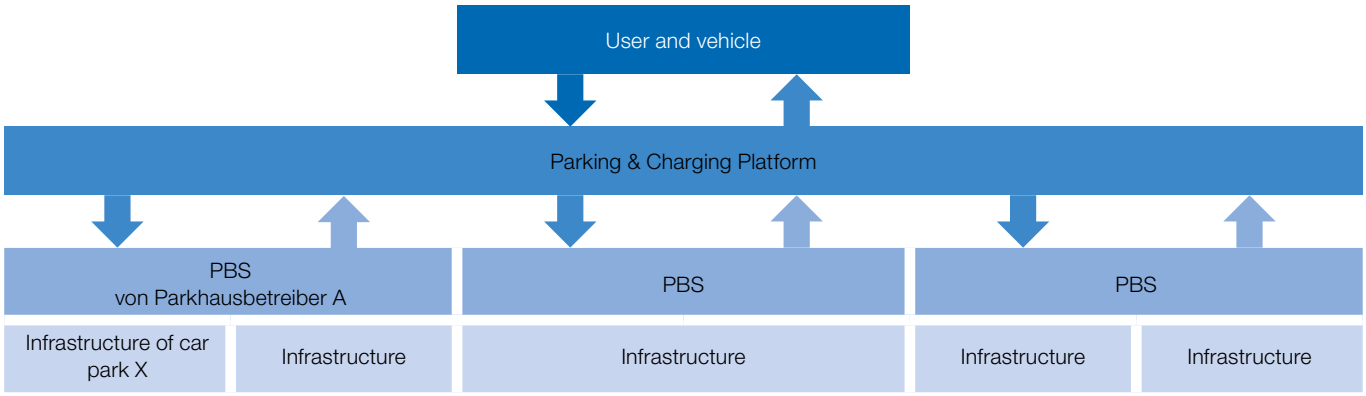


Figure 8: Classification of the PMS in the context of parking & charging

The most important focus of the PMS is the user, who will receive a better parking and charging experience with the help of the functionalities of the PMS, and the operator, who can ensure reliable and cost-effective operation. To do this, the PMS must provide basic information, such as the dimensions of the entrance and exit as well as details of the charging infrastructure, in order to provide the user with a choice in advance.

Users want to park their car close to their destination and charge if necessary

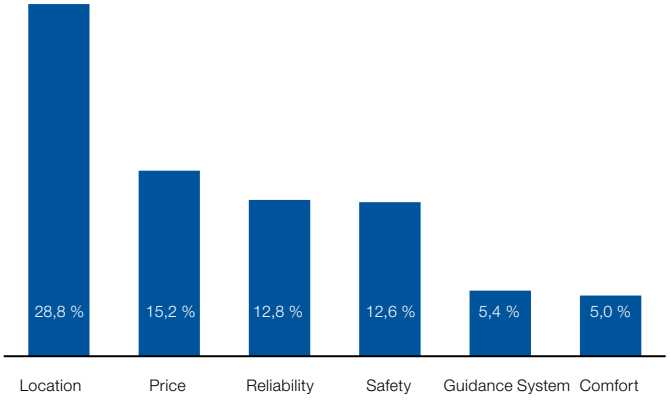
The parking facility must be available for the user group

- intuitively findable,
- plannable and comfortable,
- and be attractively designed

The parking facility must comply with vehicle requirements:

- Dimensions of the vehicle
- Charging system and speed
- Interface to the navigation system

Criteria for Choosing a Car Park (Source survey)



In order to select the parking option, the user group requests **information** about the parking options near its destination

User interface

Figure 9: Level of users and vehicles

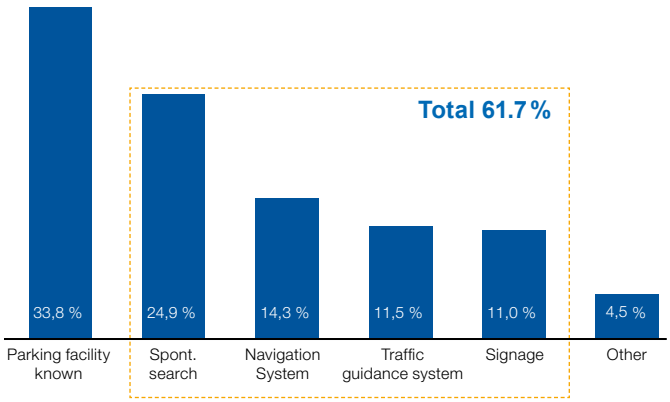
The overarching platform connects users and infrastructure on different channels:

- Inter-operator app
- Online portal
- Navigation app from the manufacturer
- Operator App
- Displayboards without individual contact point
- Analogue card

On the way to becoming a mobility hub, further services can be linked:

- Car-Sharing,
- Public transport and long-distance public transport …

How Do You Choose Your Parking Garage? (Source survey)



To provide the necessary information, the platform must be filled with data from the PBS → **PBS**

Figure 10: The Parking & Charging platform as user interface

A Smart Parking & Charging platform can serve as an intermediary to link users and PMS and provide the relevant data and information. This platform can take the form of a cross-operator app, an online portal, a navigation app of the vehicle manufacturer, or own apps and has not yet been established across the board. As part of the study's survey, it became apparent that over 60 % of participants had not yet determined their parking option before starting their journey and could therefore be addressed via a platform. Especially with increasing requirements due to necessary charging infrastructure, the share of digital trip planning will increase.

The PMS connects the charging infrastructure with an overarching service solution such as a Smart Parking & Charging platform and serves in part as a backend for the charging infrastructure or parking management. Thus, real-time data transmission can provide an overarching platform with information that reflects the current state of the parking facility. Within this study, the scope of a PMS was not yet uniformly defined and questions remain open about the necessary functions, data and technical components.

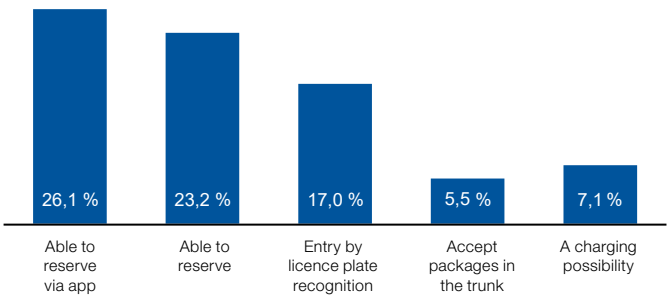
For the consortium we have set up the PBS as a **modular system**:

1. Functions
What does the PBS need to do?
Which services do I want to offer?

2. Data
If I implement this function,
what data do I need?

3. Technical implementation
Which components have to be installed for data generation?

How Do You Choose a Parking Place? (Source survey)



To network the PBS, data, interfaces and components must be collected and provided by the infrastructure → **Infrastructure**

Figure 11: Structure of the parking management system

Approach	Entry & Exit	Search	Parking & Charging	Pay
■ provide basic information ■ Capture real-time utilization and occupancy ■ Provide interfaces for valet apps ■ Offer reservation option for parking & charging ■ Analyze usage behavior	■ Enable physical access ■ Automate user management ■ Visualize the current status of the parking garage	■ Control dynamic parking guidance system ■ Enter and display parking space status	■ Offer services during parking ■ Control charge management of the charging columns ■ Manage charging options and services ■ Capture and display availability & status of charging infrastructure ■ Record and display availability & status of building technology ■ Manage roaming for different providers	■ Manage payment methods ■ Manage prices ■ Manage automated billing

Figure 12: Functions of a parking management system

Within the consortium, the components of the parking management system were developed and summarized in two workshops. In the first workshop, typical personas of the parking process were considered and their wishes and requirements for a PMS were analyzed. In the following workshop we determined what extent these requirements can be mapped by a PMS, which functions a PMS should be able to implement and which components are needed for this. The consolidated result is structured on the parking process and can be seen in Figure 12.

