eCHARGE 4DRIVERS

Deliverable 1.2

A priori users' concerns & expectations relevant to EV charging

www.echarge4drivers.eu

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Task 1.2 **Task 1.3**	A priori users' concerns and expectations relevant to EV charging Field data analytics
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List of abbreviations and acronyms

Abbreviation	Meaning
API	Application Programming Interface
BEV	Battery Electric Vehicle
CIS	Charging Infrastructure Satisfaction
CP	Charging Point
CPO	Charging Point Operator
D	Deliverable
eMSP	electroMobility Service Provider
EV	Electric Vehicle
GAM	Grenoble-Alpes Métropole
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
KPI	Key Performance Indicator
LEV	Light Electric Vehicle
M	Mean
OD	Origin Destination
PHEV	Plug-in Hybrid Electric Vehicle
SD	Standard Deviation
T	Task
TEN-T	Trans-European Transport Network
UTAUT	Unified Theory of Acceptance and Use of Technology

EXECUTIVE SUMMARY

The aim of this deliverable is to report the work performed under Task 1.2 ‘A priori users’ concerns and expectations relevant to EV charging’ and Task 1.3 ‘Field data analytics’ of the eCharge4Drivers project. This report presents the a priori users’ concerns and charging expectations. Based on a large-scale survey with almost 3,000 valid responses across the 10 project demonstration areas, the current users’ charging habits, perceptions, concerns and expectations are measured; the users’ mobility and parking habits are surveyed as well as factors influencing users’ decision making regarding charging an EV. Furthermore, real user patterns are analysed next to social media posts about charging infrastructure.

The majority of the respondents were male and highly educated. On average 63% of the **EV drivers** have a private vehicle and 32% a company car. The reasons for choosing an EV are primarily environmental friendliness, energy efficiency and low operating and maintenance costs. The vehicle kilometres travelled for a day vary between 30 in Berlin up to 148 in Turkey, with an average of 81 across the demonstration areas. Between 73% and 88% of the respondents have access to a private garage or driveway at home, and the vehicle is parked there approximately 12 hours, with variation between 8 and 14 hours.

EV drivers plan their **charging** according to the anticipation on the next trip, the state-of-charge below a certain level and when there is a possibility to charge. There is little variation in these reasons across the different demonstration areas. The usage of apps by EV users varies between 30% in Greece up to 80% in Northern Italy.

In terms of analysed **charging sessions** for 9 demonstration areas, the data showed many outliers. In general – and corrected for the outliers by using the median, the length of the sessions varies between 45 minutes up to almost 3 hours at slow chargers for 7 to 17kWh, and between 30 minutes and an hour for 10 up to 25kWh at fast chargers. Overall weekdays have three different peaks, one at morning, one at noon and the last one in the evening; and weekends the frequency of the sessions is lower, and the morning peak disappears. In the pilots where there are slow CPs and fast CPs, slow CPs are mostly used during weekdays whereas fast CPs are the most used in the weekend.

User **clustering** revealed three segments: the regular user, the sporadic user and the users with very different behaviour. Clustering of charging points revealed occupancy differences: at most demonstration sites a small number of charging points has a clearly higher occupancy, and this varies between 9% and 32%.

Overall, the **satisfaction** of EV drivers with the eMSP/CPO scores high: on average 5,5 out of 7. This is a score of 8/10 overall. There is quite some variation though, with scores ranging between 3,83 and 6,36. It is noteworthy that two dimensions related to issues during a charging experience score lowest: compensation with an average of 3,32 out of 7 and contact, with an average of 4,02. When asked about an ideal charging session, the characteristics are commonly shared across the demonstration areas: on top, there is a charging pass that works immediately, next comes short connection and waiting time.

With respect to **preference** for future charging solutions, fast charging and smart charging stand out. EV drivers also indicate that they are willing to pay more for fast charging solutions. Berlin stands out in this analysis with also clear preference for mobile charging and battery swapping.

When looking at **LEV users**, the main reasons for driving a LEV are: environmental friendliness, low operating and maintenance costs. LEV users drive their vehicle on average 26 km. The LEV is most often parked at home at a private parking or along the public road, and the respondents from Greece, Grenoble, Luxembourg and Northern Italy also indicated the employer’s parking. A minority of LEV users charge at an eMSP charging point. The usage of apps varies for LEV users between 10% (Barcelona) and 67% (Berlin), with an average of 22% across all areas. Similarly, as for the EV drivers, fast charging is preferred most often in the demonstration areas where it was offered as an option for future charging solution, with Berlin scoring high for battery swapping and mobile charging.

Respondents who don't own an (L)EV were surveyed with respect to the intention to buy an EV. The results vary across the demonstration areas. Between 21% (Greece) up to 70% (Austria) of the respondents, with an average of 45% across the areas, indicated that it is slightly to very likely that they will buy an EV soon; this proportion increases when asked about the intention within 5 years. For Greece this even raises from 21% to 68%. The reasons for buying an EV are very consistent across the areas: environmental friendliness, energy efficiency and to a lesser extent, low operating and maintenance costs. In terms of future charging behaviour, it is interesting that overall, the majority (73% on average) of these respondents have a private garage or parking at home.

Mentions about e-mobility and charging on **social media** are also an interesting source for data analysis. The most frequent terms and emotions with respect to e-mobility and charging on Twitter are analysed in three different languages (English, Spanish, German). English statements have overall positive connotations and Spanish statements have more negative connotations; German statements are also quite positive.

Based on the results presented in this report, the following recommendations are formulated. From the survey, it is concluded that overall satisfaction with CPOs/eMSPs is 8/10, yet user satisfaction with charging solutions can be improved, especially in case of issues. Easy ways for contact, responsiveness and appropriate compensation would help the (L)EV driver. Among the different charging solutions to be developed in the project, users prefer fast charging solutions. There is also an increased willingness to pay compared to other charging solutions. From the field data analytics, it is clear that on many occasions the connection time exceeds the charging time. It is recommended to develop appropriate strategies to optimally measure charging sessions that allow for accurate data usage. Most respondents to the survey were male, as were the EV drivers; this is in line with current findings in literature. It is recommended to actively work on strategies to involve women in the e-mobility evolution.

1. INTRODUCTION

1.1 Project introduction

eCharge4Drivers is an H2020 project running from June 2020 to May 2024 and deployed by a consortium of 32 partners. Charging an electric vehicle (EV) is still not as convenient as refuelling a conventional vehicle, potentially posing a barrier to increase the market uptake of EVs. eCharge4Drivers works to substantially improve the EV charging experience within cities and for long trips. The project will develop and demonstrate user-friendly charging stations and innovative charging solutions as well as smart charging services for the users. By capturing users' perceptions and expectations on the various charging options and their mobility and parking habits, eCharge4Drivers will organise demonstrations in 10 areas across Europe, including metropolitan areas and Trans-European Transport Network (TEN-T) corridors. Charging stations in these areas will offer user-friendly and convenient functionalities for EV drivers of passenger and light vehicles and motorcycles, such as direct payment methods and bigger, user-friendly displays. Using the knowledge generated, the project will also propose an EV Charging Location Planning Tool, fostering the broad implementation of charging infrastructure in Europe.

1.2 Purpose of the deliverable D1.2

The aim of this deliverable is to report the work performed under Task 1.2 'A priori users' concerns and expectations relevant to EV charging' and Task 1.3 'Field data analytics'. Users include drivers of passenger vehicles, taxis, light delivery vans and light vehicles. After selecting the study questions and corresponding KPIs, wide questionnaire surveys were organised in each demonstration area, field data was analysed and the use cases to be demonstrated in each area were refined, including user types to be targeted and infrastructure and services to be deployed. This is the outcome of Task 1.2 and 1.3 and it presents the findings from the surveys, the social network analysis and the field data analytics**.**

The objectives related to this deliverable have been achieved in full and as scheduled.

1.2.1 Description T1.2: A priori users' concerns and expectations relevant to EV charging

Using the KPIs from Task 1.1, a questionnaire was developed to address the identified study questions. A large scale survey was conducted in all demonstration areas. The survey included socio-demographic questions and validated scales to measure perceptions about **service quality of charging options** [Vanhaverbeke et al, 2018; Nuyttens et al, 2020]. To guarantee representativeness of the results, different user's profiles were defined to identify the target groups to be sampled, e.g., users from urban and peri-urban areas and from varying demographics groups, for example drivers of passenger cars, taxi drivers, light deliverers and drivers of light vehicles. The survey was administered to the customers of the project partners and was extended to a broader population, to include also people beyond early adopters, urban users or garage parkers. Particular attention was given to ensure equal gender representation among respondents by closely monitoring the quota and taking action to increase the number of female respondents. The data were analysed per demonstration area and comparatively, to reveal the users **charging habits, perceptions, concerns and expectations as regards different charging options, as well the users' mobility and parking habits, and to identify factors influencing their decision making as regards charging an EV.**

1.2.2 Description T1.3: Field data analytics

Big data analytics techniques and spatial econometrics were used to contrast real user patterns or disruptions coming from quantitative data analysis, with subjective user perceptions coming from the qualitative and user-centred analysis of Task 1.2. Aggregated real usage data from the CPOs and eMSPs in the consortium were used to analyse timing and duration of charging sessions per location and type of charging infrastructure or other charging solution. The analysis takes into account characteristics of users, of the charging session and characteristics of the charging location. Additionally, the general sentiment on EVs and in particular on charging habits and problems were collected using information scrapping services through social networks for historical data of user preferences.

1.3 Intended audience

Deliverable D1.2 is public.

This deliverable presents information that is useful for different stakeholders in the e-mobility landscape. The description below is only a brief overview of the main stakeholders that might benefit from the content of this deliverable.

Insights regarding the users' assessment of the current charging infrastructure in different European regions are provided. This helps to identify what the (L)EV users' expectations are regarding the provided service of eMSPs and CPOs and how the current service can be improved. Additionally, results about how (L)EV drivers use the current charging infrastructure are presented. This enables CPOs and eMSPs to identify if the infrastructure is used according to their expectations and enable them to formulate appropriate strategies if not.

For the eMSPs and CPOs that are active in the demonstration areas, this document provides insightful information regarding the different types of (L)EV users in the area, and where and when they prefer to charge their (L)EV. This information is also interesting for the local authorities, especially with respect to the current state of EV adoption in the area, but also with regards to the local (L)EV users' expectations and how they can further stimulate this adoption. Public authorities in general can consult this deliverable for examples on (L)EV and charging infrastructure usage in different European regional contexts.

This deliverable also describes the future needs and preferences of (L)EV users concerning different charging options (I.e., fast charging, smart charging, battery swapping, etc). This information is for example of importance to OEMs. The deliverable results can inspire to provide more adapted solutions for the (L)EV users' needs and preferences.

1.4 Structure of the deliverable and its relation with other work packages/deliverables

This deliverable reports on two tasks: T1.2 A priori concerns and charging expectations and T1.3 Field data analytics. The data collection tasks are described in the table below.

Table 1 eCharge4Drivers D1.2 data collection tasks

Data Collection tasks	Leader	Data collection methodology
Task 1.2: A priori users' concerns and charging expectations (VUB) D1.2 : A priori users' concerns and expectations relevant to EV charging	VUB	Users' questionnaires/Surveys: EV-users (customers of the project partners + people beyond early adopters, urban users or garage parkers) + Non- EV users (broader population)
Task 1.3: Field data analytics	MOSAIC	• Aggregated real usage data from the CPOs and eMSPs in the consortium

D1.2 : A priori users' concerns and expectations relevant to EV charging	• Existing data on mobility and parking habits from previous studies and data by parking agencies of the demonstration areas • Social networks for historical data of user preferences

To define the impact areas in the overall eCharge4Drivers context, it has been clarified which project activity will focus on the assessment, analysis and use of the data collected. Table 2 provides an overview of the relevant project tasks, related to this deliverable and of the topics that will be studied in the assessments.

Table 2 eCharge4Drivers assessment activities

Assessment tasks	Leader	Topics assessed
Task 1.2: A priori users' concerns and charging expectations D1.2 : A priori users' concerns and expectations relevant to EV charging	VUB	• Current users charging habits, perceptions, concerns and expectations as regards different charging options • Current users' mobility and parking habits • Factors influencing users' decision making as regards charging an EV
Task 1.3: Field data analytics D1.2 : A priori users' concerns and expectations relevant to EV charging	MOSAIC	• Real user patterns or disruptions coming from quantitative data analysis (big data analytics techniques and spatial econometrics)

The topics assessed in each eCharge4Drivers analysis and assessment phase, allow identifying which the areas that are expected to be impacted are and which the goals of the related study questions will be. For this deliverable, Table 3 defines each impact area, the goals of the study questions that have been identified and the relevance for the project. Also the link with later deliverables is indicated in this table.

Table 3 eCharge4Drivers impact areas

Impact area	Goal of the study questions	Relevance in eCharge4Drivers
Usage	Study if the project has an impact on the way users utilise the charging infrastructure and the related services	• A priori analysis reported D1.2 and D2.1. • A posteriori analysis reported in D6.3 and D7.1.
Quality of Experience	Study if the project has an impact of the users' satisfaction and perceptions of the different aspects of the charging experience.	• A priori analysis reported D1.2 and D2.1. • A posteriori analysis reported in D6.3 and D7.1.
Acceptance	Study if the project has an impact on users' attitude related to the charging infrastructure, the related services and – in general - electric driving.	• A priori analysis reported D1.2 and D2.1. • A posteriori analysis reported in D6.3 and D7.1.
Environment & Society	Study if the project is able to achieve sustainability improvements and if it is able to stimulate electric mobility among the society.	• A priori analysis reported in D1.2 and D2.1. • A posteriori analysis reported D6.3 and D7.1.

2. ELECTROMOBILITY CONTEXT

During the last years, the adoption of the electric vehicle (EV) technology has been accelerating. This adoption resulted last year in a combined market share for battery electric vehicles (BEVs) and plug-in electric vehicles (PHEVs) of 10% in Europe (EAFO, 2021). This trend is also visible for light electric vehicles (LEVs), for which almost 250.000 new vehicles were registered in the same year across the European Union member states. This translates in a need for more infrastructure, but also on that front an extension of the existing network is observed with approximatively 200.000 regular charging points (< 22 kW) and 25.000 fast charging points (>22 kW) installed in the union (EAFO, 2021). Since the EV uptake and charging infrastructure roll out are accelerating, it is the right time to assess the existing charging infrastructure and reflect on possible improvements. In this deliverable, three complementary studies have been carried out to identify how current users use their vehicle and the existing charging infrastructure. Additionally, possible improvements or future charging options that users would like to experience are examined. The first study is a survey with almost 3.000 responses across Europe on the mobility of (L)EV users and non-users. The second study determines user profiles based on analytics of historical data of charging infrastructure in the demonstration areas. The third analysis is a social media analysis.

The contribution of this deliverable is a detailed description of charging habits of EV drivers in 10 European regions, based on declared and perceived use. Moreover, the users' charging experiences are explored, enabling the identification of improvements regarding service of existing charging infrastructure and their acceptance of various enhanced charging experiences.

In the context of the project, the resulting insights of this deliverable are of relevance for the development of infrastructure in the demonstration areas during the project and for the development of the different software tools built in this project, namely the location planning tool and enhanced travel planner tool.

In the next section the context of the study is situated. Next, the methods of the three studies are explained. The results of the survey and the field analytics are presented for each demonstration area in section 4. Section 5 describes a comparative analysis across all demonstration areas for usage, quality of experience and acceptance. The results of the social media analysis are discussed in section 6. Section 7 presents the conclusion of this report and in section 8 recommendations are formulated.

The development of charging infrastructure and the uptake of EVs has long been pictured as a "chicken and egg" problem. Charging infrastructure is required for inciting people to buy EVs and EVs are required for operators to profitably extend the charging infrastructure network. In recent years, EVs have become more attractive with respect to purchase price (De Clerck et al., 2018) and range (Van Mierlo et al., 2021), and the infrastructure has been extended to such extent that European cities are now connected with each other as for conventional vehicles. The growth of the EV technology on the European market has the consequence that it is now not only needed to provide public charging infrastructure, but to also reflect on how this infrastructure needs to be in order to accommodate the users needs as much as possible in the future. It is therefore important to determine the differences between users and their use of the charging infrastructure. Additionally, it is crucial to assess what should be improved now (Nuyttens, De Clerck, & Vanhaverbeke, 2020) and what other charging options and technologies they would like to see developed in the future, especially with the coming stages of EV market growth. These next stages consist of the adoption of the EV technology by the majority of the population. While early adopters are more inclined to the technological and technical aspects of EV infrastructure, the majority needs user-friendly solutions in order to conveniently use the infrastructure.

Several studies show that the usage of the charging infrastructure differs according to user profiles. Helmus & van den Hoed (2015) find in Amsterdam that six different profiles exist depending on various parameters such as start time of the charging sessions, duration of the charging session or the amount of energy charged. Robinson, Blythe, Bell, Hübner, & Hill (2013) determine that different profiles also charge at different places, which implies that the profile has not only a temporal aspect but also a spatial aspect. It has also been documented that user do not always use the existing infrastructure as intended. Examples of undesired use of the charging infrastructure are: much longer connection times than necessary for the vehicle to be charged (Wolbertus, Kroesen, van den Hoed, & Chorus, 2018) or systematic charging the vehicle while the battery is more than half full in order to benefit of a parking space (Speidel & Bräunl, 2014). This problem is not common according to van der Kam, van Sark, & Alkemade (2020), but may become more problematic as the adoption of EVs increases. Also uncoordinated charging by similar charging profiles might impact the electricity network with peak demands (Robinson et al., 2013). Therefore, a better understanding of the user's usage, preference and expectations might direct us towards improvements of the existing infrastructure, to provide solutions that match both the user's needs and the infrastructure's purpose.

Existing solutions to above cited problems exist. Smart charging, for example, enables peak demand balancing with minimal impact for the users (Bons et al., 2020) and no need to adapt or coordinate with other users. Another example might be user friendly charging stations that provide a range of charging options to adapt to the users' power need and prevent longer connection times. A complementary solution are app-based services that are able to monitor and report the state of charge of the battery to the user in order for him or her to disconnect the vehicle once the battery is fully charged. However, it is important before implementing these solutions to assess their acceptance by the users.

3. METHODOLOGY

This section summarises the methodology for each of the three studies reported in this deliverable to define the eCharge4Drivers a priori users' concerns and expectations relevant to EV charging. First the survey design and distribution is described, next the field analytics and finally the social media analysis. The three methods are described in more detail in Annexe A1.

3.1. Survey design and distribution

The survey design was based on the KPIs identified in D1.1 for the different impact areas. The survey was addressed to 3 types of users: **EV users, LEV users and non-EV users.** The emphasis of the survey's questions for EV-users was on the following topics: their use of the vehicle, their motives, their parking behaviour, their charging behaviour, the quality of their experience with existing public charging infrastructure, their acceptance of charging options tested in later phases of the project and app-based services. Similar questions were asked to LEV users with some modifications given the specific LEV context for charging. Finally, the questions for non-EV users focused on their mobility behaviour and their intention and motives for buying an EV in the future. Besides these questions, also socio-demographic information about the respondents was gathered such as age, gender, education, income, etc. The questions were mainly based on existing scientific frameworks such as the CIS (Charging Infrastructure Satisfaction)-diagnostic (for the quality of experience regarding existing charging infrastructure) from Vanhaverbeke et al. (2018) and Nuyttens et al. (2020), and the UTAUT (Unified Theory for Acceptance and Use of Technology) model (for the acceptance of smart charging, fast charging, battery swapping, mobile charging services and user friendly charging stations) from Venkatesh, Thong & Xu (2012). The development of the survey was an iterative process involving the demonstration areas for feedback and piloting of the survey. The final survey was translated to the local language(s) of all demonstration areas to accommodate the respondents.

The survey was launched on the 23rd of November 2020 and stayed online and available for respondents until the 8th of March 2021. The distribution of the survey was coordinated per region by the responsible partner of the respective demonstration area and supported by ERTICO and POLIS through their communication channels. All survey links were grouped on a dedicated page of the project website for easy referral[1]. In Annexe A2 the survey dissemination strategy for each demonstration area is described in detail.

In total 4.703 respondents participated in the survey, of which 2.966 respondents were eligible for analysis after data cleaning. The data analysis is based on the different data sets of the demonstration areas. Full descriptive statistics of the data are presented for each demonstration area in Annexe A2.

3.2. Field data analytics

This part of the analysis is based on charging sessions provided by consortium partners acting as CPO or eMSPs of the different demonstration areas, with the exception of Zellik where the infrastructure still needed to be installed at the time of analysis. Several analyses were performed, namely a descriptive analysis, user clustering, temporal clustering, the identification of user mobility flows and an assessment of the COVID-19 effect on the demonstration area.

- Descriptive analysis: The first analysis details the charging session data in a descriptive analysis that presents the main characteristics of the data set. Geographical and temporal aspect are

[1] https://echarge4drivers.eu/questionnaires/

summarised, describing where people charge, when they charge, how long they charge, at what power they charge, how much energy they consume, etc.

- User clustering: The second analysis is a user clustering performed to group users based on their behavioural attributes (e.g., number of sessions, charging points visited, energy consumed, session duration, day, …) and identify clusters of users denoting similar charging patterns. This method is applied for demonstration areas with sufficient data. The clustering is performed using different algorithms i.e. *Model-based*" (Fraley & Raftery, 2002), "*kmeans*" (Likas, Vlassis, & J. Verbeek, 2003), "*pam*" (Park & Jun, 2009) and "*clara*" (Schubert & Rousseeuw, 2019) and compared using different metrics in an automated process implemented by the R package "clValid" (Brock, Pihur, Datta, & Datta, 2008). After careful comparison of the different clustering results, the most appropriate result is selected as the resulting user cluster for the demonstration area.

- Temporal clustering: The third analysis is a temporal clustering that groups the charging points into groups based on their occupancy distributions and identifies charging points that show similar activity patterns.

- User mobility flows analysis: A fourth analysis describes user mobility flows based on origin-destination patterns that aim at detecting corridors for long-distance trips between the cities in the demonstration areas.

- Covid-19 effect analysis: Finally, the impact of Covid-19 and related mobility restrictions are measured for the demonstration areas, if the provided data enables the analysis. This analysis gives insight on how Covid-19 might have impacted some results.

Detailed results of above-described data analyses are presented in the Annexe A2. In section 4, the main results per demonstration area are summarised.

3.3. Social media analysis

A social media analysis has been conducted to understand from a different perspective the general sentiment towards electric mobility and charging infrastructure. This analysis is based on tweets gathered from the Twitter v2 API[2] and it has been performed in the three most common languages of eCharge4Drivers, English, German and Spanish.

Tweets that match a set of constructed queries related to electromobility have been collected, and three datasets compiled for English, German, and Spanish.

First, the key topics of discussion that exist in the data have been determined applying topic modelling techniques, and the final topics obtained are:

- **Government and policies** – government initiatives relating to electric vehicles and charging.
- **Charging infrastructure** – local issues, companies and opinions regarding publicly available charging networks and access.
- **Market and Production** – Information regarding market, manufacturing, and sales of electric vehicles.
- **Technology** – issues surrounding the technological development of electric vehicles, batteries, cost, and range.
- **Environment** – discussion relating to emissions, power generation and climate change.

[2] https://developer.twitter.com/en/docs/twitter-api/early-access

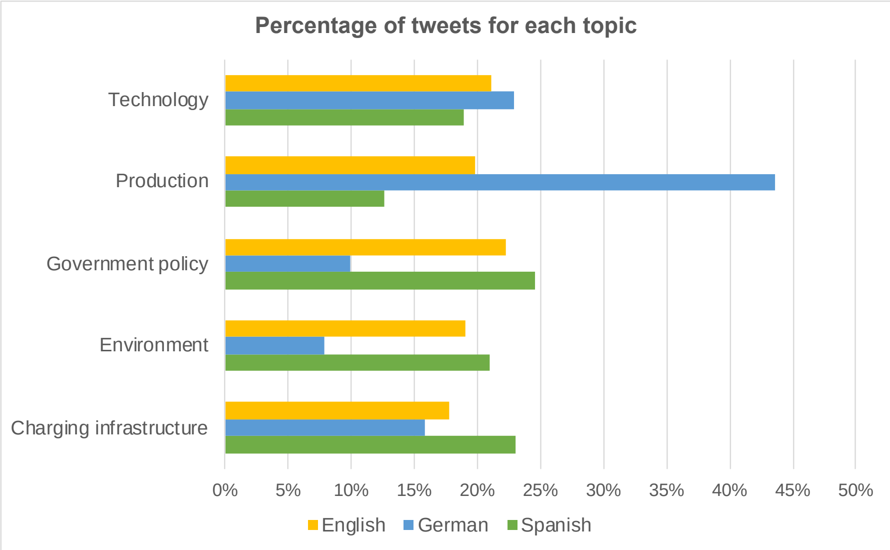

Figure 1. Percentage of tweets for each topic (tweets posted between the 01/01/2016 and the 10/02/2020)

Sentiment analysis and emotion analysis are placed with the aim to uncover and quantify the emotions of people towards the Electric Vehicle domain. For each predefined topic, sentiment analysis (i.e., positive, negative reaction) and emotion analysis are applied on the datasets compiled.

4. RESULTS FROM DEMONSTRATION AREAS

This section presents the results and main conclusions of the survey analysis and the field data analytics for each demonstration area. The detailed description of the findings can be found in Annexe A2.

4.1. Austria

Context

As of 2021, there were estimated that the number of registered EVs in Austria would be 66383 electric cars. There are 48702 BEV and 17681 PHEV. In November 2020, 15.4% of the new registered passenger cars were EVs. Sales are expected to increase over the next few years due to the increased offer of EV models and government policies, like tax exemptions and subsidies per charging point and sustainable investments.

Survey results

The survey was distributed by SMARTRICS in their monthly newsletter and via social media channels. After data cleaning, the data set contains 96 respondents, of which 77 drive an electric car. Of all respondents, 80% are males, with a higher education degree (92%), full time employed (74%), married with or without children (78%) and living in a detached house (61%). 36% of the respondents have solar panels, 21% a heat pump and 8% a geothermal power system at home. The modal income category is 3.000-4.999€ (48%).

Of the 77 electric car drivers and 1 electric van driver, 97% drive a BEV. 60% of the respondents own the vehicle privately, 37% have a company car and 3% use a car-sharing service. 22% have a company charging pass. There is an almost uniform spread in terms of age of the vehicle across the categories of less than a year up to more than 4 years. 49% of the respondents indicate that the battery capacity of the vehicle is between 20 and 40kWh and the range varies between 200 and 249km (27%). Top 3 reasons for choosing an EV are: environmental friendliness, efficient in energy consumption and low operating and maintenance costs.

Asked about a random day of the week, EV drivers indicated they drove 65km (SD=58.55) and spent 1.55 hours (SD=1.13) on the road. 73% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 14.62 hours (SD=6.74) a day. Figure 2 shows how often EV drivers charge at different charging locations: mostly at home (with a charge station, 56%; by a socket 44%), but also at public chargers. Partly also at work, although 55% of the EV drivers never charge at work. Most popular charging time is between 3pm and midnight. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip or based on the state of charge of the battery; also when they are close to the usual place of charging or if there is an opportunity to charge. Charging behaviour is much less described as part of daily habit, to anticipate on unexpected trips or to keep the battery fully charged.

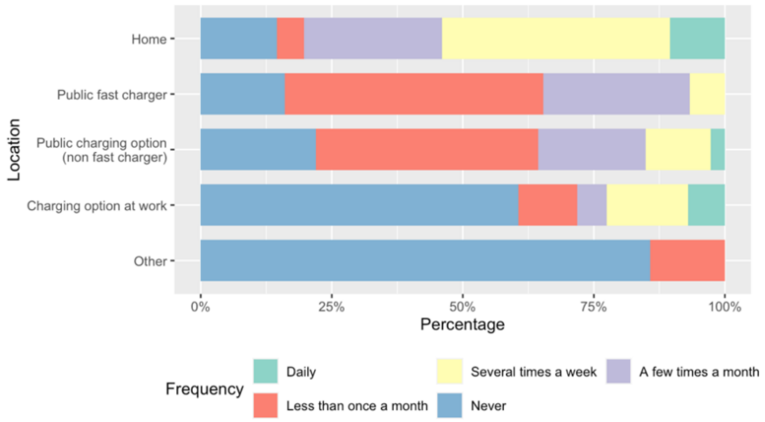

Figure 2: Frequency of charging at different locations for Austrian EV drivers

20% of the EV drivers indicate that, more than once a month, they have to wait at a charging point because it is occupied by an ICE vehicle, 55% never experienced this. What matters most for an ideal charging session is that the charge pass works immediately and that there is a short connection time at the charging point. To a lesser extent an integrated cable would improve the session and easy payment with cash is overall scored not so important.

The Austrian respondents are overall satisfied with the service by CPO/eMSPs and give them a score of 5.6 on 7 (SD=1.1). The different dimensions to measure satisfaction were: tangibility (M=5.3; SD=1.06), availability (M=5.7; SD=1); reliability (M= 5.7; SD= 1.06) and privacy (M=5.3; SD=1.2). The perceived value and loyalty were both evaluated as 5.4 out of 7 (SD=1.3, resp. SD=1.1).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Austrian respondents choose fast charging station (46%), user friendly charging station (30%) and smart charging station (18%). Respondents would not mind paying more for fast charging, to a lesser extent for smart charging and much lesser for a user-friendly charging station.

72% of the respondents use app-based services; 75% of them have 3 apps or more installed on their phone. Apps are used mostly a few times a month, especially for travel destinations on holiday and for leisure activities.

The questionnaire was also addressed to non-EV drivers. In Austria 13 respondents participated. 70% indicated that it is slightly to very likely they will buy an electric car as soon as possible, and the intention increases when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness, low operation and maintenance costs and energy efficiency. 83% have access to a private car park or garage and the vehicle is parked there for 10.75 hours (SD=12.58) while the vehicle was on the road for 1 hour (SD=0.82).

Field data analytics

SMATRICS is Austria's largest provider of e-mobility charging services, fulfilling both the roles of Charge Point Operator as well as Mobility Service Provider. SMATRICS operates a total of 480 charging points, of which 270 are fast charging points (≥50kW) and 32 charging points allow for High Performance Charging (≥150 kW). The publicly accessible charging infrastructure is implemented among different branches of various strategic site partners, like Fast Food restaurants, retail, shopping centres, supermarkets and petrol stations. To support long trips SMATRICS also runs 10 stations directly located on the highway.

In this pilot the sessions from the CPs located in the cities of Graz, Innsbruck, Salzburg and Wien between 2019-01-01 and 2020-08-31 have been analysed. There are 4140 unique users and 114 unique charging points (64 AC and 50 DC).

In general, Sundays have the lowest number of sessions, while all working days have similar behaviours in terms of hourly distribution and number of sessions. The number of sessions continuously increase from 5 am to 8 am, then morning, noon and afternoon peaks occur for the different days. And finally, it starts decreasing again from 4 pm. During late evening – from 10 pm to midnight, Fridays and Saturdays have more sessions than the other days.

For the analysis of the duration of the sessions it has been analysed separately the AC CPs which can range from 11kW to 43kW and the DC CPs, which correspond to the ultra-fast CPs ranging from 50kW to 350kW. The average duration in the AC CPs is 132 minutes and presents a high number of outliers, up to 4485 minutes (more or less 3 days). In the case of DC charging stations, the average duration is lower (30 minutes) and presents a lower number of outliers. Then, the session duration clustered by branch type has also been analysed, in average the longest durations occur in parkings and the shortest ones in fast food restaurants.

Complementary to the duration of sessions, the energy consumed per charging session has been analysed with the objective of better understanding the charging style of the users from the Austrian demonstration area. The average energy consumption is 12 kWh for the AC case and 17 kWh for the DC case. Also, it should be noted that the algorithm detects as outliers the sessions above 17 kWh (AC) and 22 kWh (DC), meaning that users typically charge between 10-20% of the total capacity of the battery in public CPs. From the analysis per branch type, it can be concluded that the highest energy consumed per session is in CPs located in Gas Stations and the lowest in CPs located in Shopping Centres.

The users that have been using the SMARTRICSs CPs within the timeframe of the study have been clustered in three different clusters based on their similarity. User Cluster 1, including most of the users (86%), is for the users who have the “general” type presenting values closer to the overall mean, whereas User Cluster 2 and 3 are created based on the diversity of the user characteristics. The users of User Cluster 2 have much more sessions than the Cluster 1 and Cluster 3 users. On the other hand, their duration per charging session is less than the overall mean. User Cluster 3 comprises users who are characterised by really long charging durations and high energy consumed per session.

The Charging Points have been clustered in two different clusters based on their occupancy. In both clusters the lowest occupancy is at 7am and the highest occupancy around 8 pm. The 90 CPs belonging to Cluster 1 have an average occupancy of 3.2% and the CPs belonging to Cluster 2 present an average occupancy of 15%.

The travel demands of the users and how the users charge between the cities of study (Innsbruck, Salzburg, Graz and Wien) have been analysed. 90% of the users only have recorded charging sessions in one city, whereas the remaining 10% presents charging sessions in more than one city. For those users, OD matrixes have been created and the mobility flows analysed. The main city acting as origin or destination is the capital of Austria, Wien. The strongest link is between Graz and Wien with 162 trips from Graz to Wien and 72 trips from Wien to Graz. Then, the third most used connection is the one from Salzburg to Wien (47 trips).

The number of users, the average sessions per day and the average occupancy percentage of the CPs decreased between 40% and 60% during the lockdown period and these attributes increased by 20% during the de-escalation and new normality, but without achieving the values from the pre-covid period.

The average daily energy consumed by user is higher in the COVID periods compared to the pre-covid, this could be because the usages where the main intention of the user was to park instead of charging the EV might be reduced. Finally, the average charging session duration is quite stable in the four periods of study.

4.2. Barcelona

Context

By the end of 2020, in Barcelona there was a total of 1124 public CPs operated by B:SM of which 834 are for cars and vans and 290 are for LEVs. The network comprises charging stations located in underground car parks and street parking locations.

The city is slightly above the Spanish average and below the levels of the European countries with the highest EV development. The evolution of electric vehicle registration in the city has been lower than estimated. As of December 2020, there were estimated that the number of registered EVs in the city would be around 6,000 (Barcelona City Hall), and in November 2020 there were 2,374 (considering cars and vans). Sales are expected to increase over the next few years due to the increased offer of EV models and government subsidies.

Survey results

The survey has been widespread in the city of Barcelona by social media, emails, and forums. More specifically for the general survey, an email was sent out to the users of the app SMOU (76695 users) from B:SM. Additionally the survey link was sent to the LEV users of SILENCE, and to ACCIONA and SEAT:MO, providers of an electric moto sharing service. After data cleaning, the data set contains 1099 respondents, of which 352 use an electric car. Of all respondents, 79% are males, with a higher education degree (79%), full time employed (73%), married with or without children (79%) and living in an apartment/studio (75%) while 14% live in a detached house. 12% of the respondents have solar panels and 14% a heat pump at home. The modal income category is 2.000-3.999€ (48%).

Of the 352 electric car drivers and 3 electric van drivers, 236 drive a BEV and 80 a PHEV. 277 respondents own the car privately, 76 have a company car and 2 use a car sharing service. 5% have a company charging pass and 4% a company fuel pass. 33% of the respondents drive the vehicle for less than a year whereas 10% do so for 4 or more years. 31% of the respondents indicate that the battery capacity of the vehicle is more than 70kWh and the range varies between 300 and 400km (22%). Top 3 reasons for choosing an EV are: environmental friendliness, efficient in energy consumption and noise reduction, following closely by the fourth reason, i.e., low operating and maintenance costs.

Asked about a random day of the week, EV drivers indicated they drove 90km (SD=69.12) and spent 2.27 hours (SD=2.36) on the road. 73% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 12.91 hours (SD=5.49) a day. Figure 3 shows how often EV drivers charge at different charging locations: mostly at home (with a charge station, 56%; by a socket 44%), but also at public chargers. Partly also at work, although 55% of the EV drivers never charge at work. Most popular charging time is between 3pm and midnight. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip or based on the state of charge of the battery; also when they are close to the usual place of charging and to take unexpected trips into account.

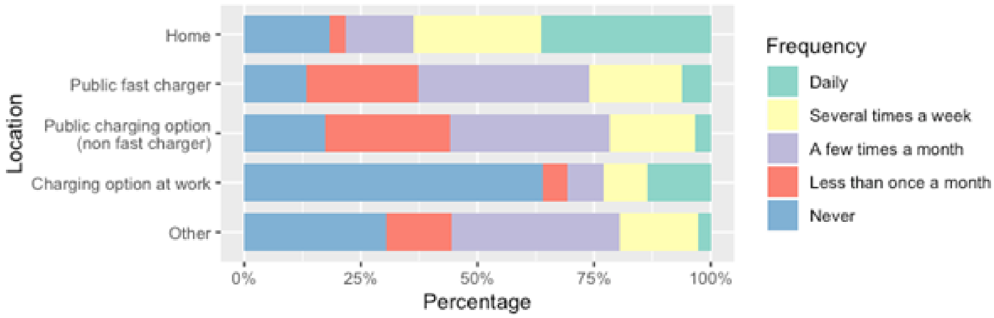

Figure 3: Frequency of charging at different locations for Barcelona EV car drivers

30% of the EV drivers indicate that daily (6%) and a few times a month (24%) they have to wait at a charging point because it is occupied by an ICE vehicle, 31% never experienced this. Approximately 30% of the respondents also need to wait a few times a month at a charging point because of an EV charging at or occupying the charging station. What matters most for an ideal charging session is that the charge pass works immediately and that there is a short connection time at the charging point. To a lesser extent an integrated cable would improve the session and easy payment with cash is overall not so important.

The Barcelona respondents are overall satisfied with the service by CPO/eMSPs and give them a score of 5.13 on 7 (SD=1.77). The different dimensions to measure satisfaction were: tangibility (M=4.86; SD=1.61), availability (M=4.84; SD=1.78); reliability (M= 4.92; SD= 1.74) and privacy (M=5.07; SD=1.26). The perceived value scored 5.29 out of 7 (SD=1.5) and loyalty was evaluated as 5.1 out of 7 (SD=1.72).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Barcelona respondents choose fast charging station (57%), regular user-friendly charging station (19%), smart charging station (9%), battery swapping (6%) and mobile charging services (2%). Respondents would not mind paying more for battery swapping and to a lesser extent fast charging; they would only use smart charging if the price were lower than the price of the current charging solution.

68% of the respondents use app-based services; 33% of them have 4 apps or more installed on their phone. Apps are used mostly a few times a month, especially for travel destinations on holiday and for leisure activities.

The questionnaire was also addressed to LEV users. 97 respondents filled out the survey; they mostly use the LEV daily or several times a week. On average, the LEV users indicate they drive about 54 km each day and spend about 1 hour and 15 minutes on the road. The most important motive to use a LEV is environmental friendliness. Most of the time, the LEV is parked at home at a private parking or at home along a public road. In terms of charging behaviour, 75% of the respondents seem to charge when the battery falls below a certain level or based on their next trip. Also, 75% of the respondents charge to take unexpected trips into account. 34% of the respondents indicate that they use the service of a CPO/eMSP to charge the LEV. Overall satisfaction is 5.23 out of 7 (SD=1.5); tangibility (M=4.72; SD=1.52) and availability (M=4.88; SD=1.4) score lowest of all satisfaction dimensions for LEVs. In terms of future charging solutions, Barcelona LEV users choose fast charging station (46%), regular user-friendly charging station (26%), smart charging station (18%), battery swapping (11%) and mobile charging services (5%). 44% of the LEV users answered that they use app-based services, mostly a few times a month or more. Apps are used for commuting and work activities, shopping and leisure activities and the LEV users are very satisfied with them.

The questionnaire was also addressed to non-EV drivers. For Barcelona 499 respondents participated. 54% indicated that it is slightly to very likely they will buy a vehicle car as soon as possible, and the intention increases to 61% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 83% have access to a private car park or garage and the vehicle is parked there for 13.24 hours (SD=7.33) while the vehicle was on the road for 2.2 hour (SD=2.87).

Field data analytics

This section encompasses the main insights and findings of the data analytics for the city of Barcelona. In this demonstration area there are two different data providers: B:SM and Electromaps, In the case of Electromaps, the dataset covers the whole Spanish territory, which allows the evaluation of the long-distance trips in the country.

The number of charging sessions in the publicly available CPs is significantly higher in the Sarrià-Sant Gervasi, Les Corts and Sants-Montjuic districts and some parts of Gràcia and L'Eixample districts, which generally represent high-income users with car ownership, with a total of approximately 400 sessions. There is also a notable number of sessions in Ciutat Vella district, which is an area with significant commercial and touristic activity in the city. The lowest activity is found in Horta-Guinardó, Nou Barris and Sant Andreu districts, which are residential areas with lower income per capita.

In the city of Barcelona there is a high predominance of slow CPs (443 unique CPs) compared to semi-fast (12 CPs) and fast CPs (39 CPs). However, when the total number of sessions were analysed very similar values were obtained, both in the case of slow and fast CPs. This means that fast charging is the most preferable technology with a prominently higher ratio of charging sessions per number of CPs, i.e., with approximately 5000 sessions per CP, almost 5 times higher than the ratio charging sessions per connector for the slow charging points.

Barcelona has fast, semi-fast and slow CPs located in street parking and slow CPs located in underground public car parks. The fast-charging technology is the predominant charging option in case of on-street CPs. From the temporal point of view, it can be inferred that EV DRIVERS choose the off-street charging stations during the weekdays, whereas there is higher tendency to use on-street charging stations during the weekend.

The users prefer to use the charging stations during the weekdays much more than the weekends. During the weekdays, there is a peak in the morning between 7 am and 8 am, and it is followed by another peak at noon from 12 pm to 1pm and another from 6pm to 7pm. During the weekends, there are only the two peaks (12-1pm and 6-7pm) both on Saturday and Sunday.

In average the duration is higher in the slow CPs, 14h and 43 minutes for the slow off-street CPs and 2h and 43 minutes for the slow on-street CPs, very similar to the average duration of the semi-fast CPs (2 hours and 49 minutes). In the case of fast CPs, the average duration is low (37 minutes) but there's a high number of outliers, this means users performing really long durations compared to the average.

Complementary to the duration of sessions, it is important to analyse the energy consumed in these sessions in order to understand the energy needs of the users of the Barcelona demonstration area. The values of the energy consumed per session in the four categories analysed are quite low, with most of the sessions consuming less than 15kWh. Fast CPs noticeably show more energy spent per session (10 kWh) compared to the rest of the CP types.

The users form the Barcelona demonstration area have been grouped in three different clusters based on their charging behaviour. The user Cluster 1 includes most of the users (86%) and comprises users that have low number of sessions, consume more energy per charging session than the average, an average power of 25 kW and short sessions duration. User Cluster 2 includes the regular users (high number of sessions) usually using the slow CPs and high average duration (around 13 hours). User

Cluster 3 includes users with similar values to the average but a bit lower. These users, on average, spend 11 hours with their vehicle connected to the CP and consume 5kWh per session.

Temporal Cluster 1 is the major cluster and contains 79% of the CPs, with generally less activity than CPs belonging to Cluster 2, which have an average occupancy of 25%. Most of the CPs belonging to Cluster 2 are off-street CPs. Both Clusters show a peak in the morning, in Cluster 1 the peak is at 5 am and in Cluster 2 is at 8 am.

The mobility flows between the Spanish provinces have been analysed, with a special focus on the trips that include Barcelona as an origin or destination point. Most of the users (87%) have sessions records always in the same province. 72 trips for OD province pairs are detected among 14 provinces (Alicante, Cuenca, Cantabria, Madrid, La Rioja, Teruel, Huesca, Barcelona, Girona, Sevilla, Murcia, Huesca, Badajoz, Ourense). The most significant corridor flow considering Barcelona as the origin or destination point is from Barcelona to Girona (with 12 trips). The furthermost province from Barcelona with at least one trip is Badajoz. Also, the corridor between Alicante and Cuenca is one of the most significant when analysing the whole Spanish territory.

The number of users and the number of sessions dropped significantly when the lockdown was imposed in Barcelona, from 1145 to 404 active users (a decrease of 65%) and from 398 to 118 sessions per day (a decrease of 70%). The reduction was similar for both on-street and off-street CPs. The numbers were partially recovered during the de-escalation period and finally, the new normality showed an increase in the number of users compared to the pre-COVID-19 scenario, contrary to the average sessions per day, which still show a reduction of a 37% compared to the pre-COVID-19 scenario.

As for the duration of the sessions, it can be inferred a very high increase in the time the users spent on each charging station, with the average value varying from 11 hours during the pre-COVID-19 period to 60 hours during the lockdown. The increase of duration shown during lockdown is probably caused by users leaving their car parked at the CPs due to the mobility limitations (for example 69 days). Once reaching the de-escalation and new normality, the figures recover similar values to the pre-COVID-19 period.

The average occupancy of the CPs and the daily energy consumed by user show a slight increase during the lockdown period. The increase of the daily energy consumed per user may be caused by users parking their vehicle at a CP strictly for charging, whereas prior to COVID-19, some users might have parked at a CP just because they needed a parking spot.

4.3. Bari

Context

Bari has been the first city in the south of Italy developing an electric car sharing service. From 2016 until the end of 2017, the service reached 1455 subscribers with 700 active customers. This car sharing service closed on 31 December 2017. In 2020, the number of electric cars has grown compared to previous years. The full hybrids and electric cars have doubled, from 2019 to 2020, the plug-in hybrids cars have had an even greater percentage growth.

Survey results

The survey has been conducted in the city of Bari according to the following communication means: by promoting and posting the survey for the general users through the social media channels (Facebook, LinkedIn) and web page of POLIBA and municipality of Bari; by contacting directly by emails all the professors, students, administrative employees of POLIBA; by organizing specific online meetings with the fleet owners and taxi companies. After data cleaning, the data set contains 245 respondents, of which 12 use an electric car. Of all respondents, 68% are males, with a higher education degree (74%), student (41%) or full time employed (40%), married with or without children (29%) and living in an apartment/studio (53%) while 36% live in a detached house. 14% of the respondents have solar panels, and 13% a heat pump. The modal income category is 1.000-2.999€ (53%).

Of the 12 electric car drivers, 42% users drive a BEV and 17% a PHEV. It is worth noting that the sample size is quite small and the descriptive statistics should be interpreted with care. 10 respondents own the car privately, 2 have a company car. 8% have a company charging pass and 8% a company fuel pass. The age of the vehicle is nearly uniformly spread from less than a year up to three years. Battery capacity varies between 41kWh and 70kWh and the range varies between 200 up to more than 400km. Top 3 reasons for choosing an EV are: driving pleasure, comfort to drive and environmental friendliness.

Having asked about a random day of the week, EV drivers indicated they drove 51km (SD=25) and spent 2.29 hours (SD=1.25) on the road. 75% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 9.49 hours (SD=6.97) a day. Figure 4 shows how often EV drivers charge at different charging locations: mostly at home at a socket (50%), but also at work or at public chargers. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip, when state-of-charge falls below a certain level and when there is a possibility to charge.

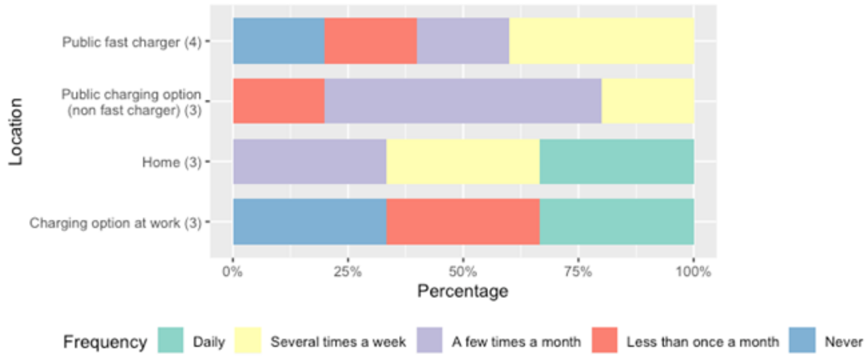

Figure 4: Frequency of charging at different locations for Bari EV drivers

55% of the Bari EV drivers never had to wait at a public charging station and 27% did so less than once a month. What matters most for an ideal charging session is that the charge pass works immediately.

The Bari respondents are overall not quite satisfied with the service by CPO/eMSPs and give them a score of 3.83 on 7 (SD=1.23). Note that only 5 respondents filled out these questions.

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Bari respondents choose fast charging station (42%), and smart charging station (58%). Respondents would not mind paying more for fast charging.

58% of the respondents do not use app-based services, but 25% intend to.

The questionnaire was also addressed to LEV users. 29 respondents filled out the survey; they mostly use the LEV daily or several times a week. 79% of the respondents own the vehicle privately and 17% use the service of a sharing company. On average, the LEV users indicate they drive about 15.43 km each day. The most important motives to use a LEV are environmental friendliness and the low operating and maintenance costs. Most of the time, the LEV is parked at home at a private parking or at home along a public road. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level and anticipating a next trip. Only 2 (7%) of the respondents indicate that they use the service of a CPO/eMSP to charge the LEV; In terms of future charging solutions, Bari LEV users choose smart charging station (50%), fast charging station (25%), and regular user-friendly charging station (25%). Only 3 (10%) respondents indicated they use app-based services, the remainder of the respondents have no intention to use an app in the near future.

The questionnaire was also addressed to non-EV drivers. For Bari 204 respondents participated. 48% Indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 55% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 74% have access to a private car park or garage and the vehicle is parked there for 8.54 hours (SD=8.22) while the vehicle was on the road for 1.75 hour (SD=2.65).

Field data analytics

This section presents the main results and conclusions from the electric mobility analysis for the Metropolitan city of Bari, an Italian city on the Scandinavian-Mediterranean corridor. In this pilot, there are 75 unique Charging Points (35 in the city centre of Bari), all from the Enel-x (Italian CPO) and 22 unique users exploiting the EVWAY app from the Route220 acting as eMSP. The data set covers the time period from 18/11/2018 to 01/09/2020.

The CPs are classified in slow CPs, semi-fast CPs and fast CPs, being the semi-fast CPs the most common ones. The observations for the analysis are from 18/11/2018 to 01/09/2020.

The values of the duration of the charging sessions in the case of semi-fast CPs are more spread and the average duration is longer (almost 2 hours). In the case of fast CPs users spend an average of 52 minutes and 54 minutes in the case of slow CPs.

Overall, in the CPs from this pilot the energy consumed is quite low, being the maximum value of 53.3 kWh. In the case of fast CPs, the average energy consumed is higher (22.96 kWh) and also the dispersion of the data. The semi-fast CPs have an average of 13.37 kWh and in the case of slow CPs 14 kWh.

4.4. Berlin

Context

Of the 1,658 publicly accessible charging points in public and private spaces at the end of the fourth quarter of 2020, 1,196 are public spaces. Of these, a total of 1,058 charging points were built at 560 locations on behalf of the Senate Administration for the Environment, Transport and Climate Protection in the period from 2015 to the end of 2020 as part of the "be emobil" project. In addition to the charging stations built on behalf of the land, four so-called third operators have signed the operator contract with the Land of Berlin and are operating or installing additional charging infrastructure in public spaces according to the Berlin model.

Survey results

The general survey was sent to several magazines and website for redistribution. Furthermore, local associations, e.g., Bundesverband für Carsharing, ADAC, Verkehrsclub Deutschland were contacted. The eMO did offer their support and distributed the survey in their January newsletter. After data cleaning, the data set contains 53 respondents, of which 27 (51%) use an electric vehicle. Of all respondents, 64% are males, with a higher education degree (88%), full time employed (70%), married with or without children (59%) and living in an apartment/studio (40%) while 13% live in a detached house. 9% of the respondents have solar panels, and 9% a heat pump. The modal income category is 3.000-4.999€ (34%).

Of the 14 electric car drivers, 86% drive a BEV and 14% a PHEV. It is worth noting that the sample size is quite small and the outcomes of the descriptive analysis should be interpreted with care. 4 respondents own the car privately, 6 have a company car and 4 use a car-sharing service. 29% have a company charging pass and 7% a company fuel card. The age of the vehicle is nearly uniformly spread from less than a year up to three years. Battery capacity varies, 40% of the respondents indicate between 41kWh and 50kWh and the range varies mostly between 100 and 199km. Top 3 reasons for choosing an EV are: environmental friendliness, comfort to drive and noise reduction.

Asked about a random day of the week, EV drivers indicated they drove 30km (SD=17) and spent 2.6 hours (SD=5.8) on the road. 75% of the EV drivers use their own garage or driveway. On average, the EV is parked at along the public road at home for 10.42 hours (SD=7.27) a day. Figure 5 shows how often EV drivers charge at different charging locations: mostly at home public chargers, but also at home. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip, when there is a possibility to charge and when state-of-charge falls below a certain level. The most popular charging time is in the evening, after working hours, between 6p.m. and 3a.m.

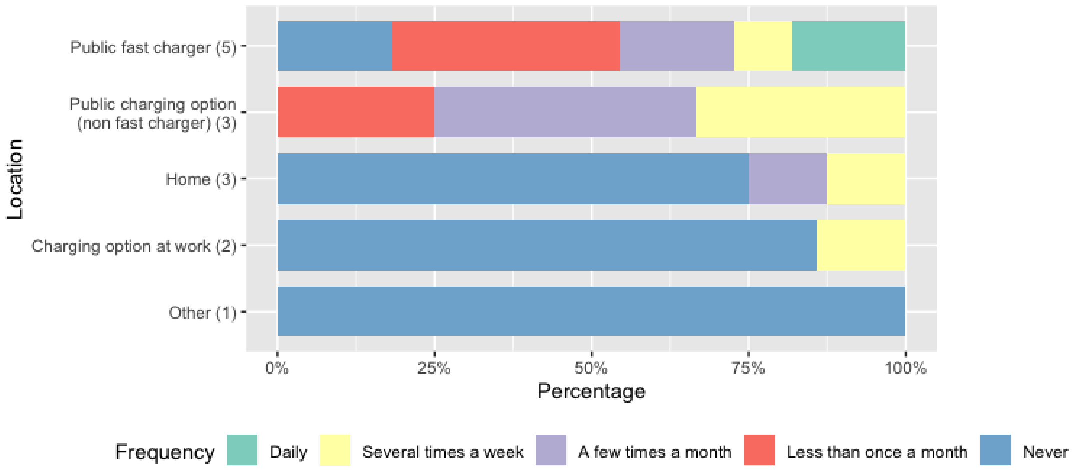

Figure 5: Frequency of charging at different locations for Berlin EV drivers

20% of the Berlin EV drivers never had to wait at a public charging station and 20% did so several times a week. What matters most for an ideal charging session is that the charge pass works immediately and short connection time at a charging point.

The Berlin respondents are overall quite satisfied with the service by CPO/eMSPs and give them a score of 4.67 on 7 (SD=1.84). Note that only 5 respondents filled out these questions.

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Berlin respondents choose smart charging (57%), battery swapping (29%) and mobile charging services (14%). Respondents would not mind paying more for battery swapping and mobile charging services.

50% of the respondents use app-based services. App-based services are mostly used for travel related to travel destinations on holiday (5 respondents), whereas 5 respondents use it for leisure activities.

The questionnaire was also addressed to LEV users. 9 respondents filled out the survey; they mostly use the LEV daily or several times a week. 38% of the respondents own the vehicle privately and 38% use the service of a sharing company. On average, the LEV users indicate they drive about 29 km (SD=29) each day. The most important motives to use a LEV are environmental friendliness, comfort to drive and the low operating and maintenance costs. The majority of the time, the LEV is parked at home at a private parking or at home along a public road. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level and anticipating a next trip. Only 2 of the respondents indicate that they use the service of a CPO/eMSP to charge the LEV; therefore, satisfaction is not reported. In terms of future charging solutions, Berlin LEV users choose battery swapping (56%) and mobile charging services (22%). 67% of the respondents indicated they use app-based services. LEV users use app-based services mostly for leisure activities (7 respondents), next for commuting and work activities (6 respondents). Overall, the users are very satisfied with the app-based services.

The questionnaire was also addressed to non-EV drivers. For Berlin 26 respondents participated. 31% indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 43% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 66% have access to a private car park or garage and the vehicle is parked there for 6.25 hours (SD=7.67) while the vehicle was on the road for 2.38 hour (SD=1.06).

<u>Field data analytics</u>

In the case of this demonstration area, there was no CPO in the consortium that could provide electromobility data from the city. With the aim of having an overview of the electromobility context, it has been decided to analyse another German city, in this case the city of Frankfurt am Main. In this demonstration area, 79 unique Charging Points operated by Hubject have been analysed.

Saturdays have the highest number of charging sessions, presenting a peak at 12 pm. The working days have a similar distribution with a morning peak between 9 am and 11 am and a second peak between 2 pm and 6 pm. Sunday is the day with lowest number of charging sessions.

The data from the sessions' duration present some outliers arriving to a maximum session duration of 59 hours. Therefore, it makes more sense to consider the median (79 minutes) as the average duration of the sessions in Frankfurt CPs instead of the mean which is 2 hours and 36 minutes.

It can be inferred that the average energy consumed per charging session in the CPs analysed in this demonstration area is 13.44 kWh. In general, the energy consumed per session is low, being the 75% of the charging sessions analysed with a consumption below 17.8 kWh.

The charging points are clustered based on their hourly occupancy behaviours. Temporal Cluster 1 includes the majority of the CPs (69.6%) and comprises the CPs that on average have a low occupancy percentage, around 0.5% in the afternoon and 1.5% in the morning. Temporal Cluster 2 includes CPs with an average occupancy between 7% and 10.5%. In both Clusters the occupancy is higher between 12 pm and 10 am.

The average sessions per day decreased by 15% during the lockdown and they doubled in the de-escalation and new normality periods. The average charging session duration decreased in all the periods while the average occupancy decreased in the lockdown and increased during the de-escalation and new normality. Finally, the average daily energy consumed remained stable during the periods analysed.

4.5. Grenoble

<u>Context</u>

The current network of public charging stations on Grenoble-Alpes Métropole (GAM) territory is composed of 31 public on-street charging points, complemented with stations in parking facilities. There are 324 EV users registered to the public network, the number is increasing, but many EV users charge their vehicles at home.

Survey results

In order to diffuse the survey, several channels have been activated. To target the general public, EV users registered to GAM charging stations network have been asked to fill the survey through a newsletter, articles have been published on GAM social media related to transport (app, website, Facebook…) as well as on external social media (mostly EV groups on Facebook). Users' associations have also published articles and sent emails to their members. After data clearing, the data set contains 134 respondents, of which 93 (69%) use an electric vehicle. Of all respondents, 78% are males, with a higher education degree (91%), full time employed (77%), married with or without children (81%) and living in a detached house (52%) while 34% live in an apartment/studio. 13% of the respondents have solar panels, 16% a heat pump and 3% a geothermal power system. The modal income category is 3.000-4.999€ (38%).

Of the 84 electric car drivers, 89% users drive a BEV and 6% a PHEV. 64 respondents own the car privately, 20 have a company car. 10% have a company charging pass and 6% a company fuel pass. 40% of the respondents have the vehicle for less than a year. Battery capacity is between 31kWh and 50kWh for 41% of the respondents and the range varies between 250 up to 400km for 45% of the respondents. Top 3 reasons for choosing an EV are environmental friendliness, low operating and maintenance costs and efficient energy consumption, but also driving comfort and driving pleasure are ranked high.

Asked about a random day of the week, EV drivers indicated they drove 100km (SD=105) and spent 2.33hours (SD=1.69) on the road. 88% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 12 hours (SD=5.9) a day. Figure 6 shows how often EV drivers charge at different charging locations: mostly at home, but also at work or at public chargers. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip and when state-of-charge falls below a certain level.

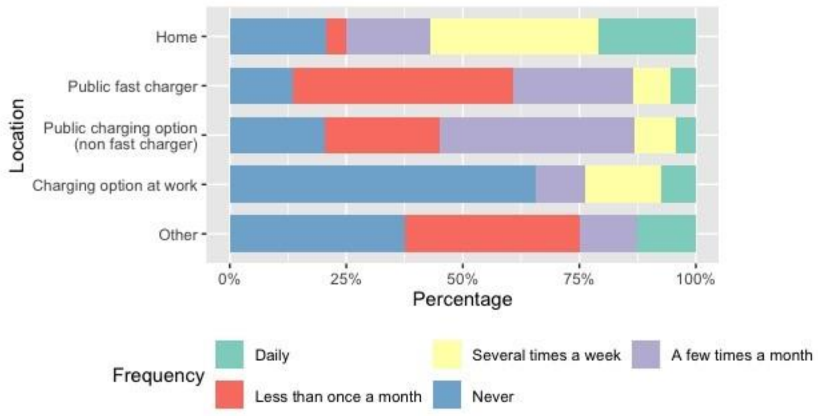

Figure 6: Frequency of charging at different locations for Grenoble EV drivers

45% of the Grenoble EV drivers never had to wait at a public charging station and 20% did so less than once a month.

The Grenoble respondents are overall quite satisfied with the service by CPO/eMSPs and give them a score of 4.51 on 7 (SD=1.7).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Grenoble respondents choose fast charging station (68%), and smart charging station (20%).

74% of the respondents use app-based services. 47% of the respondents have 4 or more apps on their phone.

The questionnaire was also addressed to LEV users. 7 respondents filled out the survey; they mostly use the LEV daily or several times a week. All respondents own the vehicle privately. On average, the LEV users indicate they drive about 15.14 km each day. The most important motives to use a LEV are environmental friendliness and the fact that it is the fastest transport mode. The majority of the time, the LEV is parked at home at a private parking at home or at the employer’s car park. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level and anticipating a next trip. None of the respondents indicate that they use the service of a CPO/eMSP to charge the LEV. Only 1 (14%) respondent indicated using app-based services, the remainder of the respondents have no intention to use an app in the near future.

The questionnaire was also addressed to non-EV drivers. For Grenoble 41 respondents participated. 37% indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 54% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 69% have access to a private car park or garage and the vehicle is parked there for 10 hours (SD=8.35) while the vehicle was on the road for 1.36 hour (SD=1).

Field data analytics

This section presents the results from the quantitative data analysis for the Grenoble-Alpes Metropole. In this pilot, there are 31 unique CPs with a power of 22kW and the available dataset covers the time-window between 17/05/2019 to 04/11/2020. All the charging points are possessed and monitored by Grenoble-Alpes Metropole through its exploitation market with Bouygues Energies et Services. Users can have access to them by registering to the network or directly without registering through the application (in this case, tariffs are higher). Charging Points network is expected to develop in the following years, notably with DC charging points and different powers.

The territory covers the city of Grenoble, but also surrounding cities such as La Tronche, Seyssinet-Pariset, Gières or Meylan, where charging points are located.

Sector 2, which corresponds to the city centre, with busy activity, is the one with the highest number of CPs and the highest number of sessions, on the contrary Sector 1, corresponding to residential and business districts, where companies may have their own private charging points for their fleet and employees, is the one showing the lowest ratio as the number of available CPs is high, but the number of sessions is low. Finally, Sectors 3 and 4, which are residential areas with a part of low-income inhabitants higher, have low number of CPs and low number of sessions.

The frequency of sessions and patterns are similar for all the days of the week, except for Sunday which is the day with the lowest number of charging sessions. Tuesdays, Wednesdays, Thursdays and Fridays have a morning peak from 8 am to 9 am, whereas on Mondays the peak shifts by one hour starting from 9 am to 10 am. On the other hand, the morning peak of the weekends is starting at 10 am. The noon peak starting from 12pm to 1 pm occurs in all working days, whereas Mondays, Tuesdays, and Wednesdays have a second peak with a lower level. In the evening, there’s not a specific peak, we have different lower peaks from 5pm to 9 pm.

In the case of the sessions’ duration, there are some really long sessions (up to 28 days). Therefore, the median is better choice to consider as the general average of duration, meaning that most of the users stay an average time of two hours in the public charging points.

The average energy consumed per session is 17.56 kWh. The algorithm detects the usages more than 50 kWh as outliers, meaning that a low number of sessions have an energy consumption above that number.

The user behaviours have been grouped in three clusters based on their similarity. Almost the half of the users from GAM belong to Cluster 1. In this cluster, users have low number of sessions, high energy and power consumed and low session duration. On the contrary, users from Cluster 2, are the users with the highest number of sessions, highest number of different CPs visited, and average energy consumed and duration similar to the overall average. Finally, users from Cluster 3 are the ones with highest duration, lowest power and low number of sessions.

Temporal Cluster 1 is the major cluster and contains 58 % of the CPs. This cluster comprises the CPs with a usage peak in the morning. Cluster 2 comprises the CPs with a higher occupancy (between 15% and 20%), and no pronounced usage peaks, most of the CPs belonging to Cluster 2 are located in the city centre.

77.15 % of the users use only CPs located in one sector, meaning that users tend to charge their vehicle always in the same area. When analysing the mobility flows between sectors can be noted that there's a strong mobility flow between Sectors 2, city centre, and Sector 1 residential and business activity, this means that there's a high number of EV drivers that use the charging points located in both Sectors.

The number of users, the number of sessions and the occupancy percentage dropped significantly when lockdown was imposed. The numbers start to recover during the de-escalation until new normality, where the number of users increases compared to the pre-COVID-19 period. As regards the average duration and average daily energy consumed by user the numbers remain similar to the pre-covid situation, except for the new normality period where the average daily energy consumed by user decreased by 25%. It should be considered that the new normality period is during summer holidays where the usage patterns can also be different.

4.6. Greece

Context

In 2020 new sales of 679 BEVs and 1452 PHEVs were registered in Greece, bringing the total of registered cars to 1105 BEVs and 2167 PHEVs. There is no official registry of charging infrastructure in Greece right now. An estimation of the charging network in Greece is less than 300.

Survey results

The general survey was sent to ICCS's internal mailing list. Also 15 local organizations and authorities, comprising of research institutes, municipalities, CPOs/eMSPs, EV & mobility associations, environmental organizations, NGOs etc., through personalised emails that promoted the survey and asked for further distribution through their networks and channels. The Research Director of ICCS, promoted the survey in an interview at the mainstream radio station Parapolitika. The survey was also widely promoted through the ICCS's social media. After data cleaning, the data set contains 210 respondents, of which 18 (9%) use an electric vehicle. Of all respondents, 65% are males, with a higher education degree (90%), full time employed (71%), married with or without children (53%) and living in an apartment/studio (76%) while 11% live in a detached house. 7% of the respondents have solar panels, and 8% a heat pump. 70% of the respondents reported an average net income in the category 1.000-2.999€.

Of the 10 electric car drivers, 70% drive a PHEV, 20% a BEV and 10% a PHEV. It is worth noting that the sample size is quite small and the descriptive analysis should be interpreted with care. 8 respondents own the car privately, 2 have a company car. 20% have a company charging pass and 40% a company fuel pass. The age of the vehicle is less than a year for 40% of the respondents. Top 3 reasons for choosing an EV are: environmental friendliness, low operating and maintenance costs and efficient energy consumption, also the innovative and hip feature as well as tax advantages score high as motives.

Asked about a random day of the week, EV drivers indicated they drove 49km (SD=23) and spent 2 hours (SD=0) on the road. 80% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 12.33 hours (SD=0.58) a day. Figure 7 shows how often EV drivers charge at different charging locations: mostly at home, but also at work or at public chargers. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip and when state-of-charge falls below a certain level.

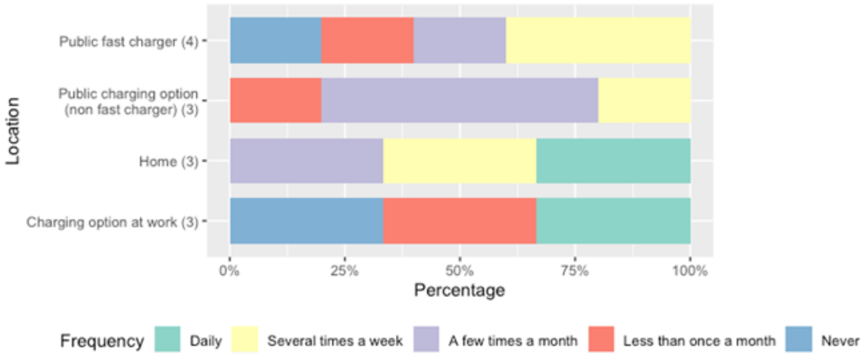

Figure 7: Frequency of charging at different locations for Greece EV drivers

50% of the Greek EV drivers never had to wait at a public charging station. What matters most for an ideal charging session is that the charge pass works immediately and that there is a short connection time at the charging point.

The Greek respondents are overall satisfied with the service by CPO/eMSPs and give them a score of 4 on 7 (SD=1.08). Note that only 6 respondents filled out these questions.

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Greek respondents choose fast charging station (50%), smart charging station (30%), and user-friendly charging stations (20%). Respondents would not mind paying more for user friendly charging stations.

30% of the respondents use app-based services, and 50% do not intend to.

The questionnaire was also addressed to LEV users. 6 respondents filled out the survey; they mostly use the LEV daily or several times a week. 67% of the respondents own the vehicle privately and none use the service of a sharing company. On average, the LEV users indicate they drive about 7.8 km each day. The most important motives to use a LEV are the low operating and maintenance costs. The majority of the time, the LEV is parked at home at a private parking or at home along a public road and also at the employer's parking. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level and anticipating a next trip, but respondents also indicate they do so after completing the daily routine, at the end of the day or when being close to the usual charging place. Only 2 (7%) of the respondents indicated that they use the service of a CPO/eMSP to charge the LEV; therefore, satisfaction is not reported. In terms of future charging solutions, Greece LEV users choose smart charging station (66%), and fast charging stations (33%). None of the respondents indicated they use app-based services.

The questionnaire was also addressed to non-EV drivers. In Greece, 192 respondents participated. 21% indicated that it is slightly to very likely to buy an electric vehicle as soon as possible, and the intention increases to 68% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and low operational and maintenance costs. 64% have access to a private car park or garage and the vehicle is parked there for 10.55 hours (SD=7.28) while the vehicle was on the road for 1.88 hour (SD=1.78).

Field data analytics

This section introduces the main outcomes from the quantitative data analytics for the Greek demonstration area. In this demonstration area, there are 4 unique charging stations from the CPO BFS. BFS is responsible for the facility management, renovation plan and business extension plan of approximately 500 car service stations located around Greece. Those stations have been serving mobility in Greece for decades, mainly by providing conventional fuels (petrol and gas stations) and car caring services. From 2019, following the transformation of transportation services, an evolution plan is under deployment to provide also electromobility services form the already established network. The first stations equipped with fast charging stations were along the major Greek highways and started their initial test operation in 2019. The initial plan anticipated that the number of stations would have grown bigger by the end of 2020, but due to the health crisis, the installation planning has been adopted and most of the new stations will be installed within 2021. It is anticipated that by the end of the year about 50 electric charging stations will be operating, while in 2022 the charging network will grow further.

As for the electromobility in Greece, it should be mentioned that it remains in a pre-mature phase, with a few electric cars being in circulation, most of them being plug-in hybrids. Moreover, the legal framework deterring the operation conditions of such stations have been recently under establishment, and as a result for a long period the user was not charged for the usage of electricity consumed during charging by the operator of the station, but only for the time the car spent in the station and no other data were kept for the charging sessions. In addition, due to the restriction applied because of the health crisis, for a long period during the time of study, individuals were not allowed to travel away from their hometown or make intercity trips and as a result the traffic was reduced in the highways, more than the reduction of traveling within the region.

In the case of 43kW CPs, the average duration is 43.86 minutes and the energy consumed per session is 7.04 kWh. In the case of 50kW CPs the average duration is 51.43 minutes and the average energy consumed per session is 25.88 kWh.

4.7. Luxembourg

Context

Luxembourg's government had tasked the countries five DSOs to roll out a nationwide charging network, “Chargy”, that is supposed to resolve the chicken-egg-problem of electric vehicles that would depend on the availability of charging infrastructure. The initial plan to roll out exclusively AC charging points (800 dual charging station of each 2 x 22 kW) had been adjusted recently. Some of the foreseen charging stations would be converted to DC fast charging of 160 or 320 kW, branded “SuperChargy”.

Survey results

Nexxtlab used social media (LinkedIn and Facebook) to target the audience in Luxembourg. Nexxtlab had motivated participants to complete the survey by offering a prize (“Help us make e-mobility easy and have the chance to win an iPad”). Given the limited direct outreach of Luxembourg's project partner Nexxtlab, the national energy agency “myenergy” and the DSO and CPO Creos had published posts on Facebook that triggered each a steep rise in response. After data cleaning, the data set contains 258 respondents, of which 139 (54%) use an electric vehicle. Of all respondents, 78% are males, with a higher education degree (77%), full time employed (77%), married with or without children (78%) and living in an apartment/studio (29%) while 45% live in a detached house. 26% of the respondents have solar panels, and 16% a heat pump. 70% of the respondents have an average monthly net income between 3.000 and 9.999€.

Of the 105 electric car drivers, 85% drive a BEV and 13% a PHEV. 72 respondents own the car privately, 33 have a company car. 17% have a company charging pass and 7% a company fuel pass. The age of the vehicle of 42% of the respondents is less than a year up. Battery capacity is for 25% over 70kWh and the range varies between 250 up to more than 400km (55%). Top 3 reasons for choosing an EV are: efficient energy consumption, driving pleasure and comfort to drive.

Asked about a random day of the week, EV drivers indicated they drove 89km (SD=82.82) and spent 2.10 hours (SD=2.23) on the road. 88% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 11 hours (SD=5.71) a day. Figure 8 shows how often EV drivers charge at different charging locations: mostly at home at a socket, but also at work or at public chargers. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip, when state-of-charge falls below a certain level and when there is a possibility to charge or when near the usual charging place.

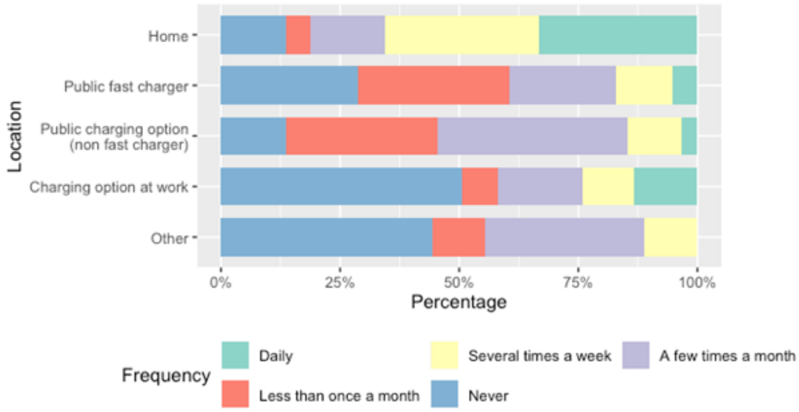

Figure 8: Frequency of charging at different locations for Luxembourg EV drivers

55% of the Luxembourg EV drivers never had to wait at a public charging station because of an EV occupying the spot, but that drops to 34% for an ICE vehicle occupying the spot.

The Luxembourg respondents are overall very satisfied with the service by CPO/eMSPs and give them a score of 5.75 on 7 (SD=1.1).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Luxembourg respondents choose smart charging station (79%). Respondents would mostly use smart charging if the price were lower than the current charging solution.

54% of the respondents use app-based services. 33% respondents have 4 or more apps on their phone, mostly for travel destinations on holidays and leisure activities.

The questionnaire was also addressed to LEV users. 24 respondents filled out the survey; they mostly use the LEV daily or several times a week. 60% of the respondents own the vehicle privately. On average, the LEV users indicate they drive about 23 km each day. The most important motives to use a LEV are the driving pleasure and comfort, next to environmental friendliness and the low operating and maintenance costs. The majority of the time, the LEV is parked at home at a private parking or at the employer's car parking. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level and anticipating a next trip. Currently, there are no CPOs/eMSPs that serve LEVs in Luxembourg. In terms of future charging solutions, Luxembourg LEV users choose smart charging station (83%). 17% of the respondents indicated they use app-based services, 17% intend to and the remainder of the respondents have no intention to use an app in the near future.

The questionnaire was also addressed to non-EV drivers. For Luxembourg 119 respondents participated. 50% indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 63% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 86% have' access to a private car park or garage and the vehicle is parked there for 11 hours (SD=6.12) while the vehicle was on the road for 1.76 hour (SD=0.8).

Field data analytics

The data analytics for the Luxembourg demonstration area covers the whole country, counting with the dataset from Chargy. The Chargy network includes public charging stations for electric cars and hybrid plug-in vehicles in Luxembourg, with nearly half of the stations located in park-and-ride car parks and the remaining in public municipal car parks. The rollout plan of the nationwide charging network “Chargy” foresees to have 400 dual charging (800 CPs) located on park-and-ride facilities and another 400 dual charging stations (800 CPS) scattered across municipalities. All the charging points have the same power (22 kW). The infrastructure is set up and operated by Luxembourgish electric distribution network operators that also act as CPO.

In May 2020, Chargy had 79 out of the planned 400 dual charging stations for park-and-ride facilities installed, while they had installed 266 out of 400 planned dual charging stations in public parking sites run by local councils. Thereby 93 out of 102 communes in Luxembourg had at least one dual charging station operational. The network is most dense and widely used in the city of Luxembourg and the more populated areas in the South of the country. The charging sessions' analysis revealed a new finding: the concentration of charging activities along the highway A6/E25 connecting Luxembourg to Belgium's Arlon.

The sessions' temporal distribution has been analysed in order to gather the day of the week and the time of the day preferred by the users. It can be inferred that the weekends have always lower session values than the weekdays. When analysing the time of the day, there is a first significant peak during the weekday mornings, from 8 to 9 am, and at noon between 12 and 1 pm, these peaks are higher on Thursdays and lower on Mondays. The noon peak is also present during the weekends, but with a lower frequency than the weekdays. With a lower frequency than the two previous peaks, there is a peak during the evenings, from 6 to 7 pm. This peak only appears during the weekdays.

From the analysis of the sessions' duration can be inferred that there are a lot of outliers, that is users that park for extremely long periods of time (the maximum value is 58 days), which are unrealistic in terms of charging session. These outliers affect the value of the average, which is of 6 hours and 17 minutes, whereas the median is 2 hours and 43 minutes. In this case, the median is a more realistic value to consider as a general duration average of users that perform a charging session.

In the case of the energy consumed per session the number of outliers is lower, which leads to more realistic conclusions. The algorithm detects usages with more than 37.5 kWh as outliers, and the average usage is 13.48 kWh, which implies that Luxembourg users tend to perform short sessions. On a sidenote, above 50% of Luxembourg's residents live in single-family houses, enabling the installation of private charging points. Therefore, it is safe to assume that most of the charging happens at home and less on public charging stations.

All CPs in Luxembourg are with 22 kW power, whereas the actual average power is 5.10 kW.

Users in Luxembourg have been categorised in three clusters. Almost 60% of the users belong to Cluster 1, which is the cluster closest to the average values. Moreover, Cluster 1 is the cluster with the lowest number of sessions per user, an average energy consumption of 7 kWh and an average charging session duration of 3 hours.Cluster 2 users have the most different patterns of behaviour to the average, with the longest session duration (8.5 hours), highest number of sessions, highest number of different CPs visited and lowest actual power. Finally, users that belong to Cluster 3 are characterised by high energy consumption per charging session and high actual power.

Two different CP clusters have been defined in the Luxembourg demonstration area. Temporal Cluster 1 CPs (90% of the CPs) have one significant peak, from 3 am to 8 am, this Cluster includes the CPs with lower occupancy (between 2.2% and 5.8%). Temporal Cluster 2 (9.8% of the CPs) has a 40% occupancy peak between 3 am and 8 am and then the occupancy progressively decreases up to 25%.

The results of user mobility flows analysis for the Luxembourg demonstration area are based on 159 canton pairs detected in the dataset. 61.43% of the users perform their charging sessions inside the same canton. The canton with the highest mobility flows is Luxembourg, being the main origin and destination, then it's followed by Capellen and Grevenmacher. The top-three mobility flows are Luxembourg – Capellen (309 trips), Luxembourg-Echternach (110 trips) and Luxembourg-Mersch (88 trips). Again, it is safe to assume that charging on private charging points is missing in that picture. Also, charging abroad is not taken into account, which might be an essential factor too, given the fact that more than 200,000 cross-border workers are employed in the Grand Duchy (Statec 2019), with almost half of them coming from France, where electricity prices are even below the Luxembourgish level.

During the COVID-19 crisis, the number of users, the average sessions per day and the average occupancy percentage of the CPs decreased considerably during the lockdown period and these attributes increased during the de-escalation achieving similar values to the pre-covid period in the new normality.

The average duration increased by 73% in the lockdown period compared to the pre-COVID 19 period, the increase is probably caused by users leaving their car parked at the CPs due to the mobility limitations.

Overall, the number of users, average sessions per day, average duration, average occupancy percentage of CPs and average daily energy consumed by user recover to similar values to the pre-covid situation in the new normality. Moreover, a comparison analysis performed between the conventional fuel sales on Luxembourg's petrol stations and the energy consumed in Chargy CPs during the COVID-19 period. It is clearly noted that the consumption of the three energy sources decreased during lockdown.

4.8. Northern Italy

Context

Electric mobility is starting to experience interesting growth volumes also in Italy. In 2018, about 20,000 electric vehicles were registered in Italy while the new registrations counted 13,000 new vehicles in 2019, 30,000 new vehicles in 2020 and an estimation of over 60,000 new registrations in 2021. The country has about 15,000 charging points for electric vehicles and the number is constantly increasing. Also, thanks to the presence of a few large national players and many other small CPO operators active mainly locally.

Survey results

Route220 disseminated the questionnaire to all its end users: private, business, and corporate. The process of collecting data by users was mainly finalised by sending a direct communication explaining the project and asking to answer the questionnaire. The main tool used was the newsletter. A first newsletter was sent on middle of November and subsequently a second newsletter with a reminder for the answer to the questionnaire was sent on the first days of December and a third one during the last days of the month. After data cleaning, the data set contains 308 respondents, of which 264 (86%) use an electric vehicle. Of all respondents, 89% are males, with a higher education degree (76%), retired (9%) or full time employed (73%), married with or without children (66%) and living in an apartment/studio (48%) while 36% live in a detached house. 32% of the respondents have solar panels, and 18% a heat pump. The modal income category is 1.000-2.999€ (41%).

Of the 246 electric car drivers, 91% users drive a BEV and 7% a PHEV. 189 respondents own the car privately, 58 have a company car. 8% have a company charging pass. The age of the vehicle is less than a year old. Battery capacity varies between 41kWh and 70kWh and the range varies between 300 up to more than 400km. Top 3 reasons for choosing an EV are: driving pleasure, comfort to drive and environmental friendliness.

Asked about a random day of the week, EV drivers indicated they drove 103km (SD=106) and spent 1.9 hours (SD=1.4) on the road. 75% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 12.5 hours (SD=6.25) a day. Figure 9 shows how often EV drivers charge at different charging locations: mostly at home at a charging station (52%), but also at public chargers. When asked about charging habits, EV drivers indicated that they charge mostly based on their next trip, when state-of-charge falls below a certain level and when there is a possibility to charge.

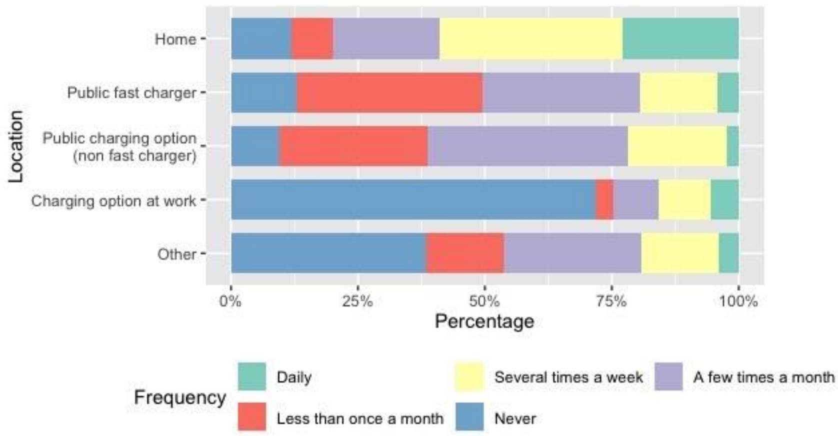

Figure 9: Frequency of charging at different locations for Northern Italy EV drivers

52% of the Northern Italy EV drivers never had to wait at a public charging station and 23% did so less than once a month. What matters most for an ideal charging session is that the charge pass works immediately.

The Northern Italy respondents are overall quite satisfied with the service by CPO/eMSPs and give them a score of 5.2 on 7 (SD=1.34).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Northern Italy respondents choose fast charging station (55%), and smart charging station (31%). Respondents would not mind paying more for fast charging.

80% of the respondents use app-based services, another 17% do not but intend to.

The questionnaire was also addressed to LEV users. 7 respondents filled out the survey; they mostly use the LEV daily or several times a week. It is worth noting that the sample size is quite small and the descriptive analysis should be interpreted with care. 57% of the respondents own the vehicle privately and 14% use the service of a sharing company. On average, the LEV users indicate they drive about 39 km each day. The most important motives to use a LEV are environmental friendliness and the low operating and maintenance costs. The majority of the time, the LEV is parked at home at a private parking or at the employer's car park. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level and anticipating a next trip. Only 1 (14%) of the respondents indicate that they use the service of a CPO/eMSP to charge the LEV; therefore, satisfaction is not reported. In terms of future charging solutions, Northern Italy LEV users choose fast charging station (71%), and regular user-friendly charging station (14%). Only 2 (29%)

respondents indicated they use app-based services, the remainder of the respondents have no intention to use an app in the near future.

The questionnaire was also addressed to non-EV drivers. For Northern Italy 44 respondents participated. 58% indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 61% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 57% have access to a private car park or garage and the vehicle is parked there for 7.13 hours (SD=8.21) while the vehicle was on the road for 2.9 hour (SD=4.02).

Field data analytics

This section will cover the main results from the Data Analytics for the Northern Italy demonstration area, which covers a total of 43 municipalities, including Milan and Turin, and includes the Trentino Alto-Adige autonomous region, located at the border with Switzerland and Austria, with a significant tourist activity. The operator and data provider for this demonstration area is Route 220.

The charging sessions analysed in this demonstration area mostly take place in the main cities of the region, Torino, Milano and Trento, and their surrounding areas. Torino is the city with the highest number of CPs installed and with the highest number of sessions. Pergine Valsugana, a city close to Trento, is the second city in number of sessions, and the one with the highest ratio between the total number of CPs in the city and the total number of sessions in the corresponding city. The cities of Chivasso and Mantova also have high usage levels with a low number of CPs.

Most of the cities in the northern Italy demonstration area have only one type of power level for their CP, whereas only Trento, Torino, San Maurizio Canavese, Rovereto, Milano, Mantova and Borgo Mantovano have different power level CPs installed. The only city with fast CPs is San Maurizio Canavese, in the Metropolitan City of Turin, very close to the Turin Airport.

Most of the CPs are Semi-Fast along with limited number of Fast chargers. Even with the limited number of Fast CPs, their usage is quite high, whereas the least preferred charging points are the 7.4 kW CPs. It highlights the fact that in the public CPs the EV users tend to use the faster options, even though these are not the most available group. However, the most popular are the 22 kW CPs (Semi-Fast) with the highest number of sessions and highest number of installed CPs.

All the days of the week have a similar frequency of sessions, except for Sunday which is the day of the week with the lowest number of sessions. On one hand, the weekdays (from Monday to Friday) have 3 different peaks: (i) from 7 am to 8 am, (ii) from 10 am to 11 am, (iii) from 3 pm to 4 pm. On the other hand, the weekend has 2 peaks: (i) from 8 am to 11 am, (ii) 3 pm to 4 pm.

By analysing the sessions' duration from the public charging points in the Northern Italy demonstration area, it can be inferred that there is a noticeable number of outliers in the semi-fast CPs that perform very long charging sessions (with a maximum of 8 days). The average duration in the case of the fast-charging points is 31 minutes, and in the case of the semi-fast CPs is 153 minutes, but due to the presence of outliers the median can be considered as a more realistic number for the general average, with 95 minutes.

As for the energy consumed during the sessions, the mean of the energy consumed in the fast CPs is 15.69 kWh and in the case of the semi-fast CPs is 11.79 kWh. In the case of semi-fast CPs there's a significant number of outliers, with a maximum value of 117.9 kWh.

Three different user clusters have been defined for the Northern Italy demonstration area based on the usage similarities. Users belonging to Cluster 1 have always values lower than the mean, especially in the case of the number of sessions, the usage period and the number of CPs visited. Cluster 2 includes users with longer session duration (almost 4 hours in average), high energy consumption and low number of sessions. Cluster 3 is the most crowded cluster (55% of the users) and consists of the users that have the highest number of sessions, highest number of CPs used, low average energy consumption and lowest duration (1h 38 mins in average).

The Charging Points are clustered based on their temporal behaviours. The two clusters have a similar hourly occupancy distribution, however, CPs belonging to Cluster 1 present a higher average occupancy than those belonging to Cluster 2. Most of the CPs from the Northern Italy demonstration area belong to Cluster 2 (96.2%).

Torino and Trento are the most popular cities to be an origin or destination point for intercity trips; the most significant OD flows are from Chivasso to Torino and from Torino to Trento

The number of users dropped significantly when the lockdown was imposed in Italy, with a drop of 60% of users. After the lockdown, it increases during the de-escalation period and reaches an 89% of the pre-COVID-19 period in the new normality. Likewise, the average sessions per day and the average occupancy also show a noticeable reduction during the lockdown. In the same way as the number of users, the average sessions per day recover a 95% of the value shown at the pre-COVID-19 period.

4.9. Turkey

Context

At the end of 2020, there were around 3.000 EV registered in Turkey and almost half of it in Istanbul. With the launching of the first electric vehicle brand of Turkey (TOGG, or Turkey's Automobile Joint Venture Group) at the end of 2022, rapid increase in the number of electric vehicles is expected in the near future. In order to meet this capacity, ZES is already giving service in all 81 cities of Turkey. ZES is operating 26 fast charging stations and providing service in 481 different locations. In the current situation, with another CPs of different CPOs, there are approximately 2 electric vehicles per 1 public AC charging point in Turkey. And for the public DC charging points, this rate is around 17:1 (EV/DC).

Survey results

ZES disseminated the questionnaire to all who have an important role in the eMobility sector: stakeholders, universities, and companies. The process of collecting data by users was mainly finalised by sending a direct communication explaining the project and asking to answer the questionnaire. The main tools used were the newsletter and mailing. The survey was shared with the relevant companies and institutions to ensure their participation and to make the survey popular by using the wide networks of the companies. In addition, some incentives were applied to ZES employees and customers of the company which are active EV users during mailing distribution. After data clearing, the data set contains 254 respondents, of which 60 (24%) use an electric vehicle. Of all respondents, 84% are males, with a higher education degree (85%), full time employed (95%), married with or without children (46%) and living in an apartment/studio (84%) while 11% live in a detached house. 7% of the respondents have solar panels, and 3% a heat pump. The modal income category is ≥ 10.000 TL (36%).

Of the 32 electric car drivers, 78% drive a BEV and 18% a HEV. It is worth noting that the sample size is quite small and the descriptive statistics should be interpreted with care. 16 respondents own the car privately, 15 have a company car, and 1 a car owned by a car sharing company. 50% have a company charging pass and 9% a company fuel pass. The age of the vehicle is less than a year. Battery capacity varies between 41kWh and 50kWh and the range varies between 250 up to 400km. Top 3 reasons for choosing an EV are: innovating- hip looking design, driving pleasure and environmental friendliness.

Asked about a random day of the week, EV drivers indicated they drove 148km (SD=168) and spent 2.16 hours (SD=1.47) on the road. 75% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 8.1 hours (SD=7.15) a day. shows how often EV drivers charge at different charging locations: mostly at work (41%), but also at public chargers. 27% of the respondents indicate that they never charge at home. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip, when state-of-charge falls below a certain level and when there is a possibility to charge. As for the most popular charging time, no conclusions can be drawn as a steady percentage of 25% of the EVs are charged throughout the day.

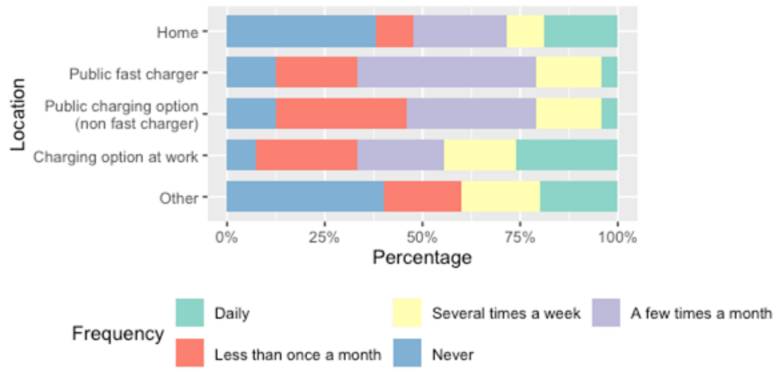

Figure 10: Frequency of charging at different locations for Turkish EV drivers

50% of the Turkish EV drivers never had to wait at a public charging station and 50% did so less than once a month. What matters most for an ideal charging session is that the charge pass works immediately.

The Turkish respondents are overall really satisfied with the service by CPO/eMSPs and give them a score of 6.3 on 7 (SD=0.81).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Turkish respondents choose fast charging station (42%), and smart charging station (58%). Respondents would not mind paying more for fast charging.

53% of the respondents do not use app-based services, but 47% intend to.

The questionnaire was also addressed to LEV users. 22 respondents filled out the survey; they mostly use the LEV daily or several times a week. 87% of the respondents own the vehicle privately and 9% use the service of a sharing company. On average, the LEV users indicate they drive about 24 km each day. The most important motives to use a LEV are environmental friendliness and the fact that it is tax advantageous. The majority of the time, the LEV is parked at home at a private parking or at home along a public road. In terms of charging behaviour, the main reason for the respondents to charge is at the end of the day or when there is a possibility to charge. Only 3 (14%) of the respondents indicated that they use the service of a CPO/eMSP to charge the LEV; therefore, satisfaction is not reported. In terms of future charging solutions, Turkey LEV users choose fast charging station (45%), regular user-friendly charging station (23%), mobile charging stations (14%) and smart charging station (13%). Only 8 (36%) respondents indicated they use app-based services, another 47% of the respondents intend to use an app in the near future.

The questionnaire was also addressed to non-EV drivers. For Turkey 194 respondents participated. 48% indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 55% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and the low operating and maintenance costs. 70% have access to a private car park or garage and the vehicle is parked there for 9.54 hours (SD=9.00) while the vehicle was on the road for 2.33 hour (SD=1.58).

<u>Field data analytics</u>

This section contains the main outcomes and conclusions from the Data Analytics for the Istanbul and Western Turkey demonstration area. The analysis shows that fast chargers (i.e., 100 kW and 120 kW) are the most commonly used, although the total number is low. On the other hand, the most common CP power level, 22 kW, has the lowest ratio.

The city of Balıkesir has a very low number of CPs for the relatively high number of sessions, with a ratio of 105 sessions per CP. Manisa, Bursa, Kocaeli and İstanbul also show a high ratio of sessions per CP. On the other side, there are cities like Sakarya, Çanakkale and Edirne that show a low ratio of session per CP, meaning a low usage of the city's CPs

When analysing the sessions' temporal distribution can be inferred that starting from 5 am, until the 4 pm the number sessions keep increasing. Then it starts to decrease again. The highest peak occurs on Sunday at 4 pm.

With regard to the duration of the sessions, the average and the median is higher for the case of semi-fast CPs, as in this type of charging points the user needs to spend more time to have a full recharge. In the case of the fast and ultra-fast charging points, the presence of outliers is low, which means that the mean can be a good measure to know the average time spent in these CPs. In both cases the mean duration is 49 minutes.

As for the energy consumed in the sessions, the lowest average energy consumed takes place in fast CPs (10.9 kWh) whereas in ultra-fast CPs have the highest average (37 kWh). On the other hand, the highest values achieved are for the case of the semi-fast CPs, having some values between 60kWh and 115 kWh.

The user clustering approach shows two major groups (Cluster 1 and Cluster 3) with low number of sessions and with high energy consumed with low duration sessions. The Cluster 2 is the least crowded cluster (15% of the users), users belonging to Cluster 2 are regular users, with the highest number of sessions, longest membership period and highest number of CPs visited.

The same clustering approach is applied also for the charging points in order to group them based on their hourly occupancy distributions. This clustering shows two clusters for the CPs. The occupancy percentage in both Clusters is low, nevertheless Cluster 1 includes the charging stations with the highest number of sessions. On one hand, Cluster 1 presents one peak at 12 pm, another at 3 pm and at 8 pm, on the other hand Cluster 2 Charging stations present a peak between 3 pm and 5 pm.

More than half of the EV users show charging sessions in the same city without charging in other cities, whereas the rest (41.7%) use also the CPs from other cities. The intercity trips are happening and will likely increase in the future in case that the necessary conditions are met. According to the analyses, these conditions are (i) installation of fast chargers for intracity and intercity trips, (ii) installation of more charging points in the cities that are located on the corridor between İstanbul and İzmir, as most of the trips happened between İstanbul and İzmir highway and the intermediary cities between them.

4.10. Zellik

Context

As of 2020, there were estimated that the number of registered EVs in Belgium would be around 105,000. There are 30,000 BEV and 75,000 PHEV. Sales are expected to increase over the next few years due to the increased offer of EV models and government subsidies. Currently, in Belgium there's a total of 8482 CPs, more in detail 4200 public charge points and 4282 private charge points. Key players in the implementation of public charging infrastructure are Allego, EVBox, Blue Corner, Ionity, Fastned, GreenFlux, ChargePoint.

Survey results

The general survey has been widespread on social media, emails, and forums. More specifically, a direct approach through emails of CPOs, car sharing companies, governmental organizations, and e-bike and LEV companies. The survey was disseminated through social media (Linkedin, Facebook, twitter), via paid ads through Facebook and Linkedin, and personal contacts were addressed. University students were approached through announcements, mails, and messages in existing WhatsApp groups, and the use of the Prolific platform, a professional paid service to guarantee 150 responses. After data cleaning, the data set contains 309 respondents, of which 109 (35%) use an electric vehicle. Of all respondents, 66% are males, with a higher education degree (84%), student (18%) or full time employed (67%), married with or without children (53%) and living in a detached house (34%) while 26% live in an apartment/studio. 34% of the respondents have solar panels, and 12% a heat pump. The modal income category is 3.000-4.999€ (45%).

Of the 50 electric car drivers, 48% drive a BEV and 38% a PHEV. 30 respondents have a company car, 19 own the car privately, and 1 a car owned by a car sharing company. 38% have a company charging pass and 22% a company fuel pass. The age of the vehicle is nearly uniformly spread from less than a year up to three years. Battery capacity lies above 70kWh and the range varies between 300 up to more than 400km. Top 3 reasons for choosing an EV are: environmental friendliness, tax-advantageous and the fact that EVs have more efficient technology in terms of energy consumption.

Asked about a random day of the week, EV drivers indicated they drove 89.6km (SD=88.23) and spent 1.5 hours (SD=0.44) on the road. 77% of the EV drivers use their own garage or driveway. On average, the EV is parked at a private parking at home for 10.71 hours (SD=6.34) a day. Figure 11 shows how often EV drivers charge at different charging locations: mostly at home at a charging station (57%), but also at work or at public chargers. When asked about charging habits, EV drivers indicate that they charge mostly based on their next trip, when state-of-charge falls below a certain level and when there is a possibility to charge.

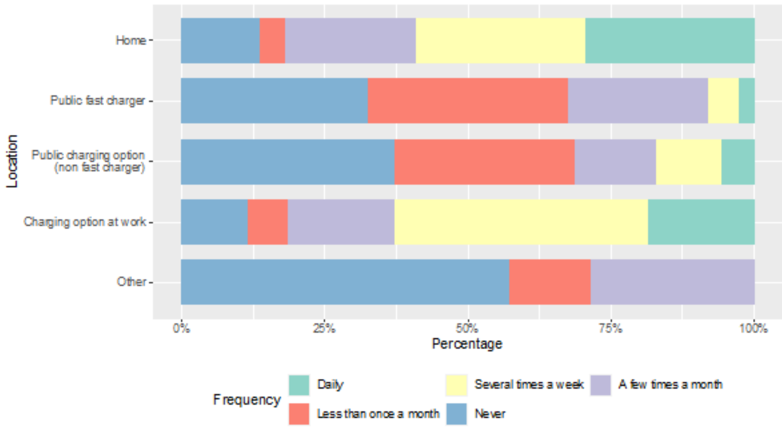

Figure 11: Frequency of charging at different locations for Zellik EV drivers

48% of the Zellik EV drivers never had to wait at a public charging station and 27% did so less than once a month. What matters most for an ideal charging session is easy payment with cash.

The Zellik respondents are overall satisfied with the service by CPO/eMSPs and give them a score of 5.46 on 7 (SD=1.13).

To measure acceptance of future technologies, respondents were asked about their preferred choice of charging station for the future. Zellik respondents choose fast charging station (50%), regular user-friendly charging station (26%) and smart charging station (22%). Respondents would not mind paying more for fast charging. Almost 75% of the respondents indicated they would only use smart charging if the price were lower.

52% of the respondents do not use app-based services, but 22% intend to.

The questionnaire was also addressed to LEV users. 48 respondents filled out the survey; they mostly use the LEV daily or several times a week. 89% of the respondents own the vehicle privately and 8% use the service of a sharing company. On average, the LEV users indicate they drive about 20.46 km each day. The most important motives to use a LEV are environmental friendliness and the driving pleasure and comfort. Most of the time, the LEV is parked at home at a private parking or at home along a public road. In terms of charging behaviour, the main reason for the respondents to charge is when the battery falls below a certain level, unexpected trips and 50% seem to make sure that the battery is always fully charged. No respondents indicate that they use the service of a CPO/eMSP to charge the LEV; therefore, satisfaction is not reported. In terms of future charging solutions, Zellik LEV users choose fast charging station (44%), battery swapping (19%), smart charging station (17%), and regular user-friendly charging station (15%). Only 14 (29%) respondents indicated they use app-based services, the remainder of the respondents have no intention to use an app in the near future.

The questionnaire was also addressed to non-EV drivers. For Zellik 200 respondents participated. 41% indicated that it is slightly to very likely they will buy a vehicle as soon as possible, and the intention increases to 49% when the horizon goes up to 5 years. The most important reasons for buying an EV are the environmental friendliness and energy efficiency. 81% have access to a private car park or garage and the vehicle is parked there for 12.78 hours (SD=7.99) while the vehicle was on the road for 1.93 hour (SD=1.30).

Field data analytics

Given that there were no chargers yet installed in the demonstration area of Zellik, no data was provided to analyse.

5. COMPARATIVE ANALYSIS

The detailed results per demonstration area provide interesting insights. In this section we compare the results across the demonstration areas in terms of usage, quality of experience and acceptance.

Before diving into the comparison of the survey results across the demonstration areas, it is worth noting that the surveys were mainly filled out by male **respondents**, varying between 65% up to 89%. The respondents overall are highly educated: between 74% and 92% have a higher education degree. With respect to housing, different groups of demonstration areas can be distinguished. In Grenoble and Austria more than half of the respondents live in a detached house; in Bari, Luxembourg, Northern Italy and Zellik this varies between 30% and 45% and in Barcelona, Berlin, Greece and Turkey this varies between 10% and 15%.

5.1. Usage

In terms of **EV ownership**, on average 63% of the respondents own a private vehicle and 32% have a company car. This varies across the regions, with an outlier at the Zellik demonstration area of 60% company cars versus approximatively 20% at five other demonstration areas (Barcelona, Bari, Greece, Grenoble and Northern Italy). Moreover, having a company charging pass varies across the areas, between 50% of the respondents in Turkey and 5% of the respondents in Barcelona.

The reasons for choosing an EV are overall quite consistent: environmental friendliness is the common denominator, except for Luxembourg; next follow energy efficiency and low operating and maintenance costs. The comfort to drive and the driving pleasure also scores high at most demonstration areas. In two areas the innovative, hip-looking design and tax advantages are also mentioned as important reasons to buy an EV.

The vehicle kilometres travelled for a day vary between 30 in Berlin up to 148 in Turkey, with an average of 81 across the demonstration areas. Between 73% and 88% of the respondents have access to a private garage or driveway at home, and the vehicle is parked there approximately 12 hours, with variation between 8 and 14 hours.

Interestingly, when asked about the charging habits, it is not so much the daily routine or end-of-the-day option that is scored highest, but rather the anticipation on the next trip, the state-of-charge below a certain level and when there is a possibility to charge that stand out as reasons to start a charging session. There is little variation in these reasons across the different demonstration areas.

The usage of apps by EV users varies between 30% in Greece up to 80% in Northern Italy.

In terms of analysed **charging sessions** for 9 demonstration areas, the data showed many outliers. In general – and corrected for the outliers by using the median- the length of the sessions varies between 45 minutes up to almost 3 hours at slow chargers for 7 to 17kWh, and between 30 minutes and an hour for 10 up to 25kWh at fast chargers.

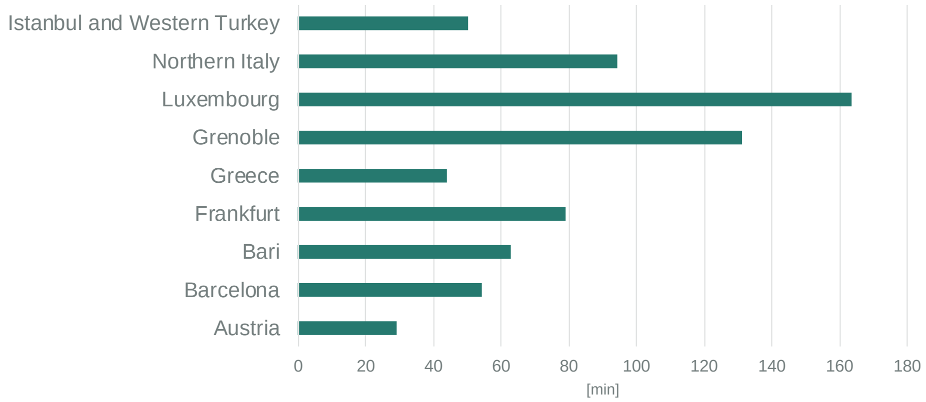

Figure 12. Average session duration (median) in each of the echarge4drivers demonstration areas

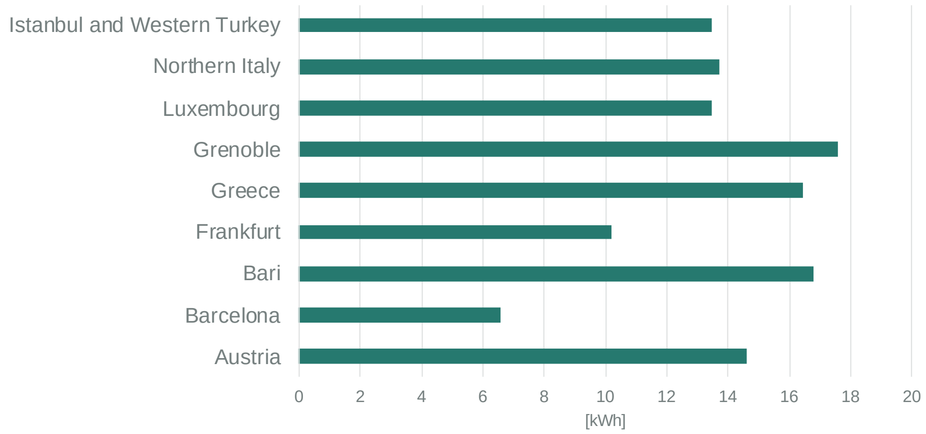

Figure 13. Average energy consumed per session in each of the echarge4drivers demonstration areas

Overall, weekdays have three different peaks, one at morning, one at noon and the last one in the evening; and weekends the frequency of the sessions is lower, and the morning peak disappears. In the pilots where there are slow CPs and fast CPs, slow CPs are mostly used during weekdays whereas fast CPs are the most used in the weekend.

User clustering revealed three segments: the regular user, the sporadic user and the users with very high behavioural diversity. Clustering of charging points revealed occupancy differences; in most demonstration areas, a small number of charging points has a clearly higher occupancy, and this varies between 9% and 32%.

When looking at **LEV users**, the main reasons for driving a LEV are: environmental friendliness, low operating and maintenance costs. For some demonstration areas also driving comfort is selected and in Grenoble the fact that it is the fastest transport mode. LEV users drive their vehicle daily between 15 (Bari, Greece) and 54 (Austria) kilometres, with an average of 26 km across the demonstration areas. The LEV is most often parked at home at a private parking or along the public road, and the respondents from Greece, Grenoble, Luxembourg and Northern Italy also indicated the employer's parking. A minority of LEV users charge at an eMSP charging point. The usage of apps varies for LEV users between 10% (Barcelona) and 67% (Berlin), with an average of 22% across all areas.

5.2. Quality of Experience

The quality of the charging experience was measured in the survey by using the Charging Infrastructure Satisfaction scale for eMSPs/CPO's (Vanhaverbeke et al, 2018; Nuyttens et al, 2020). EV drivers were first asked to indicate the eMSP/CPO they had their last charging experience with. Next, statements about the tangibility (look and feel), availability, reliability and privacy for that experience were presented with scores on a scale of 1 (strongly disagree) to 7 (strongly agree). In case a respondent had experienced issues when charging, also statements about responsiveness, contact and compensation were presented. Finally, all EV drivers rated perceived value, loyalty and overall satisfaction for their last charging experience.

The quality of experience for the selected eMSPs/CPOs are described in detail in Annexe 1.2. For this overall discussion, the average of all eMSPs/CPOs was calculated per demonstration area. In Figure 14 the scores for all dimensions and all demonstration areas are visualised. Note that there are three columns in grey for the demonstration areas with a limited number of respondents (Bari: 5; Berlin:12; Greece:6) where caution is due in terms of interpreting the results. When calculating overall averages, the scores of these three sites were omitted.

Overall, the satisfaction of EV drivers with the eMSP/CPO scores high: on average 5,5 out of 7 if we leave out the small samples in the grey columns. This is a score of 8/10 overall. There is quite some variation though, with scores ranging between 3,83 and 6,36. In Figure 14, the traffic light visualisation is based on the distribution of scores for a specific dimension (in the rows), going from highest (green) to lowest (red) score in the same row. When looking at the different demonstration areas, it is clear that the scores for the Turkish eMSPs/CPOs are highest for all dimensions. Also, the scores for Luxembourg's eMSPs/CPOs are overall high. The eMSPs/CPOs at the demonstration areas Austria and Zellik come in a second group with good to average scores, and next come Northern Italy, Barcelona and Berlin[3]. Overall, the scores are lowest for eMSPs/CPOs in Bari[4], Grenoble and Greece[5].

When comparing across the dimensions at individual sites (within each column), it is noteworthy that compensation scores lowest at all demonstration areas, with an average of 3.32 out of 7 (leaving out the small samples). Next comes contact, with an average of 4.02. Both dimensions are related to charging experiences where there was an issue. The other dimensions score on average approximately 5.3 out 7 (excluding the small sample sizes).

	Austria	Barcelona	Bari	Berlin	Greece	Grenoble	Luxembourg	Northern Italy	Turkey	Zellik
Tangability	5,31	4,86	4,75	5,15	4,67	4,65	5,61	5,10	6,02	5,52
System Availability	5,68	4,84	4,30	4,88	4,67	4,56	5,79	5,13	5,84	5,29
Reliability	5,71	4,96	4,08	4,93	4,44	4,45	5,70	5,12	6,21	5,39
Privacy	5,35	5,07	5,47	4,56	4,28	4,66	5,26	5,08	6,20	5,19
Responsiveness	*4,06*	*3,25*	*2,40*	*3,87*		*2,62*	*4,44*	*3,59*	*6,00*	*4,20*
Contact	*5,07*	*4,86*	*4,83*	*4,67*		*4,35*	*5,64*	*5,24*	*6,17*	*5,12*
Compensation	*3,07*	*2,69*	*2,00*	*3,89*		*2,46*	*3,27*	*2,93*	*5,17*	*3,67*
Perceived Value	5,40	5,29	4,50	4,00	4,54	4,65	5,53	5,27	6,01	5,49
Loyalty	5,40	5,10	3,62	4,40	3,62	4,59	5,64	5,13	6,17	5,12
Customer Satisfaction	**5,64**	**5,13**	**3,83**	**4,67**	**4,06**	**4,51**	**5,75**	**5,29**	**6,36**	**5,46**

Figure 14: Quality of Experience with eMSP/CPO of EV drivers

When asked about an ideal charging session, the characteristics are commonly shared across the demonstration areas: on top, there is a charging pass that works immediately, next comes short connection and waiting time. An integrated cable in the charging station and a cash payment option are scored much lower.

Also, **LEV drivers** were asked about their satisfaction with eMSP/CPO. Similarly, first the respondents indicated the eMSP/CPO they had the last charging experience with and next they rated the statements.

[3] Demonstration area with small sample size.
[4] Idem.
[5] Idem.

As was already discussed above in the detailed demonstration area discussion section, the LEV drivers answered that they do not often charge with an eMSP/CPO. Only for the Barcelona demonstration area the results can be considered representative with a sample size of 59 respondents. Sites with a sample size lower than 5 are not included in the overview; the results for Luxembourg and Northern Italy should also be interpreted with caution given the limited number of respondents (resp. 15 and 6).

As can be seen in Figure 15, in Barcelona the overall satisfaction is 5,2 out of 7, that is 7,5/10. Across the sites, Luxembourg performs best on most dimensions, next Barcelona and then Northern Italy. Across the dimensions, similarly as for the EV drivers, compensation, but also responsiveness scores lowest.

	Barcelona	Luxembourg	Northern Italy
Tangability	4,72	4,98	5,15
System Availability	4,88	5,23	4,88
Reliability	5,03	5,39	5,17
Privacy	4,94	5,40	4,67
Responsiveness	*3,19*	*5,00*	*3,90*
Contact	*4,96*	*6,33*	*5,17*
Compensation	*2,96*	*2,00*	*2,00*
Perceived Value	5,21	5,05	4,92
Loyalty	5,14	5,43	4,92
Customer Satisfaction	**5,23**	**5,36**	**4,94**

Figure 15: Quality of Experience with eMSP/CPO of LEV drivers

5.3. Acceptance

To inform the future development of charging solutions in the project, the (L)EV drivers were asked to first express their preference for one of the specific solutions that are planned for roll-out in their respective demonstration area, and next were asked to score statements that measure their intention to use the solution. The statements are based on the UTAUT model (Venkatesh et al, 2012). Here we report the intention to use, measured by different statements that the respondent needed to score from 1 to 7. The full details of the UTAUT model can be found in Annexe A1.1 in terms of method and in Annexe 1.2 in terms of results for all the demonstration areas.

For the **EV drivers** the preference for fast charging solutions (dark grey) appears clearly in the chart in Figure 16. For all demonstration areas, except for Bari, where this solution was listed, almost 50% or more of the respondents preferred this option above the other solutions. In Bari, smart charging scored best with 58% (versus 42% for fast charging). Smart charging was the only solution, next to the generic category of others, offered in Luxembourg and there 79% of the respondents made this choice. In Greece 30% and in Zellik 22% marked smart charging as preference. Berlin stands out with battery swapping (29%) and mobile charging (14%), whereas for the other few sites were this was an option for the proportions are much lower. Finally, user friendly charging solutions were chosen, varying from 4% in Grenoble up to 94% in Turkey where it was the only option next to the generic category of others.

Next to this preference for fast charging, also the willingness to pay for this solution stands out when compared to the other solutions.

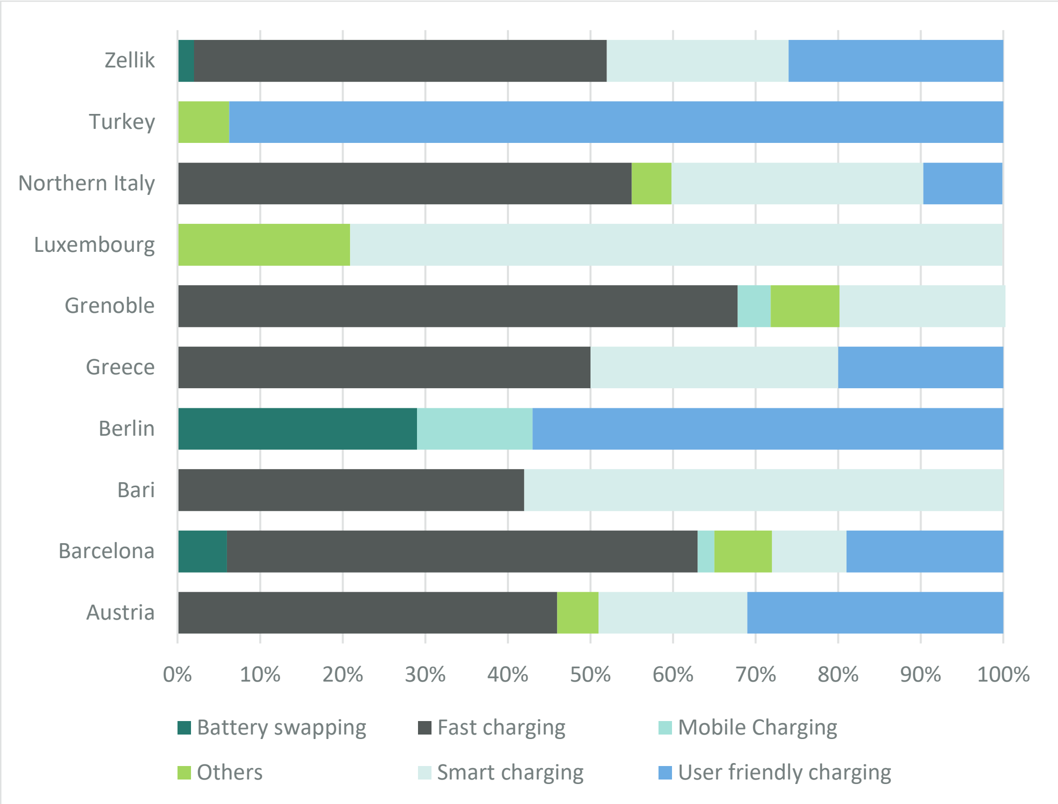

Figure 16: Preferences for future charging solutions of EV drivers

In Figure 17 the scores (out of 7) for the intentions to use the preferred charging solution are listed. For the sake of clarity, there is a small table for each of the solutions representing the demonstration areas where the respective solution was offered. Note that the intention scores have limited variation, both across the demonstration areas and the different solutions. The mobile charging solution score in the Grenoble demonstration area is remarkable, yet only 3 respondents choose this option. Generally, the intention to use the preferred solution is very high between 5,6 and 6,5 out of 7.

	Austria	Barcelona	Berlin	Greece	Grenoble	Luxembourg	Northern Italy	Zellik
Smart charging	6,1	5,9	5,6	6	5,7	5,5	6	6

	Austria	Barcelona	Greece	Grenoble	Northern Italy	Zellik
Fast charging	6,2	6,1	5,8	5,7	6,2	6,2

	Barcelona	Greece	Northern Italy	Turkey	Zellik
User friendly charging	6,1	6	5,7	6,1	5,6

	Barcelona	Berlin	Zellik
Battery swapping	5,8	5,7	5,7

	Barcelona	Berlin	Grenoble
Mobile Charging	5,2	6,5	3,1

Figure 17: Intention to use the future charging solution of EV drivers

Also, for LEV drivers the preference for the new charging solutions to be tested in the demonstration areas were surveyed and visualised in Figure 18. Similarly, as for the EV drivers, fast charging is preferred most often in the demonstration areas where it was offered as an option. In Berlin 56% of the respondents choose battery swapping, in Zellik this counts for 19%. Furthermore, in Berlin 22% prefer mobile charging, as do 14% in Turkey. Lastly, in Bari, Greece and Luxembourg the majority prefers smart charging.

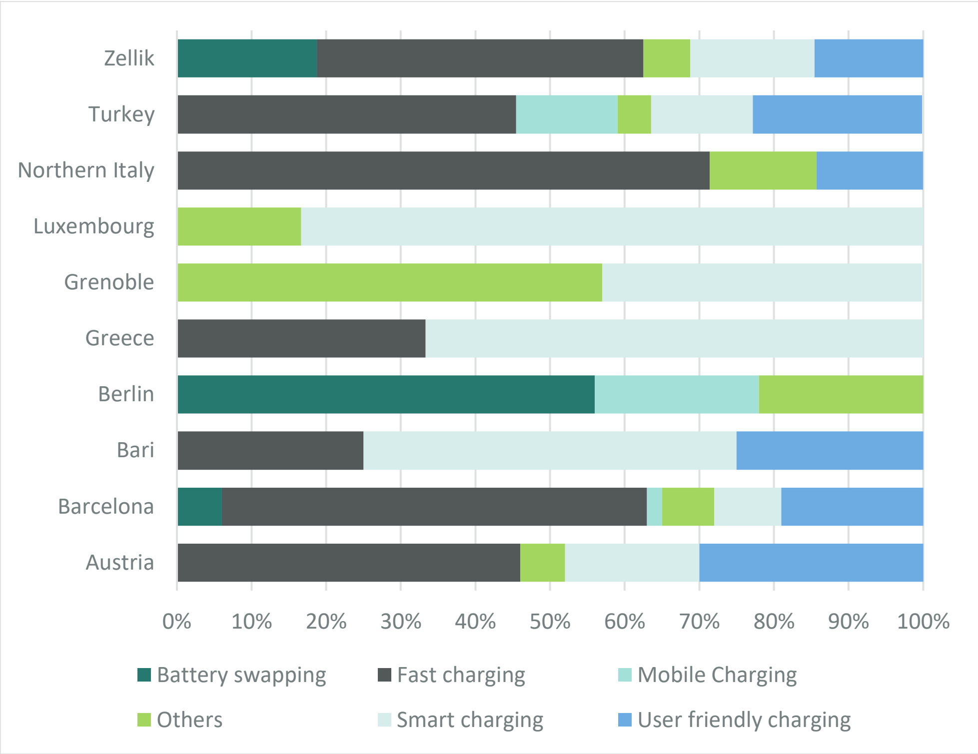

Figure 18: Preferences for future charging solutions of LEV drivers

In terms of intention to use the chosen solution, the numbers of respondents limit the analysis. Where we could calculate a score based on a representative sample, the result varies between 5,4 and 5,9 out of 7, with an outlier of 6,5 for mobile charging in Berlin.

Respondents who don't own an (L)EV were surveyed with respect to the intention to buy an EV. The results vary across the demonstration areas. Between 21% (Greece) up to 70% (Austria) of the respondents, with an average of 45% across the areas, indicated that it is slightly to very likely that they will buy an EV soon; this proportion increases when asked about the intention within 5 years. For Greece this even raises from 21% to 68%. The reasons for buying an EV are very consistent across the areas: environmental friendliness, energy efficiency and to a lesser extent, low operating and maintenance costs. In terms of future charging behaviour, it is interesting that overall, the majority (73% on average) of these respondents have a private garage or parking at home.

6. SOCIAL MEDIA ANALYSIS

This section outlines the main conclusions and results of the analysis performed for the three languages, it draws for each of the defined topics the conclusions based on the analysis of the most frequent terms and the emotions expressed in the tweets. The collected tweets were posted in the period between the 01/01/2016 and the 10/02/2020. The followed methodology is detailed in Annexe A1.3 and the specific results for each language and topic are available in Annexe A2.

Charging Infrastructure

The most repeated words in the three languages analysed are general words about charging infrastructure, for example Charging Point, Charging Station, Charging Infrastructure or Charging network.

In the English tweets there's an emphasis on rapid chargers and street parking, public chargers and petrol stations. In the case of the German tweets there's no emphasis on the power level of the CP but the terms charge at home (*haus laden)* and charge at work (*arbeit laden)* appear very frequently. In terms of charging location, in the case of the Spanish tweets appears the word shopping mall (*Centro commercial*).

When analysing the emotions expressed by the tweets belonging to this topic, we can see that English tweets are the most positive and the Spanish tweets the most negative; in terms of emotions the one that appears the most in the case of English and German is trust, and in the case of Spanish is sadness.

Environment

In English, the most frequent terms in the Environment topic are terms related to climate change and pollution, i.e., *Climate change*, *air quality*, *clean air*, *air pollution*, also words related to green energy, i.e., *renewable energy*, *solar panel* and then words in the field of fossil fuels such as *fossil fuels*, *petrol* and *diesel*.

In the German tweets, the most frequent words are related to batteries (*batterien*) and its materials, i.e., lithium and cobalt (*kobalt*) and also general terms like buy an EV (*Elektroauto kaufen*), charge an EV (*Elektroauto laden*) and drive an EV (*Elektroauto fahren*). Also, the terms to burn (*verbrennen*), petrol (*benzin*) and diesel (*diesel*) are among the most frequently mentioned terms.

In the Spanish tweets, general terms such as urban mobility (*movilidad urbana*), sustainable mobility (*movilidad sostenible*), electric mobility (*movilidad eléctrica*). There's also emphasis in the word change, as the bigrams change of model (*cambio modelo*), change of vehicle (*cambio vehiculo*), mobility change (*cambio movilidad*) and climate change (*cambio climático*) are among the most frequent ones. Furthermore, an emphasis in other ways of mobility as public transport (*transporte* público) and bicycles (*Bicicleta*) appear in a high number of tweets.