In the slide deck supplied, there is a further slide with examples for each function. The necessary data and technical components are listed in Figure 13 and provide an overview of the technical equipment of a parking garage with PMS.

User Interfaces

User Data:

- Reservation of a parking space
- Long-term parker
- Features of the vehicle
- Special characteristics of the user
- Vehicle position
- Aim of the user
- State of charge of the vehicle

Figure 13: Overview of the technical equipment of a multi-story car park

Infrastructure

Parking Data:

- Available parking spaces
- Available charging stations
- Opening hours
- Reserved parking spaces
- Position parking garages
- Charging pole occupancy status
- Charging time / duration
- Charging power
- Counter reading
- Car park boundaries (entry height)

Parking Technology:

- Access technology
- License plate recognition
- Visual parking guidance system (reservation and spontaneous parking)
- Occupancy sensors
- Occupancy display at the parking lot
- Charging column control
- Advertising space
- Charge management
- Billing and Authentication:
  - EC card
  - Credit card
  - Customer account
  - Cash
  - NFC
  - RFID reader
  - QR code

Guide to Retrofitting Charging Infrastructure

As part of the consortium study, a living lab was created in which new technologies and business models can be tested and implemented. A dynamic booking system for optimized utilization of the charging infrastructure among a limited group of users as well as contactless unlocking of the charging stations via an app are already being developed.

We have transferred the findings and experiences from our own development of a variable charging infrastructure with one charging station with DC and AC charging points as well as five AC charging stations from four different manufacturers into a guide, taking into account existing literature. This guide is primarily aimed at retrofitting into existing infrastructure and the operational activities and decisions required for implementation. Therefore, points that are already described in detail in the existing guides are not included here and can be found in the following literature:

a) VDE Guide

(b) EHI guidelines

c) BMVIT guidelines

Needs analysis

The first building block of the guide to retrofitting charging infrastructure is a needs analysis, on the basis of which a complete charging park can be dimensioned. The core task is to determine the necessary charging capacity as well as the number and performance of the individual charging columns. Basically, the demand can be determined from two perspectives: From the point of view of the market and from the point of view of the infrastructure.

The market view is based on the potential users that are eligible for the charging infrastructure. For this purpose

- the number of expected users of the charging park, and
- the weighted charging power demand is calculated as the mean value of the necessary charging power of different user groups.

The required number of charging points and the corresponding grid connection capacity are derived from this.

The infrastructure view considers the prerequisites that are available for charging infrastructure on site. This consists of the infrastructurally possible grid connection capacity, which can be obtained from the grid operator, and constructional or infrastructural limitations (e.g. transformers). In some cases, the infrastructure thus limits the expansion of a charging park, but this can be partially compensated for with the help of other technologies such as charge management or stationary battery storage.

In order to calculate the theoretical number of charging stations to cover the demand, the number of parked electric vehicles and the simultaneity factor are required. The number of parked electric vehicles can be derived from data from the operation of parking garages, for example, or determined with the help of current statistics. For example, 0.9 % of registered cars in Germany are electric vehicles with charging facilities. Depending on the target group of the charging infrastructure, whose attitude also differs with regard to electromobility according to milieu logic, the charging infrastructure should be adapted accordingly to the total number of parking spaces.

The simultaneity factor indicates how many electric vehicles occupy charging stations at the same time and is thus an indicator of capacity utilization. There are various empirical studies in which a value for the simultaneity factor was determined. In a study by Netze BW in the E-Mobility Carré[1], a simultaneity factor of 0.22 was determined in a field test of an equipped underground car park of a residential building. In contrast, in another, but less extensive test in Ostfildern, a simultaneity factor of 0.5 was determined in a residential area[2]. For the operation in a multi-story car park there are no scientific studies so far that allow an assessment here. However, it must be taken into account that within the studies the charging behavior was considered and there were vehicles that were connected to the grid daily and others that were only connected once a week. This results in a diverse picture of electric vehicles for the parking garage, which are theoretically dependent on charging stations, but have no practical need for them.

The weighted charging power demand estimates the total demand of a charging park with the help of different user groups and their individual needs regarding charging power. As shown in Figure 14, the power demand per customer group is analyzed. This is based on the kilometer requirement per charging process, the parking duration, the number of customers per day and the average consumption. By determining the necessary charging power via the kilometer requirement and parking duration, an estimate can be made as to which type of charging station

[1] https://www.netze-bw.de/News/netze-bw-hochlauf-der-elektromobilitaet
[2] https://www.netze-bw.de/e-mobility-allee

Structure:
The weighted charging power demand estimates the power demand of the charging infrastructure with the help of different user groups and their individual needs.

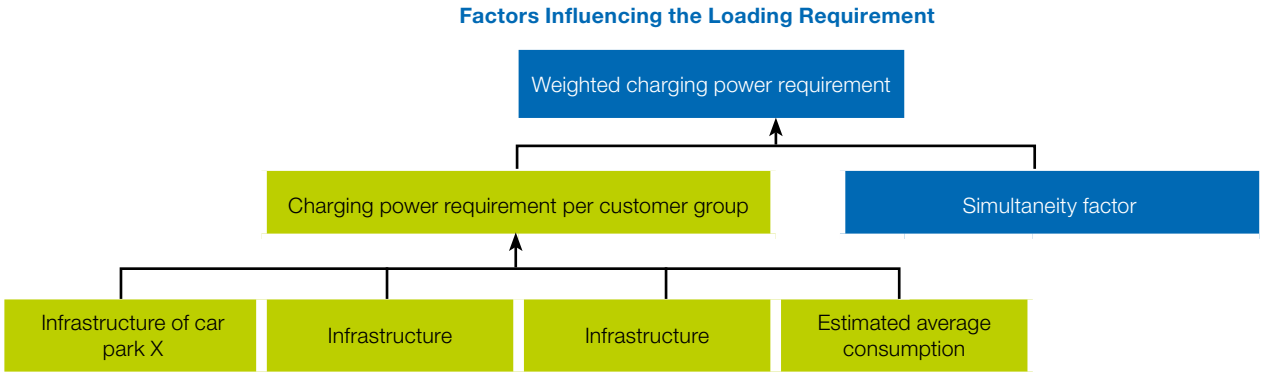


Figure 14: Overview of the factors influencing the charging demand

(direct current or alternating current) and which grid connection power is necessary.

The concrete calculations of the entire needs analysis are recorded in the excel file for the consortium study and can thus be applied to each project. However, they only serve as an initial assessment of the needs and cannot be applied as detailed planning and may deviate in individual cases.

Technical Measures
After the concept phase in the form of the needs analysis, the guide to retrofitting charging infrastructure contains the chapter on technical measures. It deals with load management as a technical component for optimizing the charging park, the installation of the grid connection and the network connection.

Load Management
One component that can help with high infrastructure demands is load management.

Load management in the charging infrastructure has the goal of realizing the best possible charging offer from a limited grid connection capacity and still guaranteeing grid security. For this purpose, the charging stations are individually controlled via the backend of the charging infrastructure so that a charging park can be operated that is optimized for charging power, for example.

To determine the need for and scope of load management, use cases should be considered and their probabilities of occurrence analyzed.
This results in the following possible applications for the use of load management:

- Offer of high charging power despite theoretical lack of grid connection power
- Interception of load peaks in the event of a high number of charging processes starting at the same time
- Reduced dimensioning of the charging infrastructure to minimize costs despite the high number of charging points
- Preventing grid overloads to ensure grid security

For this purpose, the following use cases can be implemented with the help of load management:

- Charging power distribution to individual charging columns and charging processes
- Centrally controlled prioritization of individual charging processes
- Perspective: Integration of dynamic pricing via load management

Load management generally increases the flexibility of the installed charging infrastructure and gives room for possible expansions without the need for additional grid connection power. Load management is also a mandatory requirement for dynamic price offers or the prioritization of certain customer groups or charging points.