The English tweets are the most positive ones, and the Spanish the most negative, in the English and German case. Trust is the most common emotion, whereas in Spanish the most common emotion is disgust.

Government and policies

In English and Spanish there's a predominance in words related to the vehicles rather than on words related to the charging infrastructure, while in German no word related to the charging infrastructure appears as the most frequent one. Also in English, among the most frequent words it appears the word tax, and the word tax together with road (road tax) and car (car tax). In German, the most frequent bigram is to buy an EV (*elektroauto kaufen*). Also, other meaningful words in the German dataset are expensive EV (*teures Elektroauto*). In the German dataset don't appear the words law, tax, or government as the most frequent ones.

In the Spanish dataset among the most frequent words appear mobility law (*ley movilidad*), reduced mobility (*movilidad reducida*) and energy transition (*transición energética*) and *plan MOVES*[6] which are public grants and funding to boost electric mobility.

German and English have a similar level of positive tweets (65% and 63% respectively) whereas Spanish has a 42% of positive tweets. In the three languages there's a high level of trust, and in Spanish there's also a high level of sadness and disgust.

Production

Tesla is the only car manufacturer that appears in the three languages. In the English tweets it also appears Nissan. The most frequent terms in the English tweets are UK market, EV sale, EV market, Invest and Brexit.

In the German tweets it appears again to buy an electric car (elektroauto kaufen) as the most frequent bigram. Then, also German car industry (*deutsch autoindustri*) and km wide-ranging (*km reichweit*). In the Spanish tweets there's also concern on the km range, as range km (*rango km*) and how many km (*cuanto km*) appear as common terms. Moreover, in the Spanish tweets there's not only electric vehicle but also hybrid vehicle (*híbrido enchufable*) among the most frequent terms.

Overall, English tweets are positive (72%) whereas the German and Spanish ones show a 53% and 56% respectively. In the three languages trust and anticipation are the most common emotions.

Technology

In the English dataset Electric car is the most frequent term, but in this case there's also terms related to the charging infrastructure such as Charging Point. The topics that users highlight the most as a barrier to EV adoption are range anxiety, mile range, can't afford and afford electric vehicle.

In the German tweets, when they talk about technology, they emphasise the terms related to the batteries (*Batterie, Akku*) and fuel cell (*Brennstoffzell*) and as a matter of fact the bigram future of EV (*Elektroauto Zukunft*) is also one of the most frequent ones. In the Spanish tweets it appears electric vehicle (*vehículo eléctrico*), hybrid vehicle (*vehículo híbrido*), Charging Point (*Punto de recarga*), battery (*batería*) and fuel cell (*pila combustible*). Moreover, the term second hand (*segunda mano*) is frequently used.

From the three languages analysed English is the most positive. Joy and trust are the most frequent emotions in English, in Spanish the most frequent emotions are trust and anticipation, whereas in German are trust and sadness.

[6] https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii

7. CONCLUSION

This report presents the a priori users' concerns and charging expectations. Based on a large-scale survey with almost 3,000 valid responses across the 10 demonstration areas, the current users' charging habits, perceptions, concerns and expectations are measured; the users' mobility and parking habits are surveyed as well as factors influencing users' decision making regarding charging an EV. Furthermore, real user patterns are analysed next to social media posts about charging infrastructure.

The majority of the respondents were male and highly educated. On average 63% of the **EV drivers** have a private vehicle and 32% a company car. The reasons for choosing an EV are primarily environmental friendliness, energy efficiency and low operating and maintenance costs. The vehicle kilometres travelled for a day vary between 30 in Berlin up to 148 in Turkey, with an average of 81 across the demonstration areas. Between 73% and 88% of the respondents have access to a private garage or driveway at home, and the vehicle is parked there approximately 12 hours, with variation between 8 and 14 hours.

EV drivers plan their **charging** according to the anticipation on the next trip, the state-of-charge below a certain level and when there is a possibility to charge. There is little variation in these reasons across the different demonstration areas. The usage of apps by EV users varies between 30% in Greece up to 80% in Northern Italy.

In terms of analysed **charging sessions** for 9 demonstration areas, the data showed many outliers. In general – and corrected for the outliers by using the median, the length of the sessions varies between 45 minutes up to almost 3 hours at slow chargers for 7 to 17kWh, and between 30 minutes and an hour for 10 up to 25kWh at fast chargers. Overall weekdays have three different peaks, one at morning, one at noon and the last one in the evening; and weekends the frequency of the sessions is lower, and the morning peak disappears. In the pilots where there are slow CPs and fast CPs, slow CPs are mostly used during weekdays whereas fast CPs are the most used in the weekend.

User **clustering** revealed three segments: the regular user, the sporadic user and the users with very different behaviour. Clustering of charging points revealed occupancy differences: at most demonstration areas a small number of charging points has a clearly higher occupancy, and this varies between 9% and 32%.

Overall, the **satisfaction** of EV drivers with the eMSP/CPO scores high: on average 5,5 out of 7. This is a score of 8/10 overall. There is quite some variation though, with scores ranging between 3,83 and 6,36. It is noteworthy that two dimensions related to issues during a charging experience score lowest: compensation with an average of 3,32 out of 7 and contact, with an average of 4,02. When asked about an ideal charging session, the characteristics are commonly shared across the demonstration areas: on top, there is a charging pass that works immediately, next comes short connection and waiting time.

With respect to preference for future charging solutions, fast charging and smart charging stand out. EV drivers also indicate that they are willing to pay more for fast charging solutions. Berlin stands out in this analysis with also clear preference for mobile charging and battery swapping.

When looking at **LEV users**, the main reasons for driving a LEV are: environmental friendliness, low operating and maintenance costs. LEV users drive their vehicle on average 26 km. The LEV is most often parked at home at a private parking or along the public road, and the respondents from Greece, Grenoble, Luxembourg and Northern Italy also indicated the employer's parking. A minority of LEV users charge at an eMSP charging point. The usage of apps varies for LEV users between 10% (Barcelona) and 67% (Berlin), with an average of 22% across all areas. Similarly, as for the EV drivers, fast charging is preferred most often in the demonstration areas where it was offered as an option for future charging solution, with Berlin scoring high for battery swapping and mobile charging.

Respondents who don't own an (L)EV were surveyed with respect to the intention to buy an EV. The results vary across the demonstration areas. Between 21% (Greece) up to 70% (Austria) of the respondents, with an average of 45% across the areas, indicated that it is slightly to very likely that they will buy an EV soon; this proportion increases when asked about the intention within 5 years. For Greece this even raises from 21% to 68%. The reasons for buying an EV are very consistent across the areas: environmental friendliness, energy efficiency and to a lesser extent, low operating and maintenance costs. In terms of future charging behaviour, it is interesting that overall, the majority (73% on average) of these respondents have a private garage or parking at home.

Mentions about e-mobility and charging on **social media** are also an interesting source for data analysis. The most frequent terms and emotions with respect to e-mobility and charging on Twitter are analysed in three different languages (English, Spanish, German). English statements have overall positive connotations and Spanish statements have more negative connotations; German statements are also quite positive.

8. RECOMMENDATIONS

Based on the results of the above-described studies, following recommendations can be distilled:

- From the survey it shows that overall satisfaction with CPOs/eMSPs is 8/10, yet user satisfaction with charging solutions can be improved, especially in case of issues. Easy ways for contact, responsiveness and appropriate compensation would help the (L)EV driver.

- Among the different charging solutions to be developed in the project, the users look most forward to fast charging solutions. There is also an increased willingness to pay compared to other charging solutions.

- From the field data analytics, it is clear that on many occasions the connection time exceeds the charging time. It is recommended to develop appropriate strategies for optimally measure charging sessions that allow for accurate data usage.

- Most respondents to the survey were male, as were the EV drivers; this is in line with current findings in literature. It is recommended to actively work on strategies to involve women in the e-mobility evolution.

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ANNEXE A.1.
DETAILED METHODOLOGY

This section provides a detailed description of the methods for the survey, the field analytics and social media analysis.

A1.1 Methodology for the survey data analysis

The survey structure was based on the KPIs identified in D1.1 for the impact areas “Usage”, “Quality of Experience”, “Acceptance” and “Environment and Society” as described in Table 4.

Table 4: KPIs per impact area that have been implemented in the survey

Usage	Quality of Experience
Frequency of use of charging options (2)	Satisfaction rate with the charging option
Travel type	Concern rate
Reasons for charging	Satisfaction rate with the app-based services
Users’ willingness to say their current state of charge of the vehicle	Satisfaction rate with the customer service
Users’ willingness to say their desired state of charge of the battery at the departure time	Unavailability of charging options due to non-Evs parking
	Unavailability of charging options due to other Evs parking
	Physical accessibility
	Data privacy perception rate
	Users’ perception of the readiness of the authentication system
	Users’ perception of the readiness of the charging system

Acceptance of eC4D products&services	Acceptance of Electromobility
Performance Expectancy (I)	Loyalty toward CPOs and eMSPs
Effort Expectancy (I)	
Social Influence (I)	
Facilitating conditions (I)	
Hedonic Motivation (I)	
Price Value (I)	
Experience – Habit (I)	

Environment & Society
Users' access to sustainable energy resources
Non-(L)EV drivers willing to shift from conventionally fuelled vehicles to (L)EV in the future

Due to the high number of referenced KPIs in D1.1 and the survey's length, some KPIs have been addressed differently in the survey than originally planned. The KPIs concerning electromobility, for example, were not explicitly surveyed using the UTAUT model as suggested in D1.1, but more generic questions were asked to the respondent such as their motives for buying EVs or the intention for non-EV users to purchase an EV in the near future.

Next to the KPIs, the survey was designed with three types of users in mind, namely EV users, LEV users and non-EV users. Additionally, similar surveys were designed for logistic service providers and taxi drivers for the different demonstration areas. However, the response rate remained very low for these target groups (< 30 for both groups), which hindered the analysis of these particular users.

Data collection and data cleaning

The development of the survey was an iterative process involving the demonstration areas for feedback and conducting the survey. The final survey was translated to the local language(s) of every demonstration area to accommodate the respondents. The survey was launched on the 23rd of November 2020 and stayed online and available for respondents until the 8th of March 2021. The distribution of the survey was coordinated per region by the demonstration areas and supported by ERTICO and POLIS through their channels. The efforts provided by the demonstration areas regarding the data collection is described in their respective analysis. All survey links were grouped on a dedicated page in the project website for easy communication (https://echarge4drivers.eu/questionnaires/).

The data from the surveys was imported from Qualtrics into R as csv-files. The same data cleaning rules were applied to all surveys. Values coded as '-99' were set as missing values. The first 5 'preview' respondents were removed, in addition to respondents not agreeing on the first GDPR questions. Respondents giving contradictory answers on Q2.1 and Q2.2 were removed (Q2.1:'Do you use any type of electric vehicle?, answer: 'Yes' and Q2.2: 'Which type of electric vehicle do you use?, answer: 'I don't use an EV'). Also, for the all demonstration areas, only respondents answering the right country on the question 'In which country do you live?' were kept in the data set. Respondents who did not finishing the questionnaire were kept in the data set. For questions which could be manually filled in, some cleaning had to be done on non-numeric answers. The number of kilometres some of the respondents had driven in 24h is very unlikely or impossible: all values > 3000 km were removed for electric cars and > 1000 km for LEV. Some of the questions were set as missing because of inconsistent answers.

In total 4.703 respondents participated to the survey, from which a total of 2.966 respondents were eligible after data cleaning as depicted in Table 5.

Table 5: Number of respondents per demonstration area

Demonstration area	Participation	Eligible after data cleaning
Austria	179	96
Barcelona	1.852	1.099
Bari	355	245
Berlin	83	53
Greece	301	210
Grenoble	279	134
Luxembourg	427	258
Northern Italy	440	308
Turkey	388	254
Zellik	399	309
Total	**4.703**	**2.966**

Data analysis

In this section the different parts of the survey analysis are detailed. The survey consisted of 4 parts for (L)EV users, namely questions concerning their socio-demographic profile, their mobility and parking behaviour, their charging behaviour and their acceptance of charging options and app-based services. The survey for non-EV users was shorter and consisted of 3 parts: their socio-demographic profile, their mobility and parking behaviour and their intention to purchase a (L)EV in the future. Before detailing the different parts, a brief explanation of the data visualisation is given.

Data visualisation

Most results presented in the survey analysis are visualised by means of horizontal box plots as depicted in Figure 19. The green box describes 50% of the respondents' answers, with the bar in the box denoting the median value of the respondents' answers, the left side of the box denoting the 25th percentile (25% of the answers are lower that this value) and the right side of the box denotes the 75th percentile (75% of the answers are lower than this value). The left whisker shows the respondent's answers between the minimum value (excluding outliers) and the 25th, percentile value whereas the right whisker shows the 75th percentile value and maximum value (excluding the outliers). The outliers, which are answers that differ significantly from the rest, are depicted as black dots and the mean value of the answers is the red dot. Note that some box plots do not have both whiskers in the case of the 25th percentile being equal to the minimum value or the 75th percentile being equal to the maximum value, or no left or right side of the box if the 25th or 75th percentile is equal to the median value. Note also that some box plots do not have outliers.

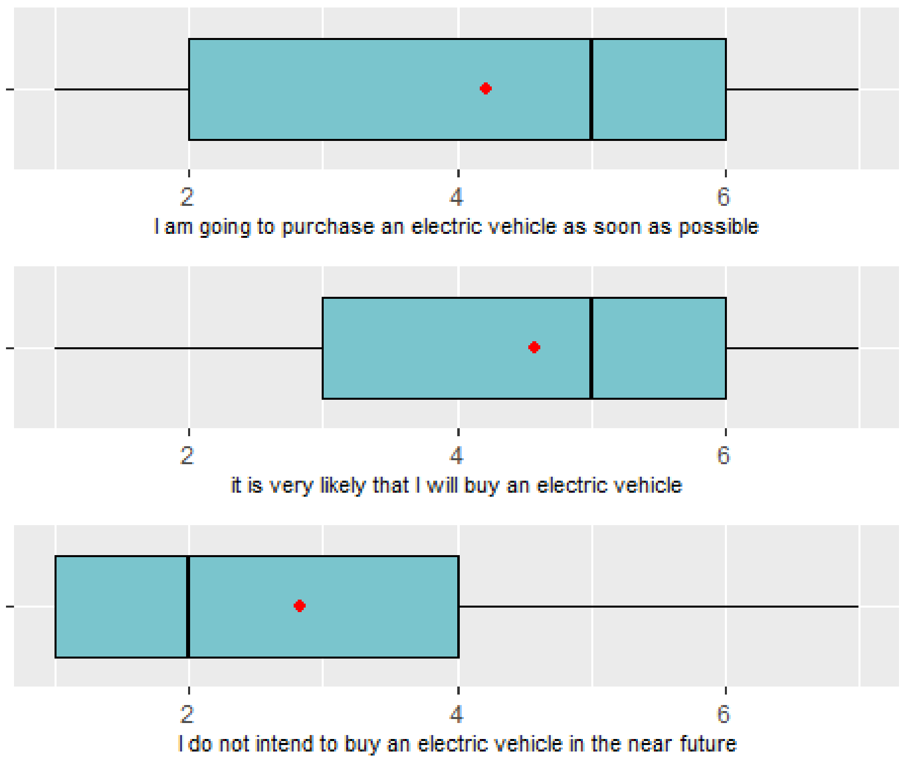


Figure 19 Example of a box plot (Non-users' Intention to buy an EV at the Barcelona demonstration area)

Socio-demographic profile

The socio-demographic profile part of the survey comprised questions such as gender, age, education, driver's licences, employment or function in the company. The type of EV owned is also asked, to redirect the respondent to the relevant survey questions. Furthermore, questions related to the (L)EV ownership duration and the user's knowledge about the (L)EV features (range and battery capacity) of his vehicle were asked.

Usage

The usage of the EV by the users is measured by four categories of questions:

- Their motive for using or having purchased an EV
- Their mobility behaviour which might be linked to charging needs

- Their parking behaviour which is closely related to the charging behaviour
- Their charging behaviour

The users' mobility behaviour was mainly measured based on the time spent on the road and the amount of kilometres they travelled during a specific day of the week before the respondents were surveyed. Their parking behaviour was described based on where they parked during that same day and how long they stayed parked at that specific spot. Finally, the respondents' charging behaviour was detailed by the reasons they decide to charge, how frequently they decide to charge at specific charging locations and at what time they charge their vehicles.

Quality of experience

The questions regarding the quality of experience of (L)EV users was based on the CIS-diagnostic model (Nuyttens et al., 2020). These series of questions were only asked for LEVs, ex. if the type was a moped or motorcycle. The respondents were asked to select the last charging point operator or electromobility service provider from whom they served their charging needs and to evaluate its services using the CIS-diagnostic. This model consists of three categories of constructs: Physical/online properties, problem-solving and satisfaction. The physical/online properties are described by 4 constructs, namely tangibility, system availability, reliability and privacy. The problem-solving category consists of 3 constructs that are only asked if the respondent experienced problems in the past. Finally, the satisfaction dimension consists of the constructs perceived value, customer satisfaction and loyalty. Below list describes the constructs and their meaning:

- **Physical/Online properties**

  - **Tangibility**: The attractiveness of the charging infrastructure based on its appearance
  - **System availability**: The technical functioning of the charging infrastructure
  - **Reliability**: The conformity between the service provided and service that was promised
  - **Privacy**: The user's assessment on the protection provided by the CPO or eMSP concerning his/her data

- **Problem solving**

  - **Responsiveness**: The efficiency with which the problems are solved by the CPO or e-MSP
  - **Compensation**: The extent to which the user is satisfied by the proposed compensation
  - **Contact**: The degree of difficulty to contact the CPO or e-MSP

- **Satisfaction**

  - **Perceived value**: The evaluation of how valuable the service is for the user
  - **Customer satisfaction**: The overall user's satisfaction regarding the service
  - **Loyalty**: The user's dedication to the CPO or e-MSP

A construct consists of a series of 3 to 5 items (questions) that together measure the opinion of the respondent concerning this construct. The items were measured using a 7-point Likert scale going from "strongly disagree" to "strongly agree". The results are described by means of a box plot per construct and CPO/e-MSP.

Acceptance

The Unified Theory of Acceptance and Use of Technology (UTAUT) is used in the survey to assess the acceptance of the respondent to use different charging options in the future (Venkatesh et al., 2012). UTAUT aims at determining the behavioural intention to use a technology, in other words a person's intention to use a technology in the future. The behavioural intention is measured in relation to other constructs. The survey questioned the four key constructs, which are: performance expectancy, effort expectancy, social influence and facilitating conditions. Furthermore, the constructs hedonic motivation and price value were also measured during the survey. These constructs are defined below (Venkatesh et al., 2012):

- **Performance Expectancy**: “The degree to which a technology will provide benefits to consumers in performing certain activities”
- **Effort Expectancy**: “The degree of ease associated with consumers’ use of technology”
- **Social Influence**: “The which extent consumers perceive important the fact that others believe they should use a particular technology”
- **Facilitating conditions**: “Which refers to consumers’ perception towards the resources and support available to perform the behaviour”
- **Hedonic Motivation**: “The fun or pleasure derived from using a technology”
- **Price Value**: “The consumers’ cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them”

The respondents were requested to answer the UTAUT model for a self-selected charging option based on the technology he or her would like to use in the future. The items for the UTAUT constructs were measured using a 7-point Likert scale going from “strongly disagree” to “strongly agree”. The results are described by means of a box plot per construct and charging option.

The respondents’ preference, frequency of use, and satisfaction regarding app-based services was also questioned.

Environment & Society

The results for this impact area are mostly described in the non-EV user section of the detailed results by means of polling their intention to adopt the technology in the future. This intention was measured by three items using a 7-point Likert scale going from “Extremely unlikely” to “Extremely likely”. The results are described by means of a box plot per item. Additionally, the type of vehicle they are most interested to adopt is reported in a bar plot.

A1.2 Methodology for the field data analysis

This section provides the description of the methodology followed to perform the quantitative analysis using real usage data from the CPOs and eMSPs in the consortium. The quantitative analysis provides conclusions on timing and duration of charging sessions per location and type of charging infrastructure or other charging solution by taking into account the characteristics of the users and the charging locations.

Descriptive statistics

The descriptive statistics analysis is used to describe the basic features of the electromobility data of each of the pilots of eCharge4Drivers aiming to summarise the quantitative descriptions in a simple form. The descriptive analysis has been performed in terms of:

- **Charging points’ location and charging sessions’ geographical distribution**: This section presents the geographical location of the CPs to be analysed, and a heatmap of the charging sessions, highlighting the areas where the highest number of sessions occurred.

- **Usage distribution by city**: In this section, the number of charging stations and their total number of charging sessions realised for each city is analysed, in order to calculate the ratio between the total number of sessions and the total number of charging stations in the corresponding city. Such an indicator is useful for charging network planning purposes since higher ratio represents higher need for expanding the existing charging network.

- **Charging power analysis**: It reflects the average number of usages for each rated power level for unique CPs and it is defined as the ratio between the number of existing rated powers coming from unique CPs and the usage frequency for those rated power levels.

- **On-street vs off-street charging points' analysis**: Presents the number of daily sessions in the on-street and off-street CPs considering the number of charging sessions per type of charging point (slow, semi-fast and fast) and per type of location (on-street and off-street).

- **Sessions' temporal distribution**: Analyses the total number of sessions occurred in each day of the week, taking into account the starting time of the session.

- **Sessions' duration**: This section evaluates the duration of the charging sessions. The boxplot is used to graphically depict groups of numerical data through their quartiles. The outliers are plotted as individual points. This boxplot is a standardised way of displaying the distribution of data based on a six-number summary (minimum, first quartile, median, mean, third quartile, maximum).

- **Energy consumed per session**: It reveals the energy in kWh consumed per session, again here the results are presented in a boxplot to graphically depict the main statistical values of the energy consumed.

User clustering

To better understand the EV user behaviour, a classification of these users into distinguishable groups depending on their charging patterns has been implemented for each demonstration area, wherever sufficient data exists for performing such analysis. For this, several clustering algorithms are applied to the data sets with the result of several user groups that share some characteristics. Note that the methodology explained in this section is abstract and that for each pilot different user group characteristics have been extracted.

Based on the sessions registered by unique users, the following behavioural attributes are created to be utilised for the user clustering processes.

Table 6. Created behavioural attributes for user clustering

Short name	Attribute
n	Number of sessions
n_cps	Number of different CPs visited by the user
av_ekWh	Average energy consumption per session in kWh
av_min	Average duration in minutes
av_power	Actual power consumed per session (60*av_ekWh/av_min)
av_dist	Average distance (calculated between CP locations) in meters
sd_ekWh	Standard deviation of average energy consumption per session
sd_min	Standard deviation of duration
sd_dist	Standard deviation of distance
diff_days	Last day – First day: Usage period

From the predetermined attributes above, a correlation analysis is performed to exclude in each case the highly correlated variables. For example, in some pilots av_min and sd_min are highly correlated and therefore sd_min has been excluded.

Then, all elements in the data are scaled by mean and standard deviation of the entire vector by subtracting the mean and dividing by standard deviation. This step is required since the units for variables are different from each other (e.g., min, kWh, etc.).

Afterwards, "*Model-based*"(Fraley & Raftery, 2002), "*kmeans*"(Likas, Vlassis, & J. Verbeek, 2003), "*pam*"(Park & Jun, 2009) and "*clara*"(Schubert & Rousseeuw, 2019) clustering techniques are chosen for comparison in order to see the proper technique and the optimal number of clusters. The process is fully automated by using "clValid"(Brock, Pihur, Datta, & Datta, 2008) functions in R. The metrics considered for the comparative analysis of the clustering algorithms are:

- Connectivity: it measures the degree of the connectedness of the clusters. [0, +inf] and needs to be minimized.
- Dunn: it measures the ratio between the smallest distance between observations not in the same cluster to the largest intra-cluster distance. [0, +inf] and needs to be maximised.
- Silhouette: it measures the degree of confidence in a particular clustering assignment. [-1,1] and needs to be maximised.

An example of comparison between the different clustering techniques is shown in Figure 20. Note that each demonstration area leads to different results in this comparison and the clustering results will be shown for the particular case of each demonstration area.

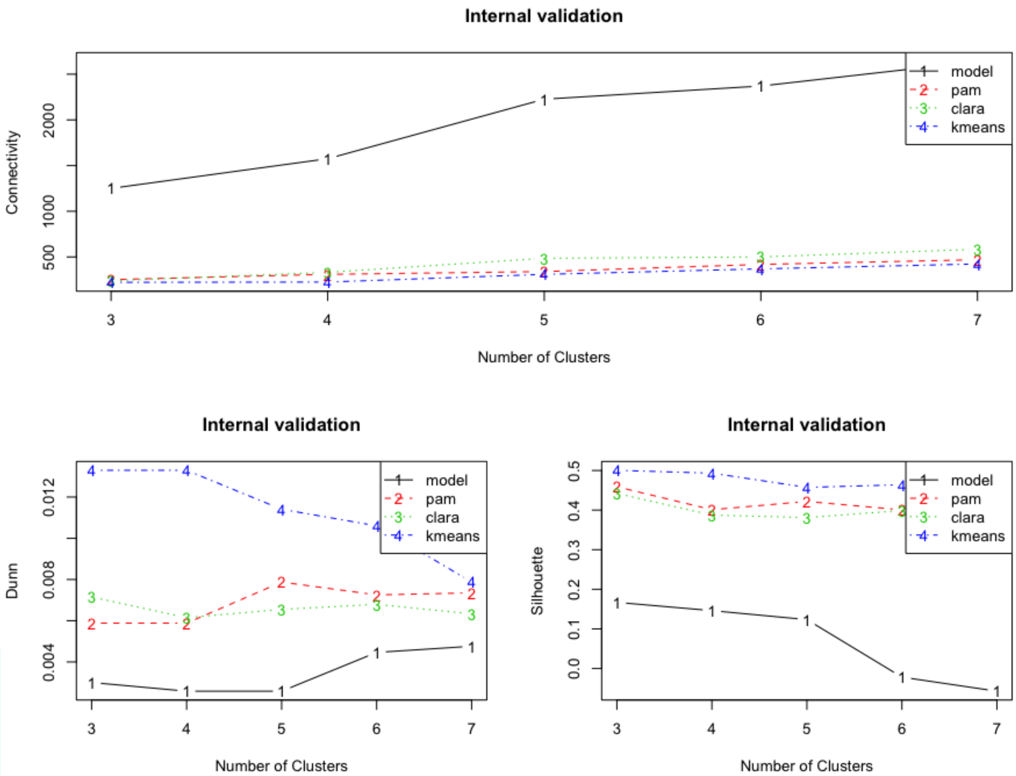


Figure 20. Comparison of different clustering algorithms

To evaluate the clusters in a visual way, and since there are more than two dimensions (variables) in the user clustering dataset, PCA (Principal Component Analysis) is performed and the data points according to the first two PC (principal components) are plotted to explain the majority of the variance.

Figure 21 presents an example of the representation of the variables in two dimensions, where the three clusters are represented.

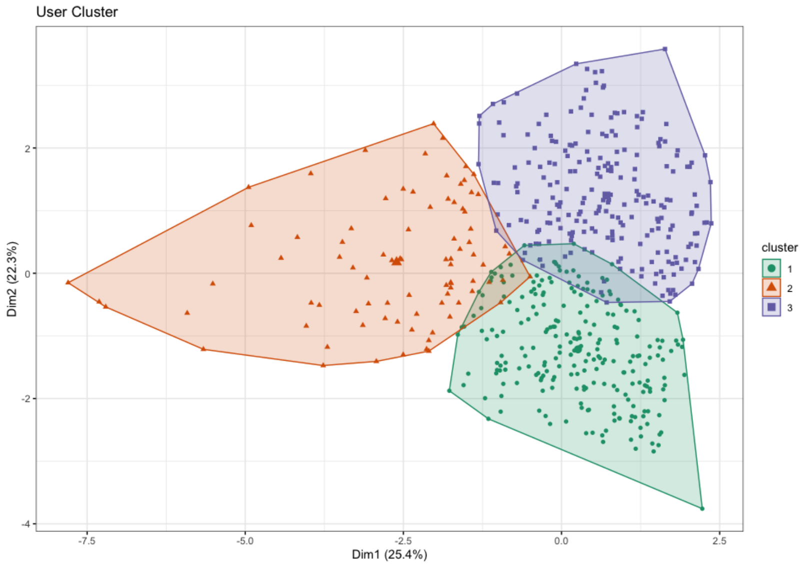


Figure 21. Example of clustering vizualization

The extracted user clusters are analysed by representing the variables in bar plots, where the average value for each parameter is displayed. The clusters defined can be exploited in the future for performing user related analysis and proposing targeted recommendations to be applied for a specific group of users instead of all.

Temporal clustering

Initially, the hourly occupancy is calculated for each CP and for each day using the minute unit. Then the daily average is calculated for each hour bins occupancy belonging to the same unique CP; each hour bins represent 60 mins (e.g., hour bin 17 → from 17:00 to 18:00).

Table 7. Example of calculation of hourly occupancy for a specific CP

Session Start = 01/01/2019 17:54	Session End = 01/01/2019 22:03	Occupancy (mins)	Hour bin
01/01/2019 17:54:00	01/01/2019 18:00:00	6 mins	17
01/01/2019 18:00:00	01/01/2019 19:00:00	60 mins	18
01/01/2019 19:00:00	01/01/2019 20:00:00	60 mins	19
01/01/2019 20:00:00	01/01/2019 21:00:00	60 mins	20
01/01/2019 21:00:00	01/01/2019 22:00:00	60 mins	21
01/01/2019 22:00:00	01/01/2019 22:03:00	3 mins	22

Then for all dates available for each unique CP, the same format of data tables is created and the average occupancy for hour bins is calculated. All hour bins and dates with no session are indicated by 0 instead of NA in order to ensure they are considered into the average calculation. In a nested data table, all average ones are stored for each unique CP.

Then, once the average hourly occupancy is calculated for each CP, the same clustering approach is applied also for the whole charging network in order to group them based on their hourly occupancy distributions.

User mobility flows

The charging sessions from unique users are analysed in order to identify Origin and Destination (OD) patterns and investigate if the users use the vehicles for long-distance trips such as from a city to another. For that, all charging sessions registered by unique users are grouped and the consecutive sessions registered in different cities are filtered considering the ordered data frame by time attribute as follows:

İstanbul
İstanbul
Yalova
Bursa
Bursa
Bursa
Balıkesir
Kocaeli

İstanbul-Yalova
Yalova-Bursa
Bursa-Balıkesir
Balıkesir-Kocaeli

Figure 22. Example of Origin and Destination trips creation

With this approach, we create OD cities pairs and detect the corridors in the demonstration area. The user mobility flows are exploited to identify the density of the electric vehicles (EVs) on the corridors. Then, for representation purposes, we plot the most significant (i.e. dense) ones to provide the most popular OD city pairs.

COVID-19 effect

For those project demonstration areas that provided a sufficient amount of historical data, the effect of mobility restrictions due to the COVID-19 on charging sessions have been measured. More specifically, the following indicators have been analysed:

- Average daily number of users
- Average sessions per day
- Average duration
- Average occupancy percentage of CPs
- Average daily energy consumed by user

Then, in order to compare the four periods defined (Pre-COVID-19, Lockdown, De-escalation and New normality) the percentage of variation compared to the pre-covid period has been calculated and plotted in a bar plot.

A1.3 Methodology for the social media analysis

The methodology followed for the social media analysis is divided in 6 phases:

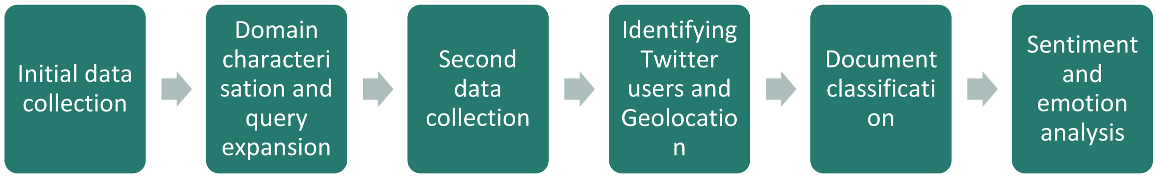


Figure 23. Social media analysis methodology

Phase 1 – Initial data collection

The Twitter v2 API was used to collect all tweets between the 01/01/2016 and the 10/02/2020 that match a set of constructed search queries.

Each query consisted of two groups of query terms connected through the AND operator. Each of these groups are described below.

- Names for electric vehicle (“electric car”, “electric vehicle”, “electric scooter” etc…)
- Words and phrases on related topics.

Query sets were constructed and three datasets compiled for English, Spanish and German.

Each constructed dataset within the project was pre-processed to clean and normalise the text for easier analysis. The three steps of document pre-processing are listed as follows:

- Stop-word removal – common low information baring words from each language were removed.
- Lowercasing – words were lowercased in order to normalise them to a common form.
- Lemmatisation – Language specific lemmatisation was performed to normalise words to a common lemma. This reduced the vocabulary size reducing words to a common base form, given the context in which they appear.

Phase Two – Domain Characterisation and Query Expansion

The next phase of work sought to establish two things. First, the key topics of discussion that exist within the data. Second, the predominant keywords and phrases that characterise those topics.

This phase produced keywords and phrases for 4 identified key topics of discussion. These topics were named as followed.

- **Environment** – environmental impact and concerns regarding electric and traditional vehicles.
- **Infrastructure** – governmental and organisational initiatives to improve electric vehicle uptake and charging networks.
- **Industry** – the technological, sales and marketing of electric vehicles.
- **General concerns** – topics that affect why someone might not want to buy an electric vehicle. For example, range anxiety.

The discovery of these topics and associated keywords was achieved through repeated iterations of a two-step process. First, topic modelling and second, phrase/keyword extraction. At each iteration, the outputs were used to gain insight on the topical content of the corpus and manually curate a collection of keywords and phrases for each of the identified topics. A summary of these methods is described below.

- **The Surprising Phrase Detection (SPD):** An algorithm for discovering the keywords and phrases that characterise a target corpus. The SPD accomplishes this through a two-step process. First, it discovers surprising words in the corpus. Second, it attempts to expand those features into phrases based on how often it co-occurs with other words in the target corpus. A word is considered a

significant feature if it appears with surprising frequency within the target corpus, when compared with a second “background” corpus (Robertson, 2019).
- **Topic Modelling:** A standard method of latent topic identification originally developed by (Ng, Blei, & Jordan, 2003). Keywords were identified by picking words with a high probability in the relevant topics of interest.

Phase Three – Second data collection

The aim of this phase was to expand on the original corpus to by discovering Tweets relevant to the topics identified in phase two. Four corpora were generated, one for each topic, using the same method described in Phase One, but substituting the original keywords with the keywords and phrases for each topic discovered in Phase Two.

Phase Four – Identifying Twitter users and Geolocation

Two significant issues were discovered over the course of this work. First, that corpora returned by the Twitter API consisted of a large quantity of Tweets from news corporations and companies. The purpose of this work was to understand public discourse and opinion, so a method for removal of these organisations was necessary. To focus on users, all Tweets posted by an account with a URL in their biographical information were filtered out as it is uncommon for a normal user to have an advertised web-presence, whereas it is extremely common for organisations.

Second, languages, such as English, are spoken in a number of countries, meaning that each corpus could consist of Tweets originating from numerous places across the globe. To geolocate Tweets to the United Kingdom, standard Named Entity Recognition was used to identify Tweets mentioning places within the UK (UK, London, Swindon etc…).

Phase Five – Document classification

Phase Five sought to use Machine Learning methods to build a probabilistic model of the final corpus and identify the core topics of discussion. The final corpus used to build each classifier was the combination of all four corpora generated in Phase 3. The final topics discovered are listed below:

- **Charging infrastructure** – local issues, companies and opinions regarding publicly available charging networks and access.
- **Environment** – discussion relating to emissions, power generation and climate change.
- **Government policy** – government initiatives relating to electric vehicles and charging.
- **Production** – Information regarding market, manufacture, companies and sales of electric vehicles.
- **Technology** – issues surrounding the technological development of electric vehicles, batteries, cost and range.

The type of classifier trained is known as an Active Learning based classifier (ALC), which will now be described. The size of each dataset constructed using the classifiers in Phase 5 can be found in the following Table.

Table 8. Size of the datasets constructed

	Charging Infrastructure	Government and policy	Environment	Market and production	Technology
English	774	832	975	868	923
German	831	411	517	2277	1197
Spanish	188	172	201	103	155

An active learning-based classifier (ALC) is a semi-supervised approach originally based on a Naïve Bayes classifier (Settles, 2011). To train an ALC, analysts first select a number of classes they wish to characterise within a corpus. In the case of this work, those classes are listed immediately above, plus an additional class to capture irrelevant information. Analysts are then shown documents, in this case Tweets, which they then label as originating from one of the desired classes. As training continues, a probabilistic model of the corpus vocabulary is built, which indicates what words are most probably related to each class. The resulting model is then used to classify unseen Tweets based on the words present and their likelihood of originating from each of the identified classes.

Phase six – Sentiment and emotion analysis

Sentiment analysis and emotion analysis are placed in order to uncover and quantify the emotions that are the way of people's response to Electric Vehicle domain. For each predefined topic that are defined in phase five, sentiment analysis (i.e., positive, negative reaction) and emotion analysis are applied. More specifically, the analysis performed for each topic and language are:

- N-gram modelling is used to create the matrices of one-word and two-word sequence to see the frequency of unique root words and the connection between the words, respectively.
- Sentiment analysis is performed to detect positive and negative sentiment on the clean corpus of tweets.
- For emotion analysis, "NRC" emotion lexicons, a list of words and their associations with eight basic emotions (anger, fear, anticipation, trust, surprise, sadness, joy and disgust) is chosen[7].

[7] https://saifmohammad.com/WebPages/NRC-Emotion-Lexicon.htm#:~:text=NRC%20Word%2DEmotion%20Association%20Lexicon,were%20manually%20done%20by%20crowdsourcing.

ANNEXE A.2.
DETAILED RESULTS

In this section the outcomes from the demonstration area survey will be described, as well as the outcomes from historical data, followed by a comparative analysis of the usage profiles. The results for each demonstration area are described in a separate section following the same structure.

For the outcomes of the survey, first, an overview is given of the socio-demographic variables of the respondents. The next subsections go into detail on the usage, the quality of experience, charging acceptance and questions relating to environment and society.

The historical data analysis provides an overview of the usage patterns of the electromobility charging infrastructure following the guidelines defined in the Usage impact area. The analysis has been conducted with real usage data from the CPOs and eMSPs in the consortium. The next subsections provide for each of the eCharge4Drivers demonstration areas: (i) descriptive analytics to describe the basic features of the electromobility data, (ii) a user clustering to classify the EV drivers into distinguishable groups depending on their charging patterns, (iii) a temporal clustering to group the charging network based on their hourly occupancy distribution, (iv) an analysis of user mobility flows in order to identify Origin and Destination (OD) patterns and investigate if the users use the vehicles for long-distance trips such as from one city to another (v) an evaluation of the effect that COVID-19 had on the electromobility, and finally (vi) an a priori assessment of the e-mobility charging infrastructure as defined in D1.1 that will serve as a basis for comparison in T6.3. As a consequence of the variety of the data providers and the electromobility context in each demonstration area some subsections of the analysis could not be performed in some cases.

Demonstration area 1: Austria

General description of the site

SMATRICS, a joint venture between VERBUND, OMV and Siemens, is a leading provider of electromobility services and is the first and only provider to operate a nationwide charging network in Austria covering the whole country (83,879 km^2).

EVs in circulation, charging and service infrastructure

As of 2021, it is estimated that the number of registered EVs in Austria is 66 383 electric cars. There are 48 702 BEV and 17 681 PHEV. In November 2020, 15.4% of the new registered passenger cars were EVs.

Sales are expected to increase over the next few years due to the increased offer of EV models and government policies, like being exempted from taxes etc., and subsidies, like subsidy per charge point and sustainable investments.

Data collection strategy for the survey

The link to the survey was published both over SMATRICS monthly Newsletter of January 2021 and the social media channels (Facebook, Twitter, LinkedIn). The newsletter generally is addressed not only to the SMATRICS customers base but to the general public. The media reach is approximately 20.000.

Survey Results

After data cleaning, the data set contains 96 respondents in total. Of the respondents, 86.46% (83) use any type of electric vehicle, whereas 13.54% (13) does not. Figure 24 shows the type of electric vehicles the respondents use, where the majority drives an electric car (92.77%).

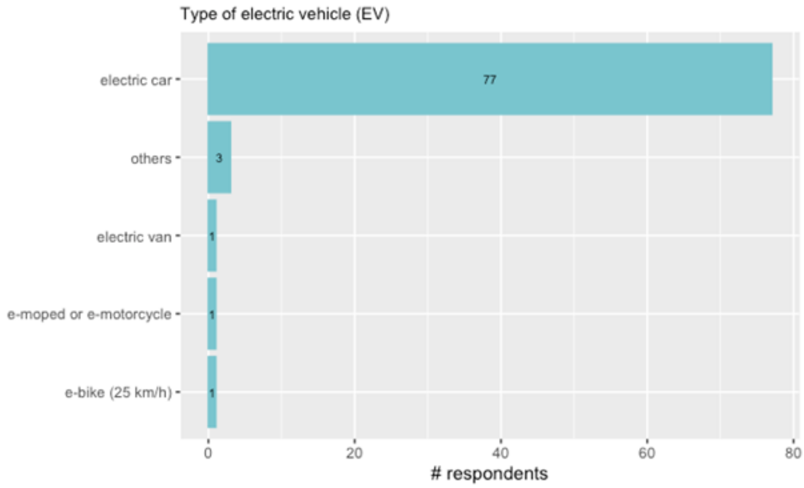


Figure 24 Type of EVs used out of 83 respondents at the Austria demonstration area

Out of the 77 respondents who use an electric car, 97.40% (75) indicated they drive a battery electric vehicle, whereas no respondents drive a plugin-hybrid electric vehicle. Only 1 of the respondents drives an electric vehicle with a range extender and no respondents drive a hybrid vehicle that combines a classical internal combustion engine with an electric motor.

In regard to the socio-demographic variables, the majority of the respondents were men 89.58%. Most respondents (45.83%) have obtained a university degree or a higher non-university degree (41.67%). The majority is full time employed (73.96%), whereas 13.45% is retired. Almost 78.12% of the respondents is married with or without children (48.96% resp. 29.17%). The different socio-demographics are detailed in Table 9. All respondents possess a driving licence. For most respondents, this concerns a driving licence B (93.75%), followed by driving licence A (54.17%). A small portion of the respondents possess a driving licence C (18.75%), and a driving licence G (9.38%).

Table 9 Socio-demographics of the respondents at the Austria demonstration area

Socio-demographics	Categories	Number of respondents (%)
Gender	Female	10 (10)
	Male	86 (90)
Degree	Primary education	1 (1)
	Secondary education	3 (3)
	Higher non-university education	40 (42)
	University education (Bachelor degree, Master degree, …)	44 (46)
	Post-university education (PhD, Post-doc,…)	8 (8)
Residential situation	I live alone	14 (15)
	I live with family	3 (3)
	I live with others: co-housing	2 (2)
	Married or in relationship with child(ren)	47 (49)
	Married or in relationship without children	28 (29)
	Other housing situation, namely :	1 (1)
	Single parent with child(ren)	1 (1)
Professional situation	Currently unemployed	2 (2)
	Employed full time	71 (74)
	Other profession, namely :	4 (4)
	Part-time employed	4 (4)
	Retired	13 (14)
	Student	1 (1)
	Temporary exemption (e.g. maternity leave, parental leave)	1 (1)
Function	Blue collar worker	2 (2)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	3 (4)
	Middle management	16 (20)
	Official / employed in a public service	7 (9)
	Own company, entrepreneur with employees	6 (8)
	Self-employed, entrepreneur without employees	5 (6)
	Senior management / management	4 (5)
	Teaching staff / employed in education	7 (9)
	White collar employee (administrative, executive or support/clerical function)	30 (38)

EV users

Out of 78 electric cars (77) and van users (1), 47 respondents own the vehicle, whereas 29 drive a company owned car, and 2 a car owned by a car sharing company. Furthermore, only 1 respondent indicated that they use their vehicle as a taxi-cab. The majority of the respondents (21.8%) indicated they enjoy a company charging pass, whereas 7.7% enjoys a company fuel pass, 65.4% does not enjoy any company benefits. Furthermore, 5.1% receives a kilometre compensation and 3.8% indicated they enjoy some other type of mobility benefit.

In terms of the battery electric vehicles, the most popular cars are the Nissan LEAF (11 respondents), followed by a Hyundai IONIQ (9) and a Renault ZOE (9 respondents). The BMW i3 (5 respondents) and the Hyundai Kona EV (5 respondents) close the top 5.

Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity between 31 and 40 kWh, where the next most popular choice is between 20 and 30 kWh. In terms of battery range, the BEV users, mostly indicate this lies between 200 and 249 km. Lastly, the majority of all EV users (24%) is driving their current vehicle for 3 years. More detailed information can be found in Table 10.

Table 10 EV characteristics at the Austria demonstration area

Vehicle characteristics	Categories	N (%)
Battery Capacity – kWh (BEV) according to respondents	<20	8 (11)
	20–30	17 (23)
	31–40	19 (26)
	41–50	8 (11)
	51–60	4 (5)
	61-70	12 (16)
	>70	5 (7)
	I do not know.	1 (1)
Battery Range – km **(BEV) according to respondents**	< 100	3 (4)
	100–149	13 (18)
	150–199	11 (15)
	200–249	20 (27)
	250–299	11 (15)
	300-400	7 (9)
	>400	9 (12)
Respondent usage of the vehicle in years	< 1 year	12 (16)
	1 year	16 (21)
	2 years	14 (18)
	3 years	18 (24)
	4 years	0 (0)
	>4 years	16 (21)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 3 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

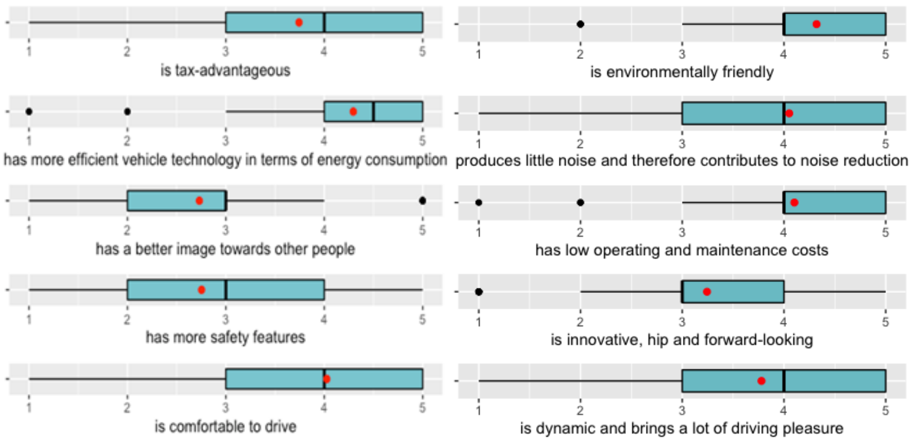


Figure 25 Reasons for EV usage or purchase at Austria demonstration area

From Figure 25, it is clear that the main reasons for using or purchasing an EV are the environmental friendliness, tax-advantageous, the driving comfort and the fact that EVs have more efficient technology in terms of energy consumption. More specifically, the environmental friendliness was the most important factor as 87% of the respondents considered this factor to be very important to extremely important. The least important factor is the safety features an EV could have compared to an ICE car, where 19% considered this factor to be not important at all.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 65.58 km, where the average time spent on the road was about 1.55 hours. The EV is mostly parked at a private parking at home for almost 14.76 hours a day on average. Figure 26 gives a more detailed overview of the parking time at different locations.

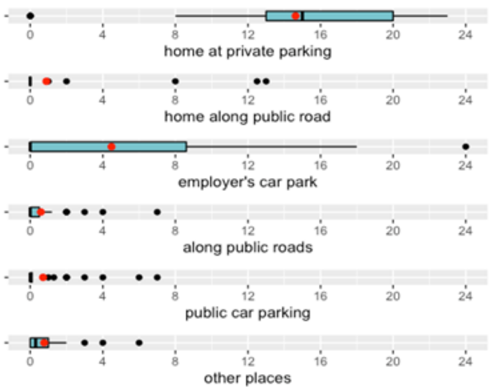


Figure 26 Respondents' EV parking time at different locations at the Austria demonstration area

When EV users park at home, the majority does so in their driveway or in a privately-owned garage (77.92%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 27).

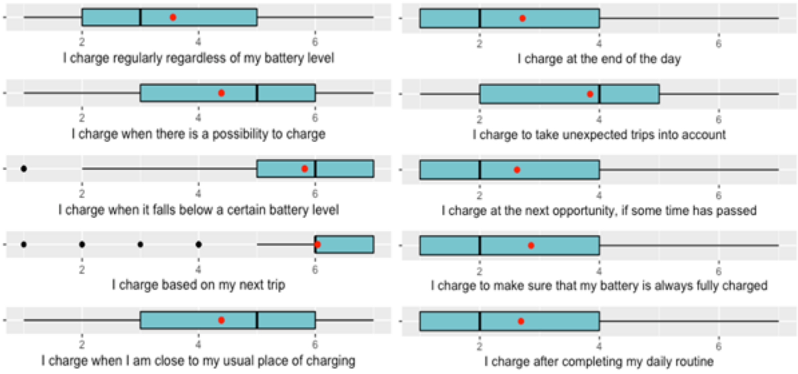


Figure 27 Respondents' charging behaviour at the Austria demonstration area

In regard to charging experience, 1.30% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 72.73% charges often at a different location, whereas 27.27% sometimes does. Respondents charge the EV most frequently at home, 10.39% of the respondents charges the EV at home daily and 42.86% does so several times a week. The main charging option at home is the charging station (56.06%), followed by a socket (43.94%). The least frequent charging place is at the workplace, where 55.84% of the respondents indicate that they never charge at work. Also, public fast chargers are more frequently used than non-fast chargers.

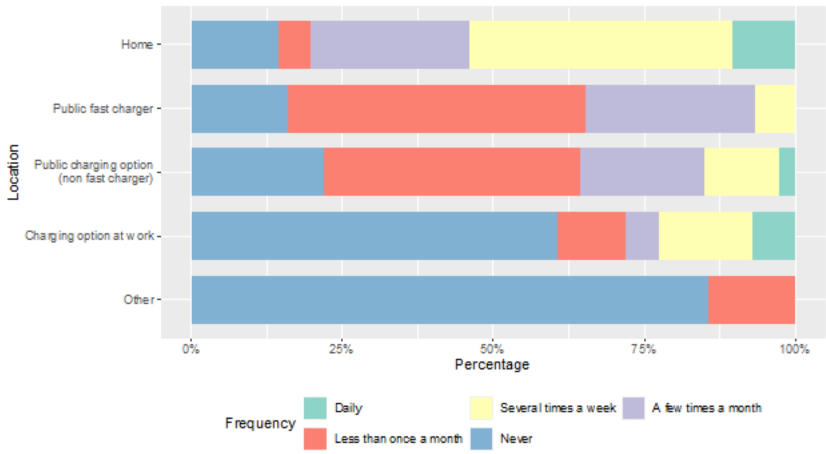


Figure 28 Respondents' charging behaviour per location at the Austria demonstration area

The most popular charging time is in the evening, after working hours, between 3p.m. and 9p.m., followed by 9p.m. and midnight. The least popular time is between 3a.m. and 9a.m.

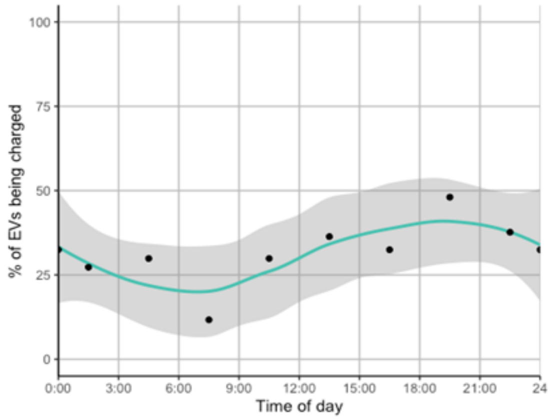


Figure 29 Respondents' charging schedule at the Austria demonstration area

In terms of the most ideal charging session, the respondents indicated that the most improvement needs to be made on the operability of the charging cards and the implementation of faster charging stations.

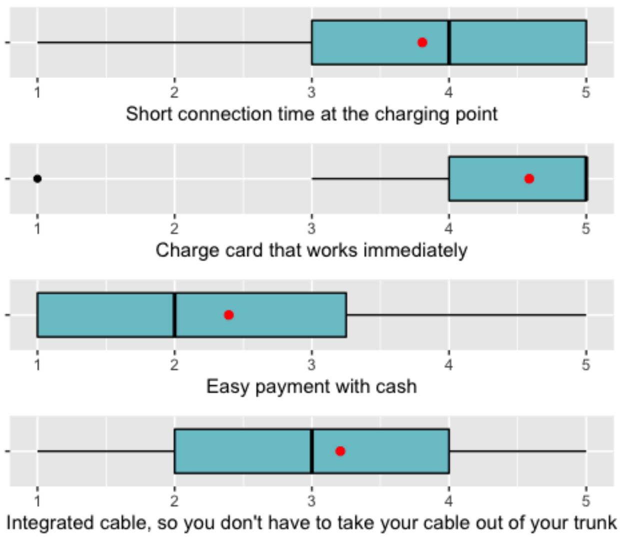


Figure 30 Most ideal charging sessions at the Austria demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that Smatrics is the most popular.

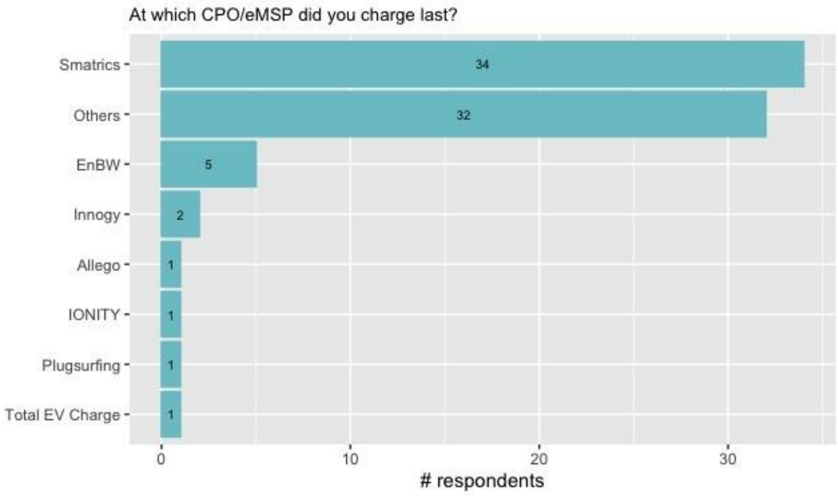


Figure 31 Last charging CPO/eMSP at the Austria demonstration area.

In what follows, we discuss the results and make comparisons for CPOs that were evaluated by at least 5 respondents.

The charging infrastructure of Smatrics scores highest overall in terms of tangibility (see Figure 32). Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for Smatrics are spread ranging from very poor to very good. Next in line is EnBW with an average of 5 on 7.

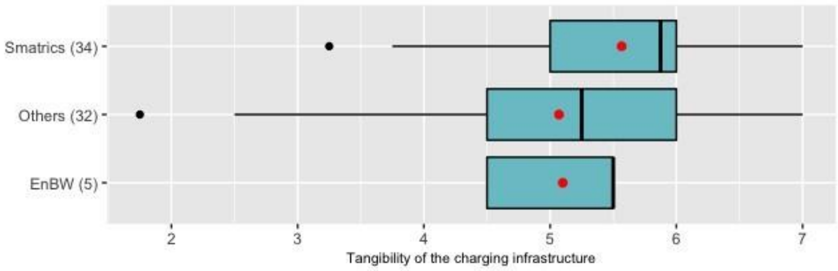


Figure 32 Tangibility of the charging infrastructure at the Austria demonstration area

For availability of the charging infrastructure, similar scores can be observed (see Figure 33 and Figure 34). The availability captures whether the charging infrastructure is available for use, the charging session can start immediately, does not block and is not inadvertently interrupted. EnBW, on average, is comparable to Smatrics. These CPOs/eMSPs score good on average (above 5.5 on 7). The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping. Smatrics has the highest score (6 on 7), and EnBW scores slightly lower.

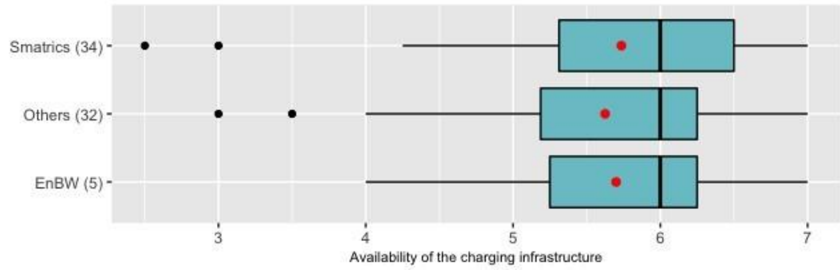


Figure 33 Availability of the charging infrastructure at the Austria demonstration area

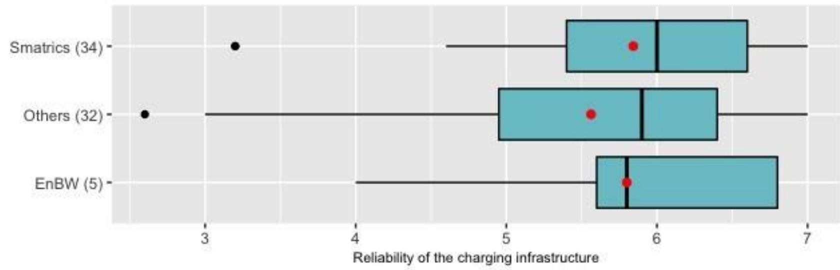


Figure 34 Reliability of the charging infrastructure at the Austria demonstration area

Looking at the privacy of the charging infrastructure, it is clear that the most reviewed CPOs receive on average similar scores, between 5 and 6 (see Figure 35). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other companies and payment credentials are protected.

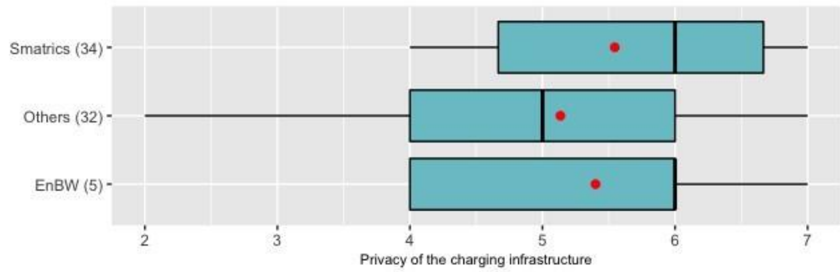


Figure 35 Privacy of charging infrastructure at the Austria demonstration area

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 11 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 11 indicated they have not. Most charging infrastructure problems are experienced when using Smatrics . Indeed, 20,6% (7 out of 34 respondents) indicated to have experienced problems with this CPO. Whereas for EnBW this is similar with 20% of the respondents experienced problems (1 out of 5 respondents).

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For Smatrics, it can be seen in Figure 36 that the scores for responsiveness varied a lot for the different respondents, ranging from bad to very good. On average the score is 4.5 out of 7.

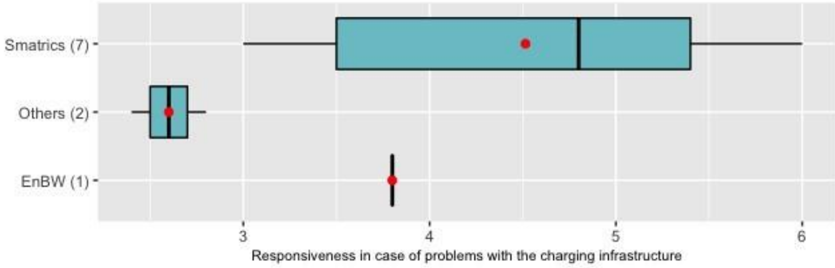


Figure 36 Responsiveness in case of problems with the charging infrastructure at the Austria demonstration area

Compared to the responsiveness in case of problems, the scores on contact are clearly higher. For contact, respondents had to indicated whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the possibility is provided to speak to a person in case of problems. Although there is still a large spread in the scores, Smatrics scores better with an average of almost 5.5 out of 7 for the contact criteria (see Figure 37).

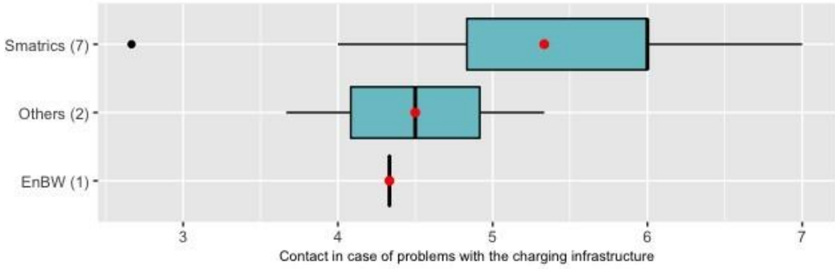


Figure 37 Contact in case of problems with the charging infrastructure at the Austria demonstration area

Lastly, respondents had to score different criteria for compensation in case of problems. Respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. Figure 38 shows that all CPOs/eMSPs score rather poorly on the compensation criteria. The user seems to expect more in case of problems than what the CPO/eMSP currently offers.

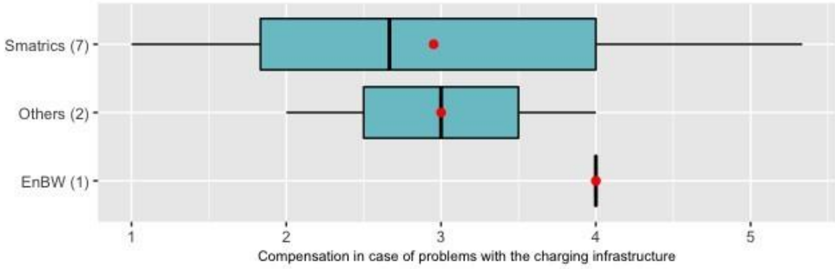


Figure 38 Compensation in case of problems with the charging infrastructure at the Austria demonstration area

Finally, the last questions in this section probe for the respondents' opinion on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. EnBW scores the best, with an average score above 6 out of 7. (see Figure 39). Smatrics scores slightly less with a score above 5 out of 7.