Additional battery storage modules in combination with a load management system can further reduce the required grid connection power or realize a cost-effective integration of photovoltaics.

Mains Connection
The grid connection is a central element of the charging infrastructure and is characterized by the intensive exchange

Charge Management

Timing/Duration:
Concept Phase

Tasks:
- Determine the need for charge management
  - Necessity of charge management is determined by analyzing use cases and their probability of occurrence
- Possible applications:
  - Offer of high charging power despite theoretical lack of grid connection power
  - Interception of peak charges to minimize the cost of initial investments
  - Reduction of the dimensioning of the electrical installation to minimize costs
  - Preventing grid overloads to ensure grid security
- Adjustable parameters
  - Power distribution over the charging processes
  - Prioritization of charging processes
  - Perspective: dynamic pricing
- Enhancements:
  - With the support of battery modules, a theoretically higher charging power can be offered than the grid connection power

Stakeholders:
- Electrician
- External service provider

Components:
- Charge managementsoftware
- Battery modules (optional)

Notes:
- Alternative or supplementary to the expansion of the grid connection

Figure 15: Load management

with the local grid operator. The installation of the grid connection requires several steps and is carried out by an electrical company. The installation process can be illustrated as follows:

1. Information on the grid connection is obtained from the grid operator in order to have a basis for the design of the grid connection and the charging infrastructure. The inquiry clarifies whether and with what maximum power the charging infrastructure can be installed and what costs are incurred for the installation. The result of this inquiry is usually a maximum available grid connection capacity.

2. The electrician then draws up a concept based on the maximum possible grid connection capacity or the required grid connection capacity calculated in the demand analysis, which includes cabling, connections, fuses and other infrastructure associated with the electrical installation.

3. When the concept is defined, the electrician carries out an official power query with the grid operator. Connected to the enquiry is the registration of the charging infrastructure by the electrician, which is accompanied by a grid connection contract with the entire power requirement.

4. In accordance with the concept of the electrician, the number and capacity of existing transformers must be considered and, if necessary, retrofitted. Further structural measures include the local technology mentioned above.

Main Connection

Timing/Duration:
Parallel with the Needs Assessment

Tasks:

- Unofficial obtaining of information on the grid connection from the grid operator
  - Inquiry with the network operator as to whether and with what capacity charging infrastructure can be set up
  - The result is usually a maximum installable mains connection power
- Conceptual design by the electrician based on the mains connection performance (cabling, connections, fuses, etc.)
- Official performance query with the network operator by the electrician (online form)
- Registration of the charging infrastructure by the electrician
  - Grid connection contract with total power requirement
  - Number of existing transformers / transformers to be retrofitted
- Structural Measures:
  - New fuse box
- **Procedure (compact)**
  - Obtaining information on performance from network operators
  - Selection of the charging power
  - Registration of the charging infrastructure
  - Grid connection contract
  - Retrofitting of local technology

Stakeholders:

- Network operator
- Electrician

Components:

- Transformers (if required)

Notes:

- Commissioning often runs via a combination of civil engineer and electrician
  - Example civil engineer as general contractor, electrician as subcontractor

Figure 16: Main connection

Network Connection

The network connection enables the connection of the charging stations with the IT infrastructure of the charging park. The charging stations are controlled and relevant data exchanged via the connected backend. This includes, for example, data required for billing or measuring the load as well as services such as remote maintenance, software updates and load management.

The connection to the network can generally be installed via hardwire or wireless. Hardwire solutions are implemented with network cables (CAT7) to each individual charging pole and are considered the most reliable solution but depending on the location are not economical or difficult to implement. In this case, wireless solutions can be used. These can be implemented either via WLAN or via mobile network (4G/5G). Depending on the chosen solution, corresponding wireless modules must be installed at the charging stations and mobile phone contracts must be concluded.

Network Connection

Timing/Duration:
Parallel to the Wiring

Tasks:
- Connection of the charging stations with the server and backend
  - WiFi
  - 4G/5G
  - Network cable
- Installation of appropriate wireless modules, depending on the chosen solution
- Laying of network cables (CAT7) from each charging station to the server

Stakeholders:
- Electrician
- IT representative

Components:
- Network cable
- WLAN modules
- Mobile radio modules

Notes:
- Hardwire solutions are usually better than wireless solutions

Figure 17: Network connection

Structural Measures

In addition to the technical measures, the guide also explains the structural measures that are necessary for retrofitting charging infrastructure. For this purpose, civil engineering and cabling are considered in the following.

Civil Engineering

Civil engineering includes the installation measures that are necessary in the ground to set up the charging stations and lay the power cables. Coordination between underground engineers and electricians is therefore important in the concept phase, since the power cables of DC charging stations, for example, have a large diameter due to the high power and the associated high amperage and must be taken into account accordingly in the planning. The conceptual design of the civil engineering measures is ideally carried out with an on-site inspection by the responsible civil engineer and then coordinated with the electrician.

In general, the following points should be taken into account:

- It should be clarified where house walls are to be drilled through (if columns are to be located outside the building) and where interior walls have to be drilled through in order to lay cables.
- In the case of cable ducts located in the building, any existing obstacles (e.g. due to existing infrastructure) are analyzed and a cable route is selected.
- In order to be able to respond to the increasing number of electric vehicles, additional reserve channels for cables should be provided.

In addition to the civil engineering measures envisaged in the concept for laying cables, charging columns are fixed in the ground using suitable foundations. These are to be cast in accordance with the type- and manufacturer-dependent specifications.

Civil Engineering

Timing/Duration:
After Electronicsplanning

Tasks:
- Conceptual design for laying the necessary cables, ideally with on-site inspection with the responsible civil engineer
- The concept should take into account the following points, among others:
  - Places where the house wall is to be pierced (if columns outside)
  - In the case of cable ducts located in the building, consider any existing obstacles (e.g. due to existing infrastructure).
  - If possible, provide additional reserve channels to respond to the increasing number of PHEVs.
  - Pouring foundations to match the selected charging columns

Stakeholder:
- Civil engineer

Components:
- Cable ducts

Notes:
- In order to save costs, it is advisable to keep interventions in the existing infrastructure (e.g. asphalt work) to a minimum.

Figure 18: Civil engineering

Wiring

The cabling connects the charging infrastructure to the local power grid with the help of power cables through the cable ducts laid by the civil engineering company. Especially for DC chargers, the cable cross-section must be taken into account if several charging stations are to be connected. This can be a major cost factor in multi-story car parks and often restricts charging capability to the vicinity of the grid connection.

The planning of the cabling is carried out by the electrician in the course of the concept creation. The necessary cable cross-section is determined, analyzed and, if necessary, coordinated with the civil engineer. Further electrical installations at switch boxes, distribution boxes, fuse boxes must also be included in the planning.

Wiring

Timing/Duration:
Parallel to Civil Engineering Works

Tasks:
- Planning of the wiring by the electrician
  - Necessary cable cross-section must be determined or analysed
  - Need to retrofit local electrical installations
    - Control box
    - Distribution box
    - Fuse box

Stakeholder:
- Electrician

Components:
- Cable ducts
- Cable
- Fuse box
- Distribution box

Notes:
- To save costs, short cable runs should be aimed for, as cabling is a significant cost driver.
- Due to the considerably larger cable diameters of fast charging infrastructure, an analysis of the existing infrastructure should be carried out beforehand to check whether a retrofit is possible in terms of space

Figure 19: Wiring

Fire Protection in Parking Garages

Fire Hazard of Electric Vehicles

As a new technology, electromobility has also been accompanied by doubts about its fire risk. Due to the lack of empirical values and the corresponding lack of clarity, the question “which safety requirements must be taken into account in the construction and operation of charging infrastructure - especially with regard to fire protection” was posed during the requirements workshop.

To this end, the consortium study focused primarily on fire protection and sought expert interviews with various stakeholders from the German fire protection sector. For example, interviews were conducted with the heads of preventive fire protection in Aachen and Munich, the latter acting as the Germany-wide spokesperson for fire protection of charging infrastructure in Germany and contributing to the new model garage ordinance.

From the fire brigade’s point of view, the basic discussion about the difference in fires between combustion and electric vehicles is “misleading”, as it is not the electrical components that increase the fire risk or fire load, but the plastic installed in the vehicle. Hence, the problem is due to the quantity of plastic components, which result in a higher overall fire load, combined with small parking spaces, which encourage the spread of fire to neighboring vehicles.

According to the ADAC, there are also no differences (ADAC 2021[1]) between the fire risk of electric vehicles and internal combustion vehicles. The VDI also sees no danger in the charging process: “No additional hazards arise from the charging process in electric vehicles [...]; among other things the formation of flammable gases is not to be expected during charging”. (VDI Guideline 2166, Sheet 2, Chap. 6.4)

A counter-example from Liverpool[2] shows that combustion engines can also lead to dangerous fires. Here, 1,300 vehicles burned out in a multi-story car park, partly because the burning petrol spread through the sewage system and ignited other floors.

Fire Protection Requirements for the Charging Infrastructure

The fire protection of garages and parking garages is based on their building class. This differentiates between the type of building (including free-standing, enclosed, underground) and is backed up with corresponding fire protection requirements (Figure 20). An underground parking garage represents the highest class, in which all structures such as walls and ceilings must be fire-resistant and retain their load-bearing capacity for 90 minutes in the event of a fire.

Building Classes			
GK1	a) Free-standing buildings	Height ≤ 7,00 m ≤ 2 usuage units total ≤ 400 m²	Fire-retardant
	b) Detached buildings used for agricultural or forestry purposes		
GK2	Building	Height ≤ 7,00 m ≤ 2 usuage units total ≤ 400 m²	Fire-retardant
GK3	Other buildings	Height ≤ 7,00 m	Fire-retardant
GK4	Building	Height > 7,00 m ≤ 13,00 m usuage units < 400 m²	Highly fire-retardant
GK5	Other buildings, including underground buildings		Fire-resistant

Figure 20: Building classes of the Garage Ordinance and fire protection classification

[1] https://www.adac.de/rund-ums-fahrzeug/elektromobilitaet/info/sicherheit-elektroauto/
[2] https://www.bbc.com/news/uk-england-merseyside-42542556

These fire protection requirements apply to every parking garage, irrespective of the charging infrastructure. Due to a lack of scientific findings and studies, there are no specific legal requirements for charging infrastructure. The building code does not regulate the installation and operation of charging columns, which means that they can be installed in any underground car park without additional building permits. Charging infrastructure is considered electrical installation in buildings and is treated as such from a legal and safety perspective. This means that for charging infrastructure in multi-story car parks, a professional electrical installation must be ensured by a specialist electrical company, as is usual for similar work in Germany.

Fire alarm systems, on the other hand, represent a fire prevention system that must be installed depending on the car park. According to § 137 of the building regulations, fire alarm systems are only required for enclosed and large car parks (> 1,000 sqm) and are not affected by the installation of charging infrastructure. Also, the increased requirement for extinguishing water for electric vehicles does not lead to changes in the building regulations.

Fire Brigade Procedures in the Event of a Fire

The greatest dangers arise in underground garages, as the source of the fire is difficult to locate and the extinguishing material has to be transported over long distances. Combined with a strong spread of smoke and temperature, this also results in a danger for people who are above the underground car park.

If a fire does occur involving electric vehicles in parking garages, the fire brigade uses a similar procedure to that for fire incidents involving combustion engines. The location of the fire hazard is analyzed and the danger area is cordoned off. A particular interest in the case of electric vehicles is to determine the local location and degree of damage to the lithium-ion storage media. Effective extinguishing measures are carried out with water and prevent further fire and smoke from being spread to other fire compartments. An open question, however, is the contamination of the extinguishing water, which must subsequently be collected and specially treated.

A difference to combustion engines can be seen in the management of the vehicles after the initial extinguishing of the source of the fire. Conventional drives are monitored for 2 – 3 hours for subsequent ignition. The batteries of electric vehicles, on the other hand, must be monitored for up to 24 hours after the fire has been extinguished. If possible, the vehicles are

moved to an open area where they can burn out if necessary. If this is not possible, it is currently being discussed who is responsible for continuous monitoring to prevent re-ignition.

Recommendations for Action by the Consortium

In discussion with the fire brigade, we have drawn up recommendations for action to reduce fire incidents in multi-story car parks and their consequences in the interests of preventive fire protection:

- Currently, charging stations are not tracked in development plans and fire protection plans, this should be changed for the sake of quick assessment of the situation for fire departments.
- Place charging stations at an easily accessible point so that in the event of a fire the fire brigade has good access to the source of the danger and the removal of burnt-out vehicles is also possible.
- A structural separation between fire compartments and/ or vehicles reduces the speed of propagation and the consequences in the event of a fire.
- Accessibility and water supply for the fire brigade must be sufficiently ensured.
- The need for fire water retention should be assessed

Future Developments

Politically, the expansion of the charging infrastructure is desired, which is why we assume that an amendment to the building code will not disadvantage charging infrastructure.
Due to the overall higher fire load of vehicles, primarily caused by the high plastic content and increased number of SUVs, a change in the building code will likely result in a stronger requirement for fire retardant materials on the mezzanine levels. This will increase construction costs for new parking garages.

In addition, the Model Garage Ordinance in Germany will be amended in 2021 and the following items may still make it into the final version:

- Lithium-ion batteries (storage batteries) will be prohibited within the parking spaces.
- They will be allowed in outdoor fireproof areas.
- The installation of medium and high voltage within the parking garage is prohibited - low voltage (as for charging infrastructure) is permitted.
- For smaller garages, the fire alarm system will only be required for garages larger than 2,500 square meters, instead of the previous requirement of 1,000 square meters.
- Fire compartments and smoke compartments will be changed – instead of smoke compartments, every 2,000 square meters will become individual fire compartments.
- The fire protection regulations for open car parks made of steel will be tightened in the next building code and the Munich Fire Brigade expects the previous regulation to be dropped in the next few years. In future, these multi-story car parks will have to be made of fire-retardant materials.

These changes can be found in an advanced preliminary version of the regulation, but has not yet been adopted. Implementation of the new nationwide building code may vary from state to state and is expected to take several years.


E-CAR STATION

Business Models

The installation of charging infrastructure is a necessary and politically motivated project. However, the investments have to pay off over their lifetime and generate sufficient revenue to be viable in our monetary-driven system. To this end, an analysis of suitable business models considered how the operation of charging infrastructure, the billing process and the business case for charging infrastructure is structured.

Operating Concept

The operation of charging infrastructure is a complex undertaking due to a multitude of partners from different industries and regulatory bodies.

In particular, the novelty of charging infrastructure has required legislators to amend the current law in such a way that the operator of charging infrastructure is not considered an electricity supplier, who must comply with the subsequent rights and obligations. Thus, from an electricity tax perspective as well as from a market perspective, it must be determined whether the operator of charging infrastructure is to be assessed as an electricity supplier or an end consumer and thus falls under the transparency obligation. For the sole operation of charging infrastructure, Metropolitan Cities MC GmbH, for example, is considered an end consumer according to Energy Industry Act (EnWG) § 3 and thus has no further transparency obligations.