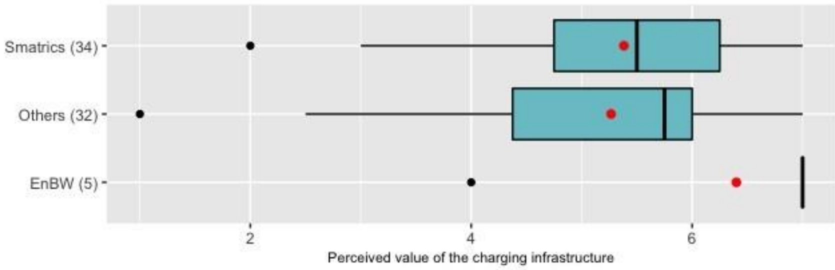


Figure 39 Perceived value of the charging infrastructure at the Austria demonstration area

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. Aside from some outliers, EnBW scores the highest on the loyalty criteria (see Figure 40). Smatrics, again, receives a wide range of (good) scores, resulting in an average of almost 5.5 out of 7, still resulting in loyal customers.

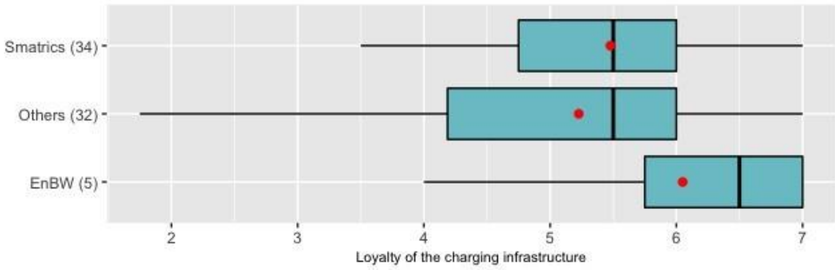


Figure 40 Loyalty of the charging infrastructure at the Austria demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the trend in the earlier questions, the highest scoring CPOs/eMSPs is EnBW. Smatrics receives good scores, resulting in an average of 5.5 out of 7 (see Figure 41).

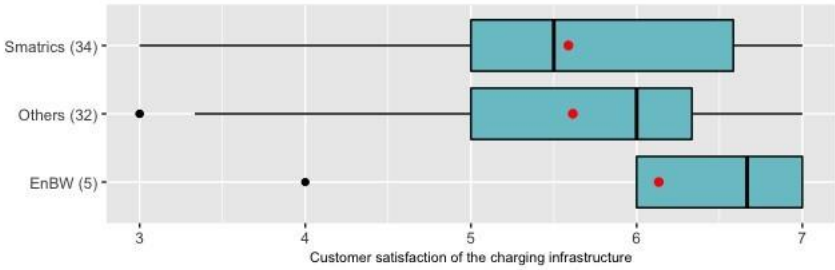


Figure 41 Customer satisfaction of the charging infrastructure at the Austria demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging is the most popular with 46.2% of respondents choosing they are most likely to use fast charging in the future. Furthermore, 30.8% of the respondents have the intention to use user friendly charging station, and 17.9% of the respondents would use smart charging in the future.

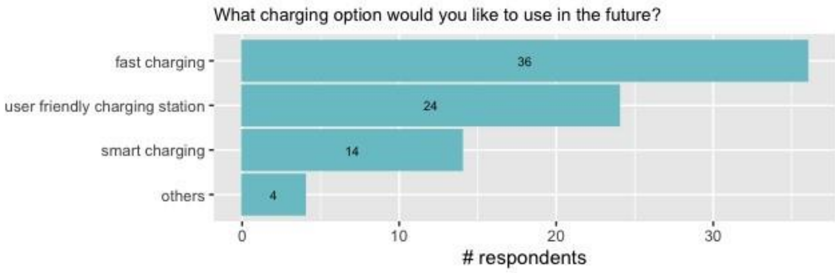


Figure 42 Most likely charging option in the future at the Austria demonstration area

The fast charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration. The behavioural intention to use fast charging is slightly higher than the behavioural intention to use user friendly charging stations and smart charging.

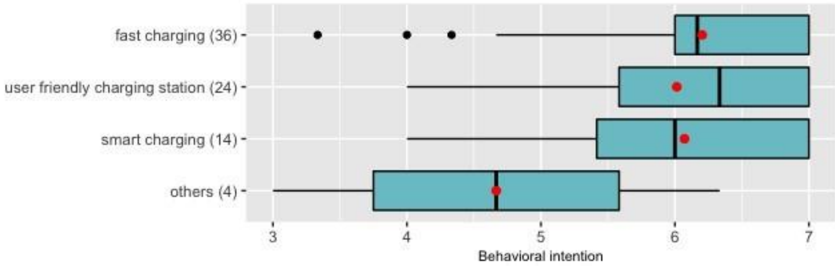


Figure 43 Behavioural intention of charging infrastructure at the Austria demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the fast charging option and smart charging score highest on these criteria, aside from a few outliers (see Figure 44).

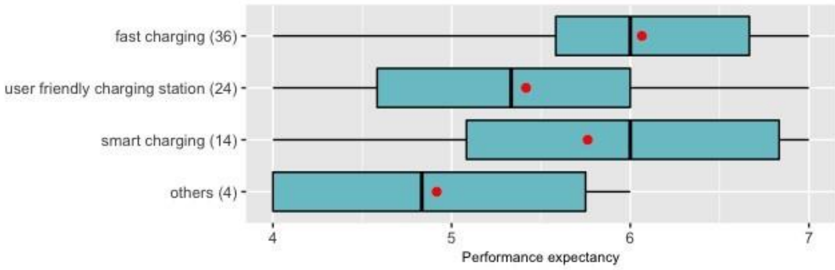


Figure 44 Performance expectancy of the charging infrastructure at the Austria demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. It is interesting to see that the scores for user friendly charging option have a larger spread in the scores than other charging options (see Figure 45). Less effort is expected for fast charging options, but fast charging also varies more than other charging options, indicating that respondents expect some effort into getting acquainted with this charging option compared to smart charging stations.

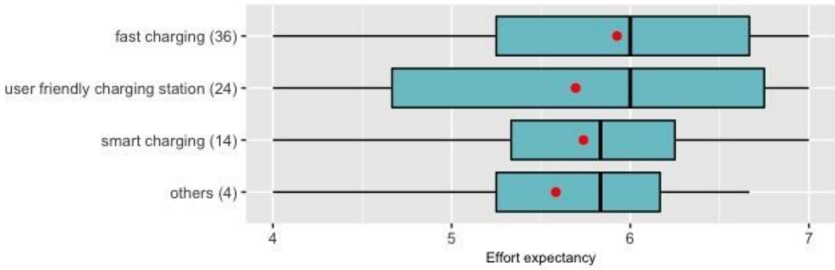


Figure 45 Effort expectancy of the charging infrastructure at the Austria demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 46). The averages and medians all lightly fluctuate between 4 and 5 on a scale of 7.

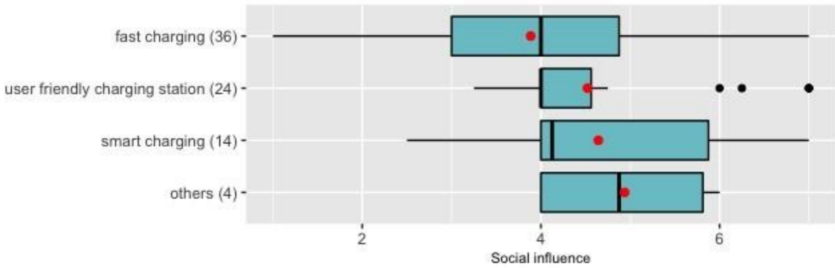


Figure 46 Social influence of the charging infrastructure at the Austria demonstration area

In terms of facilitating conditions, the charging options have more or less the same expectations around 5 out of 7. On average visibly higher than the other charging options is battery swapping (see Figure 47). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

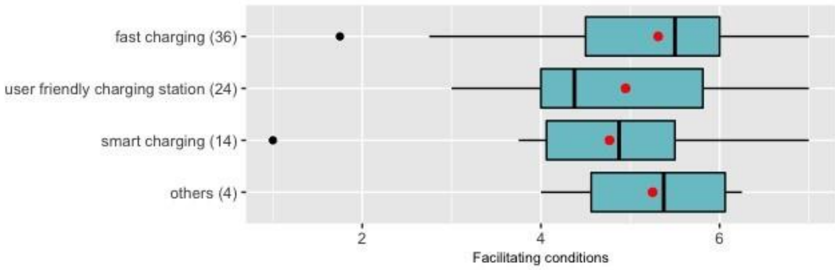


Figure 47 Facilitating conditions of the charging infrastructure at the Austria demonstration area

As for hedonic motivation, quite similar distributions can be observed for the different charging options (see Figure 48). Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

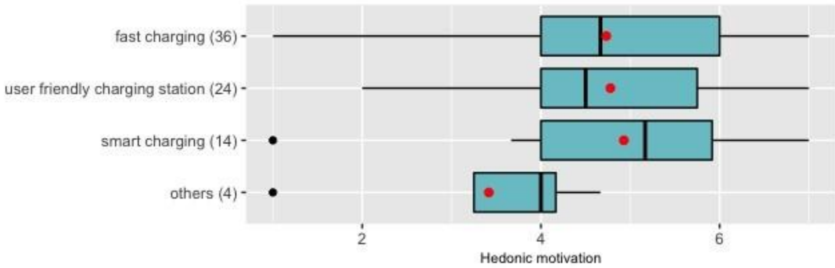


Figure 48 Hedonic motivation of the charging infrastructure at the Austria demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, it is interesting to note that almost all respondents would not want to pay more for the different charging options (see Figure 49).

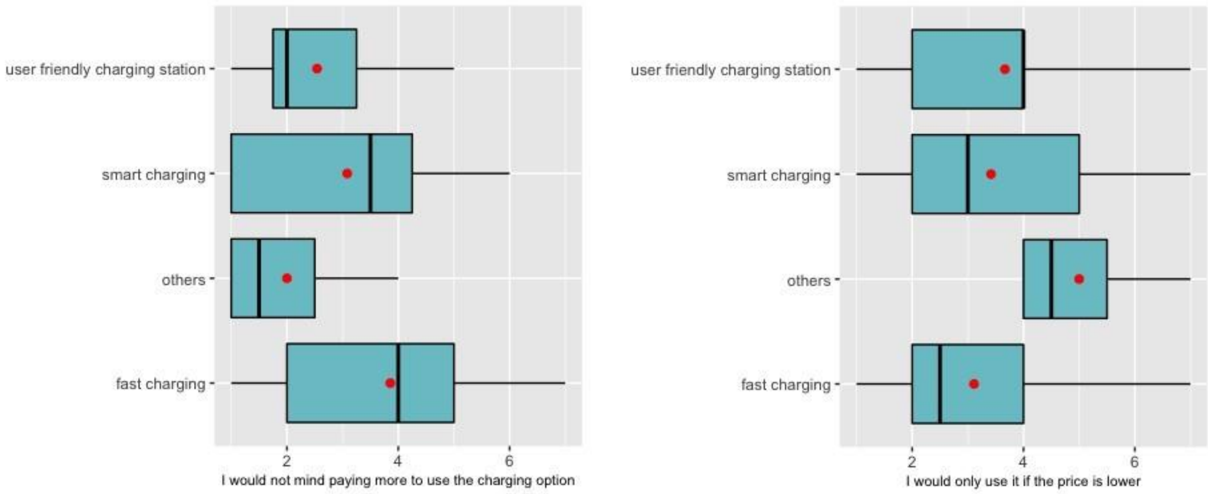


Figure 49 Price value of the charging infrastructure at the Austria demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. The majority of the respondents, 71.8% (56 respondents) indicated they use app-based services, another 15.4% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, a third of the EV respondents has 4 or more apps on their phone. About 73.2% of the app-based service users use this at least a few times a month, as can be seen in Figure 50.

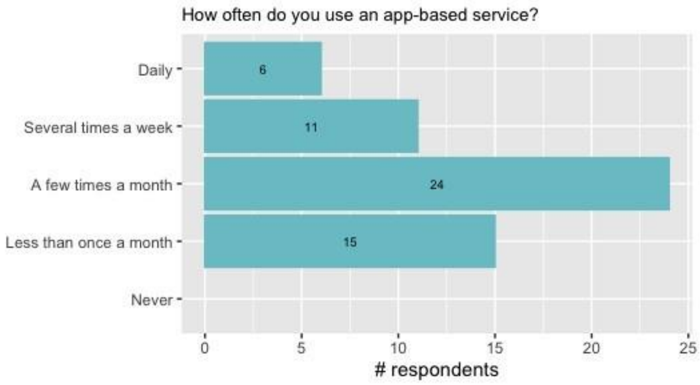


Figure 50 Usage of app-based services at the Austria demonstration area

App-based services are mostly used for travel related to travel destinations on holiday (42 respondents), whereas 39 respondents use it for leisure activities. To a lesser extent, the app-based services are used for commuting and work activities (16 respondents) and shop/errands (15 respondents). 75% of the respondents has 3 or more mobility apps on their phone. In terms of satisfaction with the used app-based services, Figure 51 shows that the respondents are satisfied above average on a scale of 1 to 7.

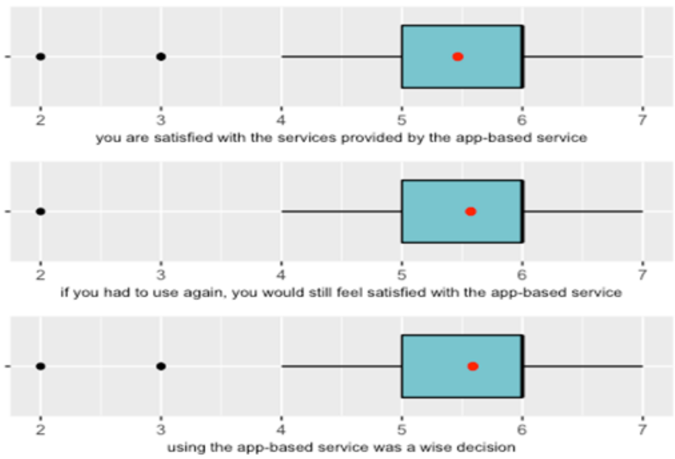


Figure 51 Satisfaction with the app-based services at the Barcelona demonstration area

LEV

In this section, there were only 2 respondents who use a light electric vehicle. As such, this section will not be discussed.

Non-EV users

Lastly, we zoom into the non-EV users, a total of 13 respondents. Interestingly, less than 50% of the respondents states that will buy an electric vehicle as soon as possible or state that it is very likely they will buy an electric vehicle.

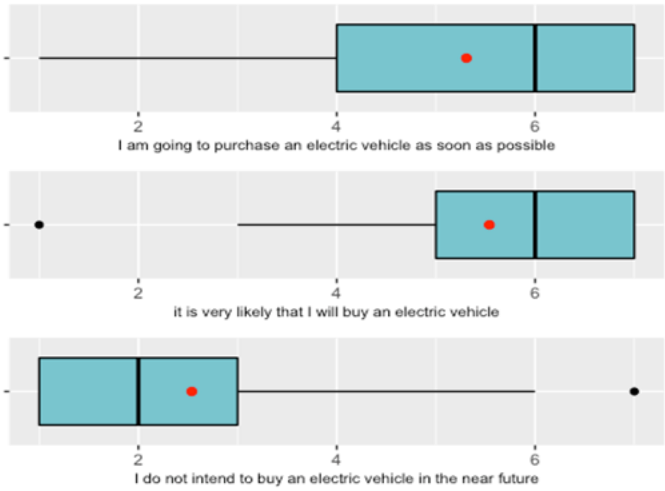


Figure 52 Non-users' Intention to buy an EV at the Austria demonstration area

Moreover, most respondents (84.6%) indicate they are mostly interested to buy an electric car. Out of these 11 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (7 respondents), an electric vehicle with range extender (2 respondents) or a plug-in hybrid electric vehicle (2 respondents).

Lastly, the most important motives for non-EV users to purchase an EV in the future is the Environmental friendliness and the fact that EVs have more efficient technology in terms of energy consumption as 81% respectively 90% considers this moderately to extremely important. At the same time, the least important motive are the safety features EVs could have as 63% of the respondents consider this not important at all to slightly important.

Key findings of the Austria report

The main reasons for electric car adoption the Environmental friendliness, the low operating and maintenance costs, the reduction of noise, and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, the big part of electric car owners' charges mostly at home. This can be seen in the chart of charging time, where the users charge overnight and in the evening. It is also clear that little charging takes place during the day, as the least frequent charging place is at the workplace, where more than half of the respondents (55%) indicate that they never charge at work. Respondents are quite satisfied with the quality of service they receive from the charging stations of Smatrics. More specifically in terms of tangibility and reliability of the charging station, and in terms of after-sales when problems arise, where the responsiveness, contact and compensation score well. Therefore, the scores on loyalty and customer satisfaction are high. Fast charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use. Also, other future charging options (smart charging and user-friendly charging options) receive high scores for the acceptance of new technologies, which means people are looking forward to the future charging options. Remarkable is that 75% of the respondents indicate they would only use the future charging options is when the price is similar or cheaper than the current charging options available.

Lastly, less than 50% of the non- EV users states that they will buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (84.6%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the Environmental friendliness (100%) and more efficient technology in terms of energy consumption (98%) in comparison with non-EV. At the same time, the least important motive is the better image EVs could have towards other people as 37% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV car users.

Field data analytics

This section presents the data analytics for the Austrian pilot. SMATRICS is Austria’s largest provider of e-mobility charging services, fulfilling both the roles of a Charge Point Operator as well as a Mobility Service Provider. SMATRICS operates a total of 480 charge points, of which 270 are fast charging points (≥50kW) and 32 charge points allow for High Performance Charging (≥150 kW). The publicly accessible charging infrastructure is implemented among different branches of various strategic site partners, like Fast Food restaurants, retail, shopping centres, supermarkets and petrol stations. To support long trips SMATRICS also runs 10 stations directly located on the highway.

Descriptive Statistics

In this pilot has been analysed the sessions from the CPs operated by Smatrics in the cities of Graz, Innsbruck, Salzburg and Wien. There are 4140 unique users, 114 unique charging points (64 AC and 50 DC). The data collection refers to the time-window between 2019-01-01 and 2020-08-31. Moreover, in this case the type of location where the charging point is located (i.e. fast-food restaurant, hotel, grocery retail, parking area, etc.) has also been considered in the analysis.

- **Charging points geographical distribution**

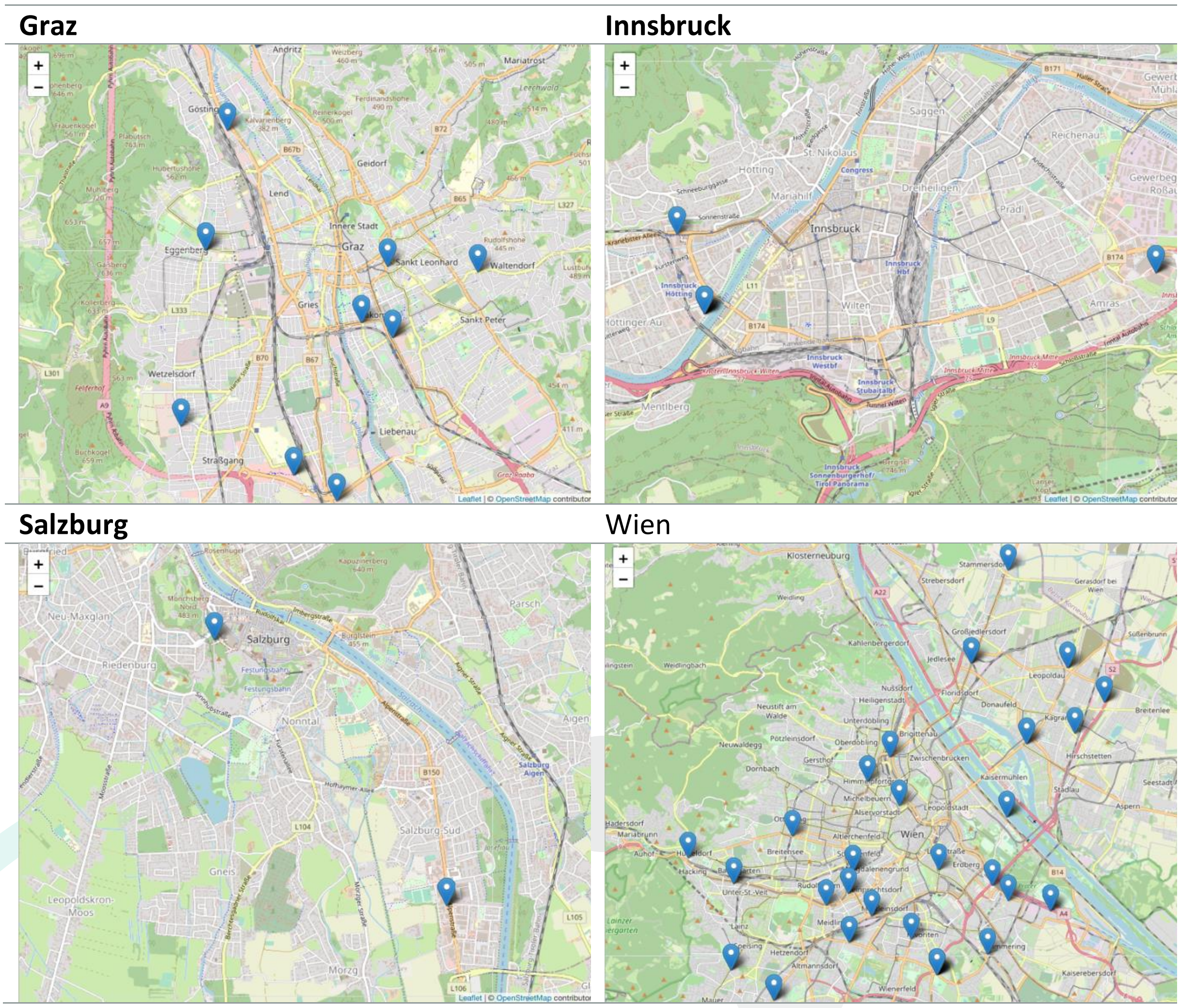


Figure 53. Charging Point locations in Austria Demonstration area

- **Sessions' temporal distribution**

The following figure represents the starting time of the sessions and their frequency. Sundays have the lowest number of sessions in general. On Saturdays, the peak is from 11 am to 12 pm.

All working days have similar behaviours, the number of sessions continuously increase from 5 am to 8 am, then morning, noon and afternoon peaks occur for the different days. And finally, it starts decreasing again from 4 pm. During late evening – from 10 pm to midnight, Fridays and Saturdays have more sessions than the other days.

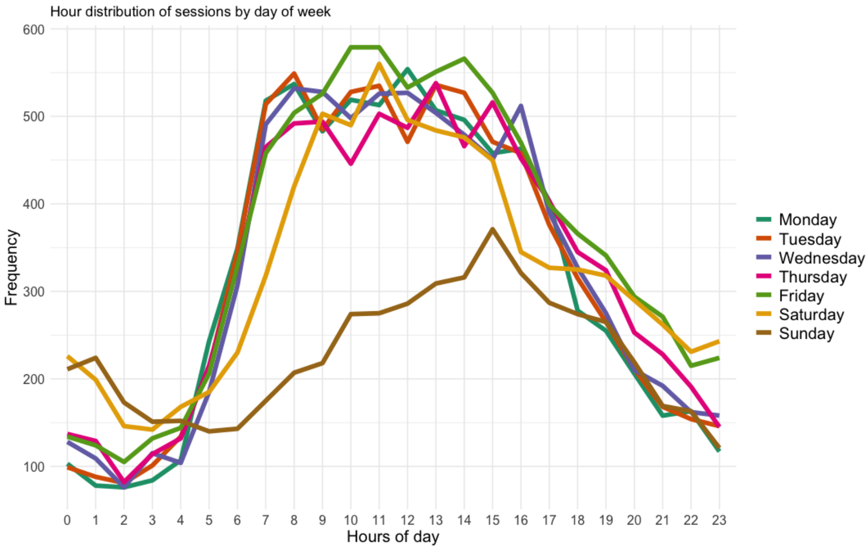


Figure 54. Sessions' temporal distribution – Austria demonstration area

- **Sessions' duration**

For the analysis of the duration of the sessions it has been decided to analyse separately the AC CPs which can range from 11kW to 43kW and the DC CPs, which correspond to the ultra-fast CPs ranging from 50kW to 350kW.

The average duration in the AC CPs is 132 minutes and presents a high number of outliers, ranging from 168 minutes to 4485 minutes (more or less 3 days). In the case of DC charging stations, the average duration is lower (30 minutes) and presents a lower number of outliers, most of them between 37 minutes and 8 hours. Also, in the case of AC charging stations the dispersion of the data is higher, this means that the variation of the values of duration among themselves is high.

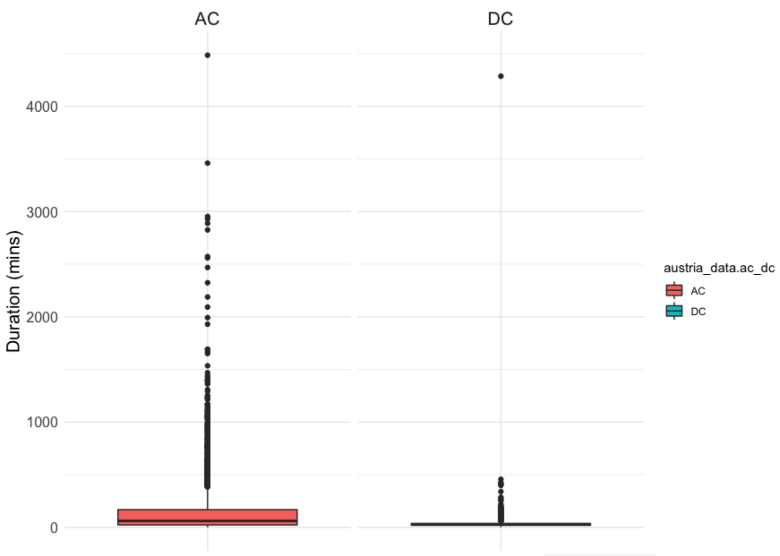


Figure 55. Boxplot of sessions duration – Austria demonstration area

Table 11. Summary of statistical values for sessions' duration – Austria demonstration area

AC Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1 min	22.64 min	61.23 min	132.41 min	168.13 min	4485 min
DC Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1 min	19.02	27.72 min	30.57 min	37.77 min	4285.98 min

The results clustered by branch type can be found in Annexe A3. From there it can be inferred that in average the longest durations occur in parking and the shortest ones in fast food restaurants.

- **Energy consumed per session**

Complementary to the duration of sessions, this subsection analyses the energy consumed in these sessions in order to understand the charging style of the users. In this case one can see that the average in both cases is similar, 12 kWh for the AC case and 17 kWh for the DC case. Again, here the AC CPs present a higher dispersion in the data. Finally, it should be noted that the algorithm detects as outliers the sessions above 17 kWh (AC) and 22 kWh (DC), this means that rarely the users charge the entire battery in public CPs.

The results clustered by branch type can be found in Annexe A3. From there it can be concluded that the highest energy consumed per session is in CPs located in Gas Stations and the lowest in CPs located in Shopping Centres.

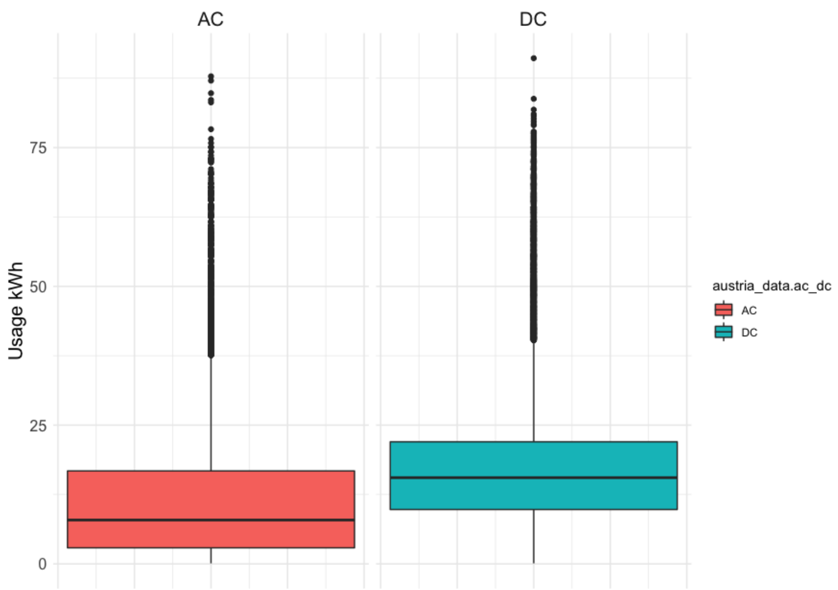


Figure 56. Boxplot for sessions' energy consumed – Austria demonstration area

Table 12. Summary of statistical values for sessions' energy consumed – Austria demonstration area

AC Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.10 kWh	2.89 kWh	7.90 kWh	12.14 kWh	16.75 kWh	87.84 kWh
DC Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.10 kWh	9.79 kWh	15.53 kWh	17.07 kWh	21.99 kWh	91.10 kWh

User Clustering

The users that have been using the Smatrics CPs within the timeframe of the study have been clustered based on their similarity. Using *k-means* algorithm three different clusters have been defined. User Cluster 1, including the majority of the users (86%), is for the users who have the "general" type presenting values closer to the overall mean, whereas User Cluster 2 and 3 are created based on the diversity of the user characteristics. As it can be seen, the users of User Cluster 2 have much more sessions, orange column represented by *n*, than the Cluster 1 and Cluster 3 users. On the other hand, their duration is less than the overall mean, User Cluster 3 users are characterised by really long durations (*av_min*) and high energy consumed per session (*av_ekWh)*. The users of User Cluster 2 visit different CPs much more than the other cluster users.

Table 13 User clusters – Austria demonstration area

User Cluster 1	User Cluster 2	User Cluster 3
1768 users (86.16 %)	80 users (3.9 %)	204 users (9.94 %)

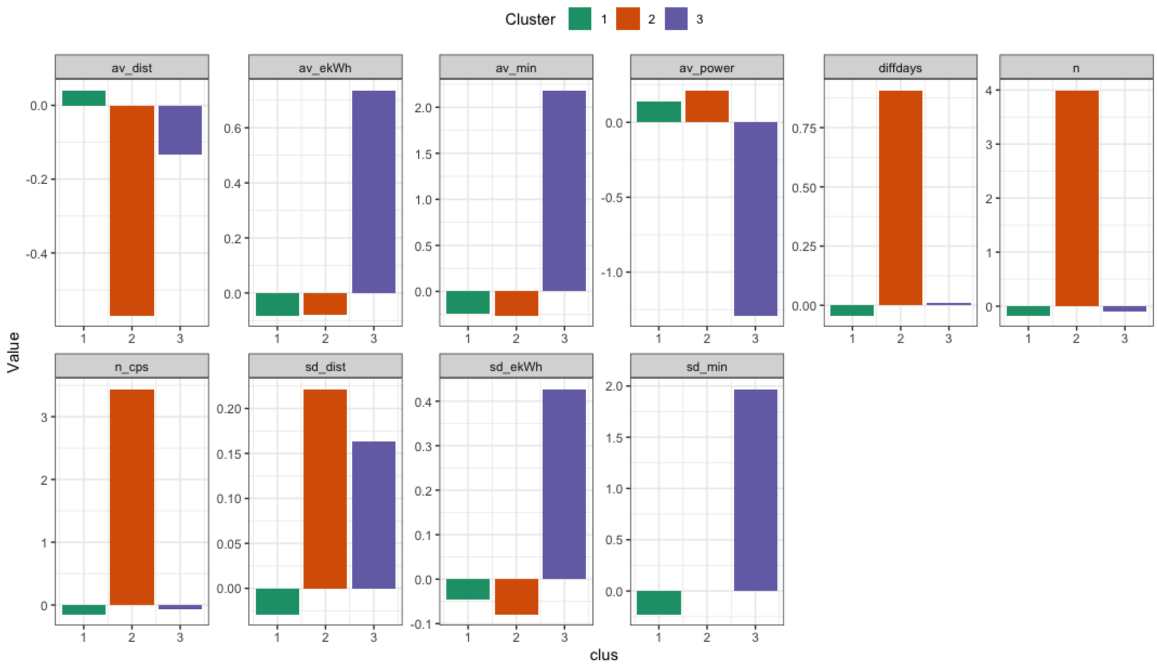


Figure 57. User clustering results – Austria demonstration area

Temporal Clustering

This section presents the clustering results of the charging points, based on their occupancy. The automatic selection function recommended *kmeans* with 2 clusters. Figure 58 presents the average occupancy of the CPs in each hour of the day. It can be seen that in both cases the lowest occupancy is at 7am and the highest occupancy around 8 pm. The 90 CPs belonging to Cluster 1 have an average occupancy of 3.2% and the CPs belonging to Cluster 2 present an average occupancy of 15%.

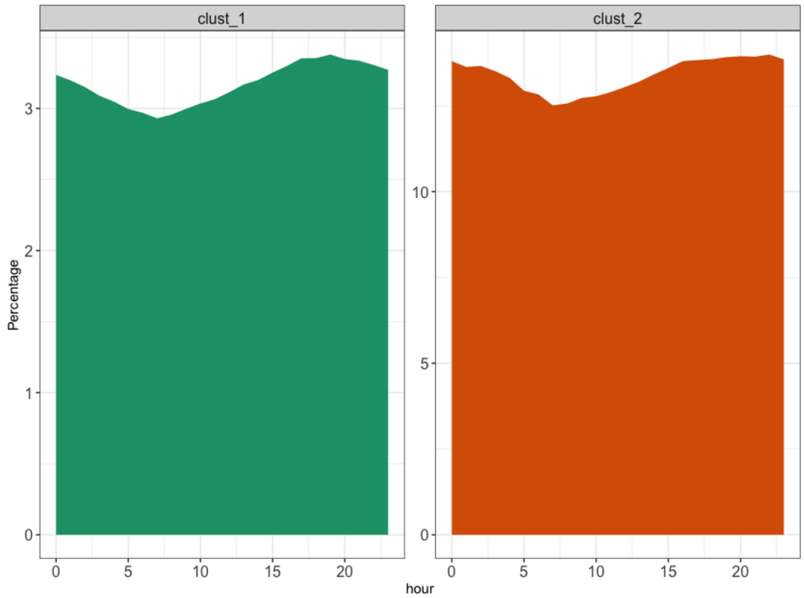


Figure 58. Charging Points' temporal clusters' hourly occupancy distributions – Austria demonstration area

The following table presents for each of the cities of study the number of CPs belonging to Cluster 1 or Cluster 2.

Table 14. Geographical distribution of CP temporal clustering

	Graz	Innsbruck	Salzburg	Wien	Total
Cluster 1	20	13	4	53	90 (78.9%)
Cluster 2	3	0	1	20	24 (21.1%)

User mobility flows

In order to analyse the travel demands of the users and how the users charge between the cities of study (Innsbruck, Salzburg, Grenz and Wien), OD matrixes have been created and the mobility flows analysed.

Figure 59. Inter-city mobility flows – Austria demonstration area

90% of the users only have recorded charging sessions in one city, whereas the remaining 10% presents charging sessions between 2 and 4 different cities. The strongest link is between Graz and Wien with 162 trips from Graz to Wien and 72 trips from Wien to Graz. Then, the third most used connection is the one from Salzburg to Wien (47 trips). The details from the number of trips can be found in Annexe A3.

COVID-19 effect

The following time periods have been established for the analysis of the COVID-19 effect in the Austria demonstration area:

Pre-COVID-19: 2020-01-16 – 2020-03-14
Lockdown: 2020-03-15 – 2020-05-17
De-escalation: 2020-05-18 – 2020-06-21
New-normality: 2020-06-22 – 2020-08-31

The number of users, the average sessions per day and the average occupancy percentage of the CPs decreased between 40% and 60% during the lockdown period and these attributes increased by 20% during the de-escalation and new normality, but without achieving the values from the pre-covid period.

The average daily energy consumed by user is higher in the COVID periods compared to the pre-covid, this could be because the usages where the main intention of the user was to park instead of charging the EV might be reduced. Finally, the average charging session duration is quite stable in the four periods of study.

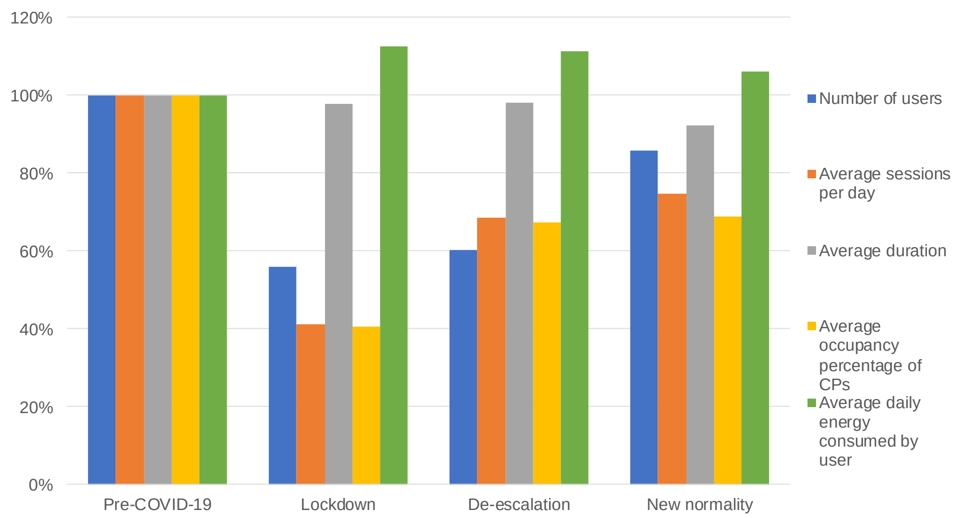


Figure 60. Variation of charging attributes with relation to the pre-COVID-19 period – Austria demonstration area

A priori assessment of the e-mobility charging infrastructure

The Table 15 provides an overview of the KPIs that have been measures in T1.3 by using historical data collected from SMATRICS between 01/01/2019 and 31/08/2020.

Table 15. Usage KPIs – Austria demonstrator

Impact Area: Usage	Result
Loyalty to the same charging option	17.51% of users reused the same charging point more than 5 times
Frequency of use of charging options	464.59
Vehicle's charging time	48.92 minutes
Availability rate (1)	2.63% of the charging options are occupied more than 10 %.

Availability rate (2)	89.47% of the charging points are occupied less than 5 %
Average usage ratio of charging options	2.36% is the average ratio.

Conclusions

The analysis performed for this pilot extracted significant and useful information about the EV and charging point usage in the Austria demonstration. Most of the users (90.43 %) use CPs from just one city. The cities of Wien and Graz are the hot points to be origin or destination for intercity trips. The overall average consumed energy of the users using AC CPs is 12.14 kWh with average duration of 132.41 minutes. In the case of DC CPs, the average energy consumed is 17.07 kWh and 30.57 minutes Three user clusters are detected: (i) most common behaviour users that have the main effect on the average values, (ii) the users with much more sessions, number of visited CPs and longer distance between the visited CPs, (iii) the users with higher energy consumption and longer durations. Two temporal clusters are detected: (i) CPs with 3.5% occupancy in average (hour bins), (ii) CPs with more than 15% occupancy in average (hour bins).

Demonstration area 2 : Barcelona

General description of the site

The city of Barcelona is the capital of the autonomous community of Catalonia and the second largest city in Spain. It extends over 101 km2 and has a population of 1,620,809 inhabitants. The metropolitan area includes 36 municipalities, extends over 633 km^2 and has a population of 3,225,058 inhabitants.

Evs in circulation, charging and service infrastructure

The evolution of electric vehicle registration in the city has been lower than estimated. As of December 2020, there were estimated that the number of registered Evs in the city would be around 6,000 (Barcelona City Hall), and in November 2020 there were 2,374 (considering cars and vans). Sales are expected to increase over the next few years due to the increased offer of EV models and government subsidies.

Currently, in Barcelona there’s a total of 1124 public CPs, 834 charging points for electric cars and vans, and 290 charging points for electric motorcycles. More in detail, there are 624 slow charging stations (3,7-7,4kW), 173 semi-fast charging points (7-22kW) and 37 fast charging stations (50kWh). B:SM is the CPO that runs a network of 551charging stations on public roads and in municipal car parks extended through the diverse districts.

Data collection strategy for the survey

The three surveys of T1.2 of eC4Drivers project (general users, taxi, and fleet owners), have been widespread in the city of Barcelona by social media, emails, and forums. More specific for the general survey, an email was sent out to the users of the app SMOU1 (76695 users) from B:SM. Additionally the survey link was sent to the LEV users of SILENCE, and to ACCIONA and SEAT:MO, providers of an electric moto sharing service.

The survey for the taxi drivers was sent to AMB Taxi (focused on the administration and management of taxi services in the Metropolitan Area of Barcelona). The link to the survey was shared in their webpage and an email was sent to taxi drivers (both electric and non-electric). For the delivery company-survey, the distribution of the LEV delivery vehicles was done by Delivery SILENCE. Furthermore, the link of the delivery survey was shared with BCL[2], who shared the link with its associates, and with Clúster de la logística de Catalunya[3].

Survey Results

After data cleaning, the data set of the general users contains 1099 respondents in total. Of the respondents, 49.77% (547) use any type of electric vehicle (EV). Figure 61 *shows the* type of electric vehicles the respondents use, where the majority (64.35%) indicated they use an electric car.

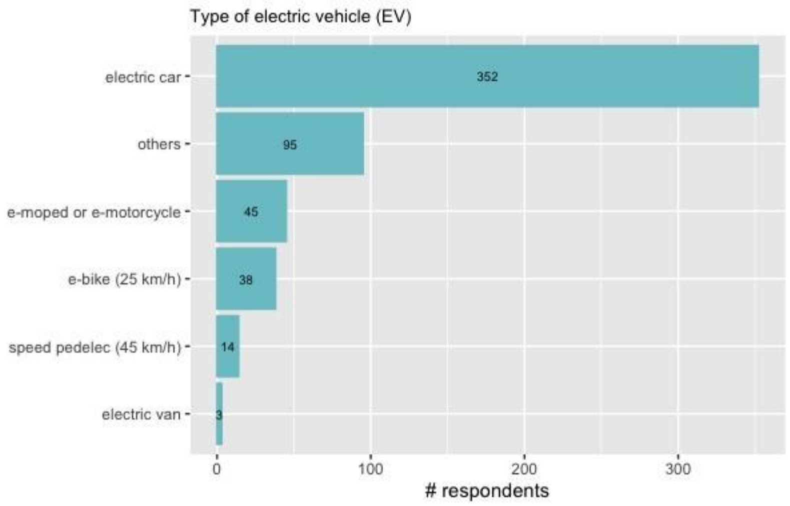


Figure 61. Type of Evs used out of 547 respondents at the Barcelona demonstration area.

Out of the 352 respondents who use an electric car, 233 indicated they drive a BEV, whereas 80 respondents drive a PHEV. Also, 23 respondents drive an electric vehicle with a range extender and 16 a HV that combines a classical internal combustion engine with an electric motor.

In regard to the socio-demographic variables of the full sample, the majority of the respondents were men (78.52%). Most respondents (57%) have obtained a university degree or a higher non-university degree (22.47%). The majority is full time employed (72.88%), whereas 15.10% is retired. Almost 80% of the respondents is married with or without children (56.51% resp. 22.75%). The different socio-demographics are detailed in Table 16. Almost all respondents (99.73%) possess a driving licence. For most respondents, this concerns a driving licence B (92.53%), followed by driving licence A (32.51%). A small portion of the respondents possess a driving licence C (8.83%), a driving licence D (3%) and a driving licence G (0.36%).

Table 16 Socio-demographics of the respondents at the Barcelona demonstration area.

Socio demographics	Categories	Number of respondents (%)
Gender	Female	232 (21)
	Male	863 (79)
	Other	4 (0)

Degree	None	2 (0)
	Primary education	20 (2)
	Secondary education	103 (9)
	Higher non-university education	247 (22)
	University education (bachelor's degree, master's degree, …)	624 (57)
	Post-university education (PhD, Post-doc,…)	103 (9)
Residential situation	I live alone	88 (8)
	I live with family	69 (6)
	I live with others: co-housing	15 (1)
	Married or in relationship with child(ren)	621 (57)
	Married or in relationship without children	250 (23)
	Other housing situation, namely:	6 (1)
	Single parent with child(ren)	50 (5)
Professional situation	Currently unemployed	103 (9)
	Employed full time	801 (73)
	Housewife/Houseman	6 (1)
	Other profession, namely:	42 (4)
	Part-time employed	31 (3)
	Retired	166 (15)
	Student	13 (1)
	Temporary exemption (e.g. maternity leave, parental leave)	8 (1)
Function	Blue collar worker	53 (6)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	94 (11)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	94 (11)
	Middle management	186 (21)
	Official / employed in a public service	105 (12)
	Own company, entrepreneur with employees	51 (6)
	Self-employed, entrepreneur without employees	77 (9)
	Senior management / management	90 (10)
	Teaching staff / employed in education	32 (4)
	White collar employee (administrative, executive or support/clerical function)	204 (23)
	Unknown/Missing	207 (18.84)

EV car users

Out of 355 electric car (352) and van users (3), 277 respondents own the vehicle, whereas 76 drive a company owned car, and 2 drive a car owned by a car sharing company. Furthermore, 5 respondents indicated that they use their vehicle as a taxi. The majority of the respondents (80.56%) does not benefit from any company benefits, 4.51% of the respondents indicated they benefit from a company charging pass, whereas 3.66% enjoys a company fuel pass. Furthermore, 3.1% receives a kilometre compensation and 5.1% indicated they receive some other type of mobility benefit.

In terms of the battery electric vehicles, the most popular cars are the Tesla model 3 (47 respondents), followed by a Nissan Leaf (41 respondents) and a Renault Zoe (17 respondents). The BMW i3 (15 respondents) and the Tesla model S (13 respondents) close the top 5. The most popular plug-in hybrid electric vehicles are the Mitsubishi Outlander PHEV (13 respondents) and the Kia Niro PHEV (10 respondents). Out of the 3 electric van users, 2 drive a Nissan e-NV200, whereas the other one drives a Citroen Berlingo Electric.

Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity of more than 70 kWh, where the next most popular choice is between 31 and 40 kWh. At the same time, 31 respondents indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 300 and 400 km. Most PHEV users do not know the battery capacity of their vehicle. In terms of battery range, the majority indicates this lies higher than 50 km. Lastly, the majority of all EV users (33%) is driving their current vehicle for less than 1 year. More detailed information can be found in Table 17.

Table 17 EV characteristics at the Barcelona demonstration area.

Vehicle characteristics	Categories	N (%)
Battery Capacity – kWh (BEV) according to respondents ***236 responses***	<20	1 (0)
	20–30	29 (12)
	31–40	37 (16)
	41–50	30 (13)
	51–60	9 (4)
	61-70	26 (11)
	>70	73 (31)
	I do not know.	31 (13)
Battery Range – km (BEV) according to respondents ***236 responses***	< 100	11 (5)
	100–149	25 (11)
	150-199	40 (17)
	200–249	43 (18)
	250–299	30 (13)
	300-400	52 (22)
	>400	35 (15)
Battery Capacity – kWh (PHEV) according to respondents ***80 responses***	2 -5	1 (1)
	5 – 10	15 (19)
	10 – 15	14 (18)
	15 – 20	4 (5)
	>20	12 (15)
	I do not know.	34 (42)
Battery Range – km (PHEV) according to respondents ***103 responses***	10-19	1 (1)
	20-29	13 (13)
	30-39	14 (14)
	40-50	33 (32)
	>50	42 (41)
	< 1 year	118 (33)
	1 year	73 (21)

2 years	82 (23)
3 years	47 (13)
4 years	14 (4)
>4 years	21 (6)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom in on the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 62 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

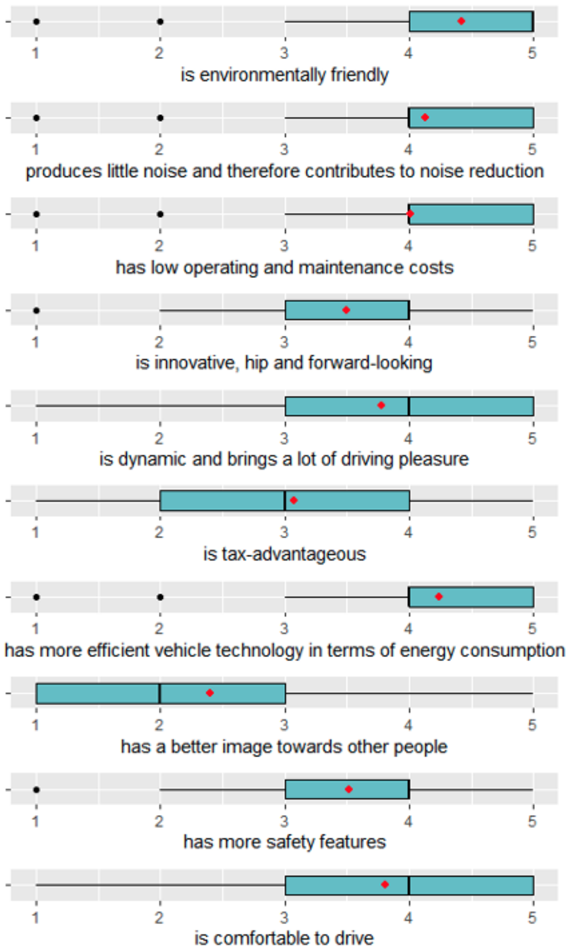


Figure 62 Reasons for EV usage or purchase at Barcelona demonstration area.

From Figure 55, it is clear that the main reasons for using or purchasing and EV are the *"environmental friendliness"*, the *"noise reduction"*, the *"low operating and maintenance costs"* and the fact that EVs have *"more efficient technology in terms of energy consumption".* More specifically, the environmental friendliness was the most important factor as 90.14% considered this factor to be very important to extremely important. The least important factor is the *"better image an EV could have towards other people"*, where 37.18% considered this factor not important at all.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 90 km, where the average time spent on the road was about 2 hours and 20 minutes. The EV is mostly parked at a private parking at home for almost 13 hours a day on average. Figure 63 gives a more detailed overview of the parking time at different locations.

Figure 63 Respondents' EV parking time at different locations at the Barcelona demonstration area

When EV users park at home, the majority does so in their driveway or in a privately-owned garage (64.79%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 64).

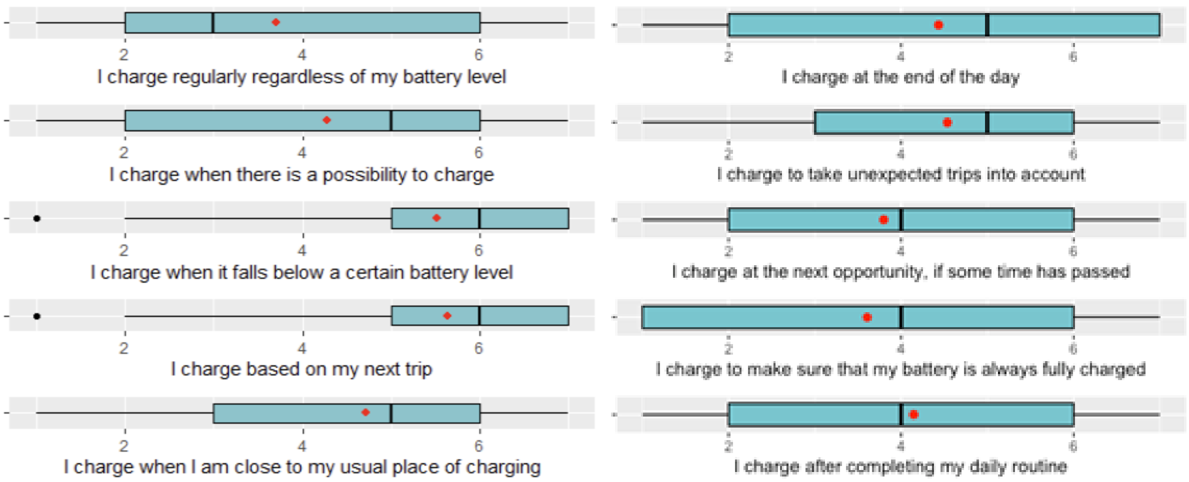


Figure 64 Respondents' charging behaviour at the Barcelona demonstration area.

In regards to charging experience, 7.10% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 67.90% charges often at a different location, whereas 25.28% sometimes charge at a different location.

Respondents charge the EV most frequently at home, 35.06% of the respondents charge the EV at home daily and 26.22% does so several times a week (Figure 65). If asked about the charging option at home, the main charging option at home is the charging station (58.11%), followed by a socket (35.50%). The least frequent charging place is at the workplace, where 53.35% of the respondents indicate that they never charge at work. Also, public fast chargers are more frequently used than non-fast chargers.

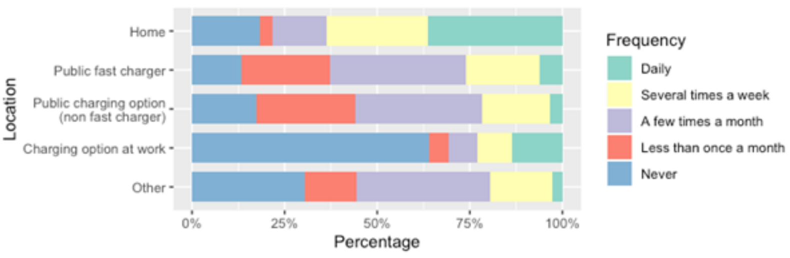


Figure 65 Respondents' charging behaviour per location at the Barcelona demonstration area.

The most popular charging time is between midnight and 3a.m., followed closely by 3a.m-6a.m (Figure 66). The least popular time is between 3 p.m. and 6 p.m. After 6 p.m. charging becomes more frequent again.

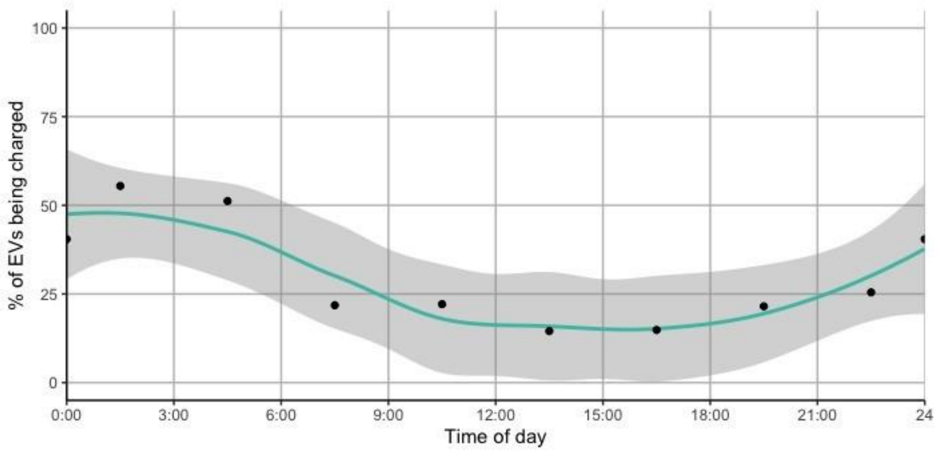


Figure 66 Respondents' charging schedule at the Barcelona demonstration area.

In terms of most ideal charging session, the respondents answered that a short waiting time for availability of the charging point is very important, as well as charging cards that work immediately. Payment with cash the least of the concerns with respect to an ideal charging session.

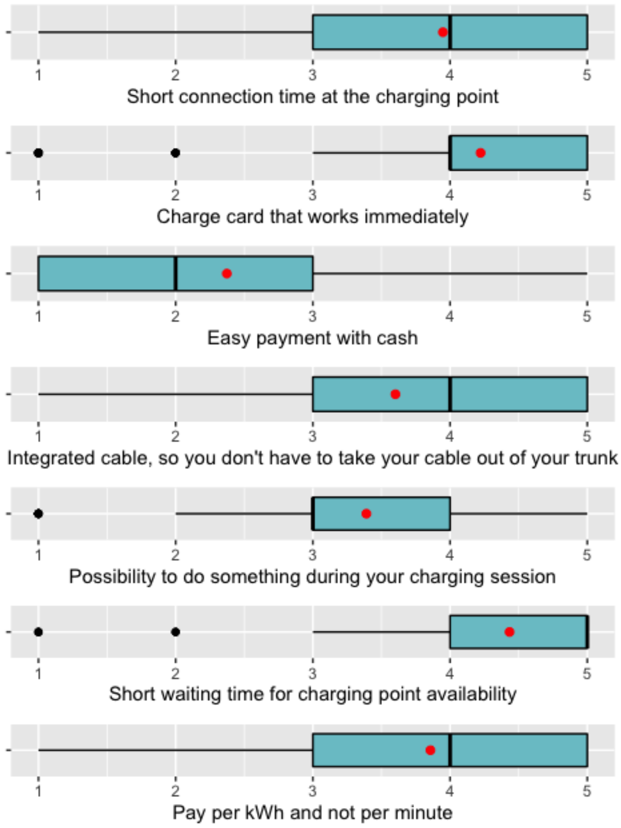


Figure 67 Charging session characteristics' importance at the Barcelona demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that Endolla Barcelona, which is managed by B:SM, is the most popular.

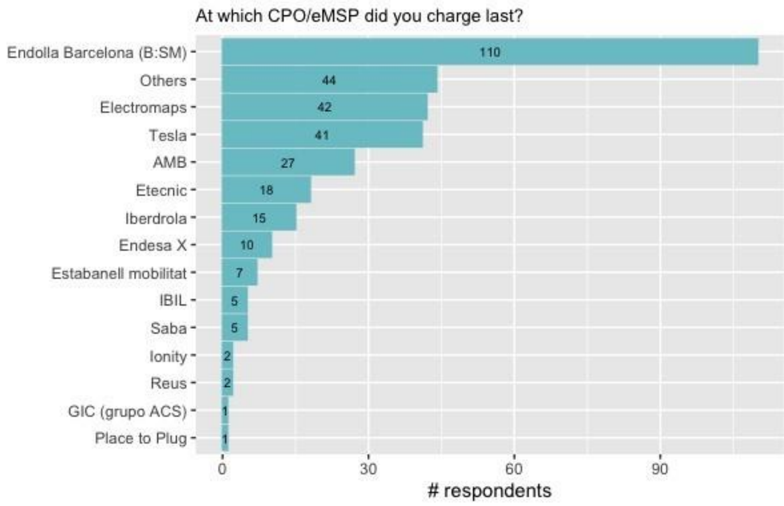


Figure 68 Last charging CPO/eMSP at the Barcelona demonstration area.

Although the Endolla Barcelona is the most popular CPO, it appears to score lower on tangibility than some other less frequently used CPOs. Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for Endolla Barcelona are spread ranging from very poor to very good. The charging infrastructure for Electromaps scores higher with an average of more than 5 on 7, whereas the Tesla charging infrastructure scores highest overall in terms of tangibility (see Figure 69). At the same time, AMB shows a similar distribution to Endolla Barcelona in terms of tangibility.

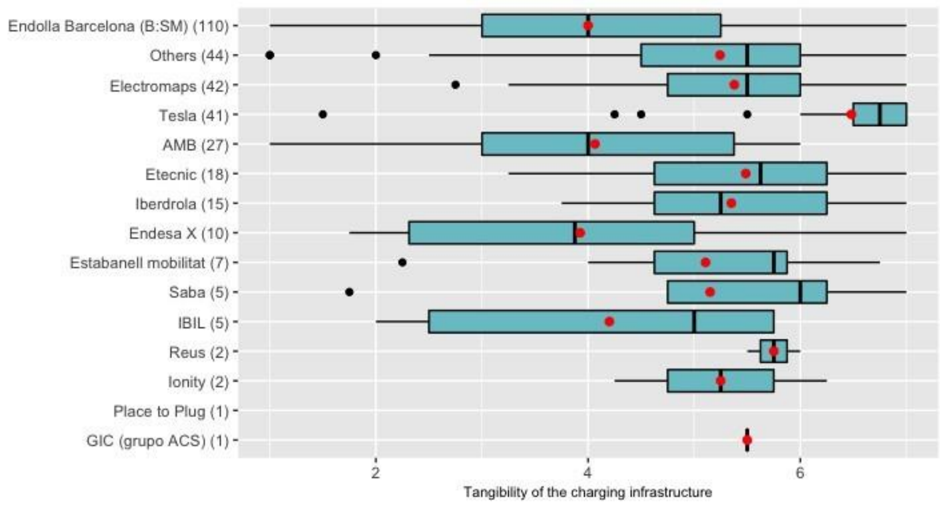


Figure 69 Tangibility of the charging infrastructure at the Barcelona demonstration area.

For availability and reliability of the charging infrastructure, similar scores can be observed (see Figure 70 and Figure 71). The availability captures whether the charging infrastructure is available for use, can start immediately, does not block and is not inadvertently interrupted. Both Tesla and Electromaps score clearly high on average for these criteria, whereas AMB is again comparable to Endolla Barcelona. These CPOs/eMSPs score quite neutral on average. The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping.

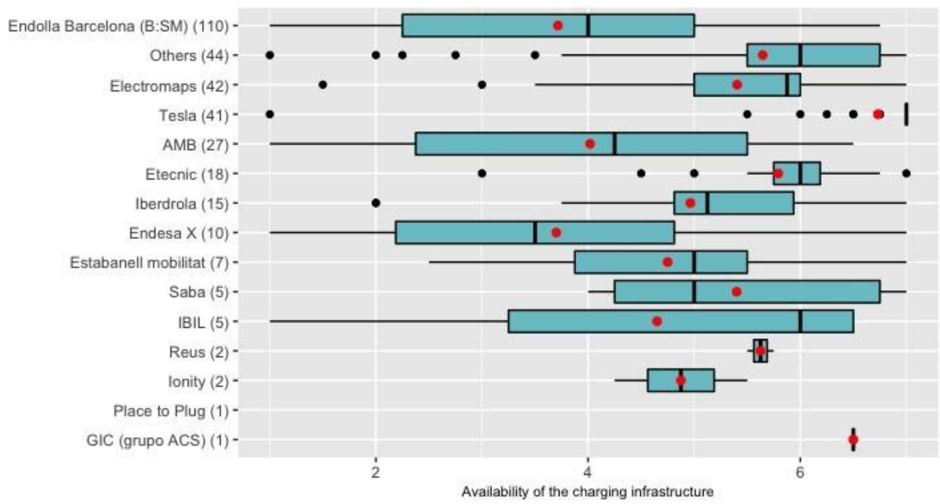


Figure 70 Availability of the charging infrastructure at the Barcelona demonstration area.