Furthermore, it is relevant whether the charging infrastructure is publicly or privately accessible. According to Section 2 No. 9 of the Charging Point Ordinance (LSV), “a charging point is publicly accessible if it is located either in the public street space or on private property, provided that the parking space belonging to the charging point can actually be accessed by an undefined group of persons or by a group of persons that can only be determined according to general characteristics”. This means that for a private charging point it must be ensured that only a selected or identifiable group can use it. With the public use of the charging park, the charging park operator is subject to further obligations:

- § 3 LSV: technical safety and interoperability (sockets / vehicle couplings according to DIN EN 62196-2 and -3) must be ensured.
- § 4 LSV: Point charging for the general public must be made possible without authentication against payment in the vicinity or via card-based payment system.
- Section 5 LSV: Notification and verification obligations vis-à-vis the regulatory authorities must be ensured.
- Supplementary obligations for technical safety according to § 49 EnWG.
- Compliance with the calibration law (§ 7 Measurement and Calibration Ordinance), i.e. calibrated measurement per kWh drawn, must be ensured.

As part of the Smart Parking and Charging study, we have worked out in Figure 21 how the operation of charging infrastructure can be implemented and which stakeholders are involved. Basically, a distinction can be made between the groups of users, operators, suppliers and service providers.

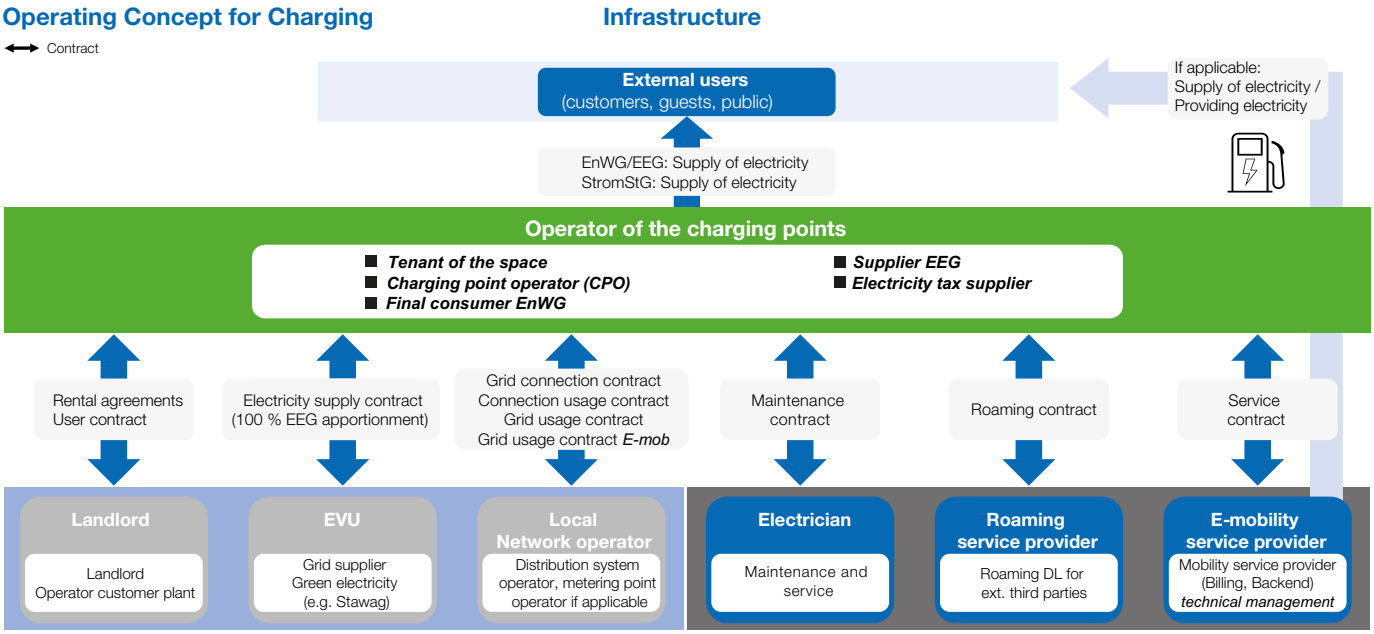


Figure 21: Operating concept for charging infrastructure and legal framework

As a customer, the external user enters into a purchase contract with the operator, who supplies him with electricity in return for payment. Billing can be carried out via the actual operator or roaming service provider.

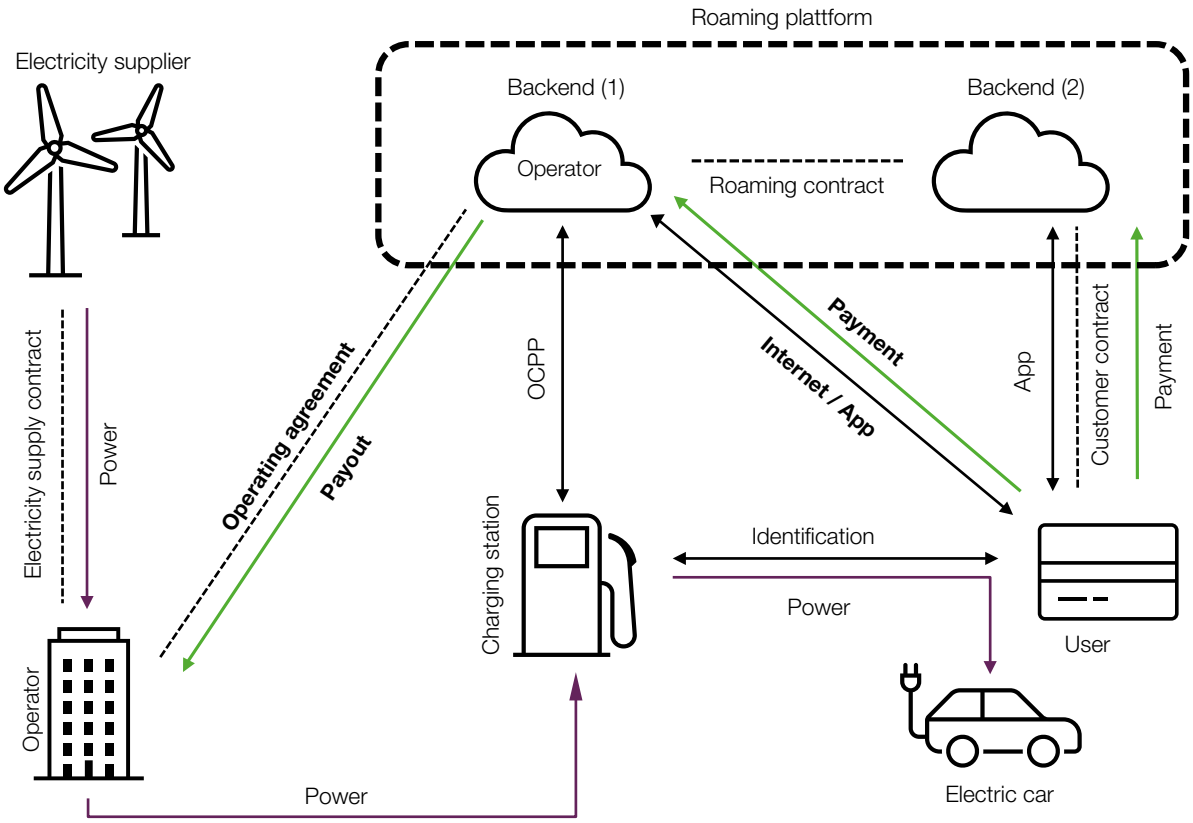
In return, the operator of the charging infrastructure has to supply or provide electricity. Suppliers and service providers are necessary to be able to offer the electricity. The landlords provide the space for the charging infrastructure and have this secured and remunerated in the form of rental contracts. The energy suppliers provide the electricity, which is specified in the electricity supply contract. It should be noted here, for example, that public funding for the charging infrastructure in NRW is only possible with "green" electricity. Installations must also be coordinated with the local grid operator and several contracts for connection and use of the grid must be concluded.