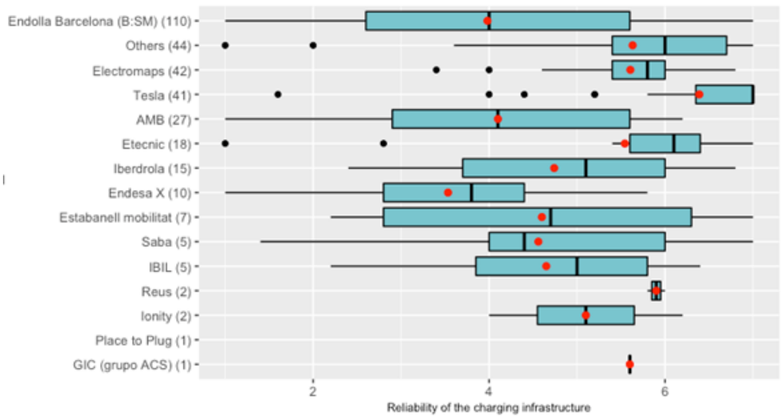


Figure 71 Reliability of the charging infrastructure at the Barcelona demonstration area.

Looking at the privacy of the charging infrastructure, it is clear that all CPOs receive similar scores. Except for Tesla, which scores clearly higher (see Figure 72). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other companies and payment credentials are protected.

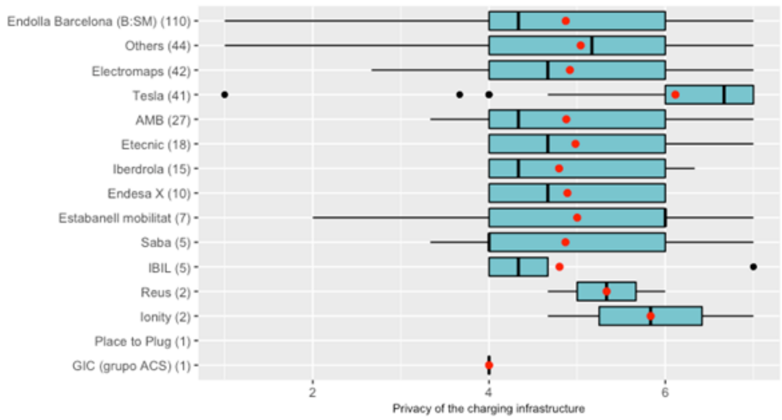


Figure 72 Privacy of charging infrastructure at the Barcelona demonstration area.

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 161 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 168 indicated they have not. Most charging infrastructure problems are experienced when using Endolla Barcelona. Indeed, 84.54% (93 out of 110 respondents) indicated to have experienced problems with this CPO. Whereas for Electromaps and Tesla this is 21.42% (9 out of 42 respondents) and 12.20% (5 out of 41 respondents) respectively. Other CPOs with a higher problem to usage frequency ratio are Endesa X with 70% (7 out of 10 respondents), IBIL with 60% (3 out of 5 respondents), Estabanell mobilitat with 57.14% (4 out of 7 respondents) and AMB with 48.15% (13 out of 27) respondents.

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For Endolla Barcelona, it can be seen in Figure 73 that the scores for responsiveness varied a lot for the different respondents, ranging from very bad to very good. Overall, the median and average are still quite low, with less than 3 out of 7. AMB scores poorly, with the lowest average overall, and Tesla scores highest in terms of responsiveness.

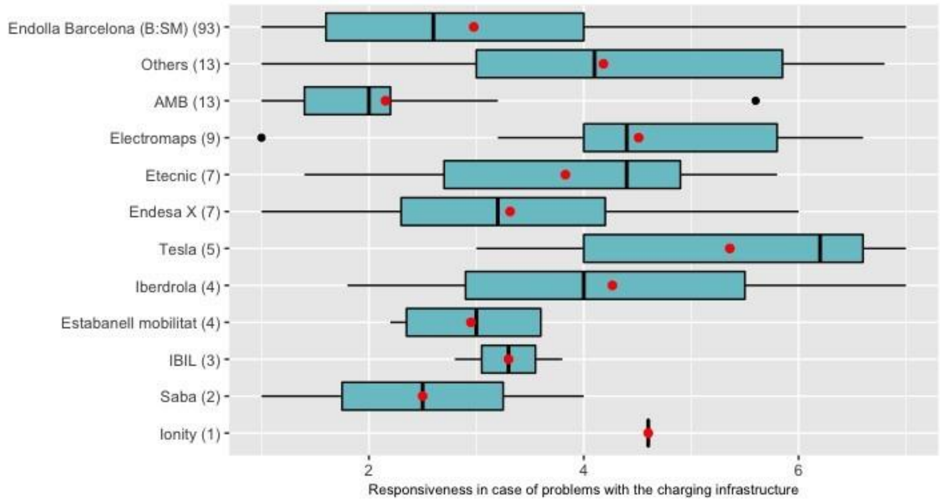


Figure 73 Responsiveness in case of problems with the charging infrastructure at the Barcelona demonstration area.

Compared to the responsiveness in case of problems, the scores on contact are clearly higher. For contact, respondents had to indicate whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the ability is provided to speak to a person in case of problems. Although there is still a large spread in the scores, Endolla Barcelona scores better with an average of almost 5 out of 7 for the contact criteria (see Figure 74). The lowest scoring CPO is now Endesa X. Again, Tesla scores best.

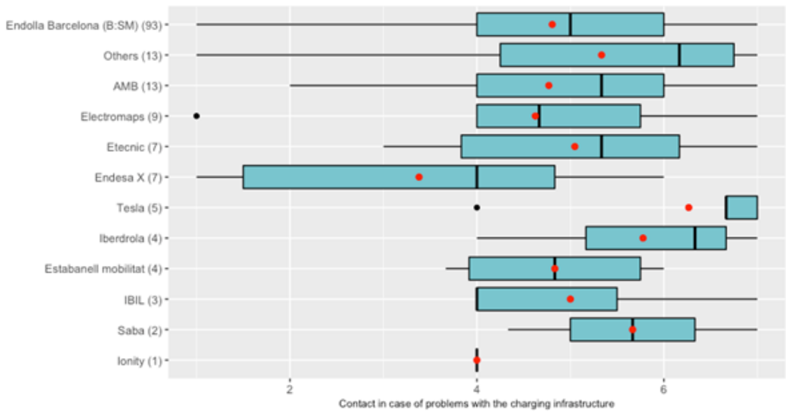


Figure 74 Contact in case of problems with the charging infrastructure at the Barcelona demonstration area.

Lastly, respondents had to score different criteria for compensation in case of problems. Respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. Figure 75 shows that all CPOs/eMSPs score rather poorly on the compensation criteria. A conclusion can be that the user seems to expect more in case of problems than what the CPO/eMSP currently offers. The ones that score best on average are Tesla and IBIL.

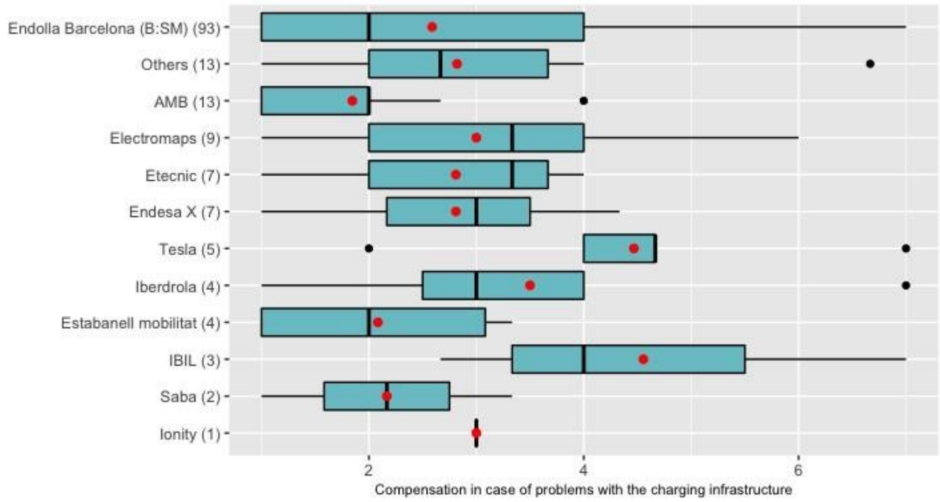


Figure 75 Compensation in case of problems with the charging infrastructure at the Barcelona demonstration area.

Finally, the last questions in this section probe for the respondents' opinions on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. Most CPOs/eMSPs score on average quite well on the perceived value criteria. Endesa X and IBIL score on average lower clearly than the others (see Figure 76).

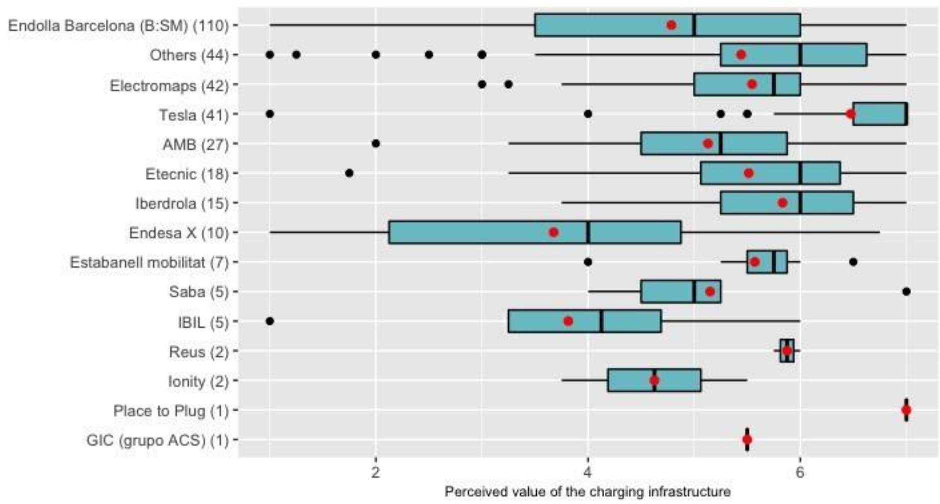


Figure 76 Perceived value of the charging infrastructure at the Barcelona demonstration area.

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. Aside from some outliers, Tesla scores clearly highest on the loyalty criteria (see Figure 77). Endolla Barcelona, again, receives a wide range of scores, resulting in an average of almost 4.5 out of 7. Electromaps seems to have loyal customers overall, with an average of almost 6 out of 7.

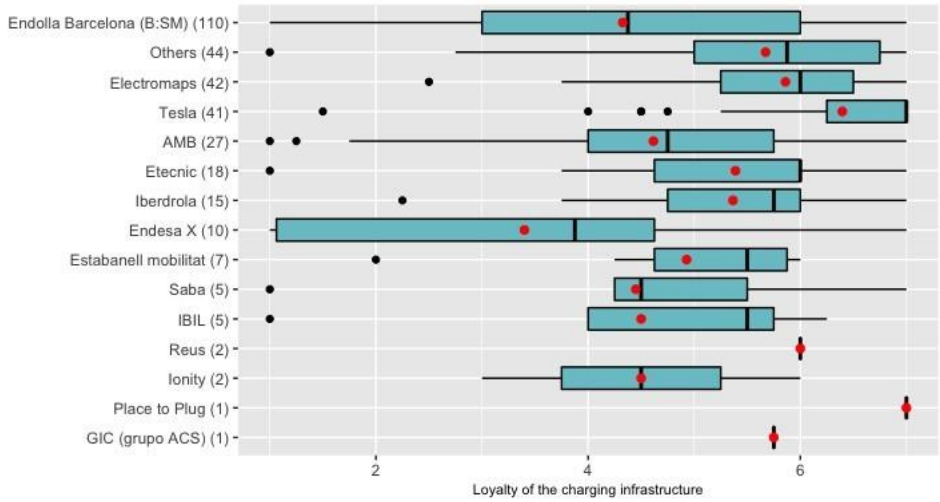


Figure 77 Loyalty of the charging infrastructure at the Barcelona demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the general trend in the earlier questions, the highest scoring CPOs/eMSPs are Tesla and Electromaps. Endolla Barcelona receives both low and high scores, resulting in an average of 4.26 out of 7 (see Figure 78).

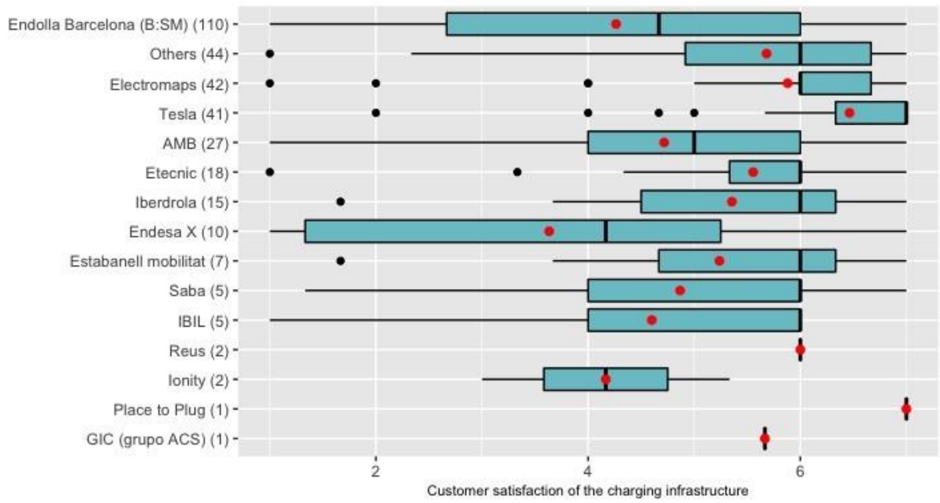


Figure 78 Customer satisfaction of the charging infrastructure at the Barcelona demonstration area.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future.

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future.

First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging options are the most popular with 56.90% of respondents choosing it.

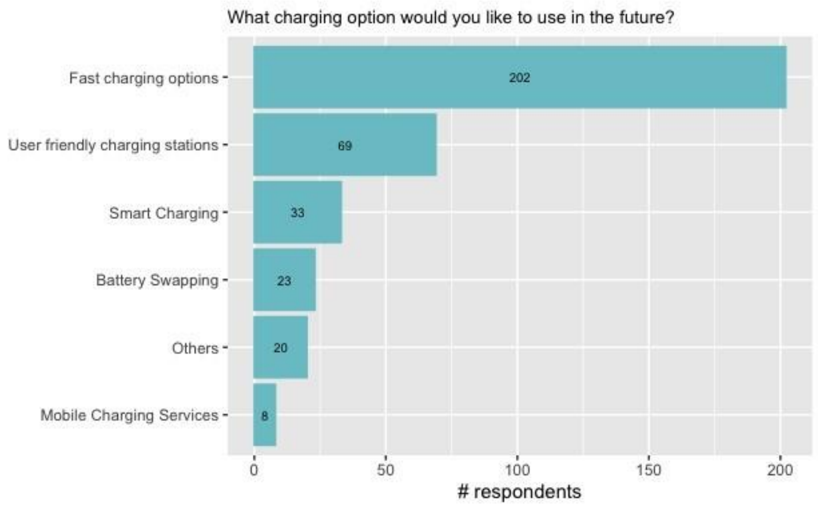


Figure 79 Most likely charging option in the future at the Barcelona demonstration area.

The fast charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration.

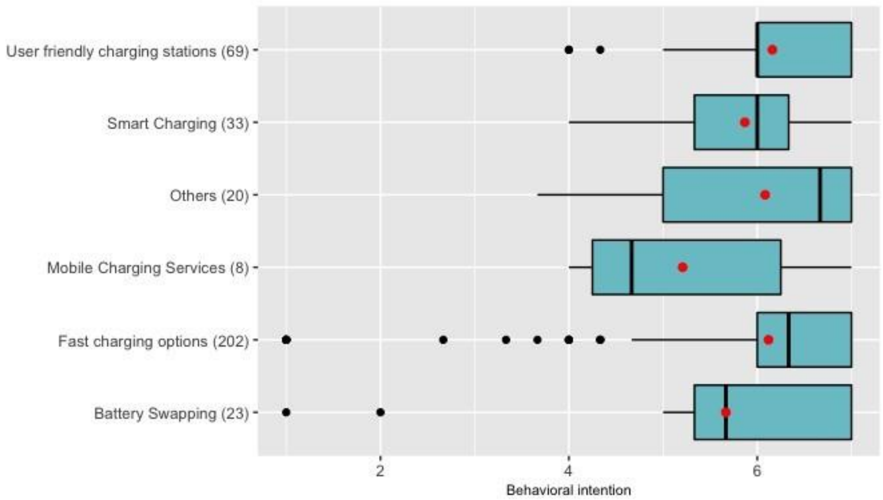


Figure 80 Behavioural intention of charging infrastructure at the Barcelona demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the fast charging option and battery swapping score highest on these criteria, aside from a few outliers (see Figure 81).

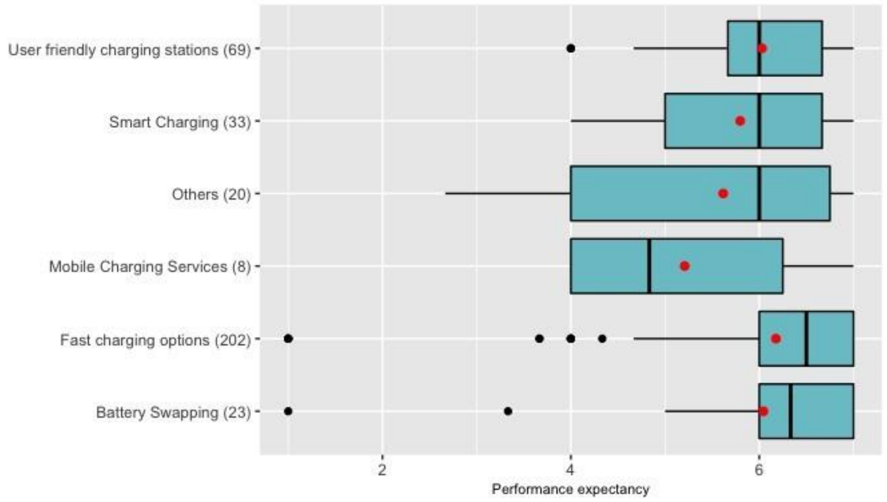


Figure 81 Performance expectancy of the charging infrastructure at the Barcelona demonstration area.

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. It is interesting to see that the scores for battery swapping vary more than other charging options, indicating that respondents expect some effort into getting acquainted with this charging option (see Figure 82). Less effort is expected for fast charging options and user-friendly charging stations.

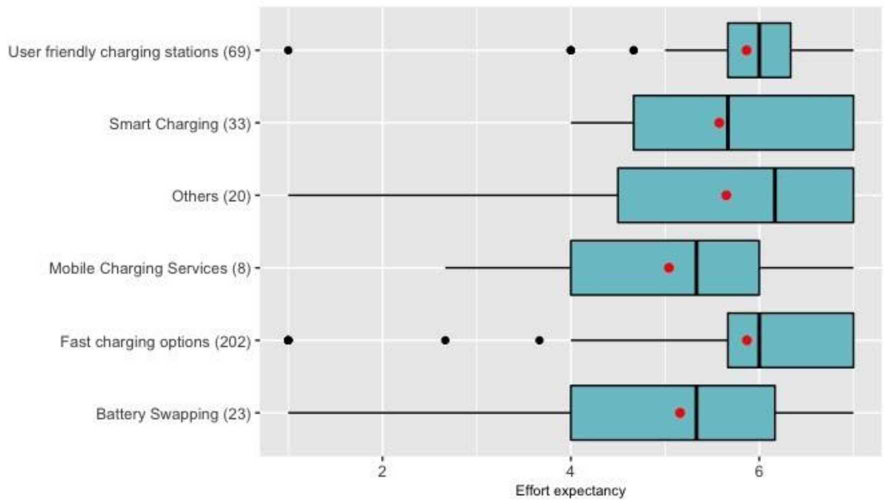


Figure 82 Effort expectancy of the charging infrastructure at the Barcelona demonstration area.

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 83). The averages and medians all lightly fluctuate between 4 and 5 on a scale of 7.

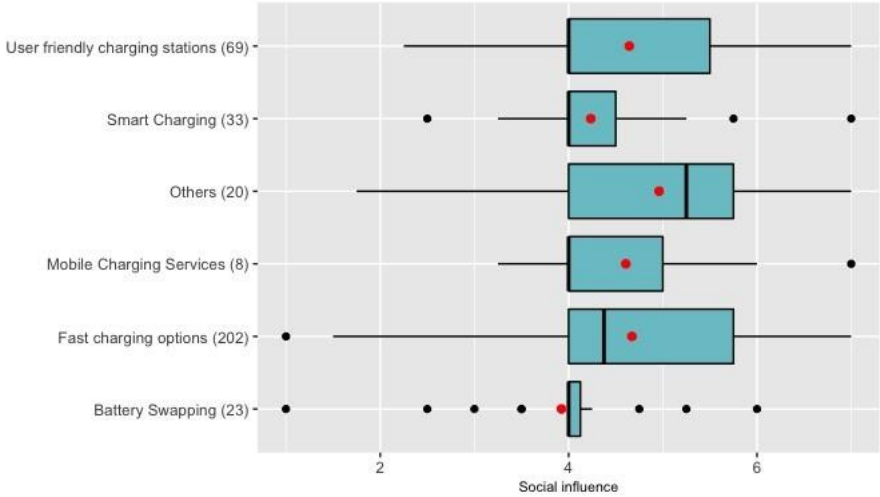


Figure 83 Social influence of the charging infrastructure at the Barcelona demonstration area.

In terms of facilitating conditions, the scores of the fast charging options are more skewed towards a 7 than the other charging options. On average visibly lower than the other charging options are battery swapping and mobile charging services (see Figure 84). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

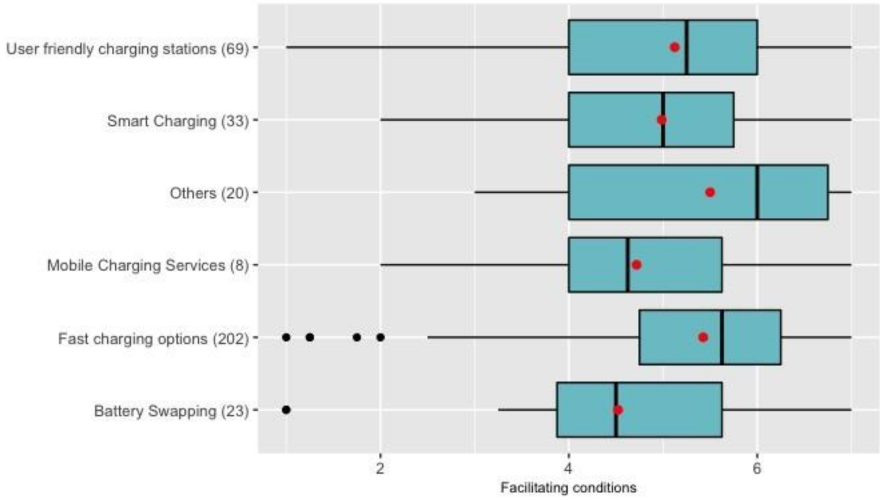


Figure 84 Facilitating conditions of the charging infrastructure at the Barcelona demonstration area.

As for hedonic motivation, quite similar distributions can be observed for the different charging options (see Figure 85). Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

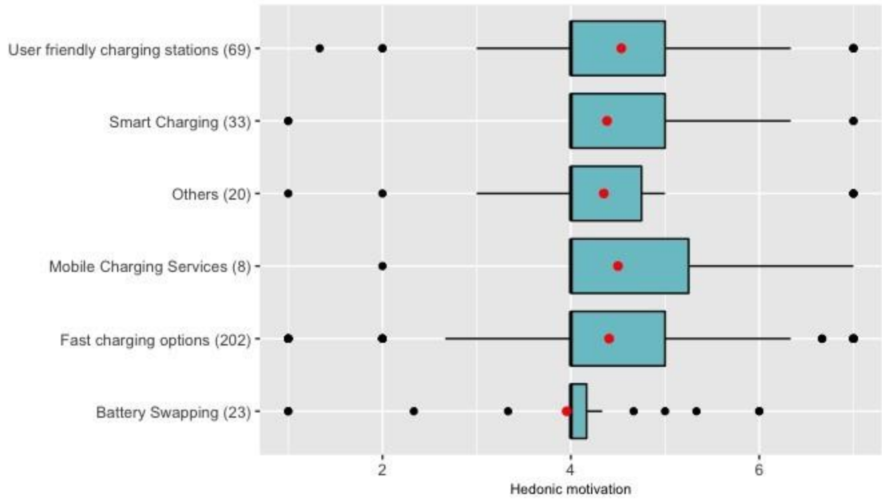


Figure 85 Hedonic motivation of the charging infrastructure at the Barcelona demonstration area.

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price was the same or whether they would only use it if the price was lower. Here, it is interesting to note that 50% of the respondents would not seem to mind paying more for fast charging options or battery swapping (see Figure 86). At the same time for smart charging, almost 75% indicates they would only use it if the price was lower.

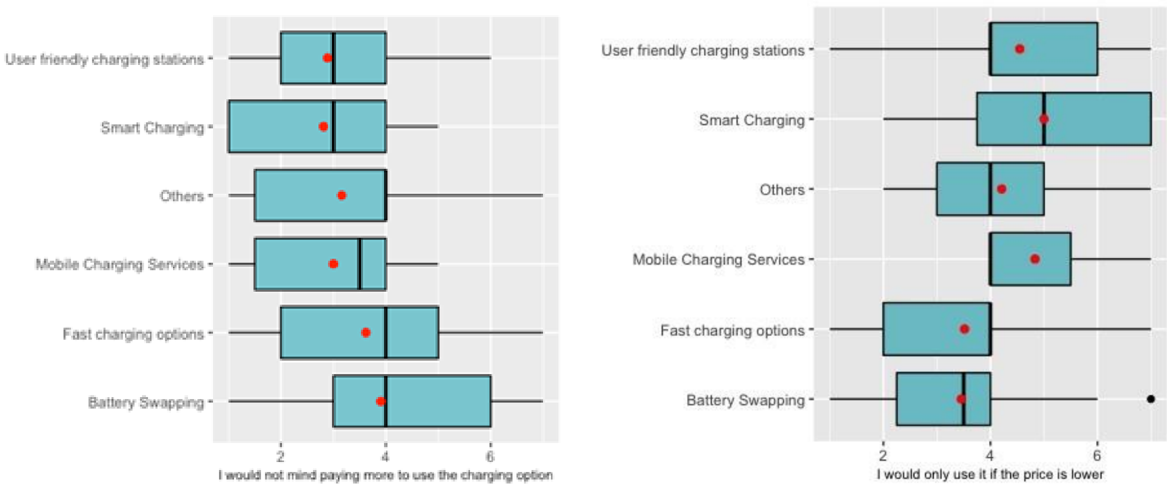


Figure 86 Price value of the charging infrastructure at the Barcelona demonstration area.

App-based services

Lastly, EV users were inquired on the use of app-based services. The majority of the respondents, 67.89% (241 respondents) indicated they use app-based services, another 23.38% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, a third of the EV respondents has 4 or more apps on their phone. About 85% of the app-based service users (205), use the app-based services at least a few times a month, as can be seen in Figure 87.

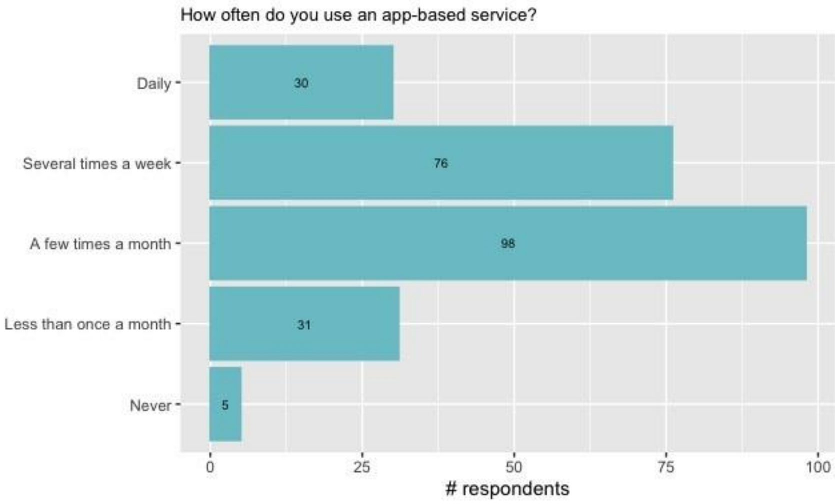


Figure 87 Usage of app-based services at the Barcelona demonstration area.

App-based services are mostly used for travel related to travel destinations on holiday (154 respondents), whereas 129 respondents use it for leisure activities. To a lesser extent, the app-based services are used for shop/errands (84 respondents) and commuting and work activities (68 respondents). In terms of satisfaction with the used app-based services, Figure 88 shows that 75% of the respondents are satisfied above average on a scale of 1 to 7.

Figure 88 Satisfaction with the app-based services at the Barcelona demonstration area.

LEV users

In this section, we zoom in to the 97 respondents who use a light electric vehicle. The majority of the respondents (62%) owns the LEV they use and are responsible for the LEV maintenance costs (61%). This is followed by users that drive a LEV owned by a sharing company (32%). At the same time, the majority of the respondents does not know what the battery capacity is or did not fill out this question (58%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 18.

Table 18 LEV characteristics at the Barcelona demonstration area.

Vehicle characteristics	Categories	N (%)
	Private	60 (62)

Owner of the LEV	Sharing company	31 (32)
97 responses	Company/Leasing company	6 (6)
Responsible LEV maintenance costs	Private	59 (61)
67 responses	Company	8 (8)
	NA	30 (31)
Battery Capacity – kWh according to respondents	< 0.5	2 (2)
	0.5-1	3 (3)
68 responses	1-3	1 (1)
	3-5	10 (10)
	5-7	8 (8)
	>7	17 (18)
	I do not know.	27 (28)
	NA	29 (30)
How often do they use the LEV	Daily	28 (29)
68 responses	Several times a week	28 (29)
	A few times a month	10 (10)
	Less than once a month	2 (2)
LEV parking	I use a garage that is my property or park on my driveway	29 (30)
68 responses	I use a fixed rented parking space	14 (14)
	I use a fixed car park which is my property	5 (5)
	I use a rented garage	1 (1)
	I do not use a fixed parking	17 (18)
	NA	31 (32)

On average, the LEV users indicate they drive about 54 km each day and spend about 1 hour and 15 minutes on the road. The majority of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 89).

Figure 89 Parking space and duration of the LEV at the Barcelona demonstration area.

Looking at the motives to use an LEV, it is clear that the most important motive is the Environmental friendliness, whereas least important is the image towards other people.

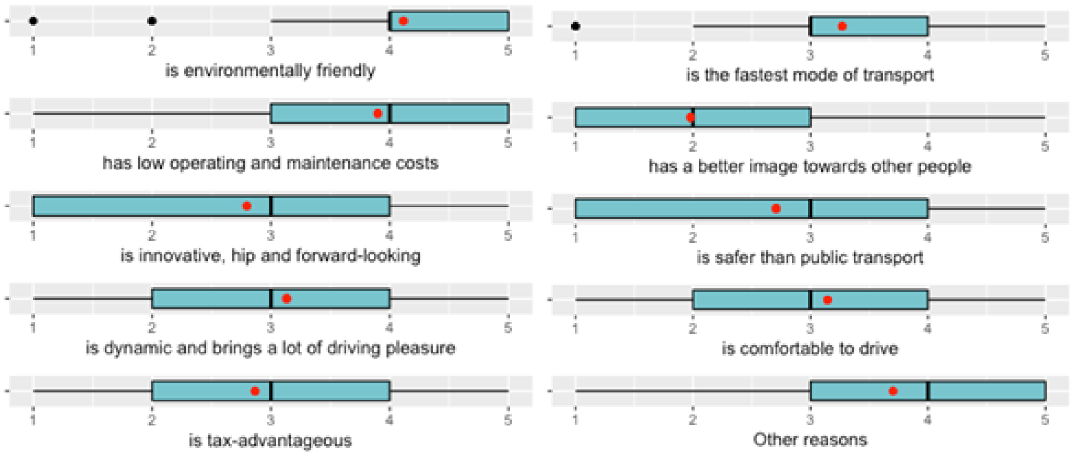


Figure 90 Motives to use LEVs at the Barcelona demonstration area.

In terms of charging behaviour, 75% of the respondents seem to charge when the battery falls below a certain level, or based on their next trip. Also, 75% of the respondents charge to take unexpected trips into account.

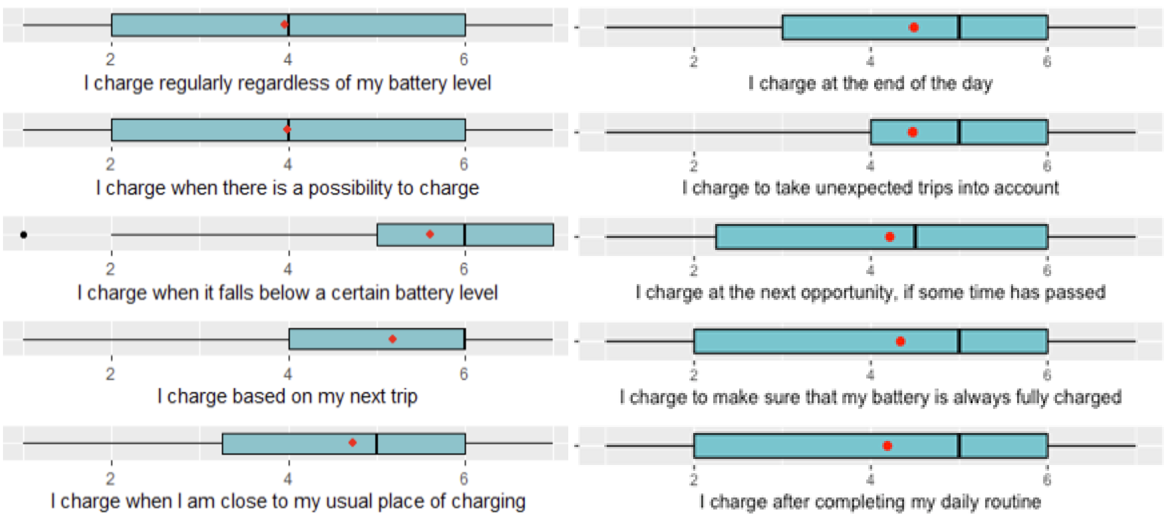


Figure 91 LEV charging behaviour at the Barcelona demonstration area.

Quality of Experience

Out of 97 respondents, only 33 respondents indicated that they used the service of a CPOs/eMSPs. Of these 33, 23 used Endolla Barcelona, 4 used Electromaps, 1 Etecnic, 1 Naturgy and 4 indicated others. As such, these samples are too small to make comparisons in terms of the charging infrastructure characteristics.

Figure 92 gives a view on the assessment of LEV users of Endolla Barcelona. On average, Endolla Barcelona scores rather satisfactory on all criteria. The tangibility and reliability of the charging infrastructure are most skewed towards the right. Also, is worth noting that for the privacy aspect, no scores lower than 3 were given by the respondents.

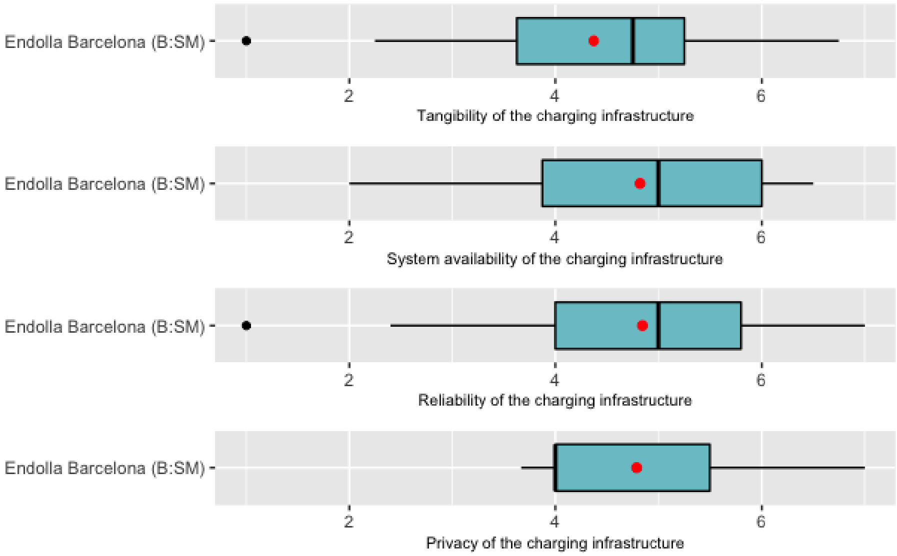


Figure 92 Assessment of the LEV charging infrastructure at the Barcelona demonstration area.

As for the assessment of Endolla Barcelona in case of problems with the charging infrastructure, the contact criterion scores best (see Figure 93). However, 75% of the respondents scores the responsiveness and compensation in case of problems lower than 4 out of 7.

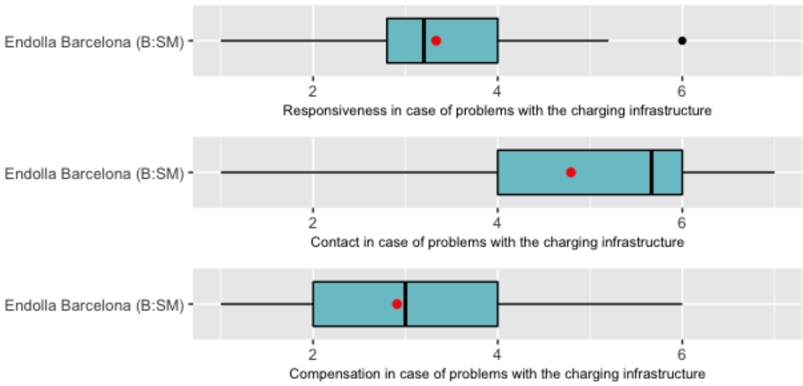


Figure 93 Assessment of the LEV charging infrastructure in case of problems at the Barcelona demonstration area.

Lastly, respondents indicate their satisfaction with the charging infrastructure in general as well as their perceived value and their loyalty to the CPO/eMSP. It is clear from Figure 94 that the majority of the LEV users is rather satisfied with Endolla Barcelona. Although some bad scores are reported, over 75% of the respondents indicate scores higher than 4.

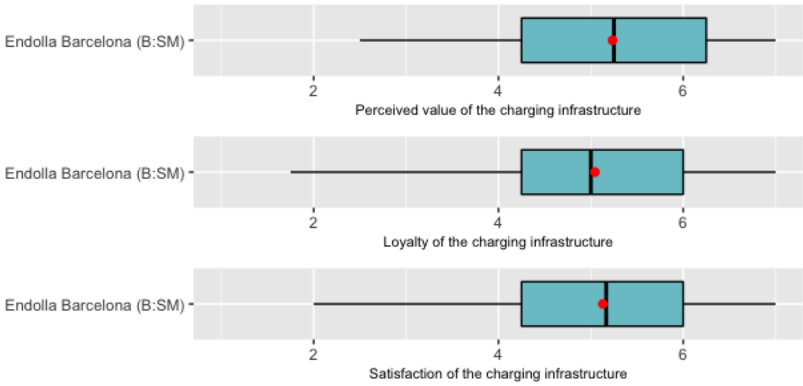


Figure 94 Satisfaction of the LEV charging infrastructure at the Barcelona demonstration area.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future.

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future.

First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging options are the most popular with 42.27% of respondents choosing they are most likely to use fast charging options in the future.

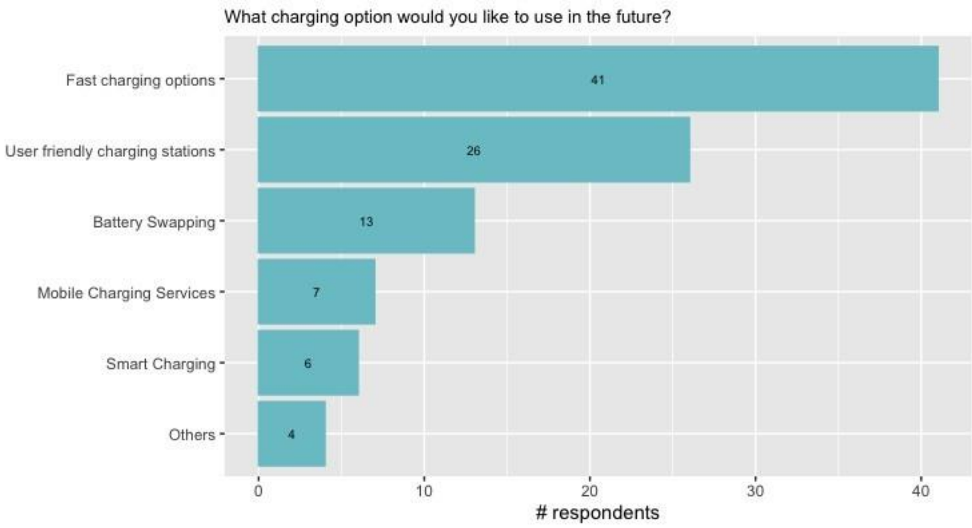


Figure 95 Preferred LEV charging option to use in the future at the Barcelona demonstration area.

Next, we take a closer look at the UTAUT constructs for the 2 biggest categories. Looking at behavioural intention, it can be seen in Figure 96 that the intention to use user friendly charging stations as well as fast charging options is rather high (aside from some outliers), where user friendly charging stations score somewhat higher on average.

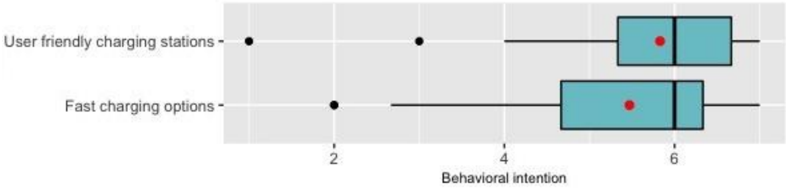


Figure 96 Behavioural intention for LEV charging options at the Barcelona demonstration area.

In terms of the performance and effort expectancy (see Figure 97 and Figure 98), the respondents evaluate both solutions well. Again, user friendly charging stations perform slightly better.

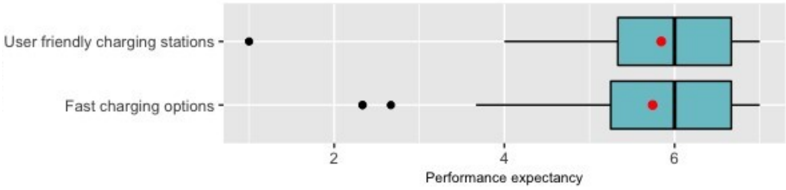


Figure 97 Performance expectancy of the LEV charging options at the Barcelona demonstration area.

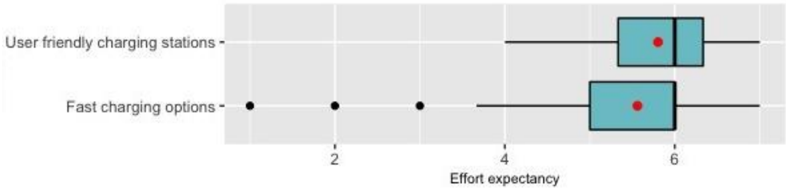


Figure 98 Effort expectancy of the LEV charging options at the Barcelona demonstration area.

In terms of facilitating conditions, 75% of the respondents range from neutral to completely agreeing with having the necessary resources and knowledge to use the charging option, and having the charging option be compatible with other forms they use. This is the case for both fast charging options as well as user friendly charging options (see Figure 99).

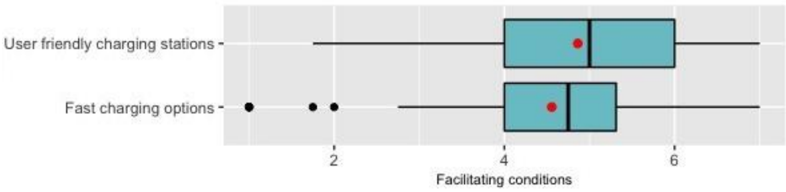


Figure 99 Facilitating conditions of the LEV charging options at the Barcelona demonstration area.

The social influence on using certain LEV charging options as well as the hedonic motivation are scored rather neutral on average (see Figure 100 and Figure 101). As such for social influence, respondents do not agree or disagree with the fact that people who are important or influence their behaviour think they should use this charging option. Neither are respondents influenced by whether a charging option is considered to be fun or entertaining, which is captured through the scores on hedonic motivation.

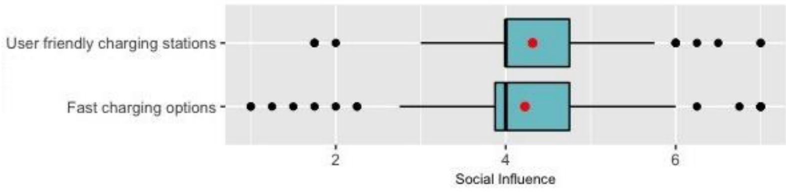


Figure 100 Social influence of the LEV charging options at the Barcelona demonstration area.

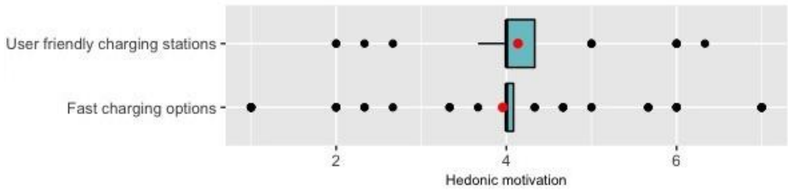


Figure 101 Hedonic motivation of the LEV charging options at the Barcelona demonstration area.

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 44.33% of the respondents, indicated they use app-based services, another 37.11% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. About 88% of the app-based service users, users this at least a few times a month, as can be seen in Figure 102.

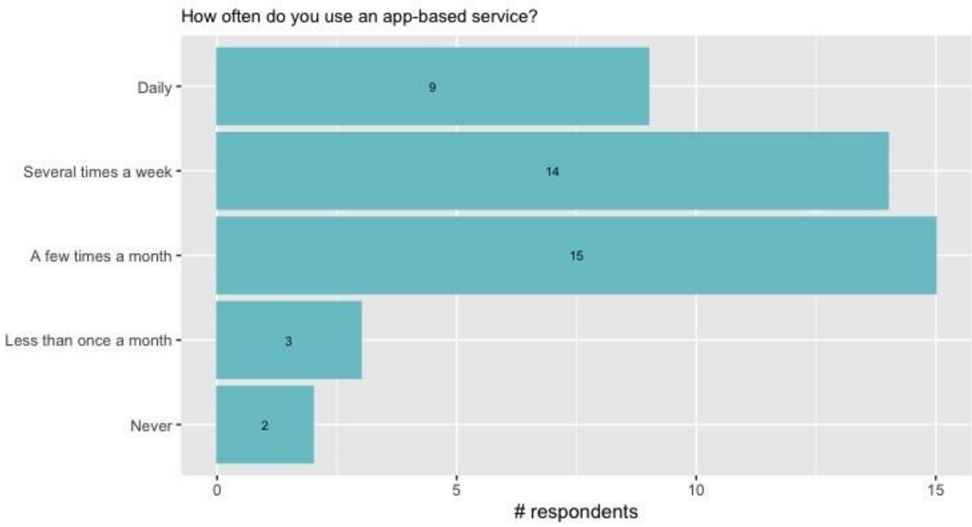


Figure 102 Usage of app-based LEV services at the Barcelona demonstration area.

While app-based services were most frequently used for trips related to travel to holiday destinations with the EV users, this is the least frequent usage for LEV users (only 21 respondents). LEV users use app-based services mostly for commuting and work activities (39 respondents), next for shop/errands (35 respondents), followed by leisure activities (31 respondents). In terms of satisfaction with the used app-based services, Figure 103 shows that 75% of the respondents are satisfied above average on a scale of 1 to 7.

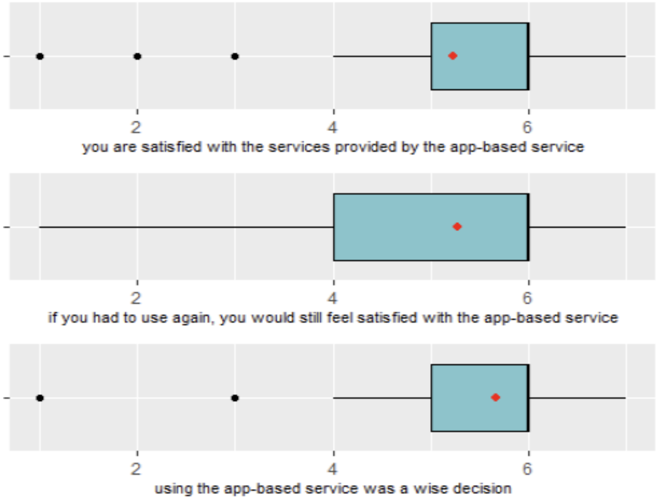


Figure 103 Satisfaction with the LEV app-based services at the Barcelona demonstration area.

Non-EV users

Lastly, we zoom into the non-EV users, a total of 499 respondents. Interestingly, over 50% of the respondents' state that they will buy an electric vehicle as soon as possible or state that it is very likely that they will buy an electric vehicle.

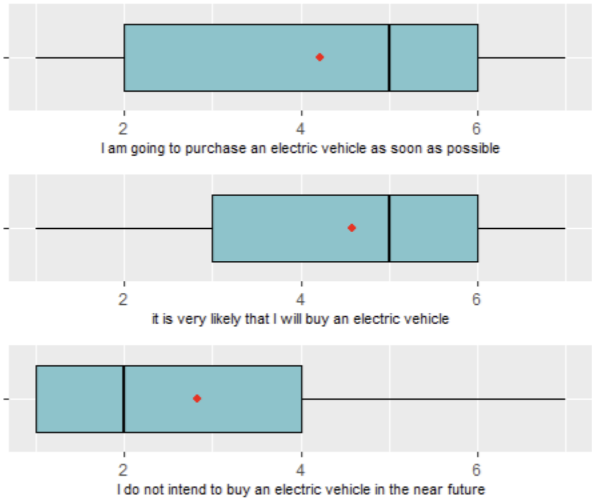


Figure 104 Non-users' Intention to buy an EV at the Barcelona demonstration area.

Moreover, most respondents (73.73%) indicate they are mostly interested to buy an electric car. Out of these 407 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (130 respondents), an electric vehicle with range extender (103 respondents) or a plug-in hybrid electric vehicle (126 respondents). The remaining 65 respondents prefer a hybrid vehicle that combines a classic combustion engine, 2 do not prefer any of the above.

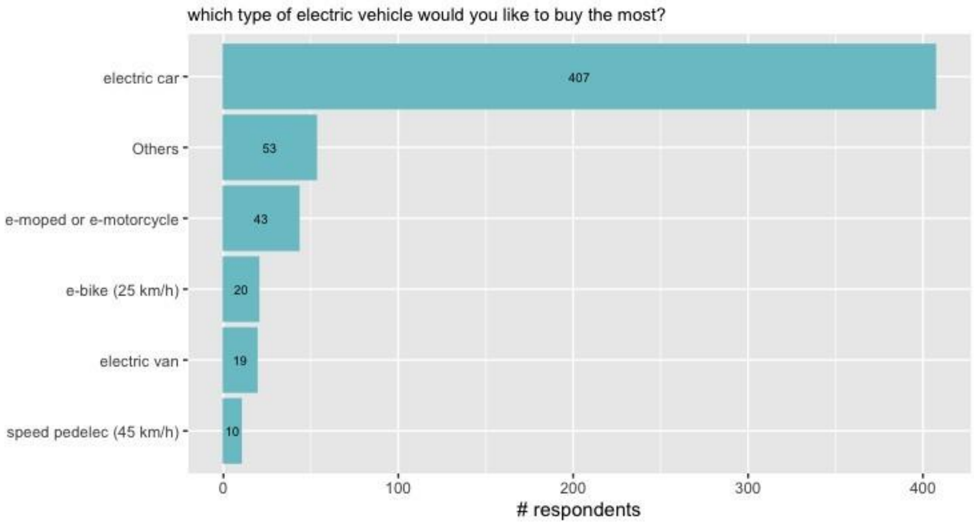


Figure 105 Type of EV that non-users intend to buy at the Barcelona demonstration area.

Lastly, the most important motives for non-EV users to purchase an EV in the future is the Environmental friendliness and the fact that EVs have more efficient technology in terms of energy consumption as 95.39% respectively 96.79% considers this moderately to extremely important. At the same time, the least important motive is the better image EVs could have towards other people as 63.13% of the respondents consider this not important at all to slightly important.

Key findings of the Barcelona report

The main reasons for electric car adoption the environmental friendliness, the low operating and maintenance costs, the reduction of noise, and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, the big part of electric car owners' charges mostly at home, as 64% of the respondents charge daily to several times a week. This can also be seen in the chart of charging time (Figure 8), where the users charge overnight and in the evening. It is remarkable that little charging takes place during the day, as the least frequent charging place at the workplace, where almost two third of the respondents (63%) indicate that they never charge at work. In general respondents are satisfied with the quality of service they receive from the CPO/eMSP they charge with. Especially Tesla and Electromaps, who scores high on perceived value, loyalty towards the CPO/eMSP and the customer satisfaction. The largest CPO in Barcelona, namely Endolla Barcelona (B:SM) scores low on average, more specific on tangibility, availability of the charging station, in case problems arise and therefore the customer satisfaction is low. Improvements can be made when problems arise at the charging station, as the responsiveness and compensation score low, meaning that where customers are not quite satisfied with the after sales-services. Fast charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use. But overall, users have great interest and belief in all the future charging options (user friendly charging stations, smart charging, battery swapping and mobile charging), which means people are looking forward to the future charging options. Respondents expect that the prices of smart charging, mobile charging stations, and user friendly charging station are lower than the prices of current charging options. For fast charging and battery swapping they expect a similar price or a slightly higher price than current charging options.

LEV users mainly bought their LEV because the Environmental friendliness and the low operating and maintenance costs. In terms of charging behaviour, 75% of the respondents charge to take unexpected trips into account. In general respondents are very satisfied with the quality of service they receive from Endolla Barcelona (B:SM), and therefore the perceived value, loyalty towards Endolla Barcelona (B:SM) and the customer satisfaction are high. Fast charging is the most preferrable charging option in the future, but respondents indicate that user friendly charging stations will be the charging option that will be the easiest to use.

Lastly, more than half of the non- EV users states that they will buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (74%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the Environmental friendliness (95%) and more efficient technology in terms of energy consumption (98%) in comparison with non-EVs. At the same time, the least important motive is the better image EVs could have towards other people as 63% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV car users.

Field data analytics

This section encompasses the insights and findings of the data analytics for the city of Barcelona. In this demonstration area, there are two different data providers: B:SM and Electromaps, In the case of Electromaps, the dataset covers the whole Spanish territory, which allows the evaluation of the long-distance trips in the country.

It should be noted that, since the data used for this analysis comes from different data providers, several data adjustments have been applied in order to combine the records of both providers. For instance, data from Electromaps shows a wide range of different power levels (from 2 kW to 50 kW) whereas B:SM show only 4 different power levels (3 kW, 7 kW, 43 kW and 50 kW). Since B:SM also makes a distinction on these levels grouping them into “Slow”, “Semi-fast” and “Fast” chargers, the data from Electromaps is also grouped following this distinction.

As a result of the data processing and merging, two final datasets are created at local and national level: i) one for the Barcelona city combining the CP datasets provided by BSM and Electromaps, and ii) one for the whole Spanish territory based on the dataset provided by Electromaps. The attributes for each of the two datasets are shown in Table 19. Note that, except for the User mobility flows part, only the Barcelona dataset will be used.

Table 19. General information for the Barcelona demonstration area

Attribute	Barcelona	Spain
Users	10705 users	5755 users
Provinces	Barcelona	Alicante, Almería, Ávila, Badajoz, Barcelona, Cáceres, Cantabria, Castellón, Cuenca, Girona, Granada, Huesca, La Rioja, Lleida, Madrid, Málaga, Murcia, Navarra, Ourense, Palencia, Sevilla, Teruel, Valencia, Zaragoza
Operators	BSM and Electromaps	Electromaps
Charging Points	426	205
Sessions	229052	71465
Time range	16/05/2018 – 17/11/2020	01/01/2019 – 21/09/2020
Power levels	BSM: 3 kW, 7 kW, 43 kW, 50 kW Electromaps: Multiple different levels for Power ranging from 2 to 50 kW.	Multiple different levels for Power ranging from 2 to 50 kW.

Descriptive Statistics

This subsection will cover the results found for the Barcelona demonstration area’s descriptive statistics analysis.

- **Sessions’ geographical distribution**

Figure 106 shows the heatmap of sessions happened in Barcelona, taking into account the Barcelona dataset. It can be noted that the number of charging sessions in the publicly available CPs is significantly higher in the Sarrià-Sant Gervasi, Les Corts and Sants-Montjuic districts and some parts of Gràcia and L'Eixample districts, which generally represent high-income users with car ownership, with a total of approximately 400 sessions. There are also a notable number of sessions in Ciutat Vella district, which is an area with significant commercial activity in the city. The lowest activity is found in Horta-Guinardó, Nou Barris and Sant Andreu districts, which are more residential areas.

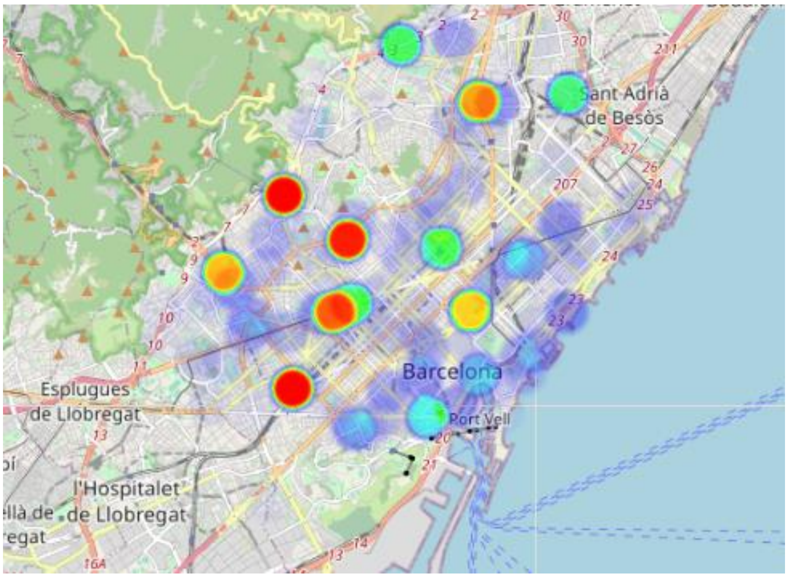


Figure 106. Heatmap of charging sessions in Barcelona

- **Charging Power analysis**

In the city of Barcelona there is a high predominance of slow CPs (443 unique CPs) compared to semi-fast (12 CPs) and fast CPs (39 CPs). However, when we analyse the total number of sessions very similar values are obtained, both in the case of slow and fast CPs (see charts in Annexe A3). The ratio between the total number of charging sessions per charging technology and the number of connectors of the same technology has been calculated in order to understand how popular each type of connector is. The results are illustrated in Figure 107 proving that fast charging is the most preferable technology with a prominently higher ratio of charging sessions per number of CPs, i.e. with approximately 5000 sessions per CP, almost 5 times higher than the ratio for the slow charging points.

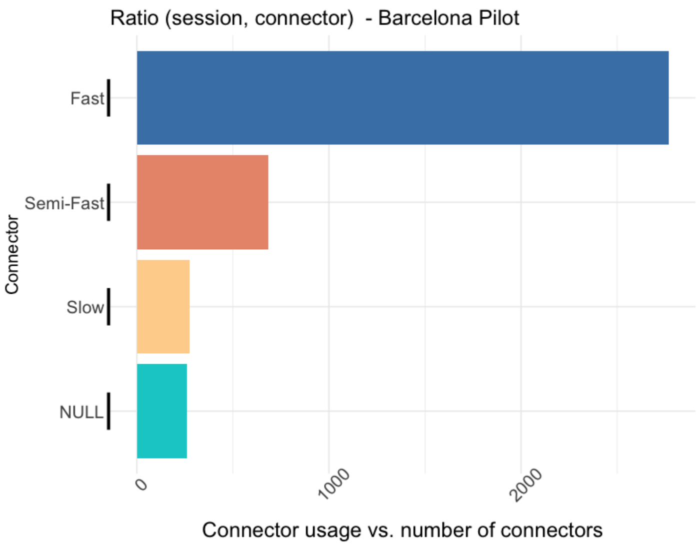


Figure 107. Ratio of total sessions per connector power level divided. By the total number of connector power types

- **On-street VS Off-street stations' analysis**

Barcelona has CPs located on-street and off-street. In order to understand the usage profile difference between these two categories, Table 20 shows the number of sessions occurred for off-street and on-street CPs, and which charging technology is used for each category (when this information is available). It must be noted that there 53% of the sessions are not considered in this table either because the charging power is undefined or the off-street/on-street classification is unspecified. It can be inferred that fast charging is the predominant charging option in case of on-street CPs, whereas since all off-street CPs are slow, all the charging sessions are slow.

Table 20. On-street and off-street charging station distribution by connector power type

	Off-street	On-street	Total
Slow	81534	13282	
Semi-Fast	0	27	27
Fast	0	51744	51744
Total	81534	65053	146587

From the temporal point of view, it can be inferred that users choose the off-street charging stations during the weekdays, whereas there is higher tendency to use on-street charging stations during the weekend (Figure 108).

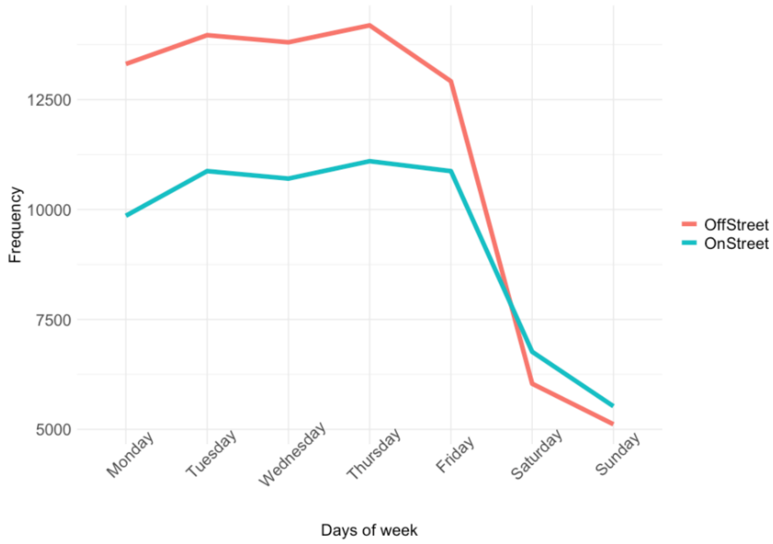


Figure 108. On-street vs. Off-street usage distribution by days of week

- **Sessions' temporal distribution**

As shown in Figure 109, the users prefer to use the charging stations during the weekdays much more than the weekend. During the weekdays, there is a peak in the morning between 7 am and 8 am, and it is followed by another peak at noon from 12 pm to 1pm and another from 6pm to 7pm. During the weekends, there is no morning peak between 7 am and 8 am, but instead there is one from 4 am to 5 am. The other two peaks (12-1pm and 6-7pm) are also valid for the weekends.