The service providers, on the other hand, have the task of ensuring that the installed infrastructure is continuously available to the customer. The electrician must carry out the installation, maintenance and service of the charging infrastructure, which is currently mandatory once a year. To integrate the largest possible group of customers, additional services can be connected via roaming service providers. In addition, the complete billing, operation of the backend and other services can be outsourced, thus reducing the scope of the operation of the charging park. Here, a wide range of tasks is possible with which the operation of charging infrastructure can be reduced to a minimum.

Billing Process

Within the framework of the operating concept, the billing process is already a component that should be designed to be as customer-friendly and flexible as possible. For this purpose, an overview of the billing process was created in Figure 18, which shows the electricity supply from left to right and the billing process from right to left. A relevant step here is above all the roaming platform, which serves as an intermediary between different suppliers.

Overview of the Billing Process



(adapted from https://www.bayern-innovativ.de/services/asset/veranstaltungen-2018/2018-11-29-emobilitaet-laendlicherbereich/teilnehmerbereich/05-Stefan-Pagenkopf-Martin-Laden-am-Parkplatz.pdf)

Figure 22: Overview of the billing process

For the billing process, the identification of the customer is relevant in order to be able to determine the payment type and provider. The user then has several options to choose from, which can be combined into payment via the charging park operator directly or via a roaming platform. If the customer pays via the roaming platform and the backend of their own provider, there is usually a customer contract with its own billing process and format. The payment is then forwarded to the charging station operator via the roaming platform and paid out. If the user pays directly to the charging station operator, no roaming is necessary and billing runs directly via the operator.

However, this system requires a closed infrastructure via roaming or operator platform. The efforts of the German government stand in the way of this, as a new charging station ordinance dictates that starting in 2023, every newly installed charging station must offer at least one ad-hoc payment system that works with common debit or credit cards. This means that, in addition to the current charging cards and apps, credit cards will also become established as a payment system.

Business Case of Charging Infrastructure

In order to be able to place the development of charging infrastructure and the associated business models in an economic framework, a business case for the installation of charging infrastructure was created as part of the Smart Parking and Charging study. The first part of this case contains a demand analysis and the second part a business case calculation.

The business case was developed in an Excel document, which can be used to calculate the installation and operation of a charging park. The charging station demand can be calculated using the weighted charging demand of individual user groups and the expected customer volume. The business case including net present value calculation can also be carried out with this information. The relevant components for the business case consist of investment costs, operating costs, as well as revenues and subsidies.

The investment costs are made up of the following cost items:

- Planning: concept development with the network operator, electrician, civil engineer and, if necessary, the leasing company
- Civil engineering works: Pouring of the foundation, milling of all cable ducts, drilling of house walls
- Electrical work: Retrofitting of switch boxes, distribution boxes and fuse boxes, cable laying
- Installation: Connection and setup of the charging infrastructure
- Grid connection costs (differ depending on the grid operator): Depending on the maximum power purchased, e.g. in Aachen 30 EUR/kW are due from a base amount of 40kW.
- Charging stations: AC charging stations, DC charging stations
- Software: load management, parking management system
- Lawyers: drafting of new and review of existing contracts
- Additional services: Sensor technology for parking space occupancy monitoring

The operating costs are made up of the following components:

- Maintenance costs: inspection, maintenance and cleaning of the charging stations
- Space costs: loss of normal parking spaces, rental costs
- Payment services: Payment processing and settlement service, and roaming service provider.
- Electricity costs: amount depending on the electricity supplier and corresponding framework agreements

The specific revenues regarding retrofitted charging infrastructure amount to the corresponding revenues from the charging processes, whereby a distinction is made here between the charging point types. Depending on the business model, different charging prices can be realized for the respective charging point types.

Finally, there is the possibility of taking advantage of government subsidies that can reduce the investment costs. For example, 50 % of the installation costs per charging station can be subsidized up to an amount of € 2,000.

The business case is available as part of the study and can be used as an initial calculation for the installation of a charging park. Here, the business case calculation provides an initial assessment of the need, investment and potential revenue, which is why a focus was placed on ease of use and operation rather than a high level of detail.

The Mobility Hubs Megatrend

In the course of the advancing socially and politically driven transformation of mobility in Germany and Europe, new, innovative topics for overcoming mobility-related problems are on the agenda. Road traffic alone is responsible for 26 % of all CO_2 emissions in Europe. This is a global problem. In addition to this global component, local emissions such as particulate matter, nitrogen oxides and noise in particular are reasons to accelerate the transformation due to direct health effects on residents of urban areas.

Economic factors due to a system burdened beyond its borders are also of great importance. The retail sector is facing trend-setting developments and citizens are demanding more livable spaces and forcing municipalities to act.

Consequently, the focus is on mobility hubs in various forms as part of a holistic solution.

The understanding of mobility hubs in the context of this consortium study is to be defined as follows: A mobility hub is a dedicated parking area for motorized private transport vehicles. In addition to transfer possibilities to other modalities, depending on the design, additional services of typical everyday life such as parcel stations and charging points are offered and, in its entirety, motorized private transport is bundled, parking search traffic is prevented. Hubs are strategic nodes in the holistic urban mobility context.

How Can They be Characterized?

Depending on their location and main function, hubs/mobility stations are classified into three types in the context of this study: The interregional station, the urban station and the neighborhood station. The main differences are the location (from outside the city to in the middle of a neighborhood) and the enabling of the core task or main task (from bundling and accelerating transfers to secure parking spaces and offers of micro mobility). Further details of the individual types can be found in the elaborations and characterizations in various figures in the appendix (Mobility Hubs supplements).

As already mentioned, the choice of location depends on the task that a mobility station has to fulfil. The more motorized individual traffic is to be intercepted from the inner-city area and condensed into public transport, the further out a station should be located. If the aim is to densify and accelerate traffic within the urban area (e.g. to make it possible to do without a car for certain routes), the choice of existing nodes such as a train station or bus station is a suitable choice. In neighborhoods, the bundling of parking residents in combination with central charging options is decisive, so that parts of neighborhoods can be designated as car-free, for example. The corresponding components of the different station types in terms of a parking management system are also detailed in the appendix and should be understood as a suggestion of a potential configuration.

In addition to the actual design of such a station, there is the question of the operation of individual services, but also the question of holistic operation and underlying business models. In addition to the details mentioned above, an overview of relevant stakeholders and their roles can be found in the appendix.

If this information is put together and compared with one's own strengths and potentials, possible monetary incentives to invest in the operation or partial operation arise.

The provision of transaction processing can serve as an example at the neighborhood level. While many people who are provided with a company car can charge at company charging points or are provided with a charging card, there are open questions about charging in the home garage or at the home parking space. It is particularly interesting here to also connect the charging infrastructure at home or in neighborhood hubs with permanently rented parking spaces online. For this purpose, communication takes place via OCPP. This enables for the operator of the charging point to also accept charging cards from an external company via roaming and to conduct transactions. However, this requires providers who can handle this multitude of small transactions. Other examples such as the holistic operation of a station or parcel stations can also be mentioned.

Recommendations for Action

The results of the consortium project can be used as a reliable information basis in the individual companies of the partners for strategic decision-making. The consortium partners benefit from the development and deepening of expertise in the entire subject area and the possible technological development of their own products and services. The results have been presented on the previous pages and substantiated by further material in the appendix. The following recommendations are to be understood as a summary and, when applied or implemented, to be enriched by the extended elaborations of the study described within this evaluation. Regarding follow-up questions or open points, please feel free to contact the executing staff at Metropolitan Cities or the FIR at RWTH Aachen University.

Recommendation #1:

- Take the perspective of the future users.
- Even if you sell products or services in the B2B area, put yourself in the position of the actual end customer (a quasi B2B2C perspective at the end of an entire chain). Using the mentioned personas and the change of perspective, you can identify needs, preferences and behaviors and derive criteria for your own products or services.
- Use the methodology of the hierarchical target system as a support to have a strategic framework for your own products and services.
- For the formation of personas, it is recommended to use the lifestyle types according to Stelzer and Heyse.