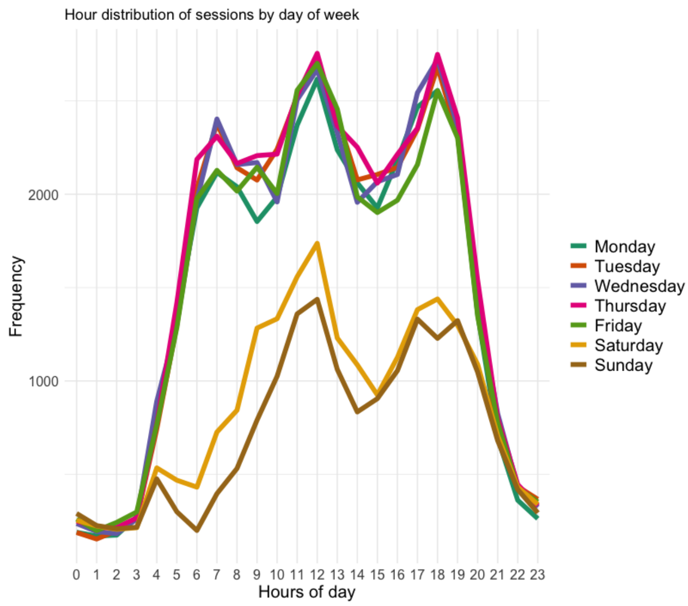


Figure 109. Sessions' temporal distribution – Barcelona demonstration area

- **Charging sessions' duration**

The boxplots in Figure 110 and Figure 111 are used to graphically depict in a standardised way the distribution of the parking duration based on a six-number summary (minimum, first quartile, median, mean, third quartile, maximum). From Figure 110, that shows the boxplots for the on-street CPs in the Barcelona demonstration area, it can be inferred that in average the duration is higher in the slow CPs, followed very closely by the duration of the semi-fast CPs. In the case of fast CPs, the average duration is low but there's a high number of outliers, this means users performing really long durations compared to the average.

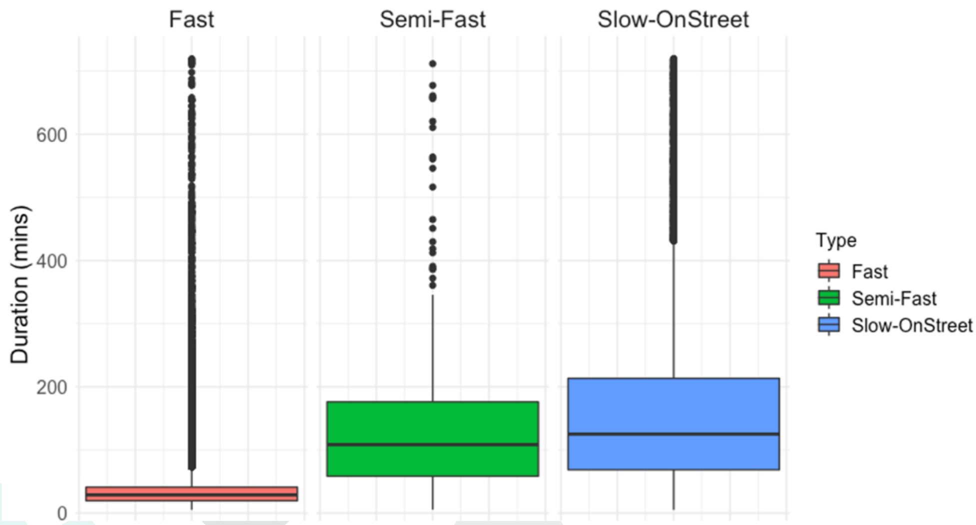


Figure 110. Boxplot of sessions duration for fast, semi-fast and slow on-street CPs – Barcelona demonstration area

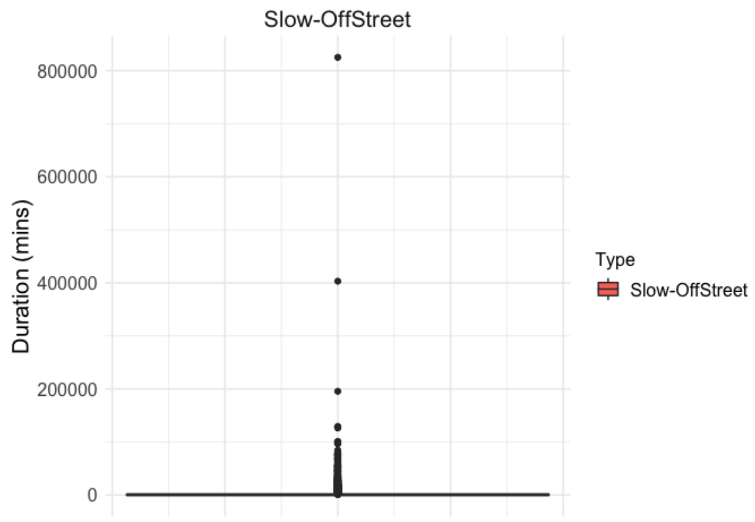


Figure 111. Boxplot of sessions duration for slow off-street CPs – Barcelona demonstration area

Figure 111 represents the values of duration for the slow CPs located in the BSM parkings, in this case users perform really long sessions, and the number of outliers is high, as we have users that leave their vehicle parked for a long time after their battery is fully charged. Table 21 presents the main statistical values of the sessions' duration, from the table we can infer that 50% of the sessions performed in fast CPs are between 19.5 minutes and 41.1 minutes. That users spend an average of 2h and 43 minutes (163 minutes) in slow on-street CPs and that 50% of the sessions of slow off-street CPs are between almost 3 hours (177 minutes) and 13 hours (837 min) and a median of 8hours and 23 minutes (503 min).

Table 21: Summary of statistical values for sessions' duration – Barcelona demonstration area

Fast Chargers					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
5.0 min	19.5 min	28.8 min	36.8 min	41.1 min	719.5 min
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
5.2 min	59.9 min	129.5 min	169.5 min	230.8 min	718.6 min
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
5.0 min	68.5 min	125.0 min	163.6 min	213.4 min	720 min
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
5.0 min	177.3 min	503.8 min	886.7 min	837.2 min	825120.2 min

- **Energy consumed per session**

Complementary to the duration of sessions, it is important to analyse the energy consumed in these sessions in order to understand the energy needs of the users of the Barcelona demonstration area. In order to get realistic results of this analysis, some filters have been applied to the original dataset: the sessions that that show more than 100 kWh and less than 0.001 kWh are filtered out to avoid irrelevant outliers. As an addition, actual power (energy consumed / duration) with a 20% than the theorical power of the station is applied for filtering.

Figure 112 shows the boxplots of the energy consumed at each session for each type of charger. It can be noted that all the rectangles are quite narrow and the values inside them are quite low, this means that most of the sessions consume less than 15kWh. Furthermore, we can see that in all the cases we have some outliers (as individual points in the boxplot with high values).

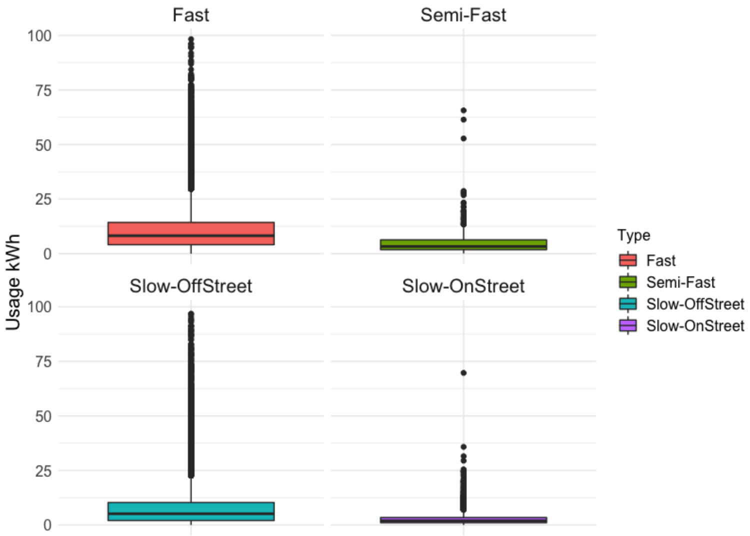


Figure 112. Boxplot for sessions' energy consumed – Barcelona demonstration area

The main statistical values for the sessions' energy consumed with the applied filters are shown in Table 22. It should be noted that fast CPs noticeably show more energy spent per session compared to the rest of the connectors.

Table 22. Summary of statistical values for sessions' energy consumed – Barcelona demonstration area

Fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.001 kWh	4.1 kWh	8.2 kWh	10.8 kWh	14.3 kWh	98.3 kWh
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.099 kWh	1.8 kWh	3.3 kWh	5.2 kWh	6.3 kWh	65.6 kWh
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.001 kWh	2 kWh	5.8 kWh	7.8 kWh	10.4 kWh	86.7 kWh
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.01 kWh	1 kWh	2 kWh	2.6 kWh	3.4 kWh	69.7 kWh

User Clustering

Even though the duration and usage information are not 100% reliable due to the outliers representing longer parking durations compared to the charging ones, it is still relevant for the user clustering to keep the real numbers. The user behaviours (whether allowed or not) based on durations will be used as how they are in order to obtain the real characteristics of the users. According to Annexe A1.2, the automated process with a predefined function in order to detect the optimal number of clusters and proper clustering method shows that the best option is *kmeans* method with 3 clusters.

Table 23 User clusters – Barcelona demonstration area

User Cluster 1	User Cluster 2	User Cluster 3
1768 users (86.16 %)	80 users (3.9 %)	204 users (9.94 %)

The user Cluster 1 includes the majority of the users (86%) and comprises users that have low number of sessions, consume more energy per charging session than the average, an average power of 25 kW and short sessions duration. User Cluster 2 includes the regular users (high number of sessions) using usually the slow CPs and high average duration (around 13 hours). User Cluster 3 includes users with similar values to the average but a bit lower. These users, on average, spend 11 hours with their vehicle connected to the CP and consume 5kWh per session. The following figure shows for each of the analysed parameters (av_dist, av_ekWh, …) how each cluster behaves compared to the mean.

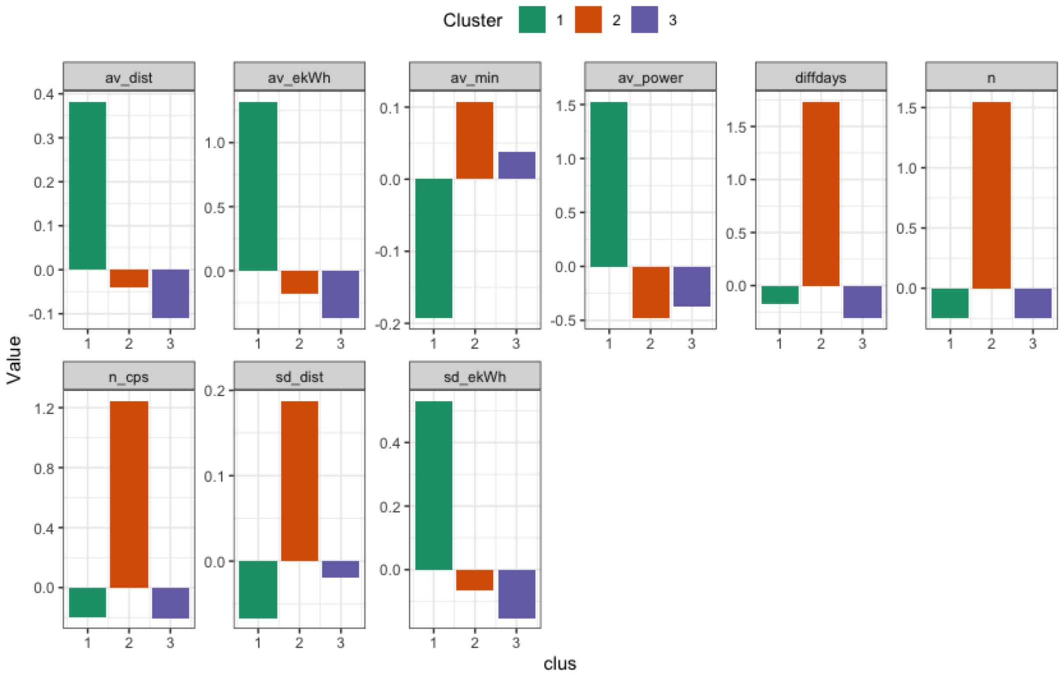


Figure 113. User clustering results – Barcelona demonstration area

Temporal Clustering

The charging stations are clustered based on their temporal occupancy behaviours. Again here, the automated clustering method and optimal number of cluster detection is done, and the results shows that the best option is *kmeans* method with 2 clusters.

Table 24 Temporal clusters – Barcelona demonstration area

Temporal Cluster 1	Temporal Cluster 2
367 CPs (79.1 %)	97 CPs (20.9 %)

In Figure 114, the horizontal axis represents the from 0 to 23 hours and the vertical axis is the occupancy percentage that is calculated within each individual cluster. Temporal Cluster 1 is the major cluster and contains 79% of the CPs, with generally less activity than CPs belonging to Cluster 2. Both Clusters show a peak in the morning, in Cluster 1 the peak is at 5 am and in Cluster 2 is at 8 am.

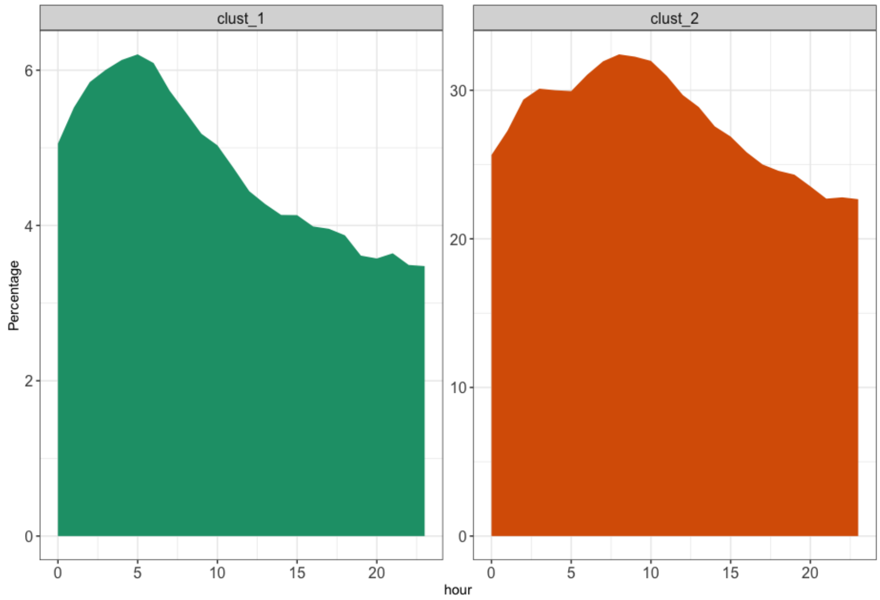


Figure 114. Charging Points' temporal clusters' hourly session distributions – Barcelona demonstration area

Figure 115 presents the CPs from the city of Barcelona, in green the CPs belonging to Cluster 1, and in orange CPs belonging to Cluster 2.

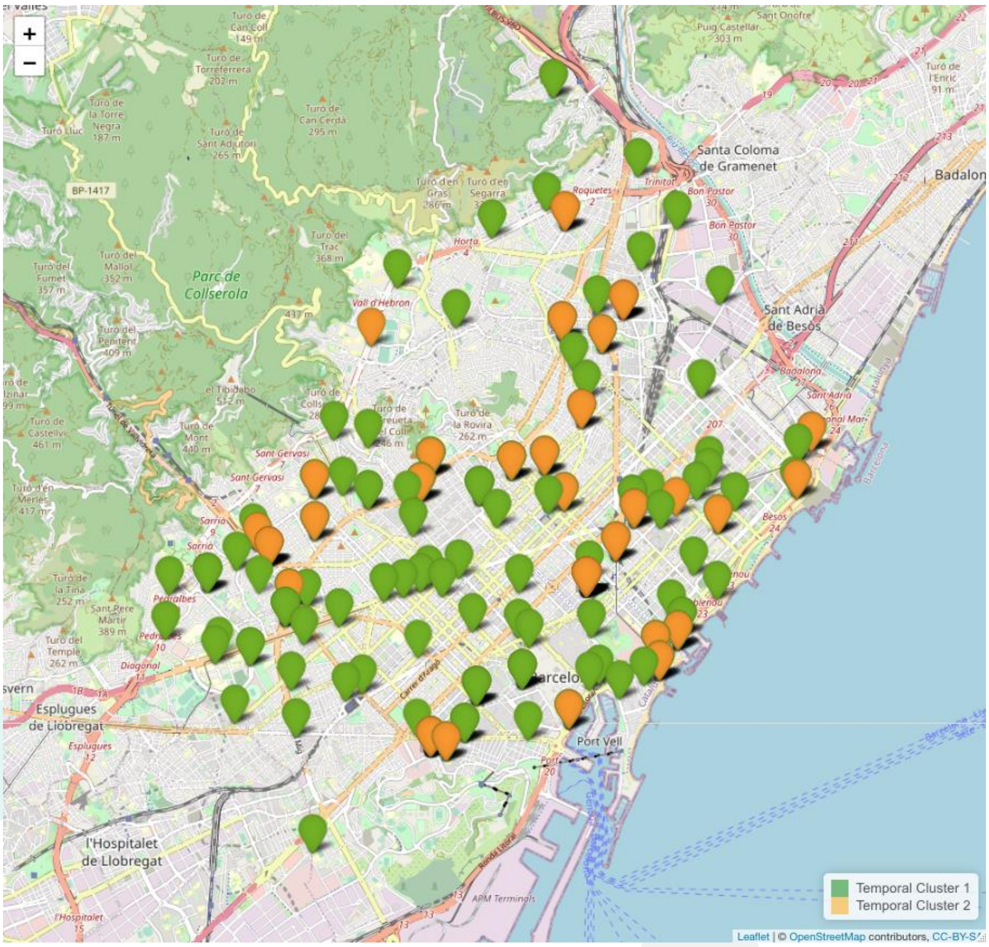


Figure 115. Charging Points temporal clustering geographical distribution – Barcelona demonstration area

COVID-19 Effect

The following time periods have been established for the analysis of the COVID-19 effect in the Barcelona demonstration area:

Pre-COVID-19: 2020-01-15 – 2020-03-13
Lockdown: 2020-03-14 – 2020-05-17
De-escalation: 2020-05-18 – 2020-06-21
New-normality: 2020-06-22 – 2020-09-01

It should be noted that the new normality period corresponds to July-September 2020, which should not be considered as a fully "standard" new normality period since it covers the summer period, where the mobility is normally reduced due to holidays. Figure 116 shows the variation of significant parameters related to charging activity. The conclusions of this analysis are as follows:

- The number of users and the number of sessions dropped significantly when the lockdown was imposed in Barcelona, from 1145 to 404 active users (a decrease of 65%) and from 398 to 118 sessions per day (a decrease of 70%). The reduction was similar for both on-street and off-street CP locations. The numbers were partially recovered during the de-escalation period and finally, the new normality showed an increase in the number of users compared to the pre-COVID-19 scenario, contrary to the average sessions per day, which still show a reduction of a 37% compared to the pre-COVID-19 scenario.
- As for the duration of the sessions, it can be inferred a very high increase in the time the users spent on each charging station, with the average value varying from 11 hours during the pre-COVID-19 period to 60 hours during the lockdown. Looking at the medians, the value for the median duration varies from 1 hour during the pre-COVID-19 period to 2 hours during the lockdown period. The difference between the median and average comparisons is due to the existence of outliers that spend an excessive time in the CPs (for example 69 days) and that make the distribution more scattered. Regardless of this fact, the increase of duration shown during lockdown is probably caused by users leaving their car parked at the CPs due to the mobility limitations. Once reaching the de-escalation and new normality, the figures recover similar values to the pre-COVID-19 period.
- The average occupancy of the CPs and the daily energy consumed by user show a slight increase during the lockdown period. The increase of the daily energy consumed per user may be caused by users parking their vehicle at a CP strictly for charging, whereas prior to COVID-19, some users might have parked at a CP just because they needed a parking spot.

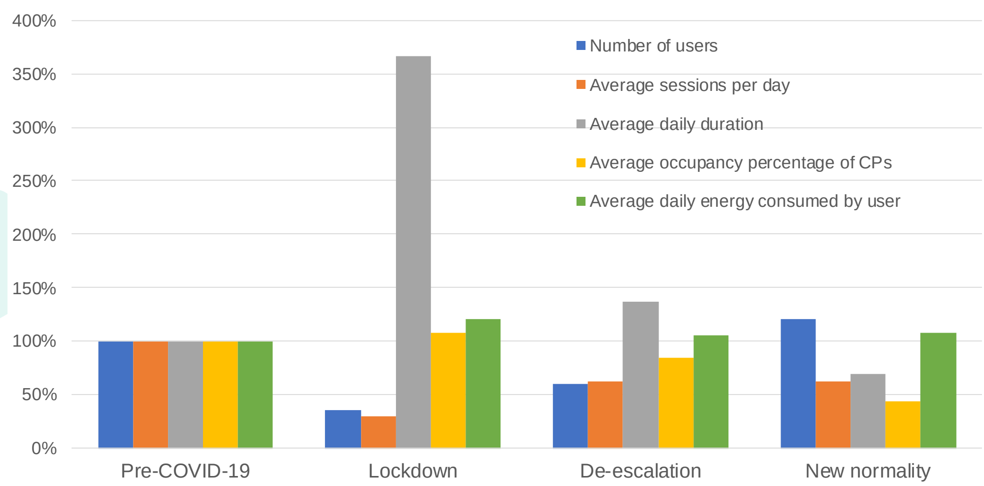


Figure 116. Variation of charging parameters with relation to the pre-COVID-19 period – Barcelona demonstration area

A priori assessment of the e-mobility charging infrastructure

The following Table shows the KPIs defined in T1.1 that could be measured with the Barcelona demonstration area data:

Table 25. Usage KPIs – Barcelona demonstration area

Impact Area: Usage	Result
Loyalty to the same charging option	15.1 % of users reused the same charging point more than 5 times between 16/05/2018 and 17/11/2020.
Frequency of use of charging options	287 is the average of uses of each charging point between 16/05/2018 and 17/11/2020
Vehicle's charging time	All: 359 minutes Slow: 650 minutes Semi-Fast: 442 minutes Fast: 33 minutes
Availability rate (1)	42% of the charging options are occupied more than 10%.
Availability rate (2)	43% of the charging points are occupied less than 5%
Average usage ratio of charging options	11% is the average ratio.

Conclusions

The data processing step has been the most crucial phase for this pilot due to its different data sources, databases, standards, formats and providers.

The analysis provided an overview of the usage for publicly available charging stations managed by B:SM and Electromaps. The users from these Charging Stations prefer the slow chargers, as they have the highest number of sessions occurred, although, if we consider the usability of the CPs (the ratio between the number of sessions and the number of charging points), fast CPs are the ones with the highest ratio. The users tend to use the off-street chargers during weekdays, whereas they prefer on-street chargers during weekends. The weekdays have similar distribution of charging point usage and have much higher values than the weekends. The clustering processes provided 3 different clusters for user based on usage behaviours and 2 different clusters for the charging point stations based on temporal distribution.

By analysing the charging sessions at national level with the data from Electromaps we can conclude that most of the sessions happened within the same province (87%). The most significant corridor flow considering Barcelona as the origin or destination point is from Barcelona to Girona. The furthermost province from Barcelona is the Alicante province.

Demonstration area 3: Bari

Context

The city of Bari is engaged in an eco-sustainable urban regeneration process. Bari has been the first city in the south of Italy developing an electric car sharing service. From 2016 until the end of 2017, the Municipality of Bari activated the “GirACI” Car Sharing service with 30 full electric cars in circulation with

24 parking areas scattered around the city. The service reached 1455 subscribers with 700 active customers with an average distance of 11 km. This car sharing service closed on 31 December 2017, and today there is no electric car sharing service in Bari.

In 2020, the number of electric cars has grown compared to previous years. The full hybrids and electric cars have doubled, from 2019 to 2020, the plug-in hybrids cars have had an even greater percentage growth. According to the PUMS, the installation of 50 charging stations for electric cars is planned in the next years. The Metropolitan city of Bari is a city on the Scandinavian-Mediterranean corridor which provides about 75 charging stations to EV users: 35 in the city centre of Bari.

Furthermore, to maximise the efficiency of the recharging infrastructures, the Puglia Region planned in the "Active Network Project" the construction on a regional scale of public recharging infrastructures for electric vehicles integrated into the electricity network. In particular, ENEL X will install approximately 70 interoperable electric charging stations in the municipalities, along the ring roads and the fast-travel routes leading to the main urban centres of the region, with the installation of two different types of charging infrastructure:

- Pole Station, capable of managing two recharges at the same time and guaranteeing the vehicle battery recharging in about 2 hours;

- Multifast recharge, capable of managing 3 recharges at the same time and guaranteeing the recharge of most electric vehicles in about 20/30 minutes.

In Apulia region, those who buy an electric vehicle enjoy an exemption from the payment of the car tax starting from the first registration and a discount from the purchase price. At the end of this period, an annual amount equal to one-quarter of that due to the corresponding petrol vehicles must be paid. Unlike other big Italian cities, the municipality of Bari has not provided any benefits for those who want to access the limited traffic zone (ZTL) with an electric or hybrid vehicle or to park for free in the public parking spaces.

Among the payment charging options in Bari, there is a subscription of about 25 euros per month, with an unlimited number of charging. If you want to top up from home, there is a rental fee for an additional meter that costs an average of 60 euros per month which can be made out to a single user, or you can recharge the car through a normal power outlet, the costs of which will go into the electricity bill.

Data collection for the survey

The three surveys of T1.2 of eC4Drivers project (general users, taxi and fleet owners), have been widespread in the city of Bari according to the following communication means:

- by promoting and posting the survey for the general users through the social media channels (Facebook, LinkedIn) and web page of POLIBA and municipality of Bari. The following figure shows the web channels used to widespread the survey;

- by contacting directly by emails all the professors, students, administrative employees of POLIBA;

- by organizing specific online meetings with the fleet owners and taxi companies, presenting the eC4Drivers project and the survey and by emailing the link of the survey.

Table 26 reports the companies that have been contacted and involved in the surveys.

Table 26. The involved companies in the survey

Company name	Type of survey (General/Taxi/delivery)	Type of respondent (EV/LEV/Non-EV/van/taxi)	Type company
Polytechnic University of Bari	general	EV/LEV/Non-EV	University
Municipality of Bari	general	EV/LEV/Non-EV	Public Authority
Nuova.co.ta.ba	taxi	taxi	private company
TAXI BARI AEROPORTO by Mavors S.r.l.	taxi	taxi	private company
apuliatrasfer	taxi	taxi	private company
sossio autonoleggio	taxi	taxi	private company
Koala Vip	taxi	taxi	private company
poste italiane	delivery	van	private company

Outcome from survey

After the data cleaning process, the data set contains 245 respondents in total. Of the respondents, 16.73% (41) use any type of electric vehicle, whereas 83.27% (204) does not. Figure 117 shows the type of electric vehicles the respondents use: the majority is divided between electric car (29.27%) and e-bikes (19.51%), while 31.71% indicated other vehicles. Upon a closer look in these other vehicles, 26.83% (11 respondents) indicated they use a “monopattino elettrico” or e-scooter.

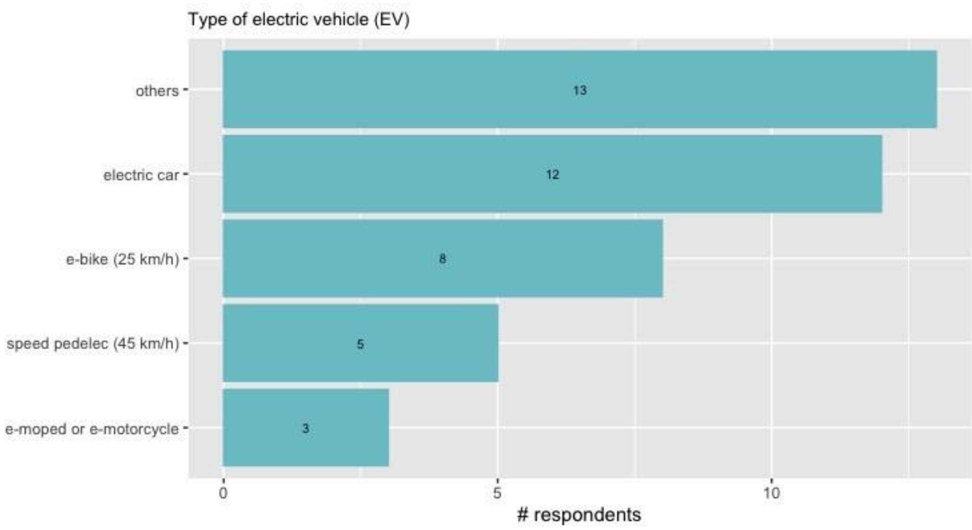


Figure 117 Type of EVs used out of 41 respondents at the Bari demonstration area

Out of the 12 respondents who use an electric car, 41.67% (5) drive a battery electric vehicle without an internal combustion engine, whereas 16.67% (2) respondents drive a plugin-hybrid electric vehicle. Also, 8.33% (1) of the respondents drive an electric vehicle with a range extender and 33.33% (4) a hybrid vehicle that combines a classical internal combustion engine with an electric motor.

The different socio-demographic are detailed in Table 27. In particular, the majority of the respondents are men 67.76%. Most respondents (45.31%) have obtained a university degree or a higher non-university degree (28.98%).

As regards the professional situation the majority are students (40.81%), whereas 39.59% is full time employed.

As regards the residential situation, the majority (51.84%) of the respondents lives with family. Also, 29.39% of the respondents is married with or without children (22.45% resp. 6.94%).

Almost all respondents (95.10%) have a driving licence. For most respondents, this concerns a driving licence B (92.65%), followed by driving licence A (15.92%). A small portion of the respondents possess a driving licence C (0.82%)..

Table 27 Socio-demographics of the respondents at the Bari demonstration area

Socio demographic	Categories	Answers number (%)
Gender	Female	77 (31%)
	Male	166 (68%)
	Other	2 (1%)
Degree	None	3 (1%)
	Primary education	6 (2%)
	Secondary education	34 (14%)
	Higher non-university education	71 (29%)
	University education (Bachelor degree, Master degree, …)	111 (45%)
	Post-university education (PhD, Post-doc,…)	19 (8%)
Residential situation	I live alone	35 (14%)
	I live with family	127 (52%)
	I live with others: co-housing	8 (3%)
	Married or in relationship with child(ren)	55 (22%)
	Married or in relationship without children	17 (7%)
	Single parent with child(ren)	3 (1%)
Professional situation	Currently unemployed	12 (5%)
	Employed full time	97 (40%)
	Housewife/Houseman	4 (2%)
	Other profession, namely :	2 (1%)
	Part-time employed	15 (6%)
	Retired	6 (2%)
	Student	100 (41%)
	Temporary exemption (e.g. maternity leave, parental leave)	9 (4%)
Function	Blue collar worker	14 (11%)

Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	14 (11%)
Middle management	3 (2%)
Official / employed in a public service	26 (21%)
Own company, entrepreneur with employees	3 (2%)
Self-employed, entrepreneur without employees	6 (5%)
Senior management / management	6 (5%)
Teaching staff / employed in education	19 (15%)
White collar employee (administrative, executive or support/clerical function)	35 (28%)

EV car users

Out of 12 electric car (12), 10 respondents own the vehicle, whereas 2 drive a company owned car. Furthermore, only 1 respondent indicated that they use their vehicle as a taxi-cab. The majority (75%) does not enjoy any company benefits. Only 8.3% indicated they enjoy a company charging pass, whereas 8.3% enjoys a company fuel pass.

In terms of the battery electric vehicles, the most popular cars are the BMW i3 (2 respondents), followed by a Hyundai Kona EV (2) and a Tesla Model 3 (1 respondent).

The plug-in hybrid electric vehicles that are used are the BMW 225xe (1 respondent) and the BMW i3 Range Extender (1 respondent).

Respondents indicate the vehicle capacity as well as the battery range without looking it up. More detailed information can be found in Table 28. As the BEV users only concern 5 respondents, the results are not further discussed.

Table 28 EV characteristics at the Bari demonstration area

Vehicle characteristics	Categories	Answer Number (%)
Battery Capacity – kWh (BEV) according to respondents	41–50	1 (20%)
	51–60	1 (20%)
	61-70	2 (40%)
	I do not know.	1 (20%)
Battery Range – km **(BEV) according to respondents**	200–249	1 (20%)
	250–299	1 (20%)
	300-400	1 (20%)
	> 400	2 (40%)
Respondent usage of the vehicle in years **(BEV and PHEV)**	< 1 year	2 (17%)
	1 year	3 (25%)
	2 years	3 (25%)
	3 years	3 (25%)

	> 4 years	1 (8%)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we analyse the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 118 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

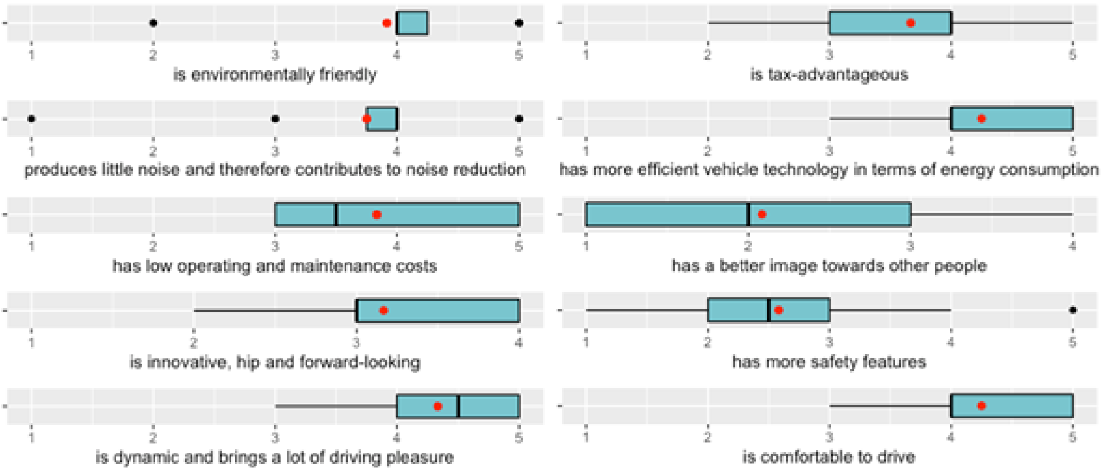


Figure 118 Reasons for EV usage or purchase at Bari demonstration area

From Figure 118, it is clear that the main reasons for using or purchasing and EV are the Environmental friendliness, the driving comfort and the fact that EVs have more efficient technology in terms of energy consumption. More specific, the "*Environmental friendliness"* is the most important factor since 83.33% consider this factor to be very important to extremely important. The least important factor is the "*better image an EV could have towards other people*", where 33.33% consider this factor not important at all.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 50.91 km, where the average time spent on the road was about 2 hours and 17 minutes. The EV is mostly parked at a private parking at home for more than 9 hours a day on average. Figure 119 gives a more detailed overview of the parking time at different locations.

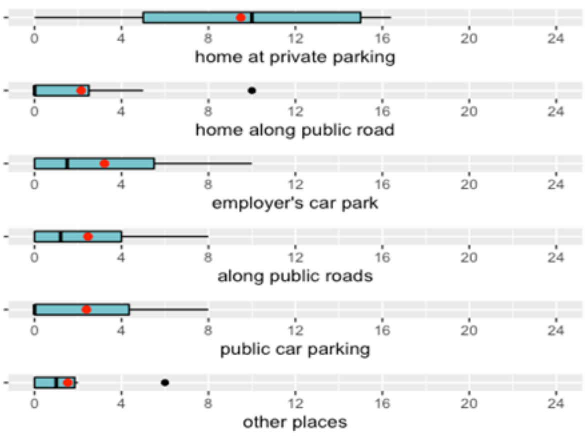


Figure 119 Respondents' EV parking time at different locations at the Bari demonstration area

When EV users park at home, they park in their driveway or in a privately-owned garage (66.67%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 120).

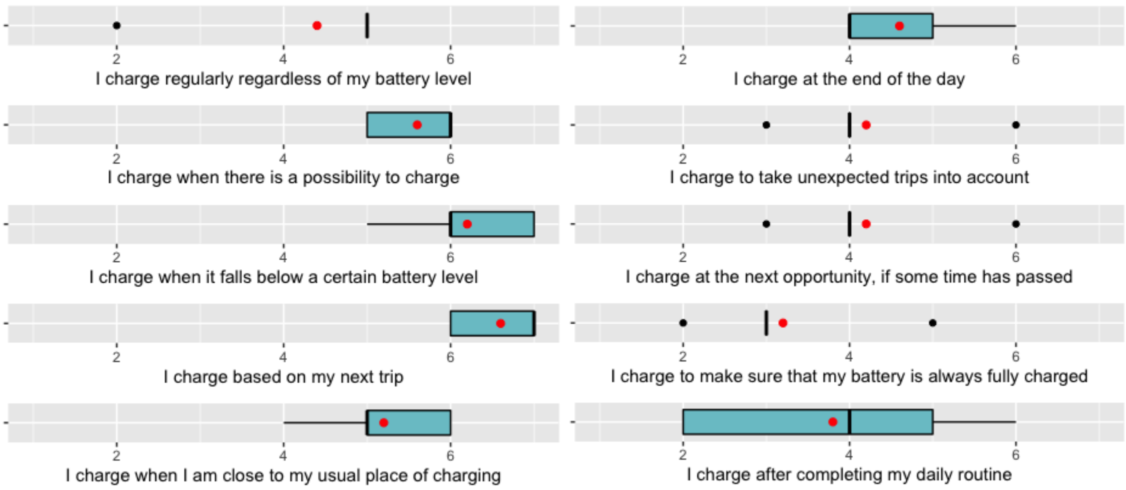


Figure 120 Respondents' charging behaviour at the Bari demonstration area

As regards the charging experience, 58.33% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 33.33% charges often at a different location, whereas 8.33% sometimes does charge at a different location.

Respondents charge the EV most frequently at home, 20.00% of the respondents charges the EV at home daily and 20.00% does so several times a week. The main charging option at home is the socket (50.00%). The least frequent charging place is at the working place, where 20.00% of the respondents indicate that they never charge at work. Also, public fast chargers are more frequently used than non-fast chargers.

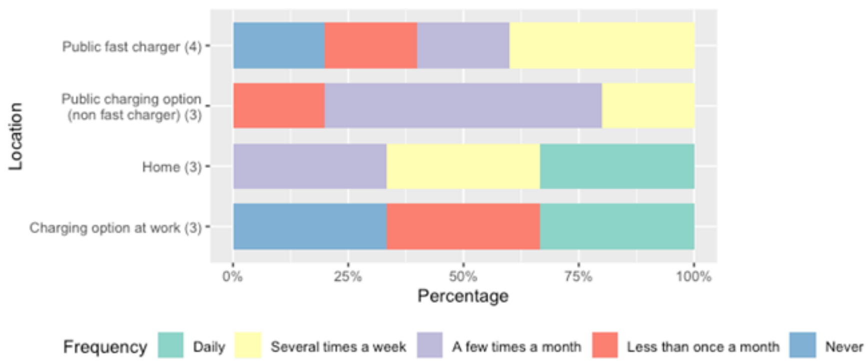


Figure 121 Respondents' charging behaviour per location at the Bari demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP), 3 respondents charged at ENEL X, while 1 charged at Duferco and 1 at evway. Due to the small sample, the quality of the charging experience is not further discussed.

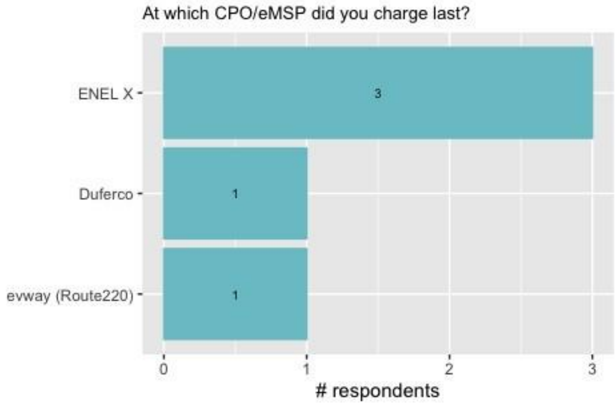


Figure 122 Last charging CPO/eMSP at the Bari demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future.

First, respondents had to indicate which charging option they were most likely to use in the future. The charging options that respondents indicated they want to use in the future are fast charging and smart charging (see Figure 123). Due to the small sample, the acceptance of the charging infrastructure is not further discussed.

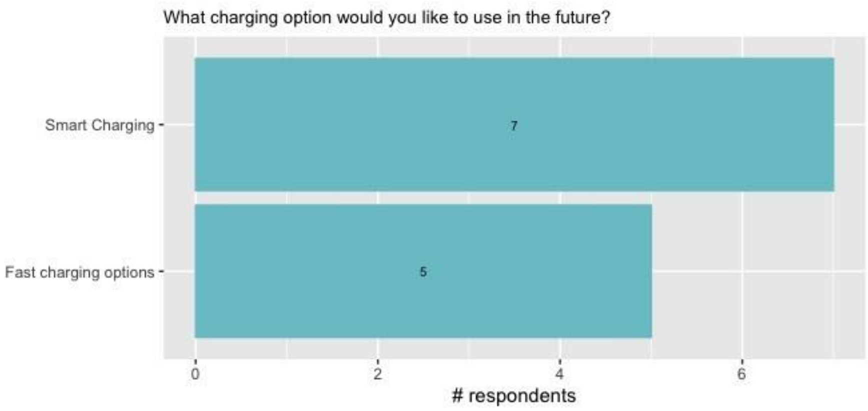


Figure 123 Most likely charging option in the future at the Bari demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, it is interesting to note that the respondents would not seem to mind to pay more for fast charging options where this is not the case for smart charging (see Figure 124).

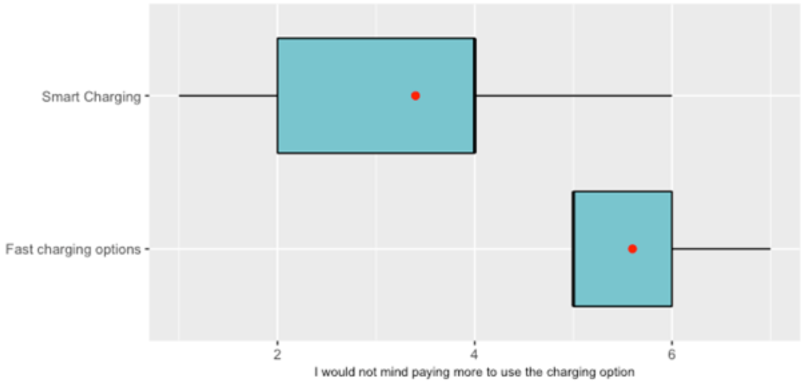


Figure 124 Price value of the charging infrastructure at the Bari demonstration area

App-based services

Lastly, EV users are inquired on the use of app-based services. The majority of the respondents (58.3%) does not use app-based services but intend to use it (about 25.0%). The remainder of the respondents have no intention to use an app in the near future.

LEV

In this section, we analyse the respondents (29) that use a light electric vehicle. The majority of the respondents (79.31%) own the LEV and are responsible for the LEV maintenance costs. At the same time, the majority of the respondents does not know the battery capacity of their LEVs or did not fill out this question (45.83%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 29.

Table 29 LEV characteristics at the Bari demonstration area

Vehicle characteristics	Categories	Answer Number (%)
Owner of the LEV	Private	23 (79%)
	Sharing company	5 (17%)
	Company/Leasing company	1 (3%)
Responsible LEV maintenance costs	Private	23 (79%)
	Company	1 (3%)
	NA	5 (17%)
Battery Capacity – kWh according to respondents	< 0,5	2 (8%)
	0,5 – 1	2 (8%)
	1-3	1 (4%)
	3-5	2 (8%)
	5-7	1 (4%)
	> 7	5 (21%)
	I do not know.	11 (46%)
How often do they use the LEV	Daily	2 (9%)
	Several times a week	13 (57%)
	A few times a month	8 (35%)
	Less than once a month	0

LEV parking	I use a garage that is my property or park on my driveway	8 (33%)
	I use a fixed rented parking space	1 (4%)
	I use a fixed car park which is my property	7 (29%)
	I use a rented garage	1 (4%)
	I do not use a fixed parking	7 (29%)

On average, the LEV users indicate they drive about 15.43 km each day. The majority of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 125).

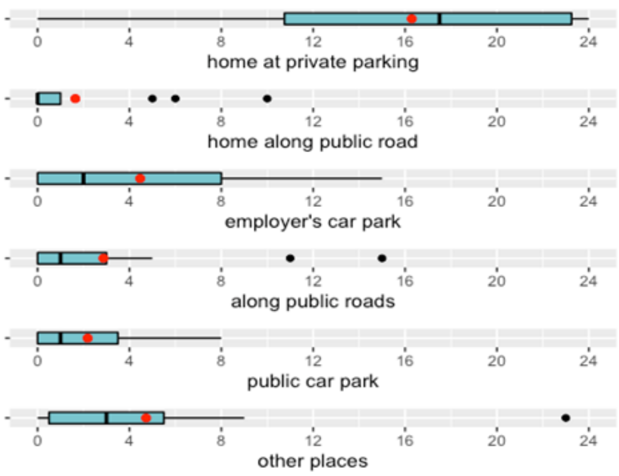


Figure 125 Parking space and duration of the LEV at the Bari demonstration area

Looking at the motives to use an LEV, the most important reason is the "*Environmental friendliness*" together with the *"low operating and maintenance costs"*, whereas least important is the *"image towards other people"*.

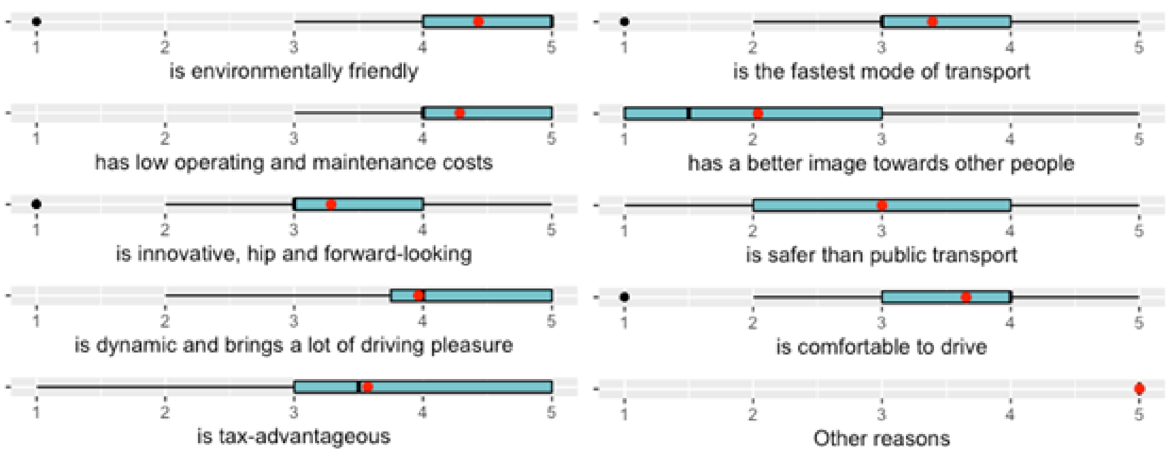


Figure 126 Motives to use LEVs at the Bari demonstration area

In terms of charging behaviour, almost all respondents seem to charge when the battery falls below a certain level.

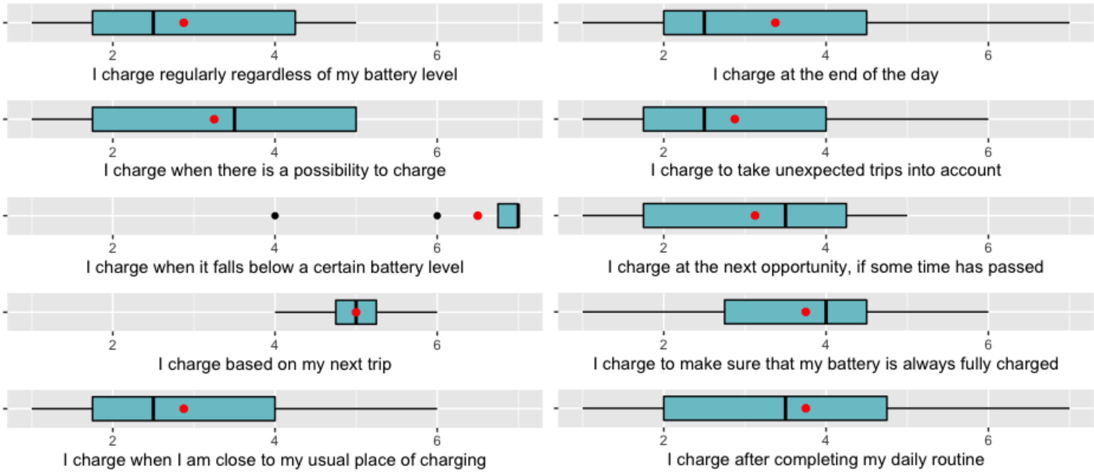


Figure 127 LEV charging behaviour at the Bari demonstration area

Quality of Experience

Out the LEV respondents, only 1 respondent indicated that they do not use the service of a CPO/eMSP. For this reason, the quality of experience will not be discussed in this section.

Acceptance

First, respondents had to indicate which charging option they are most likely to use in the future. Clearly, fast charging options are the most popular with 43,75% of respondents choosing they are most likely to use fast charging options in the future. 18.75% of the respondents indicated that they would use battery swapping, 16,67% smart charging and 14.75% would like to use user friendly charging stations in the future. Due to the small sample, the acceptance of the charging infrastructure is not further discussed.

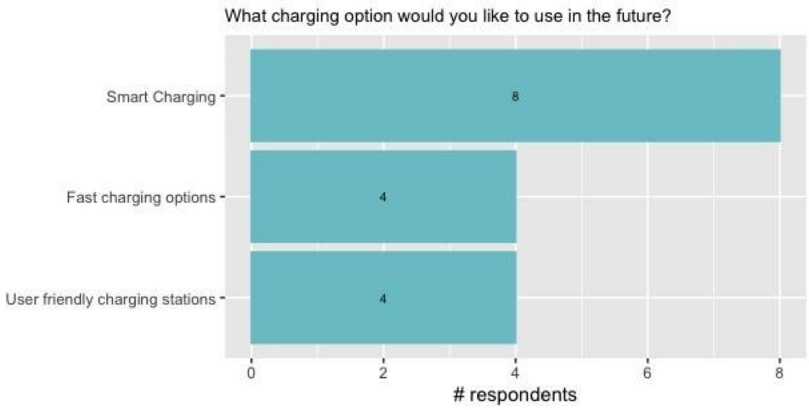


Figure 128 Preferred LEV charging option to use in the future at the Bari demonstration area

App-based services

Lastly, LEV users are inquired on the use of app-based services. Here, only 3 respondents indicated they use app-based services, the remainder of the respondents have no intention to use an app in the near future.

Non-EV users

Lastly, we analyse the non-EV users, that are 204. Over 50% of the respondents' state that it is very likely they will buy an electric vehicle.

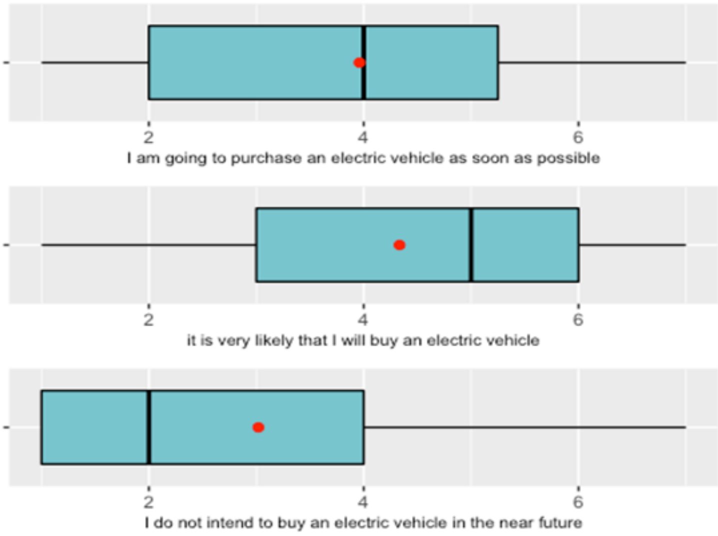


Figure 129 Non-users' Intention to buy an EV at the Bari demonstration area

Moreover, most respondents (76.4%) are mostly interested to buy an electric car (Figure 130). Out of these 94 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (28 respondents), an electric vehicle with range extender (9 respondents) or a plug-in hybrid electric vehicle (24 respondents). The remaining 34 respondents prefer a hybrid vehicle that combines a classic combustion engine.

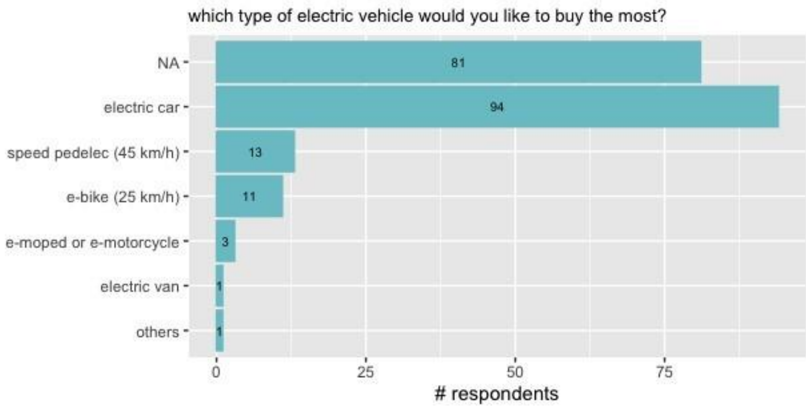


Figure 130 Type of EV that non-users intend to buy at the Bari demonstration area

Lastly, the most important reasons for non-EV users to purchase an EV in the future are the *"environmental friendliness"* and the *"more efficient technology in terms of energy consumption"* since 96.64% and 98.32% respectively considers this moderately and extremely important.

At the same time, the least important reason is the *"better image EVs could have towards other people"* since 58.82% of the respondents consider this not important at all to slightly important.

Key findings of the Bari report

The main reasons for electric car adoption are the green environmental footprint, and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, it is interesting that 58.3% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 33.3% charges often at a different location. Remarkably, the least frequent charging place is at work, where 30.0% of the respondents indicate that they never charge at work. Smart charging is the most preferrable charging option to use in the future.

LEV users mainly bought their LEV because it is environmentally friendly, and because of the low operating and maintenance costs. Almost all LEV users charge their LEV when it falls below a certain battery level and based on the next trip. Interesting to see is that users do not take unexpected trips in mind. Smart charging is the most preferrable charging option in the future.

Lastly, over half of the non- EV states that it is very likely they will buy an electric vehicle. The respondents that would like to buy an EV in the future are mostly (76.4%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (96.6%) and more efficient technology in terms of energy consumption (98.3%) in comparison with non-EV. At the same time, the least important motive is the better image EVs could have towards other people as 58.8% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV users.

Outcome from historical data

This section presents the electric mobility analysis for The Metropolitan city of Bari an Italian city on the Scandinavian-Mediterranean corridor. In this pilot there are 75 unique Charging Points (35 in the city centre of Bari), all from the CPO Enel-x and 22 unique users, the information regarding the users for this study comes from users using the EVWAY app from the EMSP Route220. The observations are from 18/11/2018 to 01/09/2020. It should be mentioned that some of the analysis could not be performed due to the lack of sufficient field data.

Descriptive Statistics

- **Charging Points geographical distribution**

Figure 131 shows the geographical distribution of the charging points from the Bari demonstration area, distinguishing the CPs according to their charging power.

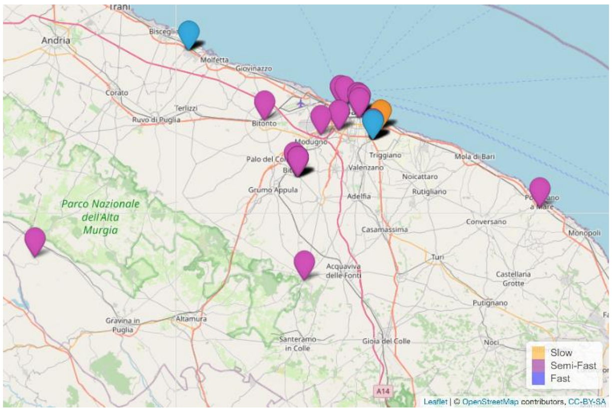


Figure 131. Charging points location and typology – Bari demonstration area

- **Sessions' duration**

The boxplot is used to graphically depict the sessions' duration through their quartiles, displaying in a standardised way the distribution of the data.
The values of the duration of the charging sessions in the case of semi-fast CPs are more spread and the average duration is longer. In the case of fast CPs users spend an average of 52 minutes and 54 minutes in the case of slow CPs.

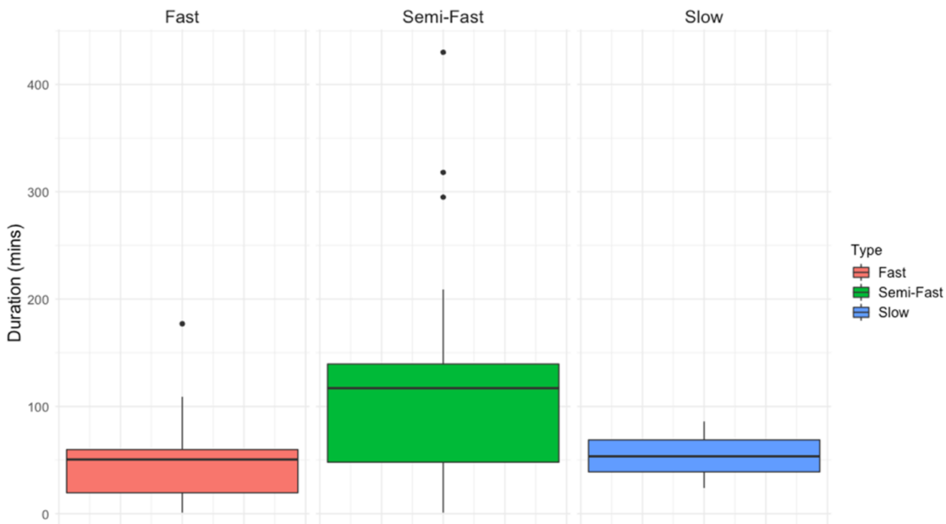


Figure 132. Boxplot for sessions' duration – Bari demonstration area

Table 30. Summary of statistical values of sessions' duration – Bari demonstration area

Fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1 min	19.5 min	50.5 min	51.57 min	59.75 min	177 min
Semi-fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1 min	48 min	117 min	117.94 min	139.5 min	430 min
Slow Charging Points					

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
24 min	39 min	53.5 min	54.25 min	68.75 min	86 min

- **Energy consumed per session**

Figure 133 represents the energy consumed per session, overall can be seen that the energy consumed is quite low, being the maximum value of 53.3 kWh. In the case of fast CPs, the average energy consumed is higher and also the dispersion of the data. The semi-fast CPs have an average of 13.37 kWh and in the case of slow CPs 14 kWh.

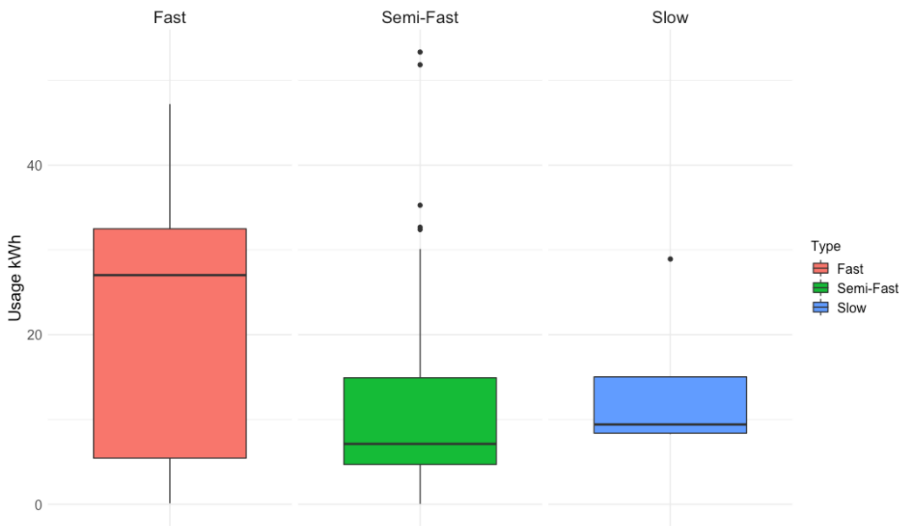


Figure 133. Boxplot for sessions' energy consumed – Bari demonstration area

Table 31. Summary of statistical values of sessions' energy consumed – Bari demonstration area

Fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.11 kWh	5.44 kWh	27.03 kWh	22.96 kWh	32.49 kWh	47.2 kWh
Semi-fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.05 kWh	4.69 kWh	7.12 kWh	13.37 kWh	14.93 kWh	53.33 kWh
Slow Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
8.29 kWh	8.39 kWh	9.41 kWh	14.01 kWh	15.03 kWh	28.93 kWh

A priori assessment of the e-mobility charging infrastructure

The following KPIs from the usage impact area have been calculated using data between 18/11/2018 and 01/09/2020.

Table 32. KPIs from T1.1 – Bari demonstration area

KPI	Result
Loyalty to the same charging option	9.09 % of the users used the same charging "point" more than 3 times
Frequency of use of charging options	2.04
Vehicle's charging time	Fast: 51.5714 minutes Semi-Fast: 117.9355 minutes Slow: 54.25 minutes

Availability rate (1)	12.5 % of the charging options are occupied more than 0.04 %.
Availability rate (2)	66.67 % of the charging points are occupied less than 0.025 %
Average usage ratio of charging options	0.02 % is the average ratio.

Conclusions

The analysis for the Metropolitan city of Bari provides and overview on the behaviour of the usage of the CPs available in the metropolitan area, although to have a complete analysis the data from the CPO would be needed.