Recommendation #2:

- Intelligently implemented charging infrastructure is a must.
- The question is no longer whether the triumphant advance of primarily battery-electric electromobility will begin, but how quickly it will occur. Accordingly, strategic considerations and business models in the private and corporate sectors must already be established today to take this trend into account.
- In essence, this means clarity about the actual charging requirements at locations, standards for payment processes and, in particular, clarity about the availability of charging points and the possibility of booking them.
- This includes the development of a data platform that includes all relevant stakeholders, from (component) manufacturers and parking space managers to financial service providers and municipalities or cities, so that holistic integration into an urban ecosystem can be achieved.
- Location is key. As for building infrastructure in general, charging infrastructure is not excluded from the rule that location is the key for the success of infrastructure projects.

Recommendation #3:

- Risks regarding possible fires caused by electromobility are significantly overestimated. Clever integration into existing building infrastructure also prevents minor risks.
- According to the current level of information, the probability of a fire is even lower than with internal combustion engines. Nevertheless, it is advisable to implement charging infrastructures close to the ground floor and with regular structural separation in order to avoid possible residual risks.
- Approval procedures do not play a separate role here, as the structure is considered an electrical installation. Nevertheless, arrangements with the local fire brigade are a sensible measure to implement processes for a potential fire case at an early stage.

Recommendation #4:

- Take digitalization seriously and understand charging infrastructure and associated parking infrastructure as part of an intelligent building periphery.
- Digitalization can be understood that the installation of charging points into existing parking infrastructure should no longer be implemented without digital services. In addition, redundancy plays an important role, for example regarding payment options and availability.

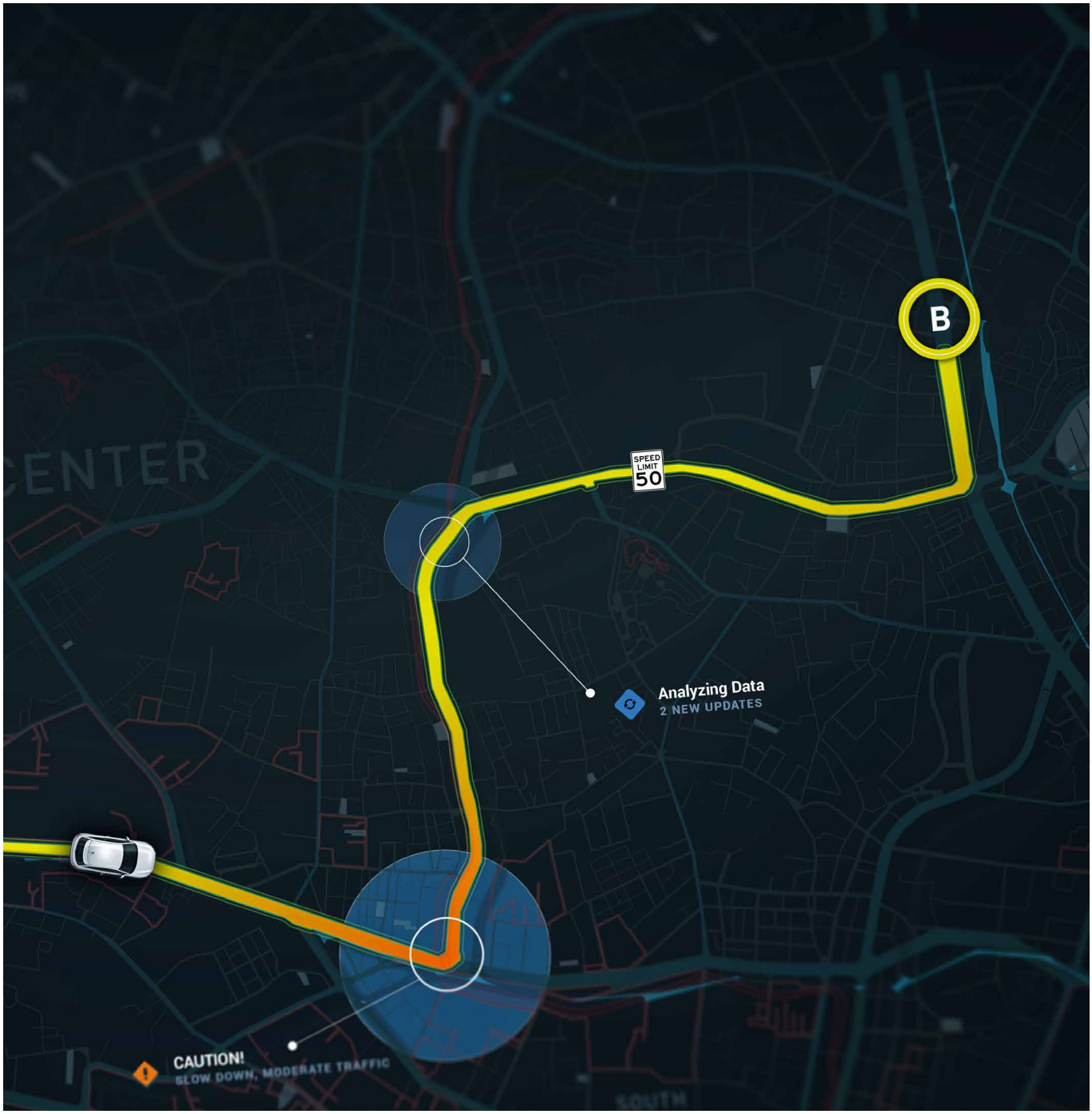
Recommendation #5:

- Forge alliances. No company will be able to satisfactorily coordinate and implement all the building blocks of a successful, intelligent implementation of charging infrastructure and or components of an intelligent parking management system without the expertise of other companies.
- Establish your strengths as well as the strengths of your products and services. As soon as additional functionalities come into play, e.g. a holistic parking management system, these can be implemented with little effort and supported by relevant partners. A hierarchical target system can also be useful as a methodology for this approach.

We would like to take this opportunity to thank you for your cooperation in the context of this consortium study. The exchanges, discussions and interactive workshop formats have enriched this study. You have made a decisive contribution to the successful completion of this study.

In the future, too, we will of course be available to you for concerns of any kind. In particular, the real laboratory in the form of the intelligently connected charging infrastructure as part of a holistic building platform is available to you on request for demonstration purposes of any kind.

We look forward to hearing from you in the future as well.

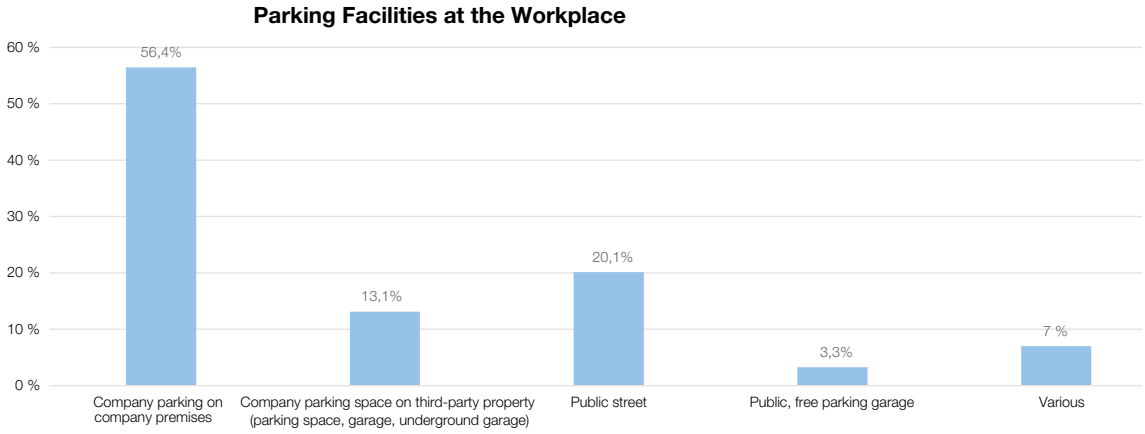


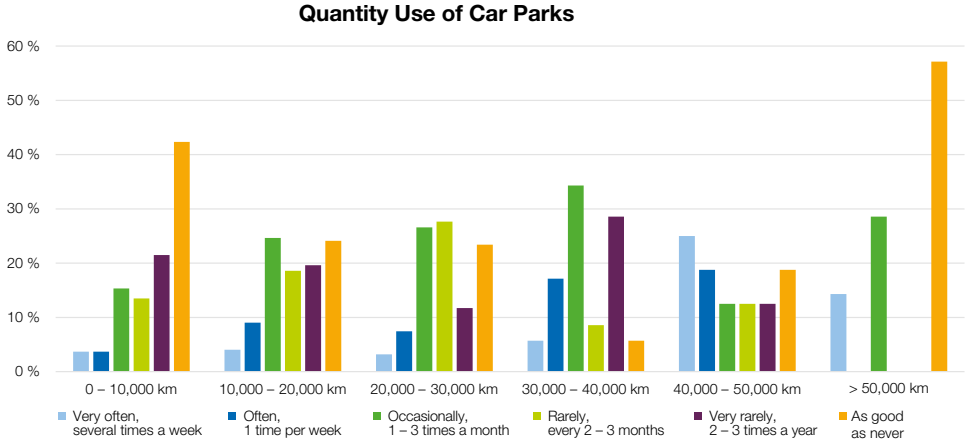
Appendix

Further Evaluations

At this point, additional evaluations of the survey follow, the results of which are to be understood as a supplement to statements made and can bring about a deeper understanding. The aim of the previous section was to highlight the issue of socio-demographic characteristics as a relevant aspect for further strategic approaches and, at the same time, to share the most important findings.

A first further section deals with parking behavior.



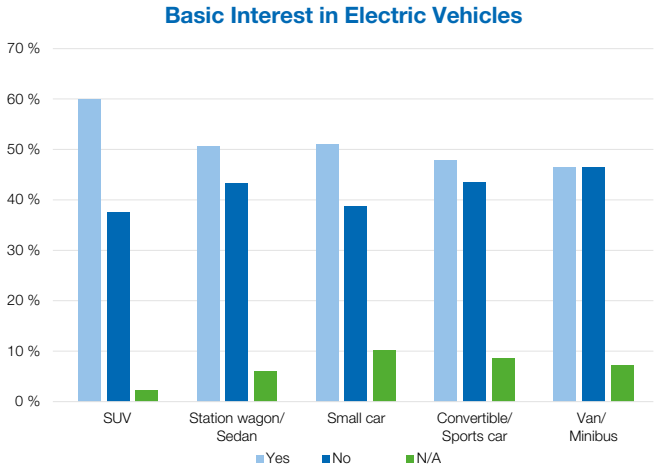


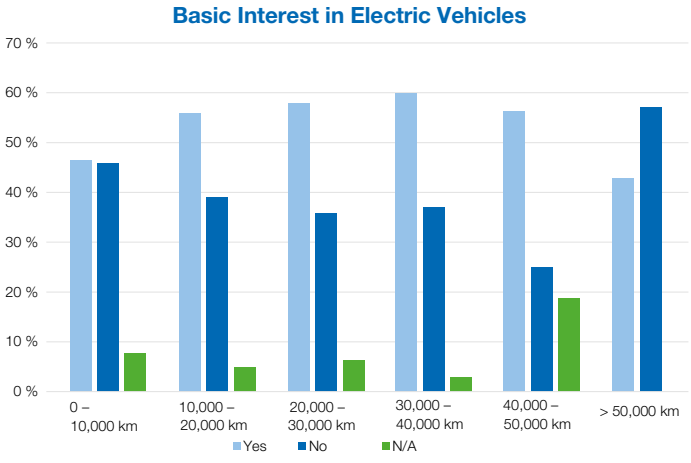
The topic of Smart Parking and Charging also includes a look at parking behavior, which is supported here with further details. A general look at the surveyed panel shows that a majority of respondents can park in the parking lot of the company where they work. This is just under 60 %. Following at a considerable distance is the group of those who park in the public street space. This group comprises 20 % of the respondents. Only around 13 % of the respondents can park their vehicle in a car park that is not part of the employer's premises and not part of the public road space.

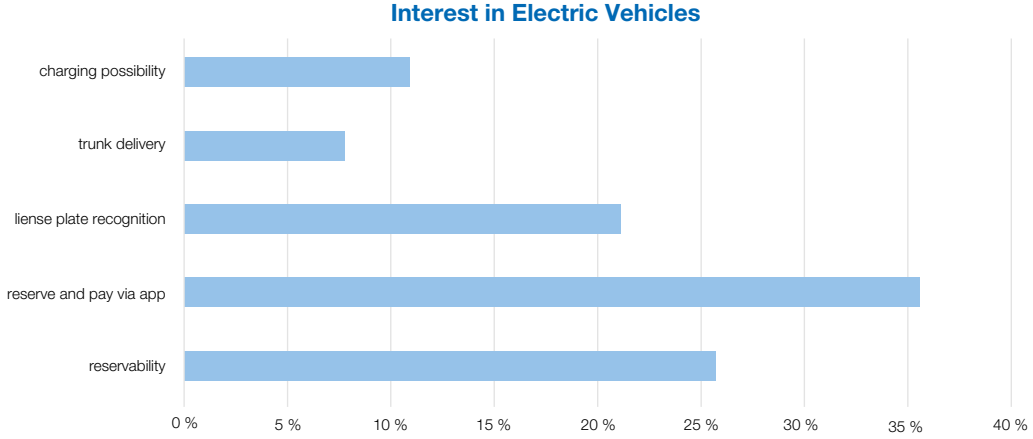
If the surveyed panel is subdivided according to the relationship between parking behavior at home and parking behavior at work, the use of car parks at the employer's clearly dominates over the use of public road space in this analysis as well.

A further characterization comprises the differentiation of the interviewed persons on the basis of the annual mileage and the categorization on the basis of quantity of car park use. It is interesting to note in this analysis that the people with a mileage of less than 10,000 km p.a. predominantly state that they park in multi-story car parks very rarely (2 – 3 times p.a.) or almost never. This statement among the few drivers accounts for 60 % of the answers and is thus significantly higher than among all other persons who stated higher mileages.

The second part of the extended evaluation delves deeper into the topic of acceptance of e-mobility in terms of fundamental interest.







Further analyses with regard to the basic acceptance of electric vehicles follow at this point. It is interesting to note that the basic interest in e-mobility among drivers of SUVs seems to be higher than among respondents who drive other types of vehicles. This may indicate that people who drive SUVs represent a significant target group for e-mobility.

From the point of view of annual mileage, it is striking that the people surveyed who drive less than 10,000 km p.a. show less interest in electric vehicles than frequent drivers. At first glance, this seems surprising, as short trips and low annual mileage are particularly common and this route profile is predestined for e-mobility.

An interesting aspect is the potential influence of different technologies on the choice of a car park. If this analysis of the change in the choice of car park due to certain technologies is carried out among people who have indicated an interest in e-mobility, no changes in response behavior can initially be seen, provided that the descriptive evaluation is compared with the results of the general panel. Reservability and an app continue to be very big levers, as does license plate recognition. Nevertheless, there is a difference in the evaluations without the explicit consideration of interest in e-mobility: all values for the individual technological options are higher than in the general panel. Relatively, for all technologies, more people indicate that they would have an impact on a potential parking change. This may be due to a higher interest in technological or process innovations among e-mobility-savvy individuals.

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