Demonstration area 4 : Berlin

Context

The charging infrastructure is built based on the so-called "Berlin model", the country's charging infrastructure concept, which is currently under revision (Elektrisch unterwegs auf Berlins Straßen – Ladeinfrastruktur im öffentlichen Raum – Berlin.de).

Of the 1,658 publicly accessible charging points in public and private spaces at the end of the fourth quarter of 2020, 1,196 are public spaces. Of these, a total of 1,058 charging points were built at 560 locations on behalf of the Senate Administration for the Environment, Transport and Climate Protection in the period from 2015 to the end of 2020 as part of the "be emobil" project. In addition to the charging stations built on behalf of the land, four so-called third operators have signed the operator contract with the Land of Berlin and are operating or installing additional charging infrastructure in public spaces according to the Berlin model.

The advantages of a uniform charging infrastructure concept are: through non-discriminatory access for mobility service providers, all e-vehicle users can charge at any charging station in the public space on the agreed terms at any charging station. At present, this public charging infrastructure is complemented by an increasing number of charging points in the public accessible area, e.g., in private parking spaces at supermarkets, petrol stations, etc. However, it is precisely on these areas and in private space that a large part of the charging infrastructure will have to be built up in the future. The reason for this is that the public space of a growing city like Berlin is subject to diverse and sometimes competing usage claims. In the inner-city sector in particular, less than half of households own their own car, which is why an appropriate and appropriate part of the transport area is attributable to the environmental network in order to bring about the mobility revolution.

Since 01.10.2020, the funding programme with amended eligibility requirements has been reopened for application. With WELMO, the Land of Berlin supports both the procurement and leasing of commercially used vehicles with pure battery operation, fuel cell drive or plug-in hybrid drive. In addition, the State of Berlin supports the construction of stationary charging infrastructure in the commercial environment as well as potential and implementation consultations on the procurement of e-vehicles and the construction of charging infrastructure.

The market for sharing vehicles of all kinds is very much on the move in Berlin; it covers cars – free floating (no fixed station, the borrowed car can be parked anywhere within the business area), cars – station-based (fixed stations to which the vehicles must be returned), electric scooters, e-Kickscooter, bikes (in addition to bike share companies, many hotels, kiosks and other tourist facilities rent bicycles at a daily rate), and cargo bikes (in addition to the sharers, some DIY stores lend cargo bikes to customers free of charge for the transport of bulky or heavy goods).

Mobility Apps/ Multimobility covering the changeover and use of different modes of transports is served by different apps e.g., Jelbi, the BVG mobility app.

Mobility-on-demand/mobility as a service, is present in the city allowing the spontaneous use of a mobile driving service via smartphone app. This includes taxis, but also more new providers that bundle several passengers and thereby reduce the cost of individual journeys.

Data collection for the survey

The general survey was sent to several magazines and website for redistribution. Furthermore, local associations, e.g., Bundesverband für Carsharing, ADAC, Verkehrsclub Deutschland were contacted. The Senate of Berlin did not agree to support the data selection process; however, the eMO did offer their support and distributed the survey in their January newsletter. The delivery companies survey was forwarded on to LEV fleet sharing companies of which two passed it on to their staff, however they choose not to pass it on to their customers.

Overall, very few responded, even after sending reminders after the Christmas Holidays in early January. The trial participating Berlin companies reached out to customers and peers via their social media accounts.

Outcome from survey

After data cleaning, the data set contains 53 respondents in total. Of the respondents, 50.94% (27) use any type of electric vehicle, whereas 49.06% (26) does not. Figure 134 shows the type of electric vehicles the respondents use, where the sample is divided between electric car (51.85%) and light electric vehicles (LEV) (49.15%). Interesting is that e-bikes (18.52%), e-mopeds/-scooters (14.81%) and other types of LEV (14.81%) are nearly all one third of the other 50%.

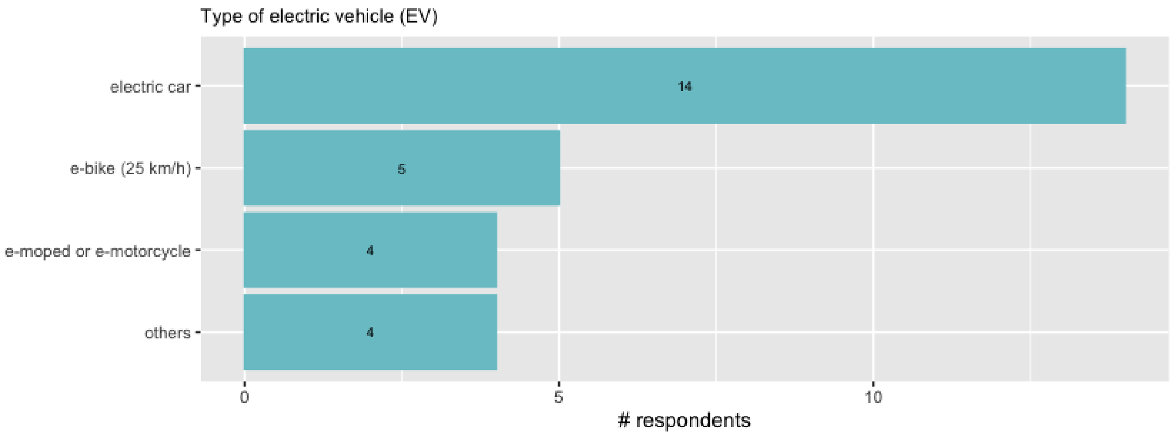


Figure 134 Type of EVs used out of 27 respondents at the Berlin demonstration area

Out of the 14 respondents who use an electric car, 85.71% (12) indicated they drive a battery electric vehicle without an internal combustion engine, whereas 14.29% (2) respondents drive a plugin-hybrid electric vehicle.

Regarding the socio-demographic variables of the full sample, the majority of the respondents were men 64.15%. Most respondents (75.47%) have obtained a university degree or a higher non-university degree (13.21%). The majority is full time employed (69.81%), whereas 2% is retired. Almost 58.49% of the respondents is married with or without children (41.51% resp. 16.98%). The different socio-demographics are detailed in Table 33. Almost all respondents (90.57%) possess a drivers licence. For most respondents, this concerns a drivers licence B (79.25%), followed by drivers licence A (22.64%). A small portion of the respondents possess a drivers licence C (15.09%), and a drivers licence G (1.89%).

Table 33 Socio-demographics of the respondents at the Berlin demonstration area

Socio demographic	Categories	Answers number (%)
Gender	Female	18 (34)
	Male	34 (64)
	Other	1 (2)
Degree	None	
	Higher non-university education	7 (13)
	Post-university education (PhD, Post-doc,…)	2 (4)
	Primary education	1 (2)
	Secondary education	3 (6)
	University education (Bachelor degree, Master degree, …)	40 (75)
Residential situation	I live alone	11 (21)
	I live with family	1 (2)
	I live with others: co-housing	7 (13)
	Married or in relationship with child(ren)	22 (42)
	Married or in relationship without children	9 (17)
	Single parent with child(ren)	3 (6)
Professional situation	Currently unemployed	2 (4)
	Employed full time	37 (70)
	Other profession, namely :	1 (2)
	Part-time employed	10 (19)
	Retired	1 (2)
	Student	1 (2)
	Temporary exemption (e.g. maternity leave, parental leave)	1 (2)
Function	Blue collar worker	4 (8)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	1 (2)
	Middle management	8 (16)
	Official / employed in a public service	5 (10)
	Own company, entrepreneur with employees	1 (2)
	Senior management / management	2 (4)
	Teaching staff / employed in education	2 (4)
	White collar employee (administrative, executive or support/clerical function)	26 (53)
	Unknown/Missing	4 (7.55)

EV car users

Out of 14 electric car (14), 4 respondents own the vehicle, whereas 6 drive a company owned car, and 4 a car owned by a car sharing company. Most of the respondents (50.0%) does not enjoy any company benefits. 28.6% of the respondents indicated they enjoy a company charging pass, whereas 7.1% enjoys a company fuel pass. Furthermore, 7.1% indicated they enjoy some other type of mobility benefit.

In terms of the battery electric vehicles, the most popular cars are the Renault ZOE (4 respondents), followed by a BMW i3 (1) and a Hyundai IONIQ (1 respondents). The Kia e-Niro (1 respondents) and the Smart EQ fortwo (1 respondents) close the top 5. The most popular plug-in hybrid electric vehicles are the Audi A3 TFSI-e (1 respondents) and the Mitsubishi Outlander PHEV (1 respondents).

Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity between 41 and 50 kWh. At the same time, 1 respondent indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 100 and 199 km. In terms of battery range for PHEV users, all respondents indicate this lies between 40-50km. Lastly, most of all EV users (50%) is driving their current vehicle for 1 year or less. More detailed information can be found in Table 34.

Table 34 EV characteristics at the Berlin demonstration area

Vehicle characteristics	Categories	Answer Number (%)
Battery Capacity – kWh (BEV) according to respondents	<20	1 (10%)
	>70	1 (10%)
	20-30	1 (10%)
	41–50	4 (40%)
	51–60	1 (10%)
	61-70	1 (10%)
	I do not know.	1 (10%)
Battery Range – km (BEV) according to respondents	> 400	1 (10%)
	100–149	3 (30%)
	150–199	3 (30%)
	200–249	1 (10%)
	250–299	1 (10%)
	300-400	1 (10%)
Respondent usage of the vehicle in years (BEV and PHEV)	< 1 year	3 (25%)
	1 year	3 (25%)
	2 years	4 (33%)
	3 years	2 (17%)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we analyse the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 135 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

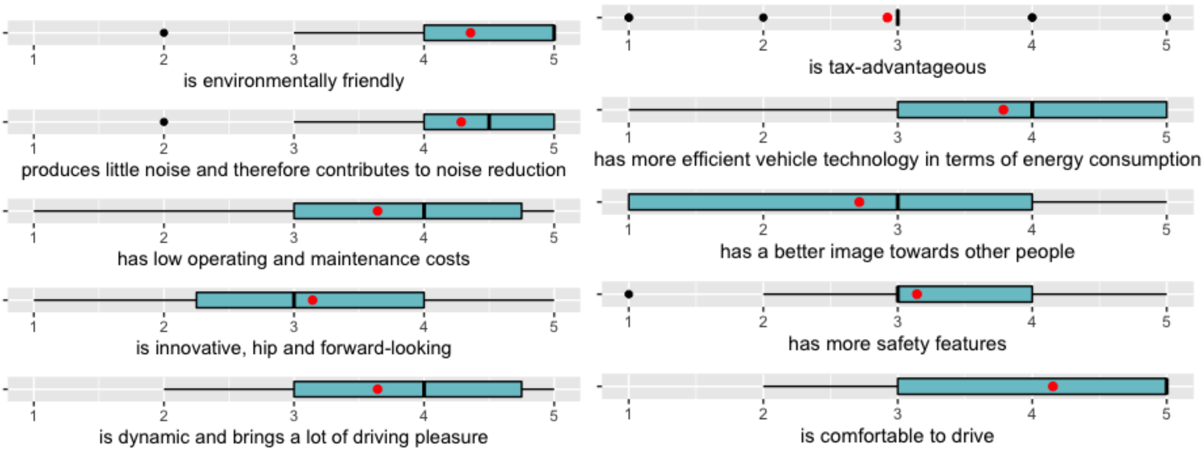


Figure 135 Reasons for EV usage or purchase at Berlin demonstration area

From Figure 3, the main reasons for using or purchasing and EV are the environmental friendliness, the driving comfort, and the fact that EVs have more efficient technology in terms of energy consumption. More specific, the environmental friendliness was the most important factor as (86%) considered this factor to be very important to extremely important, the least important factor is the better image an EV could have towards other people, where 43% considered this factor to be not important at all to slightly important.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 30 km, where the average time spent on the road was about 2.6 hours. The EV is mostly parked at home along the road for almost 9 hours a day on average. Figure 136 gives a more detailed overview of the parking time at different locations.

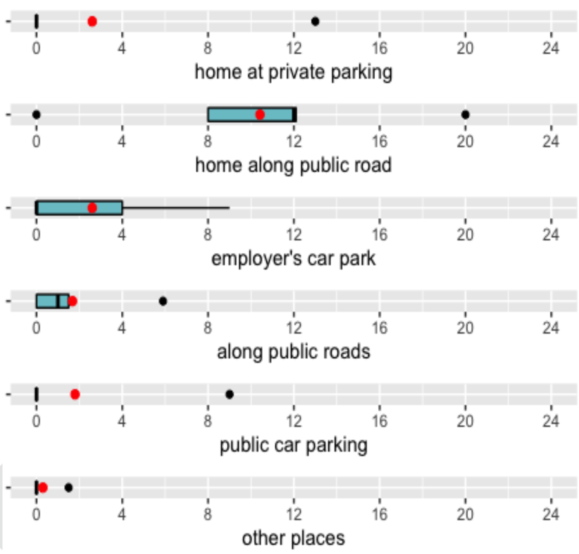


Figure 136 Respondents' EV parking time at different locations at the Berlin demonstration area

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level, based on the next trip or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 137).

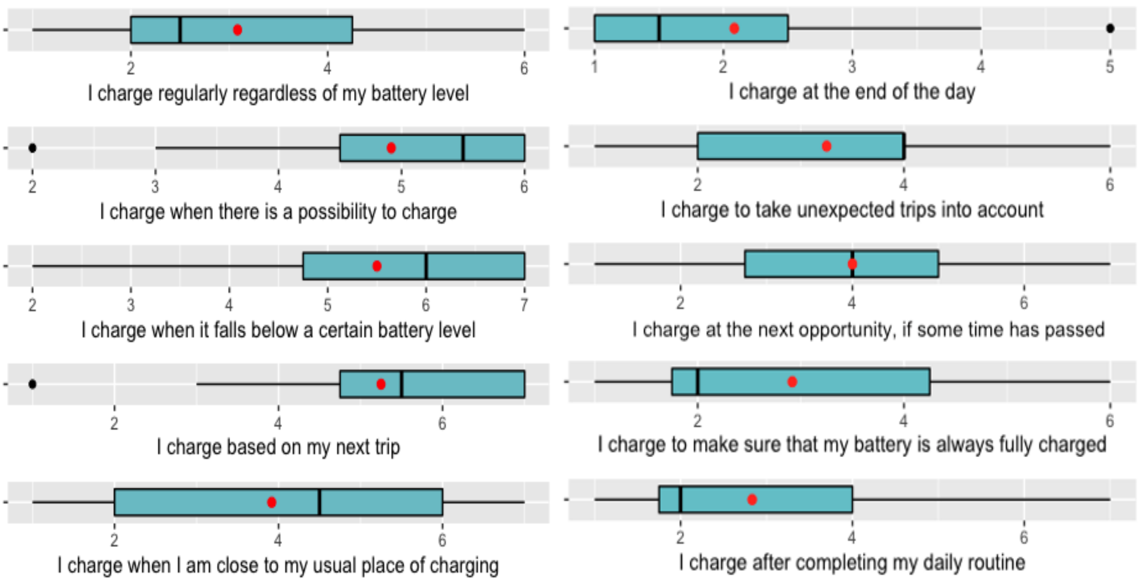


Figure 137 Respondents' charging behaviour at the Berlin demonstration area

Regarding the charging experience, 14.29% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 57.14% charges often at a different location, whereas 28.57% sometimes does. Respondents charge the EV most frequently at a public charging point, 18.0% of the respondents charges the EV in public daily and 13.0% does so several times a week. The main charging option at home is a socket (37.50%), but 62.5% does not charge at home. The least frequent charging place is at the workplace, where 85.00% of the respondents indicate that they never charge at work.

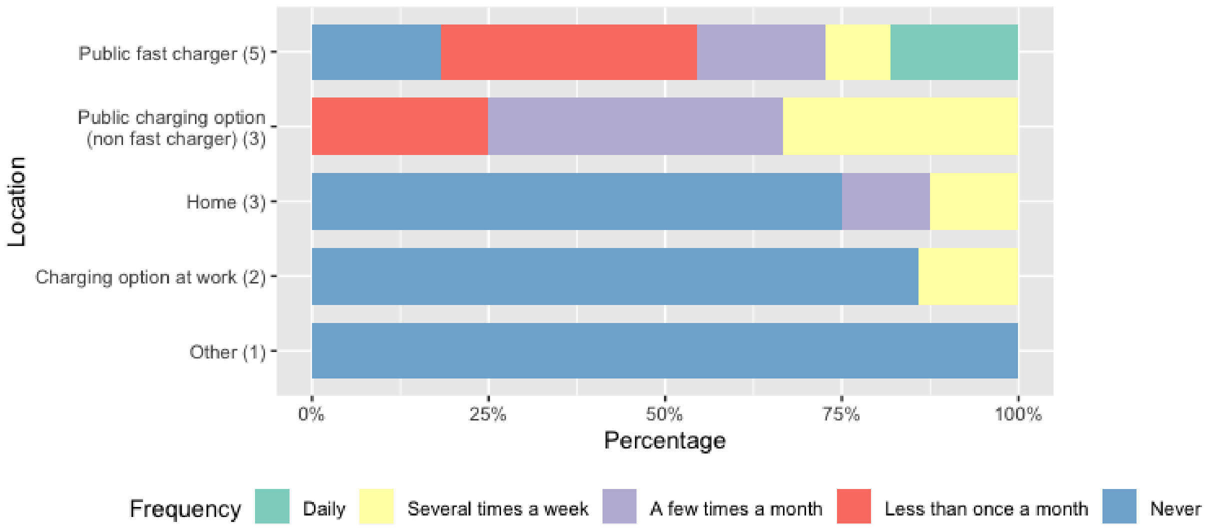


Figure 138 Respondents' charging behaviour per location at the Berlin demonstration area

The most popular charging time is in the evening, after working hours, between 6p.m. and 3a.m. Due to the small number of respondents, it is difficult to make a statement about afternoon charging. There is an outlier here who very often charges in the afternoon. Overall, the least popular time is between 9a.m. and 1:30p.m.

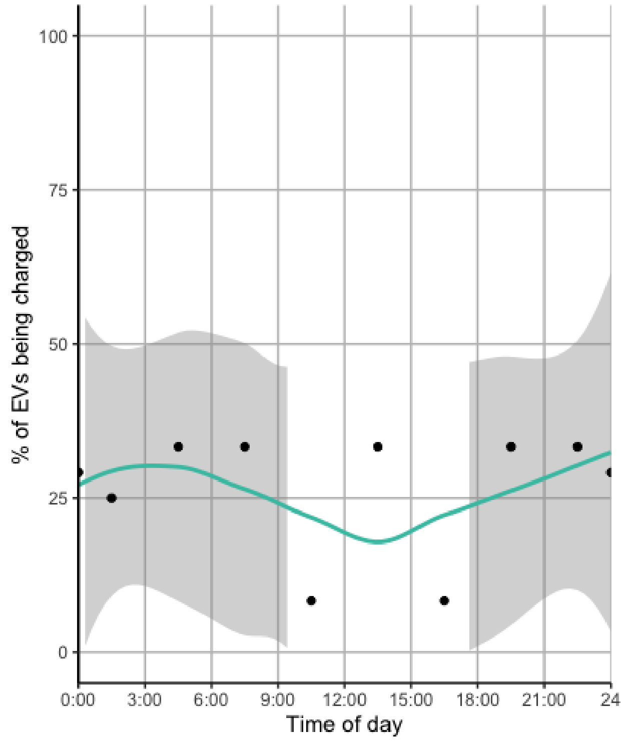


Figure 139 Respondents' charging schedule at the Berlin demonstration area

In terms of the most ideal charging session, the respondents indicated that the most improvement need to be made are the improvement on the operability of the charging cards and the implementation of faster charging stations (Figure 132).

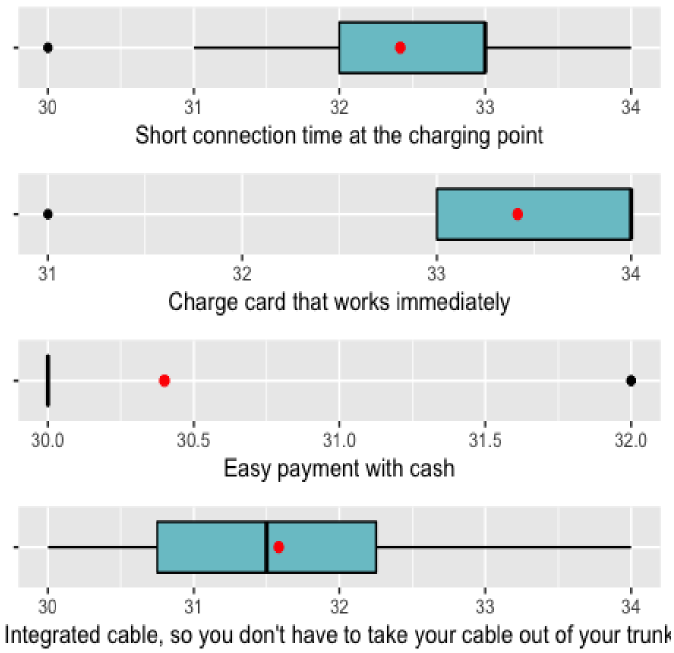


Figure 140 Most ideal charging sessions at the Berlin demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, the most popular CPOs/eMSPs are with 2 respondents each EnBW, Innogy, New Motion.

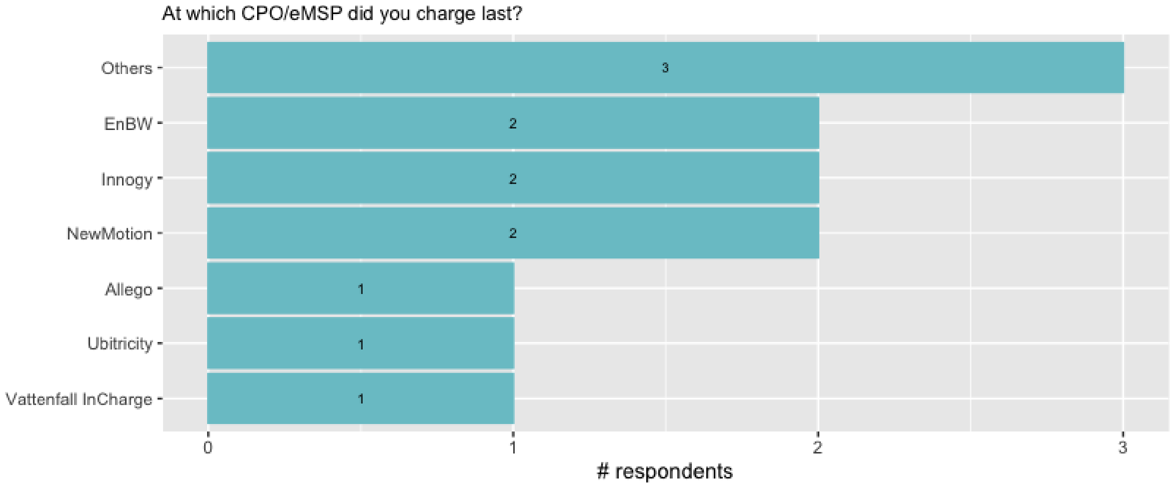


Figure 141 Last charging CPO/eMSP at the Berlin demonstration area

Given the low number of respondents for each CPO/eMSP, the dimensions of satisfaction are not discussed in detail.

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e. the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, smart charging is the most popular with 57.14% of respondents choosing they are most likely to use smart charging in the future. Furthermore, 28.57% of the respondents have the intention to use battery swapping, and 14.29% of the respondents would use mobile charging services in the future.

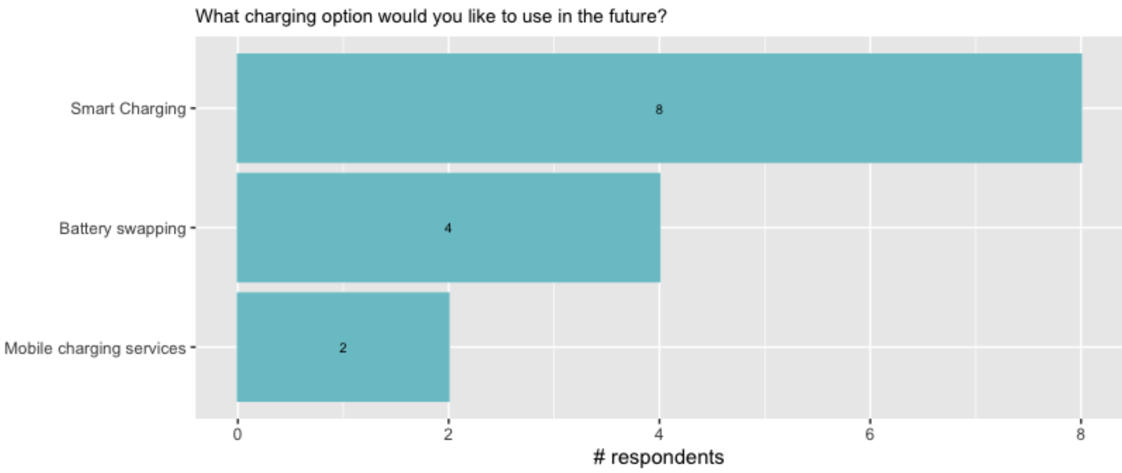


Figure 142 Most likely charging option in the future at the Berlin demonstration area

Smart charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration. The behavioural intention to use smart charging is like the behavioural intention to use battery swapping.

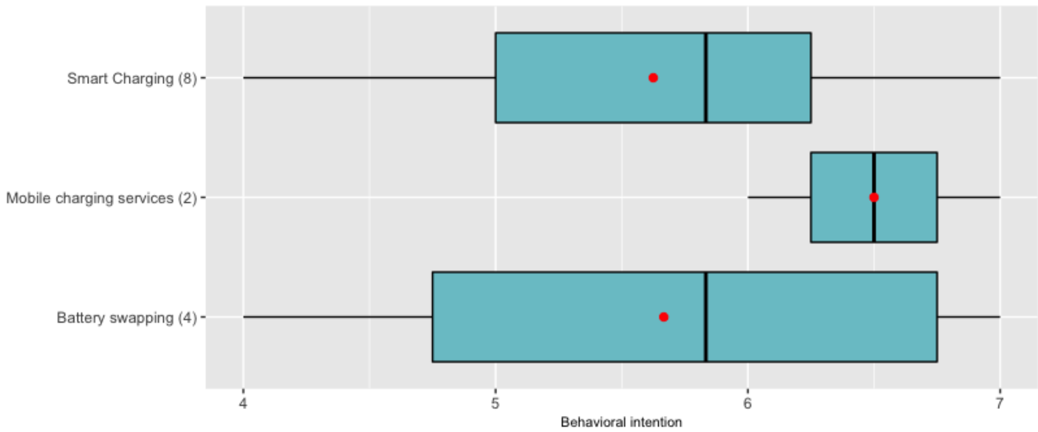


Figure 143 Behavioural intention of charging infrastructure at the Berlin demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the battery swapping scores the highest on these criteria (see Figure 136).

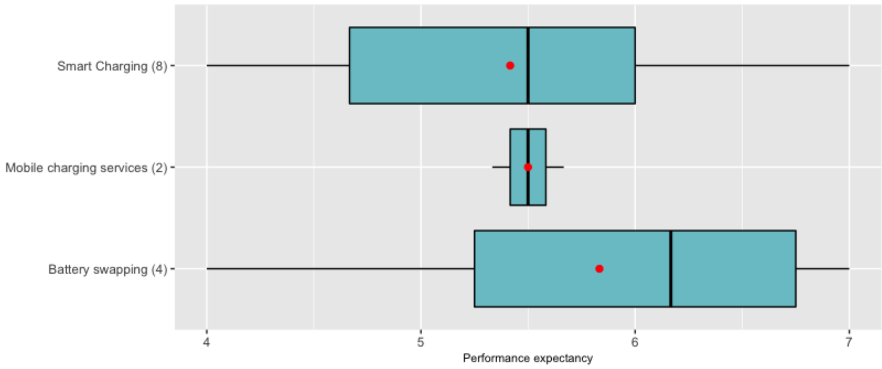


Figure 144 Performance expectancy of the charging infrastructure at the Berlin demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. It is interesting to see that the scores for mobile charging services are higher than other charging options (see Figure 137). Less effort is expected for battery swapping and smart charging, but smart charging also varies more than other charging options, indicating that respondents expect some effort into getting acquainted with this charging option compared to battery swapping and mobile charging services.

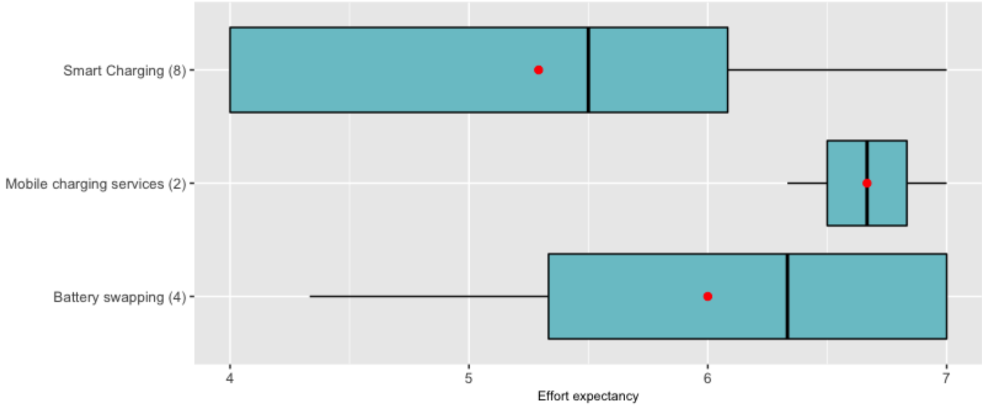


Figure 145 Effort expectancy of the charging infrastructure at the Berlin demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 138). The averages and medians of smart charging and battery swapping lightly fluctuate between 4 and 5 on a scale of 7. A low score was giving to the social influence of mobile charging services.

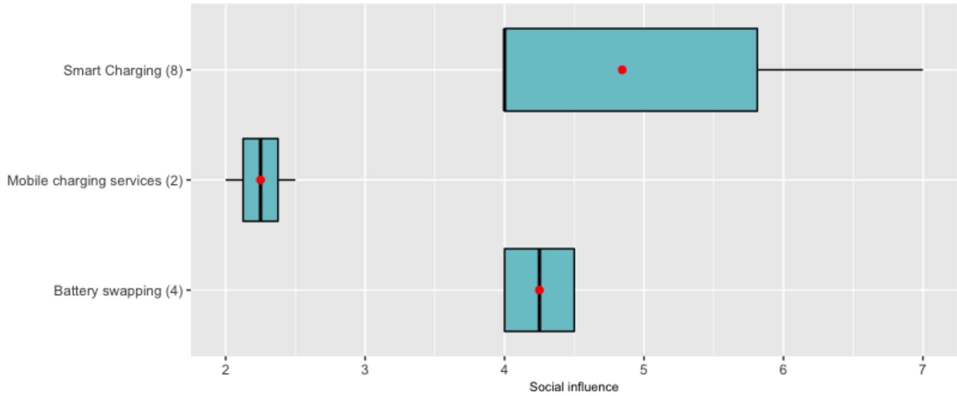


Figure 146 Social influence of the charging infrastructure at the Berlin demonstration area

In terms of facilitating conditions, battery swapping, and smart charging have more or less the same expectations between 4 and 5 out of 7. On average visibly higher than the other charging options are the mobile charging services (see Figure 139). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

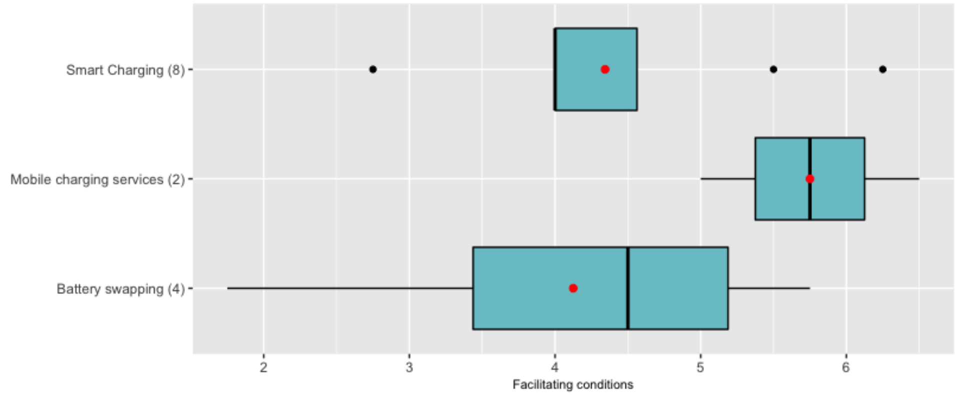


Figure 147 Facilitating conditions of the charging infrastructure at the Berlin demonstration area

As for hedonic motivation, quite similar distributions can be observed for the different charging options (see Figure 148). Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

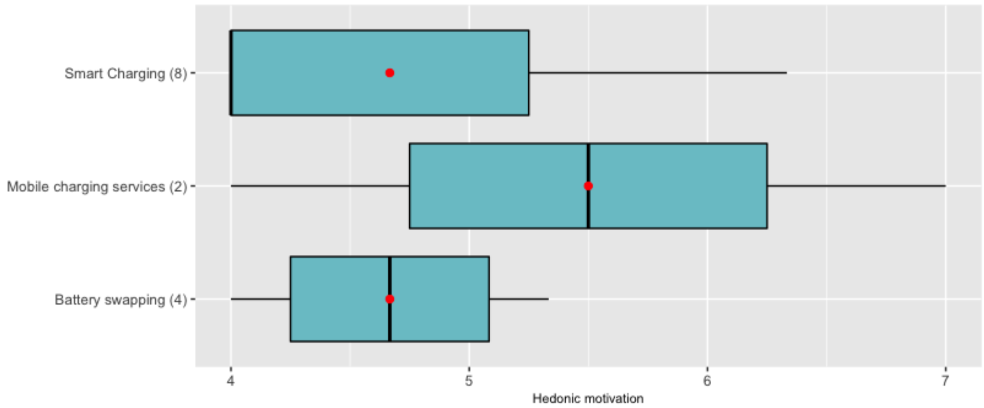


Figure 148 Hedonic motivation of the charging infrastructure at the Berlin demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price were the same or whether they would only use it if the price were lower. Here, it is interesting to note that the respondents would not seem to mind paying more using battery swapping or smart charging (see Figure 141). At the same time for mobile charging services and smart charging, almost all respondents indicate they would only use it if the price were lower compared with current charging options.

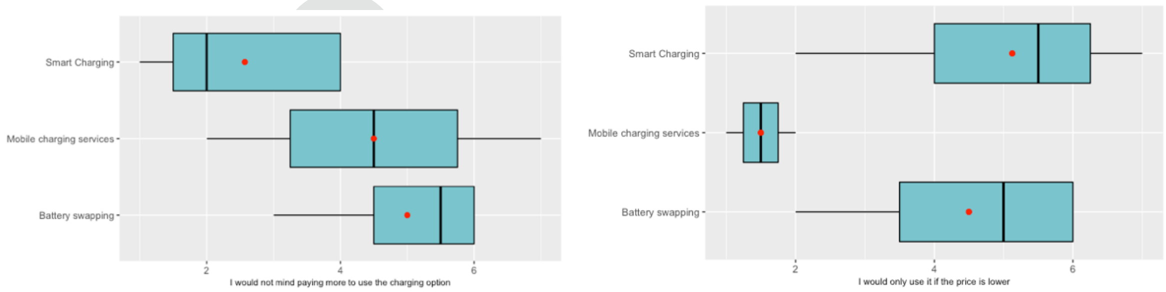


Figure 149 Price value of the charging infrastructure at the Berlin demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. Half of the respondents, 50.0% (7 respondents) indicated they use app-based services, another 14.3% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, a third of the EV respondents has 4 or more apps on their phone. About 71.4% of the app-based service users use this at least a few times a month, as can be seen in Figure 142.

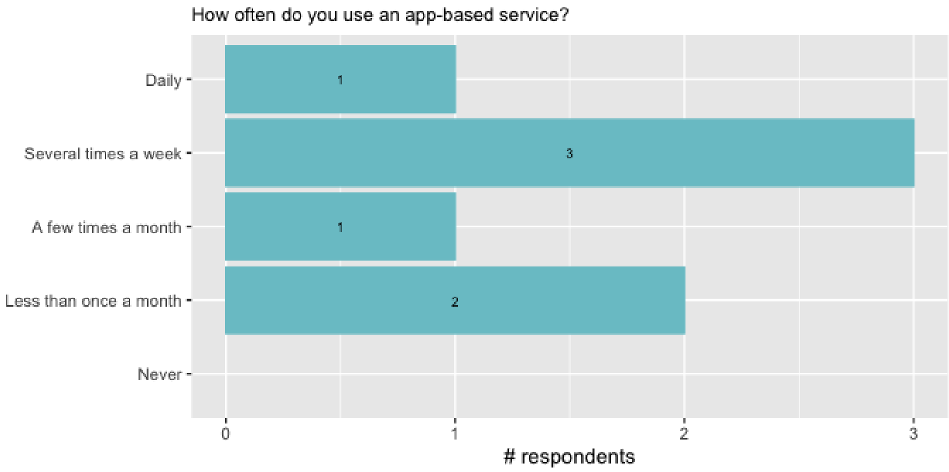


Figure 150 Usage of app-based services at the Berlin demonstration area

App-based services are mostly used for travel related to travel destinations on holiday (5 respondents), whereas 5 respondents use it for leisure activities. To a lesser extent, the app-based services are used for commuting and work activities (4 respondents) and shop/errands (2 respondents). In terms of satisfaction with the used app-based services, Figure 143 shows that the respondents are satisfied above average on a scale of 1 to 7.

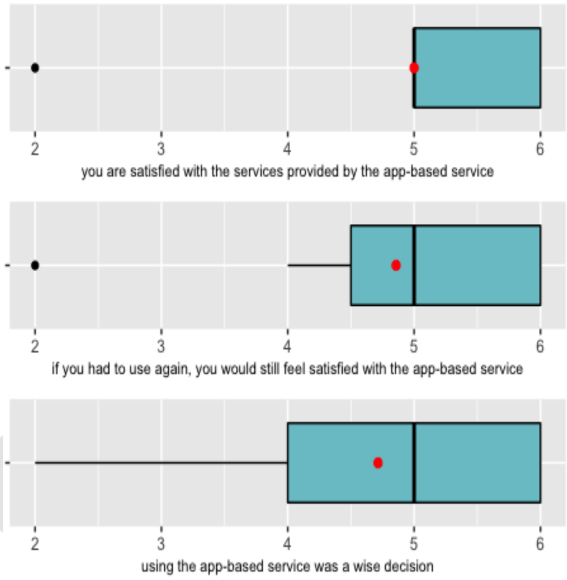


Figure 151 Satisfaction with the app-based services at the Berlin demonstration area

LEV

In this section, we zoom in to the 9 respondents who use a light electric vehicle (LEV). The majority of the respondents (55.56%) own the LEV they use and are responsible for the LEV maintenance costs (55.56%). At the same time, the majority of the respondents does not know what the battery capacity is or did not fill out this question (55.56%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 35.

Table 35 LEV characteristics at the Berlin demonstration area

Vehicle characteristics	Categories	Answer Number (%)
Owner of the LEV	Private	5 (38%)
	Sharing company	5 (38%)
	Company/Leasing company	3 (23%)
Responsible LEV maintenance costs	Private	3 (38%)
	Company	5 (62%)
Battery Capacity – kWh according to respondents	0,5 – 1	1 (12%)
	1-3	3 (38%)
	I do not know.	4 (50%)
How often do they use the LEV	Daily	1 (12%)
	Several times a week	6 (75%)
	Less than once a month	1 (12%)
LEV parking	I use a garage that is my property or park on my driveway	3 (38%)
	I do not use a fixed parking	5 (62%)

On average, the LEV users indicate they drive about 29.29 km each day. Most of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 152).

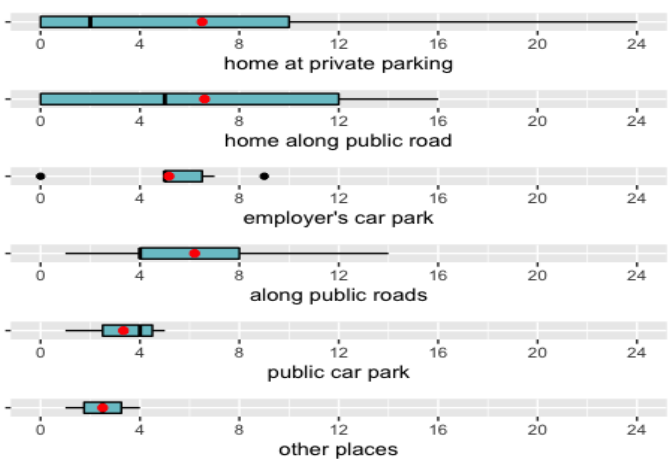


Figure 152 Parking space and duration of the LEV at the Berlin demonstration area

Looking at the motives to use an LEV, it is clear that the most important motive is the environmental friendliness together with driving pleasure and comfort, whereas least important is the image towards other people.

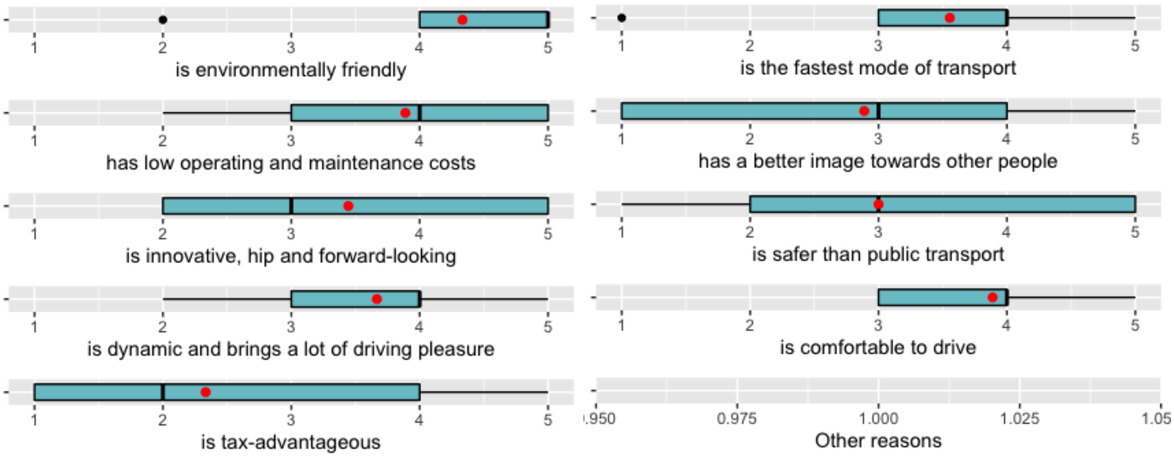


Figure 153 Motives to use LEVs at the Berlin demonstration area

In terms of charging behaviour, all the respondents (100%) seem to charge when the battery falls below a certain level or based on their next trip. Also, 50% of the respondents charge to take unexpected trips into account.

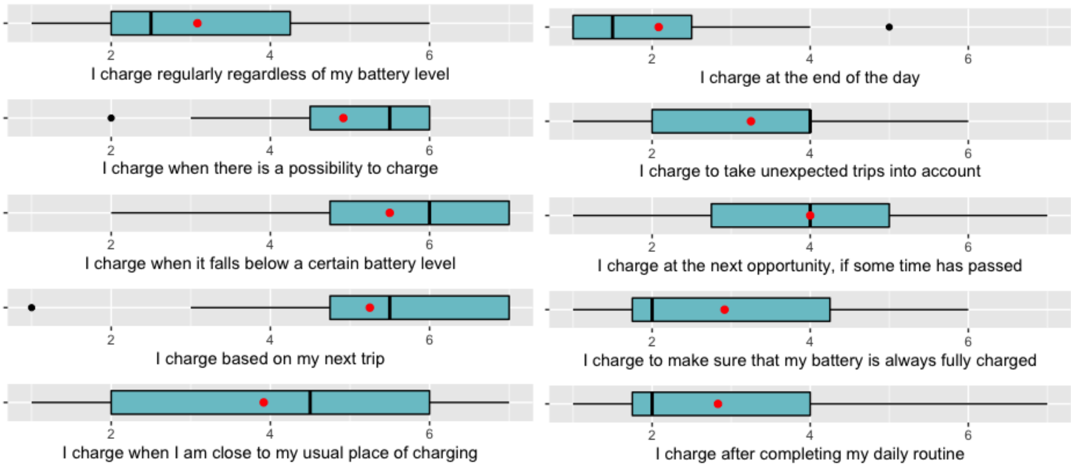


Figure 154 LEV charging behaviour at the Berlin demonstration area

Quality of Experience

Out of 9 respondents, only 2 respondents indicated that they used the service of a CPOs/eMSPs. As such, the quality of experience will not be discussed in this section.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e. the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging options are the most popular with 55.56% of respondents choosing they are most likely to use battery swapping in the future. 22.22% of the respondents indicated that they would use mobile charging services.

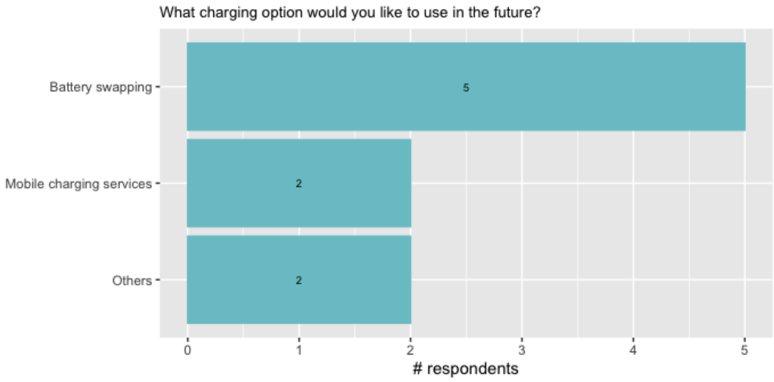


Figure 155 Preferred LEV charging option to use in the future at the Berlin demonstration area

Due to the small set of answers, we only discuss the UTAUT model for battery swapping.

Next, we take a closer look at the UTAUT constructs for the 2 biggest categories. Looking at behavioural intention, it can be seen in Figure 148 that the intention to use battery swapping is rather high.

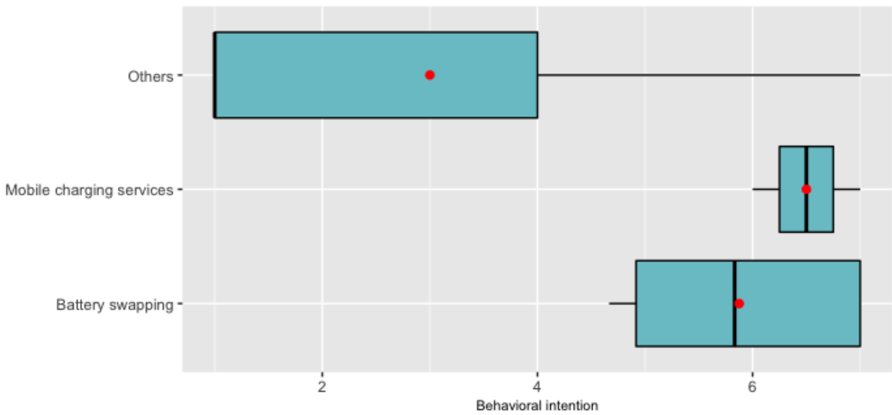


Figure 156 Behavioural intention for LEV charging options at the Berlin demonstration area

In terms of the performance and effort expectancy (see Figure 149 and Figure 150), the respondents evaluate all the solutions well. Again, battery swapping scores very high.

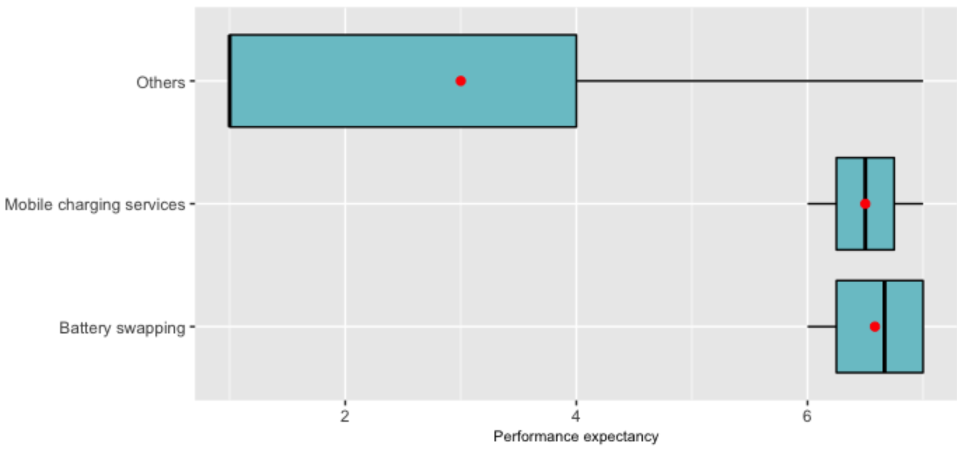


Figure 157 Performance expectancy for LEV charging options at the Berlin demonstration area

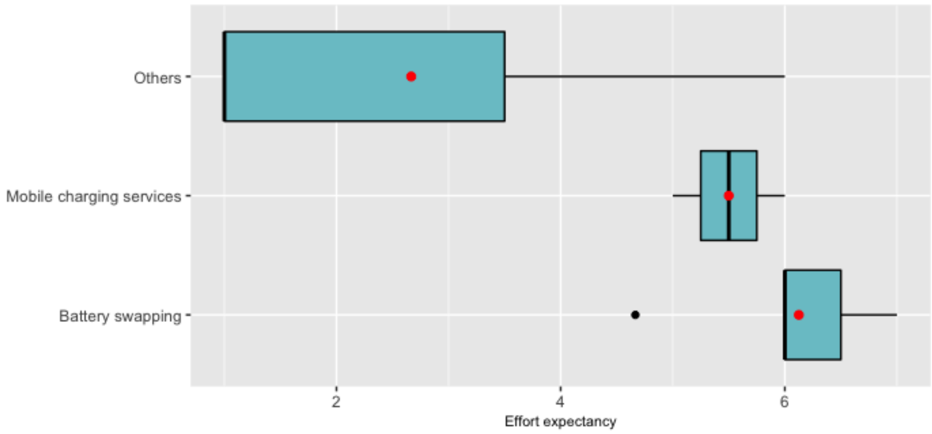


Figure 158 Effort expectancy of the LEV charging options at the Barcelona demonstration area

In terms of facilitating conditions, more than 75% of the respondents ranges toward very good with having the necessary resources and knowledge to use the charging option and having the charging option be compatible with other forms they use (see Figure 151).

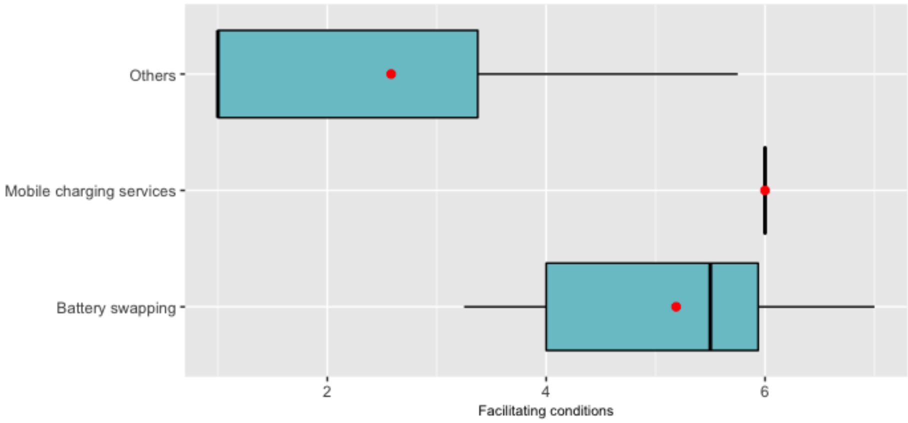


Figure 159 Facilitating conditions of the LEV charging options at the Berlin demonstration area

The social influence on using certain LEV charging option scores good (see Figure 152 and Figure 153). As such for social influence, respondents do agree with the fact that people who are important or influence their behaviour think they should use this charging option. For the hedonic motivation, respondents are not influenced by whether a charging option is considered to be fun or entertaining, which is captured through the scores on hedonic motivation.

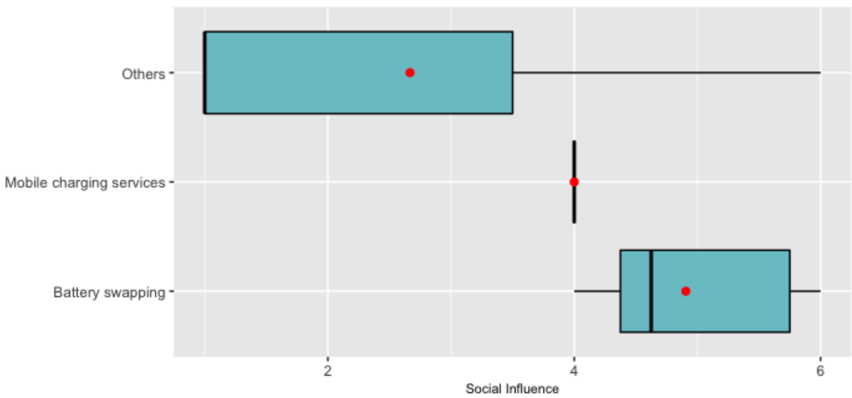


Figure 160 Social influence of the LEV charging options at the Berlin demonstration area

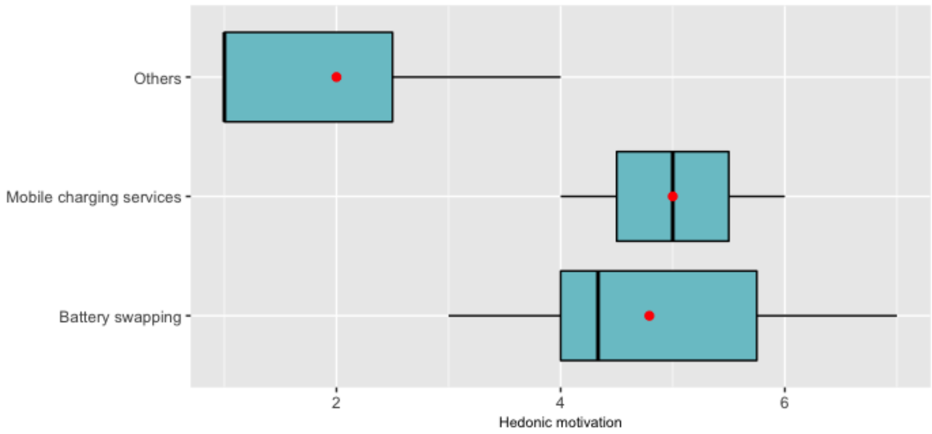


Figure 161 Hedonic motivation of the LEV charging options at the Barcelona demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their LEV charged by the charging option, whether they would only use it if the price were the same or whether they would only use it if the price were lower. Here, respondents indicated to pay the same amount of money for future charging options in comparison with current charging options (see Figure 154).

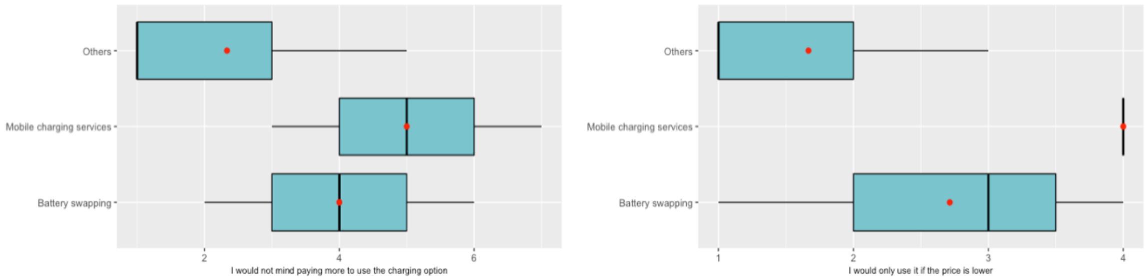


Figure 162 Price value of the LEV charging infrastructure at the Berlin demonstration area

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 66.67% of the respondents, indicated they use app-based services, another 11.1% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. About 83.3% of the app-based service users, use this at least a few times a month, as can be seen in Figure 155.

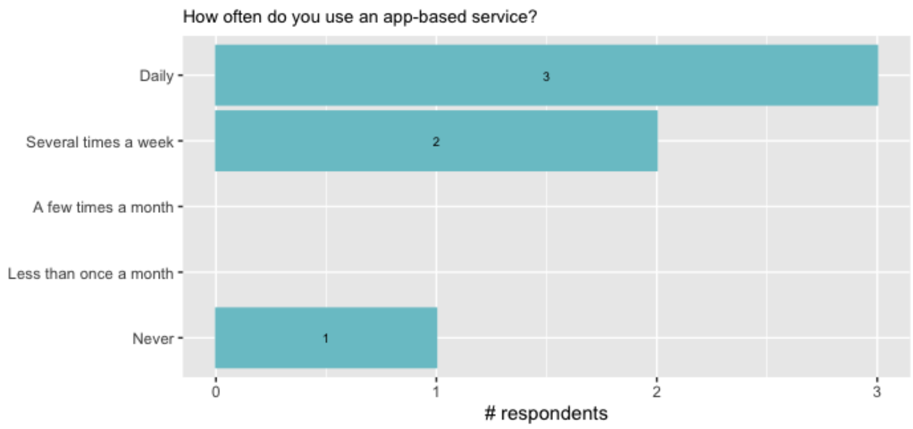


Figure 163 Usage of app-based LEV services at the Berlin demonstration area

While app-based services were most frequently used for travel by the EV users, this is the least frequent usage for LEV users (only 5 respondents). LEV users use app-based services mostly for leisure activities (7 respondents), next for commuting and work activities (6 respondents). In terms of satisfaction with the used app-based services, Figure 156 shows that all the respondents are satisfied above average on a scale of 1 to 7.

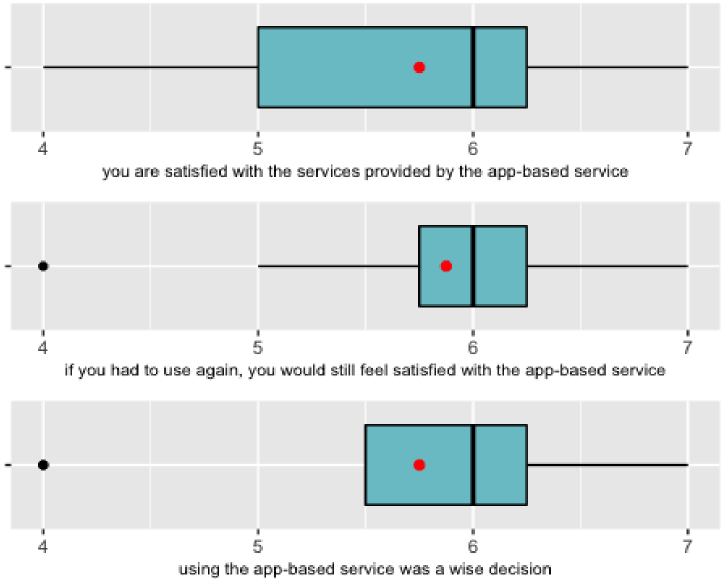


Figure 164 Satisfaction with the LEV app-based services at the Berlin demonstration area

Non-EV users

Lastly, we zoom into the non-EV users, a total of 26 respondents. Interestingly, only 34.6% of the respondents' states that will buy an electric vehicle as soon as possible or state that it is very likely they will buy an electric vehicle.

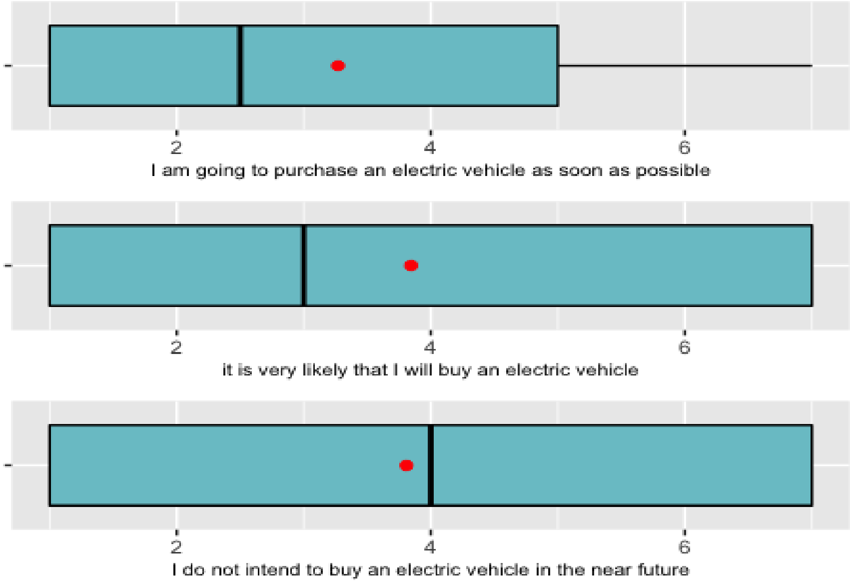


Figure 165 Non-users' Intention to buy an EV at the Berlin demonstration area

Moreover, it is interesting that almost half of the respondents who wants to buy an EV, wants to buy an electric car (44.4%) and the other half wants to buy an LEV (44.4%). Out of these 4 respondents interested in buying an electric car, they all prefer a battery electric vehicle (4 respondents).

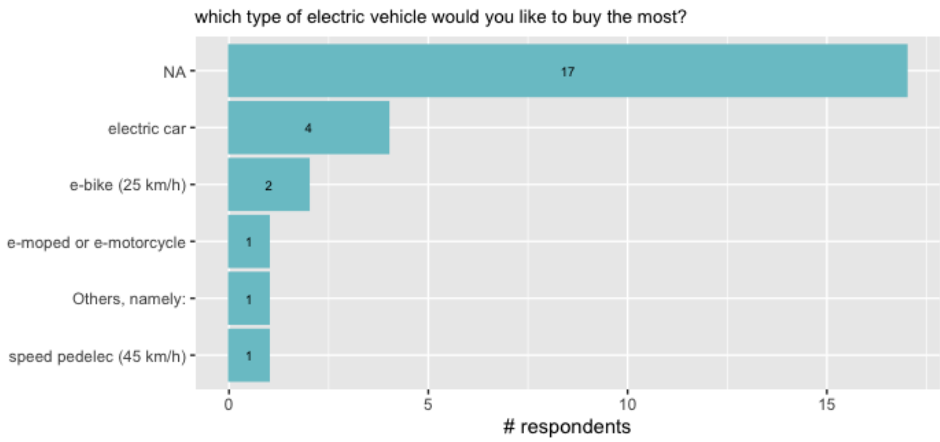


Figure 166 Type of EV that non-users intend to buy at the Barcelona demonstration area

Lastly, the most important motives for non-EV users to purchase an EV in the future is the environmental friendliness and the fact that EVs have more efficient technology in terms of energy consumption as 87% respectively 75% considers this very to extremely important. At the same time, the least important motive is the better image EVs could have towards other people as 75% of the respondents consider this not important at all to slightly important.

Key findings of the Berlin report

The main reasons for electric car adoption are the green environmental footprint, and the fact that EVs contribute to the noise reduction and have a better driving comfort. The EV users mostly park public along the road near their home. This could be a reason why the big part of electric car owners' mostly charges at a public charging station. This can be seen in the chart of charging time, where the users charge overnight and in the evening. It is also clear that little charging takes place during the day, as the least frequent charging place is at the workplace, where 85% of the respondents indicate that they never charge at work. Interesting to see, is that a big part of the respondents never charges at home, as 62.5% indicate they have no charging option at home. Smart charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use. It is remarkable to note that the respondents would not seem to mind paying more using battery swapping, but 75% of the respondents indicate they would only use smart charging when the price is cheaper than the current charging options available. Interestingly people are very satisfied about the app-services on their phone and have 4 apps or more on their phone which 57% uses it several times a week.

LEV users mainly bought their LEV because it is environmentally friendly, and because it is the fastest way of transportation. LEV users use their LEV often to go to work. In terms of charging behaviour, half of the LEV users charge their LEV when they are close to their usual place of charging. Battery swapping is the most preferrable charging option in the future and users see this also as the charging option the easiest to use. Users don't want to pay more for battery swapping in comparison with current charging options.

Lastly, only 37% of the non-EV users states that they will buy an electric vehicle in the short-term horizon. Of these 37% almost half wants to buy a LEV. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (87%) and more efficient technology in terms of energy consumption (75%) in comparison with non-EVs. At the same time, the least important motive is the better image EVs could have towards other people as 75% of the respondents consider this not important at all to slightly important.

Outcome from historical data

In the case of this demonstration area, there was no CPO in the consortium that could provide electromobilty data from the city. In order to have an overview of the electromobility context, it has been decided to analyse another German city, in this case the city of Frankfurt. Therefore, this section presents the quantitative data analysis for the city of Frankfurt. In this demonstration area, 79 unique Charging Points operated by Hubject have been analysed.

Descriptive Statistics

- **Sessions' temporal distribution**

Figure 167 presents the daily distribution of the charging sessions. Saturdays have the highest number of charging sessions, presenting a peak at 12 pm. The working days have a similar distribution with a morning peak between 9 am and 11 am and a second peak between 2 pm and 6 pm. Sunday is the day with lowest number of charging sessions.

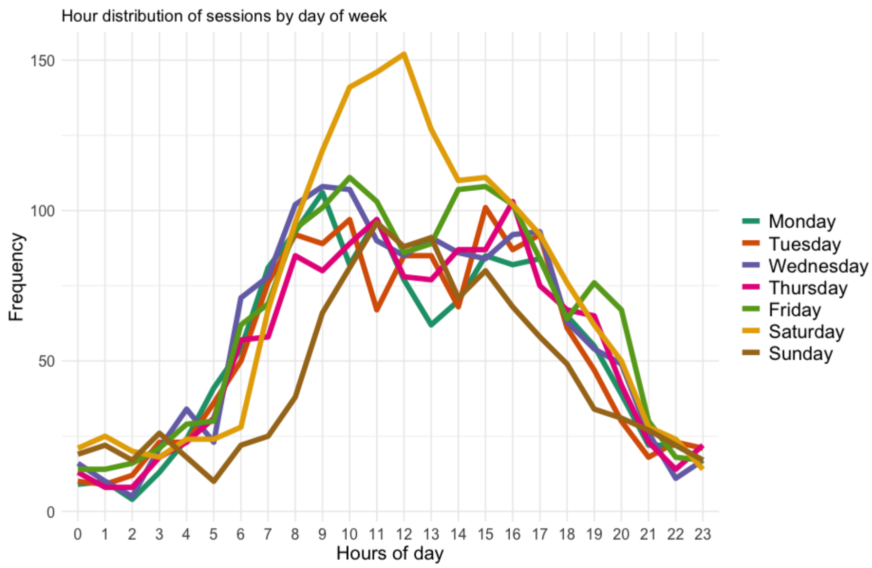


Figure 167. Sessions' temporal distribution – German demonstration area

- **Charging sessions' duration**

Figure 168 and Table 36 present meaningful information about the duration of the sessions. The data presents some outliers arriving to a maximum session duration of 59 hours. Therefore, it makes more sense to consider the median (79 minutes) as the average duration of the sessions in Frankfurt CPs.

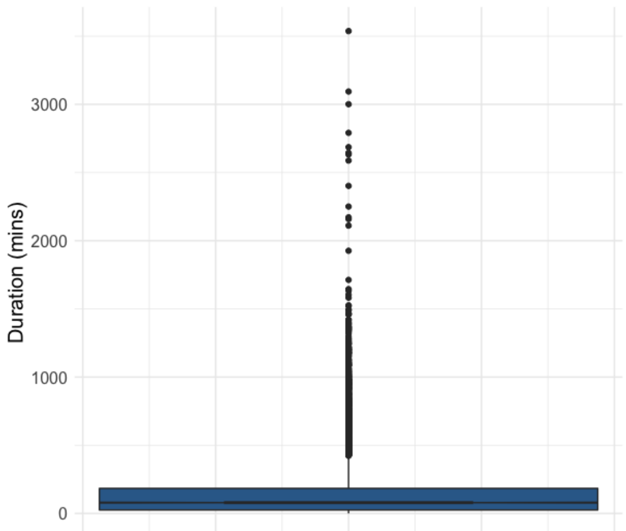


Figure 168. Boxplot of sessions duration – German demonstration area

Table 36. Summary of statistical values for sessions duration – German demonstration area

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
0.08 min	25.27 min	79.12 min	156.89 min	183.80 min	3537.27 min

- **Energy consumed per session**

It can be inferred that the average energy consumed per charging session in the CPs analysed in this demonstration site is 13.44 kWh, as shown in the figures below. In general, the energy consumed per session is low, being the 75% of the charging sessions analysed with a consumption below 17.8 kWh.

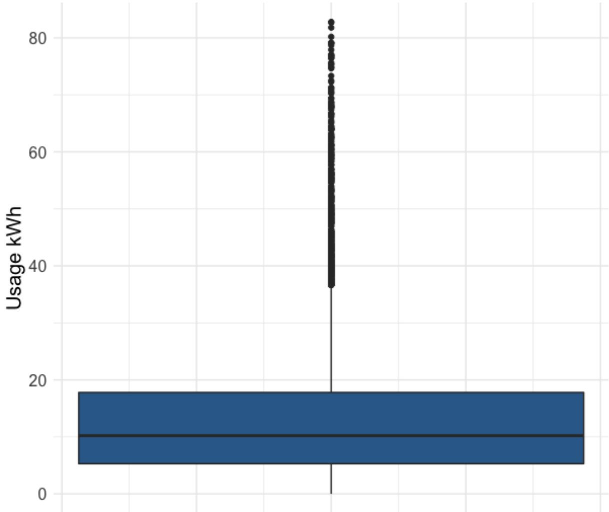


Figure 169. Boxplot for sessions' energy consumed – German demonstration area

Table 37. Summary of statistical values for sessions' energy consumed – German demonstration area

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
0.01 kWh	5.29 kWh	10.21 kWh	13.44 kWh	17.80 kWh	82.80 kWh

Temporal Clustering

The charging points are clustered based on their hourly occupancy behaviours. The clustering method that provides best results is *kmeans* with 2 clusters.

Table 38 Temporal clusters – German demonstration area

Temporal Cluster 1	Temporal Cluster 2
55 CPs (69.6 %)	24 (30.4 %)

Temporal Cluster 1 includes the majority of the CPs (69.6%) and comprises the CPs than on average have a low occupancy percentage. Temporal Cluster 2 includes CPs with an average occupancy between 7% and 10.5%. In both Clusters the occupancy is higher between 12pm and 10 am.

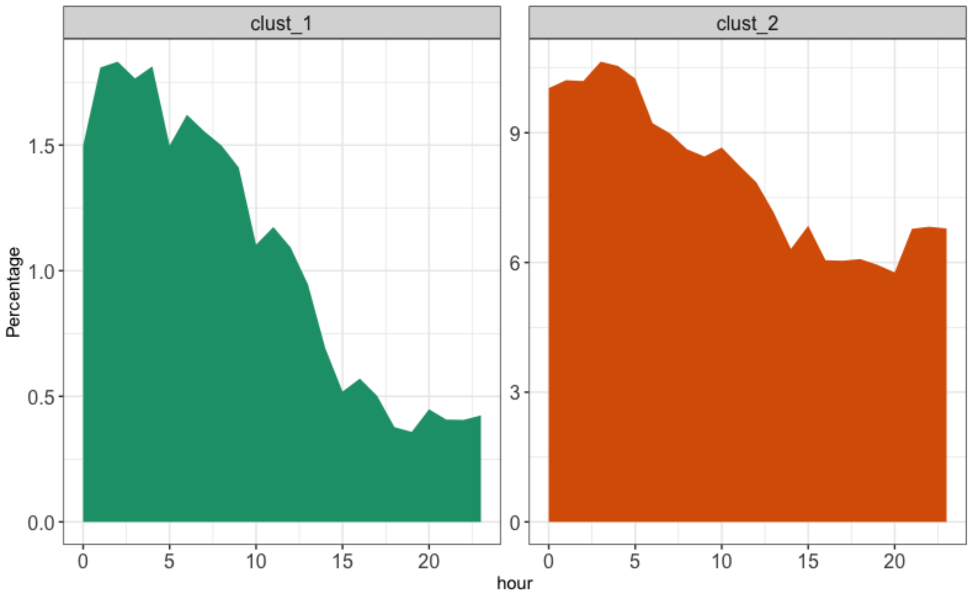


Figure 170. Charging Points' temporal clusters' hourly occupancy distributions – German demonstration area

COVID-19 effect

The following time periods have been established for the analysis of the COVID-19 effect in the Germany demonstration area:

Pre-COVID-19: 2020-01-13 – 2020-03-14
Lockdown: 2020-03-15 – 2020-05-17
De-escalation: 2020-05-18 – 2020-06-21
New-normality: 2020-06-22 – 2020-09-01

The average sessions per day decreased a 15% and they double in the de-escalation and new normality periods. The average charging session duration decreases in all the periods while the average occupancy decreases in the lockdown and increases during the de-escalation and new normality. Finally, the average daily energy consumed remains stable during the periods analysed.

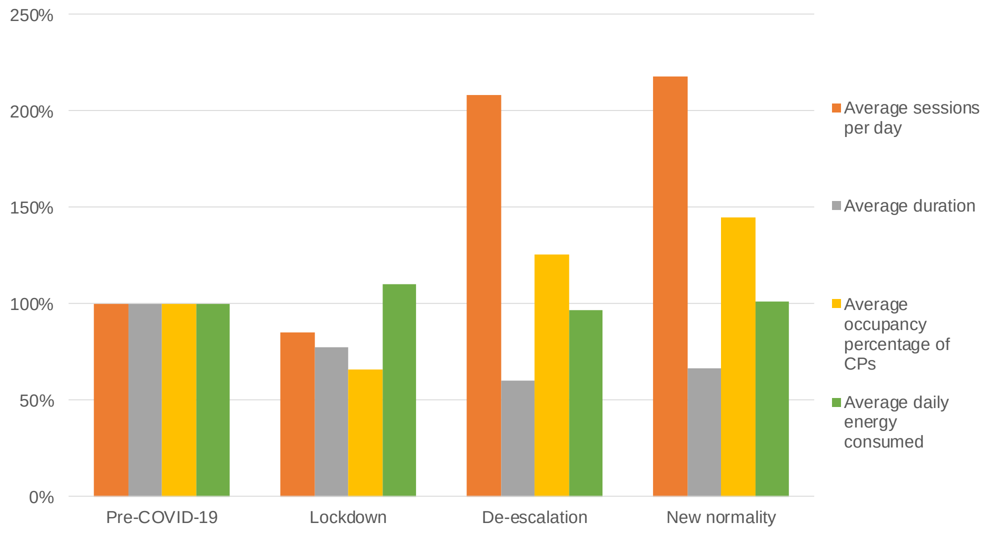


Figure 171. Variation of charging attributes with relation to the pre-COVID-19 period – German demonstration area

A priori assessment of the e-mobility charging infrastructure

Table 39. Usage KPIs – German demonstration area

Impact Area: Usage	Result
Frequency of use of charging options	121.33
Vehicle's charging time	156.8 minutes
Availability rate (1)	6.33 % of the charging options are occupied more than 10 %.
Availability rate (2)	74.68% of the charging points are occupied less than 5 %
Average usage ratio of charging options	3.32% is the average ratio.

Demonstration area 5: Grenoble

Context

The current network of public charging stations on GAM territory is composed of 31 public on-street charging points, complemented with stations in parking facilities. There are 324 EV users registered to the public network, the number is increasing, but many EV users charge their vehicles at home.

According to its Master Plan on EV development, GAM also supports the carsharing operator Citiz by dedicating some charging stations and is currently upgrading some old charging stations to make them accessible to all. In the next months, GAM will also develop new charging stations, in particular in park and ride facilities, and will support private sector to equip their sites with charging points (condominium properties, companies). Since May 2020, in order to increase users' participation to operational costs and encourage EV turn over on charging stations, GAM has experimented kWh tariffication combined with paying car park after 2 hours, which has permitted to increase income.

Data collection for survey

In order to diffuse the survey, several channels have been activated. To target the general public, EV users registered to GAM charging stations network have been asked to fill the survey through a newsletter, articles have been published on GAM social media related to transport (app, website, Facebook…) as well as on external social media (mostly EV groups on Facebook). Users' associations have also published articles and sent emails to their members. Regarding professionals, companies and taxis, GAM has contacted professionals already in GAM mobility networks (Mpro and professionals having beneficiated from GAM financial support for EV purchase), and taxis from Grenoble.

Outcome from survey

After data cleaning, the data set contains 134 respondents in total. Of the respondents, 69.40% (93) use any type of electric vehicle, whereas 30.60% (41) does not. Figure 172 shows the type of electric vehicles the respondents use, where the majority 90.32% (84) indicated they use an electric car.

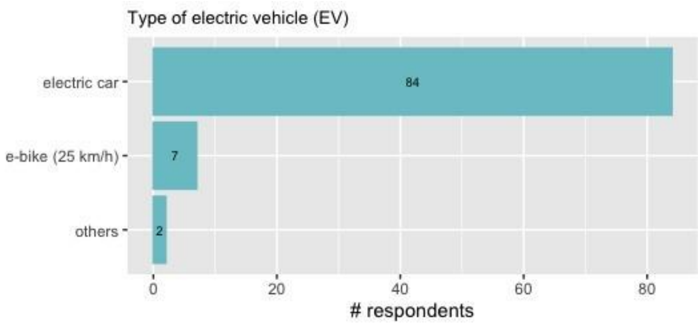


Figure 172 Type of EVs used out of 93 respondents at the Grenoble demonstration area

Out of the 84 respondents who use an electric car, 89.29% (75) indicated they drive a battery electric vehicle without an internal combustion engine, whereas 5.95% (5) of the respondents drive a plugin-hybrid electric vehicle. Also, 2.38% (2) drive an electric vehicle with a range extender and 2.38% (2) a hybrid vehicle that combines a classical internal combustion engine with an electric motor.

In regards to the socio-demographic variables of the full sample, the majority of the respondents were men (78.36%). Most respondents (46.27%) have obtained a university degree or a higher non-university degree (32.09%). The majority is full time employed (76.87%), whereas 7.46% is retired. Almost 81.34% of the respondents is married with or without children (50.75% resp. 30.60%). The different socio-demographics are detailed in Table 40. Almost all respondents (98.51%) possess a drivers licence. For most respondents, this concerns a drivers licence B (87.31%), followed by drivers licence A (37.31%). A small portion of the respondents possess a drivers licence C (7.46%), a drivers licence D (4.48%), no respondents have a drivers licence G.

Table 40 Socio-demographics of the respondents at the Grenoble demonstration area

Socio demographics	Categories	N (%)
Gender	Female	28 (21)
	Male	105 (78)
	Other	1 (1)
Degree	None	1 (1)
	Primary education	2 (1)
	Secondary education	8 (6)
	University education (Bachelor degree, Master degree, …)	62 (46)
	Post-university education (PhD, Post-doc,…)	18 (13)
Residential situation	I live alone	16 (12)
	I live with family	5 (4)
	I live with others: co-housing	1 (1)
	Married or in relationship with child(ren)	68 (51)
	Married or in relationship without children	41 (31)
	Single parent with child(ren)	3 (2)
Professional situation	Currently unemployed	4 (3)
	Employed full time	103 (77)
	Housewife/Houseman	1 (1)
	Other profession, namely :	7 (5)
	Part-time employed	8 (6)
	Retired	10 (7)
	Temporary exemption (e.g. maternity leave, parental leave)	1 (1)
Function	Blue collar worker	5 (4)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	2 (2)
	Middle management	44 (37)
	Official / employed in a public service	17 (14)
	Own company, entrepreneur with employees	7 (6)
	Self-employed, entrepreneur without employees	8 (7)
	Senior management / management	20 (17)
	Teaching staff / employed in education	6 (5)
	White collar employee (administrative, executive or support/clerical function)	10 (8)

EV car users

Out of 84 electric car (84) users, 64 respondents privately own the vehicle, whereas 20 drive a company owned car. Furthermore, 2 respondents indicated that they use their vehicle as a taxi-cab. The majority of the respondents (73.81%) does not enjoy any company benefits, 9.52% of the respondents indicated they enjoy a company charging pass, whereas 5.95% enjoys a company fuel pass. Furthermore, 7.14%

receives a kilometre compensation and 3.57% indicated they enjoy some other type of mobility benefit. In terms of the battery electric vehicles, the most popular cars are the Renault ZOE (23 respondents), followed by a Nissan LEAF (9) and a Tesla Model 3 (7 respondents). The Kia e-Niro (6 respondents) and the Hyundai IONIQ (4 respondents) close the top 5. The most popular plug-in hybrid electric vehicles are the BMW i3 Range Extender (2 respondents) and the Volkswagen Passat GTE (2 respondents). Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity between 41 and 50 kWh, where the next most popular choice is between 20 and 30 kWh. At the same time, 4 respondents indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 300 and 400 km. Lastly, 40% of all EV users is driving their current vehicle for less than 1 year. More detailed information can be found in Table 41.

Table 41 EV characteristics at the Grenoble demonstration area

Vehicle characteristics	Categories	N (%)
Battery Capacity – kWh (BEV) according to respondents	<20	3 (4)
	20–30	12 (16)
	31–40	10 (13)
	41–50	21 (28)
	51–60	5 (7)
	61-70	11 (15)
	>70	9 (12)
	I do not know.	4 (5)
Battery Range – km **(BEV) according to respondents**	100–149	5 (7)
	150–199	11 (15)
	200–249	8 (11)
	250–299	16 (21)
	300-400	18 (24)
	>400	11 (15)
Battery Capacity – kWh (PHEV) according to respondents	5 – 10	2 (40)
	10 – 15	3 (60)
Battery Range – km **(PHEV) according to respondents**	30-39	2 (29)
	40-50	1 (14)
	>50	3 (43)
	I do not know	1 (14)
Respondent usage of the vehicle in years	< 1 year	34 (40)
	1 year	13 (15)
	2 years	20 (24)
	3 years	9 (11)
	4 years	0
	>4 years	8 (10)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 173 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

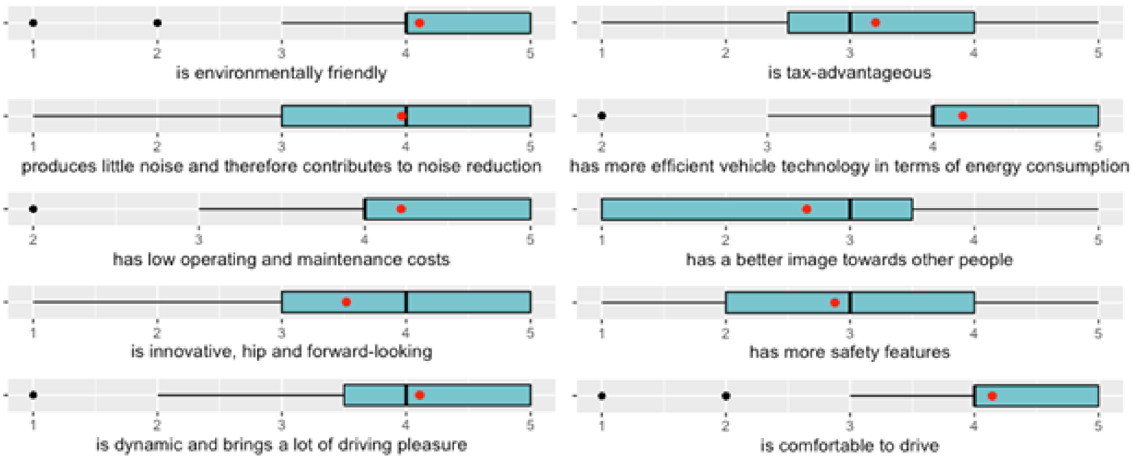


Figure 173 Reasons for EV usage or purchase at Grenoble demonstration area

From Figure 173, it is clear that the main reasons for using or purchasing and EV are the environmental friendliness, the low operating and maintenance costs and the fact that EVs have more efficient technology in terms of energy consumption and are more comfortable to drive. More specific, the comfort of driving was the most important factor as (83.33%) considered this factor to be very important to extremely important. The least important factor is the better image an EV could have towards other people, where 28.57% considered this factor to be not important at all.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 100.83 km, where the average time spent on the road was about 2 hours and 20 minutes. The EV is mostly parked at a private parking at home for almost 12 hours and 20 minutes a day on average. Figure 174 gives a more detailed overview of the parking time at different locations.

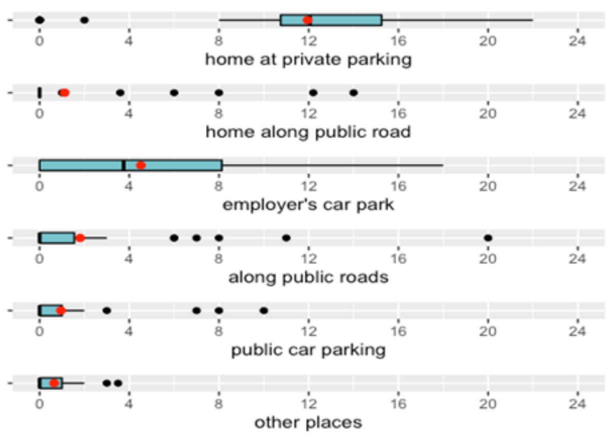


Figure 174 Respondents' EV parking time at different locations at the Grenoble demonstration area

The respondents' parking location at home was mostly the driveway or a privately-owned garage (73.81%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or based on their next trip. For the other statements, the opinions are more divided (see Figure 175).

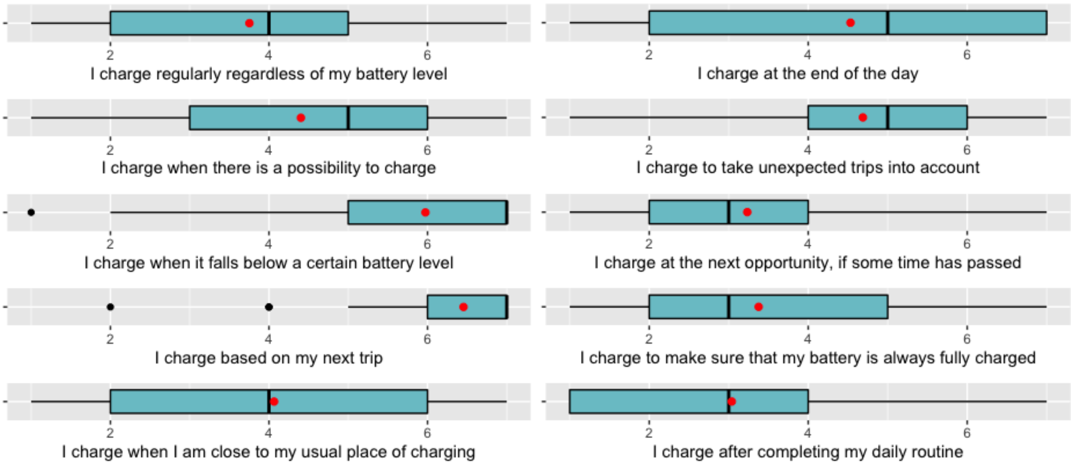


Figure 175 Respondents' charging behaviour at the Grenoble demonstration area

Regarding charging experience, 8.33% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 61.90% charges often at a different location, whereas 29.76% sometimes does. Respondents charge the EV most frequently at home, 19.48% of the respondents charges their EV at home daily and 33.77% does so several times a week. The main charging option at home is the charging station (65.22%) followed by a socket (28.99%). The least frequent charging place is at the workplace, where 57.14% of the respondents indicate that they never charge at work. Also, public fast chargers are more frequently used than non-fast chargers.

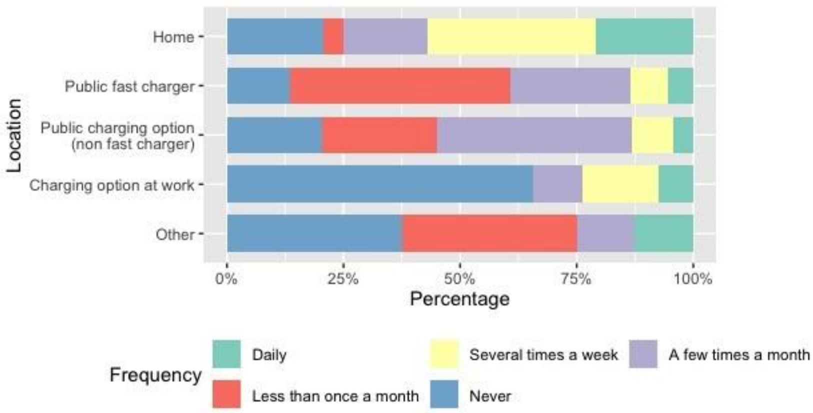


Figure 176 Respondents' charging behaviour per location at the Grenoble demonstration area

The most popular charging time is between midnight and 3a.m., followed closely by 3a.m-6a.m. The least popular time is between 9 a.m. and 1 p.m. After 6 p.m. charging becomes more frequent again.

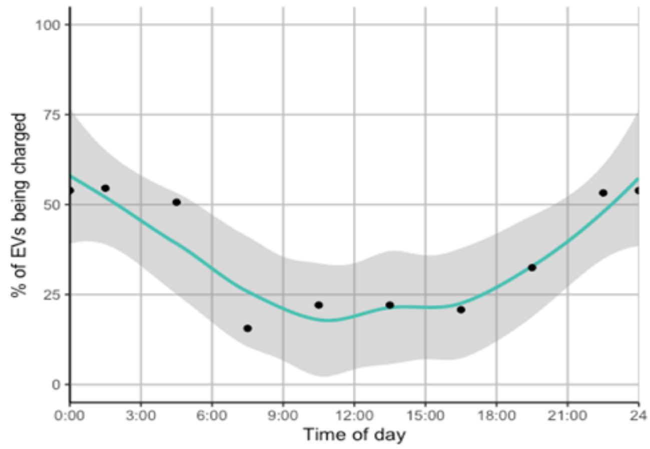


Figure 177 Respondents' charging schedule at the Grenoble demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that Grenoble-Alpes Métropole charging points is the most popular.

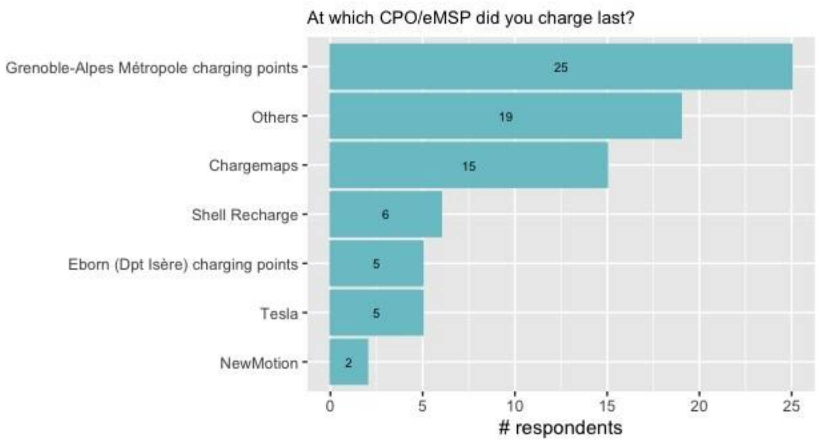


Figure 178 Last charging CPO/eMSP at the Grenoble demonstration area

In what follows, we discuss the results and make comparisons for CPOs that were evaluated by at least 5 respondents. Although Grenoble-Alpes Métropole is the most popular CPO, it appears to score lower on tangibility than some other less frequently used CPOs. Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for Grenoble-Alpes Métropole are spread ranging from very poor to very good. The charging infrastructure for Chargemaps scores higher with an average of more than 5 on 7, whereas the Tesla charging infrastructure scores highest overall in terms of tangibility (see Figure 179).

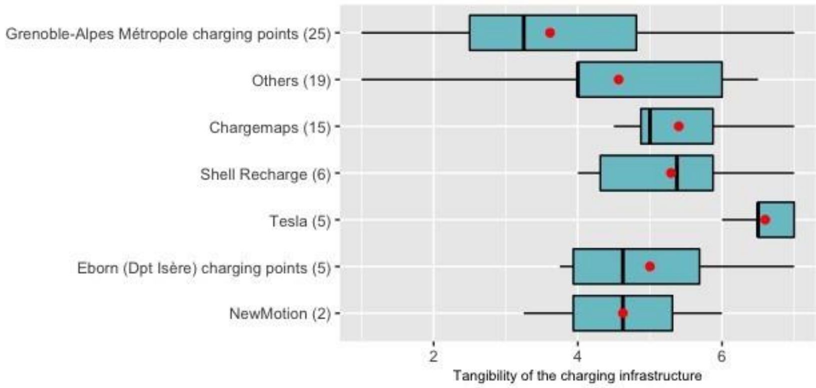


Figure 179 Tangibility of the charging infrastructure at the Grenoble demonstration area

For availability and reliability of the charging infrastructure, similar scores can be observed (see Figure 180 and Figure 181). The availability captures whether the charging infrastructure is available for use, can start immediately, does not block and is not inadvertently interrupted. Tesla scores significantly higher on average for these criteria, whereas Chargemaps and Shell Recharge score slightly better than Grenoble-Alpes Métropole. The latter scores quite neutral on average. The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping. It can be noted that Grenoble-Alpes Métropole scores lower than neutral on average for reliability. This indicates some clear discontentment of the respondents in terms of the reliability criteria.

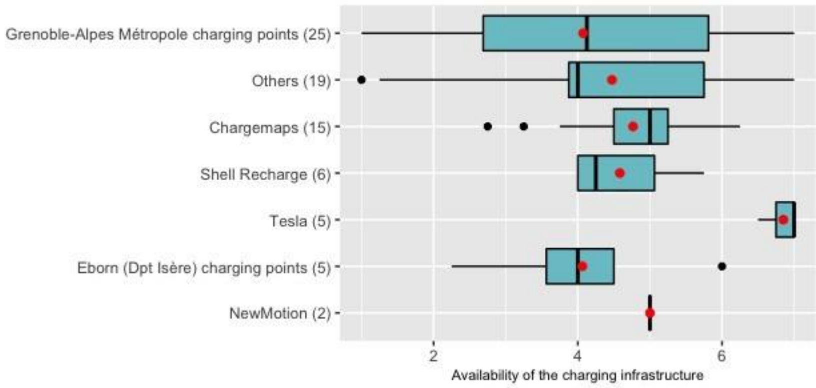


Figure 180 Availability of the charging infrastructure at the Grenoble demonstration area

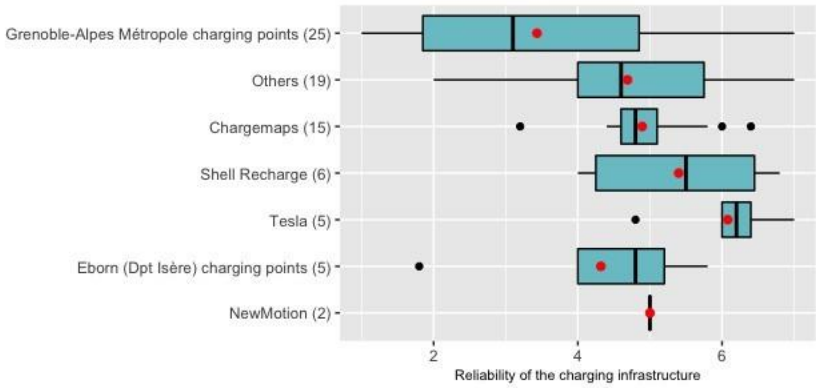


Figure 181 Reliability of the charging infrastructure at the Grenoble demonstration area

Looking at the privacy of the charging infrastructure, it is clear that all CPOs receive similar scores. Except for Tesla and Chargemaps, which score slightly higher (see Figure 182). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other companies and payment credentials are protected.

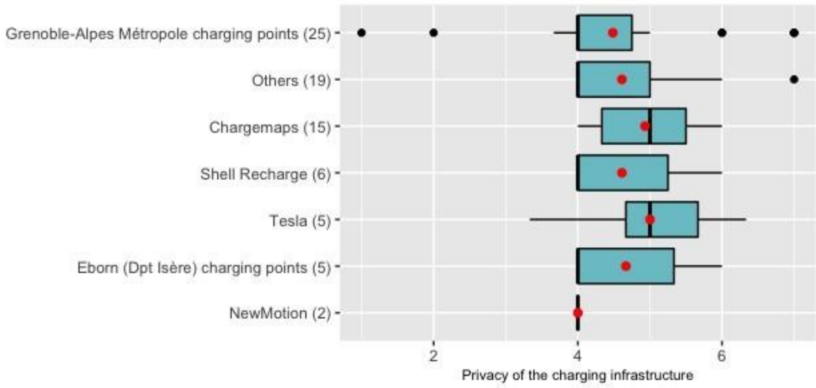


Figure 182 Privacy of the charging infrastructure at the Grenoble demonstration area

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 28 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 28 indicated they have not. Most charging infrastructure problems are experienced when using Grenoble-Alpes Métropole charging points. Indeed, 68% (17 out of 25 respondents) indicated to have experienced problems with this CPO. Whereas for Chargemaps this is only 20% (3 out of 15 respondents)

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For Grenoble-Alpes Métropole, it can be seen in Figure 183 that over 75% of the respondents scores the responsiveness poorly (less than 4 out of 7), with an average of less than 3. Chargemaps scores better, with an average of about 3.5 out of 7.

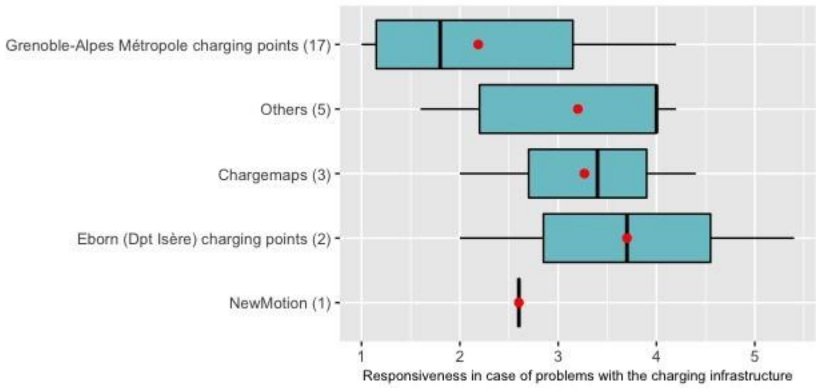


Figure 183 Responsiveness in case of problems with the charging infrastructure at the Grenoble demonstration area

Compared to the responsiveness in case of problems, the scores on contact are clearly higher. For contact, respondents had to indicate whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the ability is provided to speak to a person in case of problems. Although there is still a large spread in the scores, Grenoble-Alpes Métropole scores better with an average of 4 out of 7 for the contact criteria (see Figure 184).

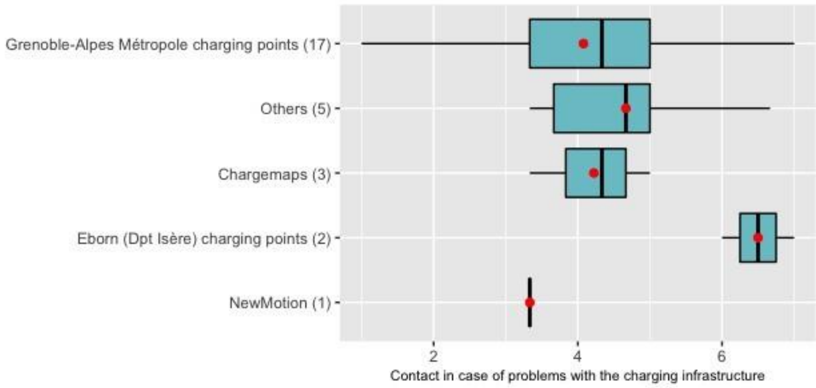


Figure 184 Contact in case of problems with the charging infrastructure at the Grenoble demonstration area

Lastly, respondents had to score different criteria for compensation in case of problems. Respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. Figure 185 shows that all CPOs/eMSPs score all poorly on the compensation criteria. A conclusion can be that the user seems to expect more in case of problems, more specific in terms of responsiveness and compensation, than what the CPO/eMSP currently offers.

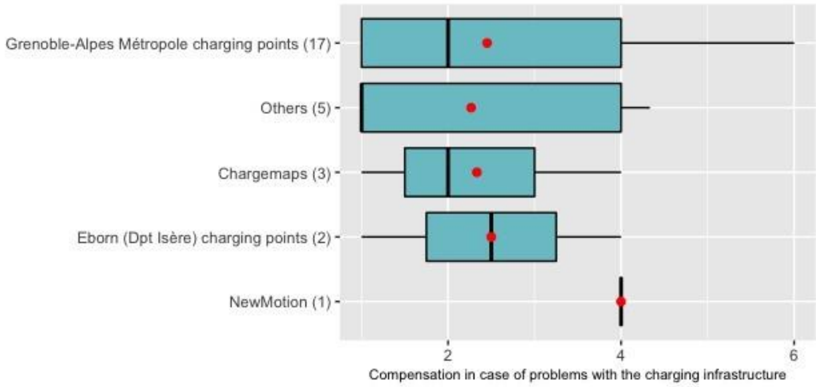


Figure 185 Compensation in case of problems with the charging infrastructure at the Grenoble demonstration area

Finally, the last questions in this section probe for the respondents' opinions on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. All CPOs/eMSPs score on average neutral on the perceived value criteria. '

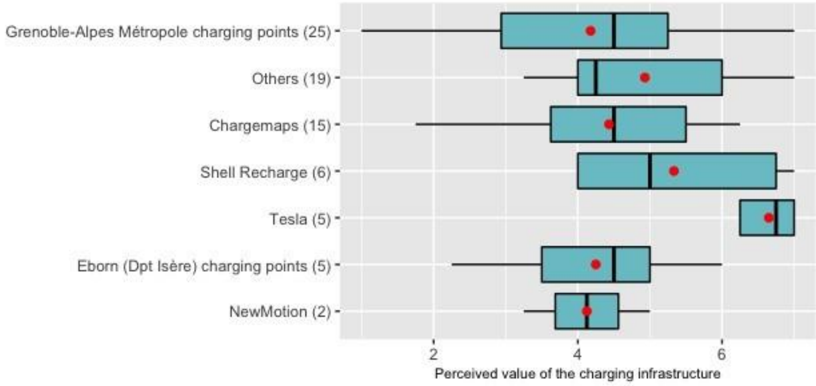


Figure 186 Perceived value of the charging infrastructure at the Grenoble demonstration area

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. Chargemaps clearly scores highest on the loyalty criteria (see Figure 187). Grenoble-Alpes Métropole, again, receives a wide range of scores, resulting. However, 50% of the respondents scores them lower than 4 out of 7.

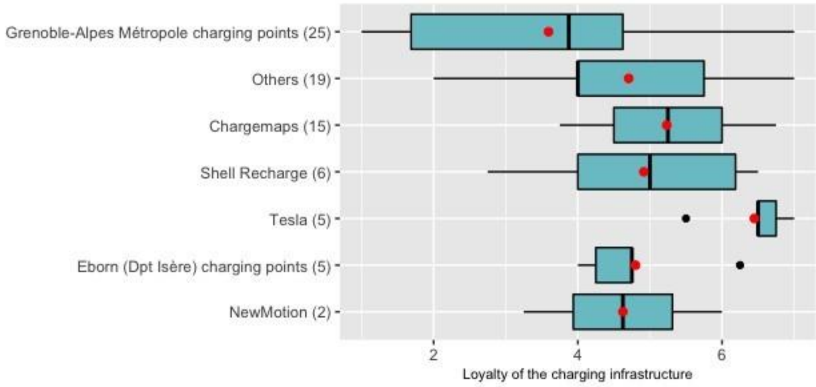


Figure 187 Loyalty of the charging infrastructure at the Grenoble demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the general trend in the earlier questions, the highest scoring CPO/eMSP is Chargemaps. Grenoble-Alpes Métropole receives both low and high scores, resulting in an average of 3.5 out of 7, meaning that the customer satisfaction is low (see Figure 188).

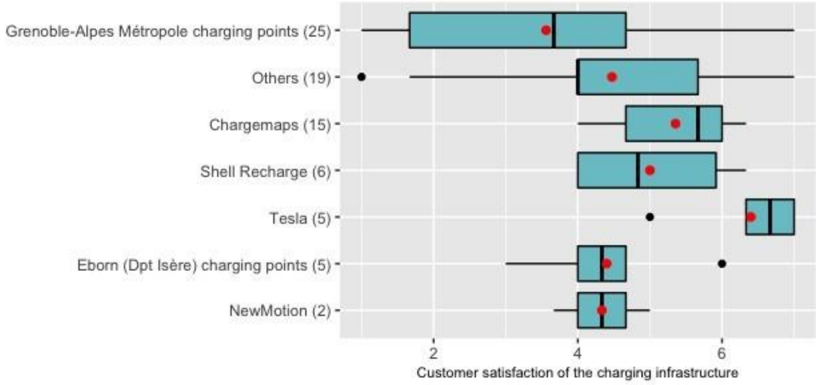


Figure 188 Customer satisfaction of the charging infrastructure at the Grenoble demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, Fast charging are the most popular with 67.86% of respondents choosing they are most likely to use Fast charging in the future.

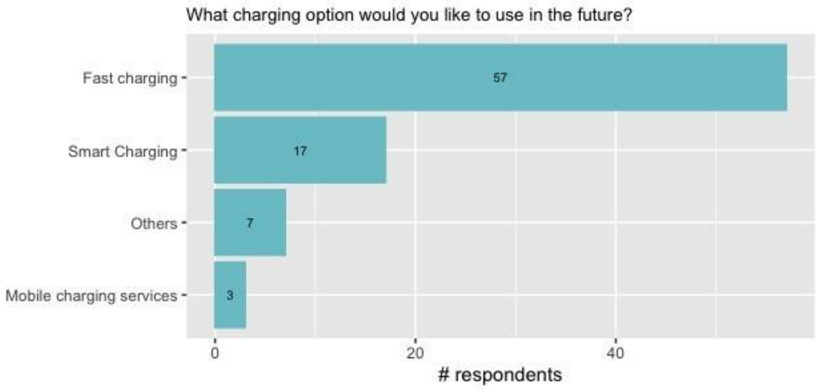


Figure 189 Most likely charging option in the future at the Grenoble demonstration area

Fast charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration.

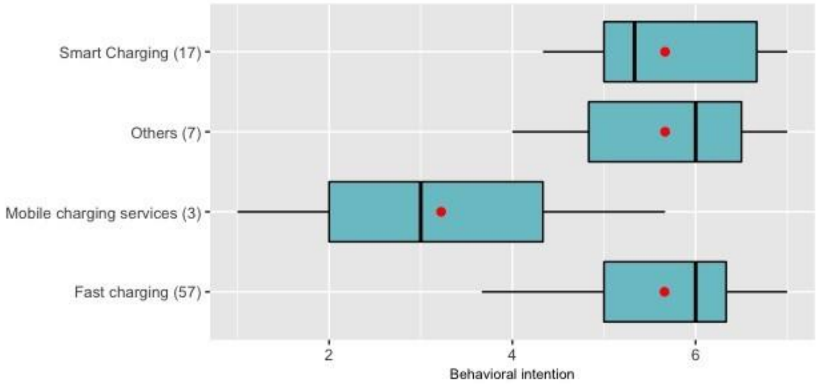


Figure 190 Behavioural intention of charging infrastructure at the Grenoble demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, fast charging scores highest on these criteria (see Figure 191).

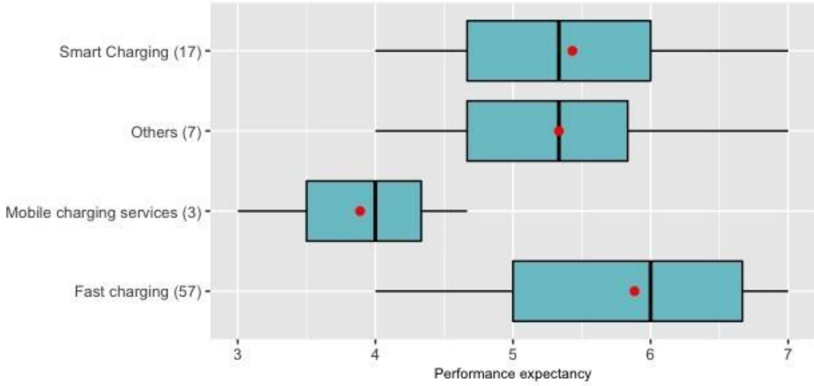


Figure 191 Performance expectancy of the charging infrastructure at the Grenoble demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. For all charging options, 100% of the respondents scores them higher than 4 out of 7 in terms of effort expectancy (see Figure 192).

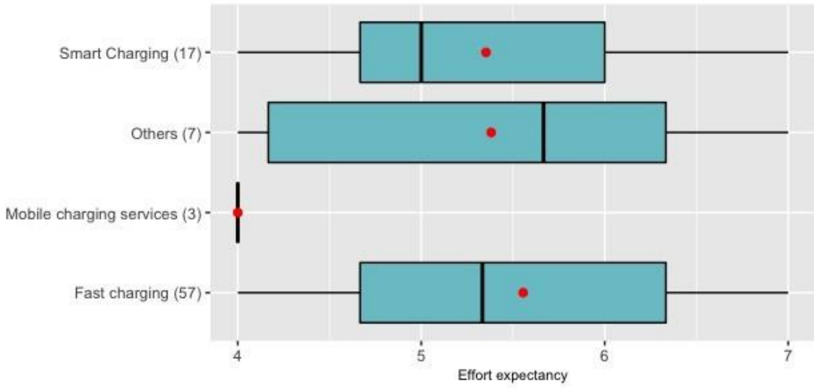


Figure 192 Effort expectancy of the charging infrastructure at the Grenoble demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 193). The averages and medians all lightly fluctuate between 4 and 5 on a scale of 7. Mobile charging services score significantly lower, but this only concerns the opinions of 3 respondents.

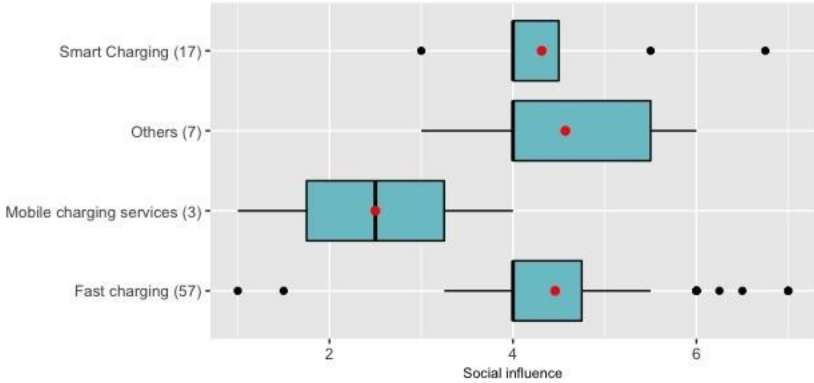


Figure 193 Social influence of the charging infrastructure at the Grenoble demonstration area

In terms of facilitating conditions, the scores of the fast charging options are more skewed towards a 7 than the other charging options (see Figure 194). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

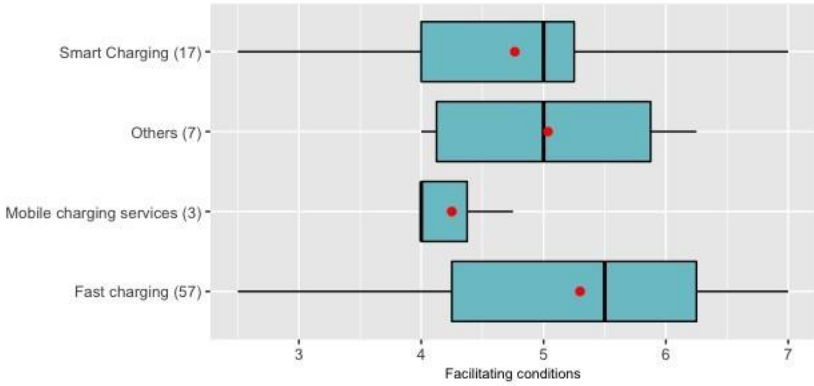


Figure 194 Facilitating conditions of the charging infrastructure at the Grenoble demonstration area

As for hedonic motivation, quite similar distributions can be observed for the different charging options (see Figure 195). Respondents are overall quite neutral about these statements. Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

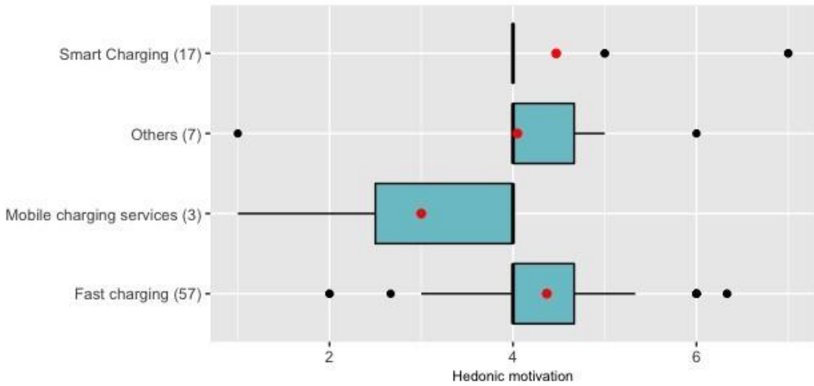


Figure 195 Hedonic motivation of the charging infrastructure at the Grenoble demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price were the same or whether they would only use it if the price were lower. Here, it is interesting to note that 25% of the respondents would not seem to mind paying more for fast charging options or battery swapping (see Figure 196). At the same time for smart charging, 75% indicates they would only use it if the price is lower.

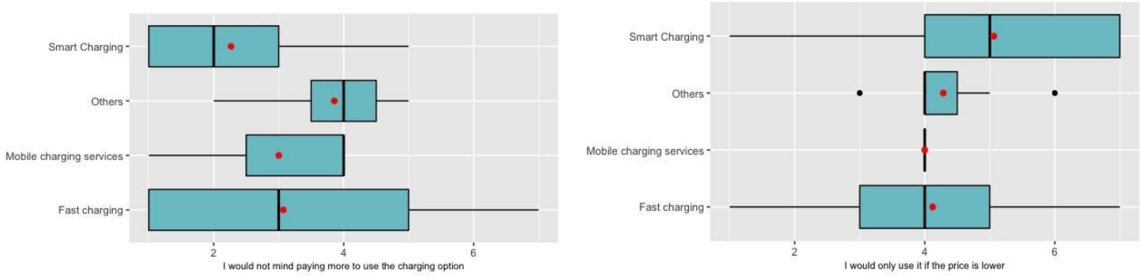


Figure 196 Price value of the charging infrastructure at the Grenoble demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. The majority of the respondents, 73.81% (62 respondents) indicated they use app-based services, another 7.14% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, 47% of the EV respondents has 4 or more apps on their phone. About 77.42% of the app-based service users, use this at least a few times a month, as can be seen in Figure 197.

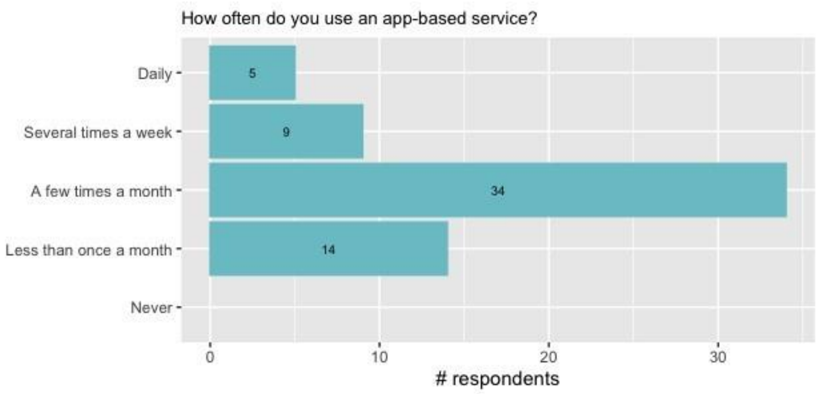


Figure 197 Usage of app-based services at the Grenoble demonstration area

App-based services are mostly used for travel related to travel destinations on holiday (48 respondents), whereas 38 respondents use it for leisure activities. To a lesser extent, the app-based services are used for shop/errands (12 respondents) and commuting and work activities (10 respondents). In terms of satisfaction with the used app-based services, Figure 198 shows that 50% of the respondents are satisfied above average on a scale of 1 to 7.

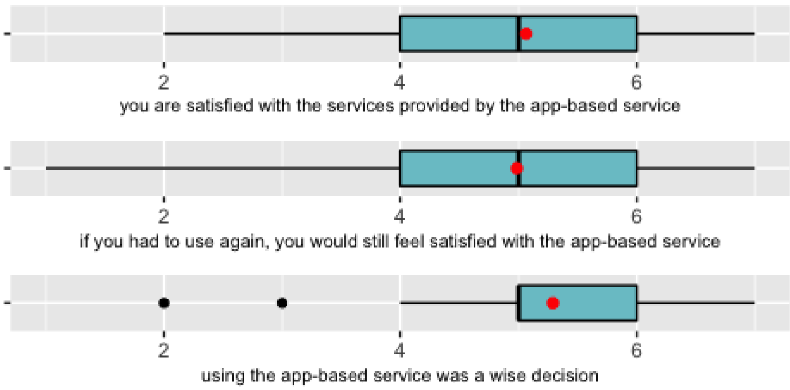


Figure 198 Satisfaction with the app-based services at the Grenoble demonstration area

LEV

In this section, we zoom in to the 7 respondents who use a light electric vehicle. The majority of the respondents (100.00%) owns the LEV they use and are responsible for the LEV maintenance costs (100.00%). At the same time, most of the respondents does not know what the battery capacity is or did not fill out this question (57.14%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 42.

Table 42 LEV characteristics at the Grenoble demonstration area

Who is the owner of the [QID3-ChoiceGroup-SelectedChoices] you normally drive?	**N (%)**
Private	7 (100)
Who is responsible for the maintenance costs of the [QID3-ChoiceGroup-SelectedChoices] you drive?	
Private	7 (100)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	
0,5 – 1	2 (29)
5-7	1 (14)
I do not know.	4 (57)
How often do you use your [QID3-ChoiceGroup-SelectedChoices]?	
Daily.	5 (71)
Several times a week.	2 (29)
Do you use a fixed car park or garage?	
I use a fixed, rented parking space.	1 (14)
I use a garage that is my property or park on my driveway.	5 (71)
I use a rented garage.	1 (14)

On average, the LEV users indicate they drive about 15.14 km each day and spend about 2 hours and 20 minutes on the road. The majority of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 199).

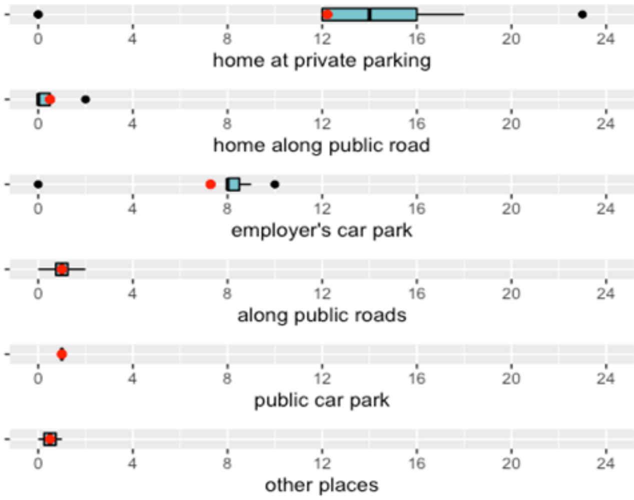


Figure 199 Parking space and duration of the LEV at the Grenoble demonstration area

Looking at the motives to use an LEV, it is clear that the most important motive is the environmental friendliness and the fact that it is considered the fastest mode of transport, whereas least important is the image towards other people.

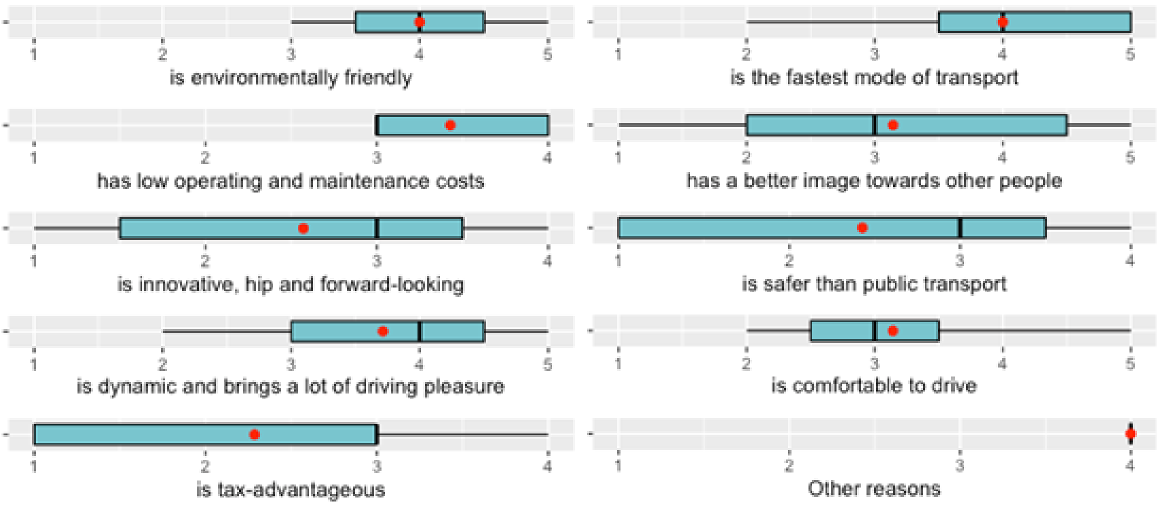


Figure 200 Motives to use LEVs at the Grenoble demonstration area

In terms of charging behaviour, almost 100% of the respondents seem to charge when the battery falls below a certain level or based on their next trip. Also, 50% of the respondents charge when they are close to their usual place of charging.

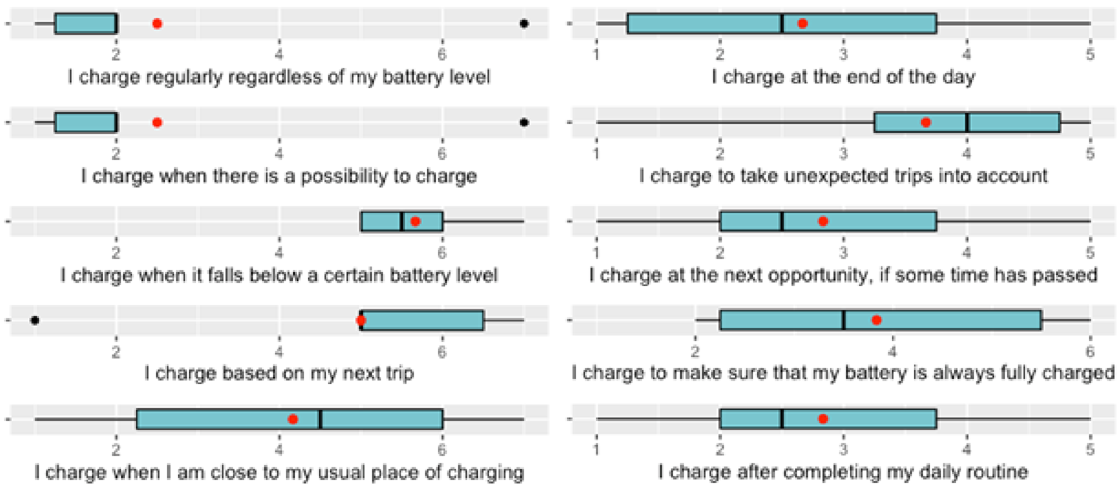


Figure 201 LEV charging behaviour at the Grenoble demonstration area

Quality of Experience

Out of 7 respondents, no respondents indicated that they used the service of a CPOs/eMSPs. As such, this quality of charging experience will not be discussed.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e. the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Only 3 respondents indicated they would use smart charging; the other respondents chose the option "Other". Due to this small sample, this section will not further elaborate on the acceptance of charging technology for LEV users.

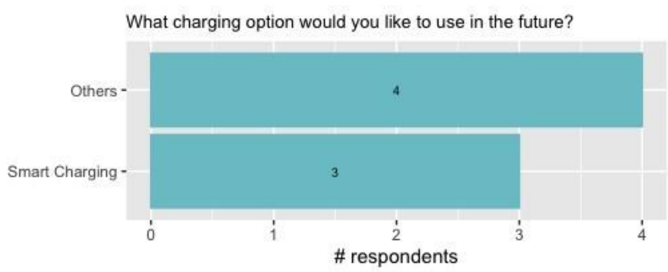


Figure 202 Preferred LEV charging option to use in the future at the Grenoble demonstration area

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, only 1 respondent indicated he/she use app-based services, the others do not but intend to or have no intention to use an app in the near future. Due to this small sample, this section will not further elaborate on the app-based services for LEV users.

Non-EV users

Lastly, we zoom into the non-EV users, a total of 41 respondents. Interestingly, over 25% of the respondents' states that they will buy an electric vehicle as soon as possible and over 50% states that it is very likely they will buy an electric vehicle.

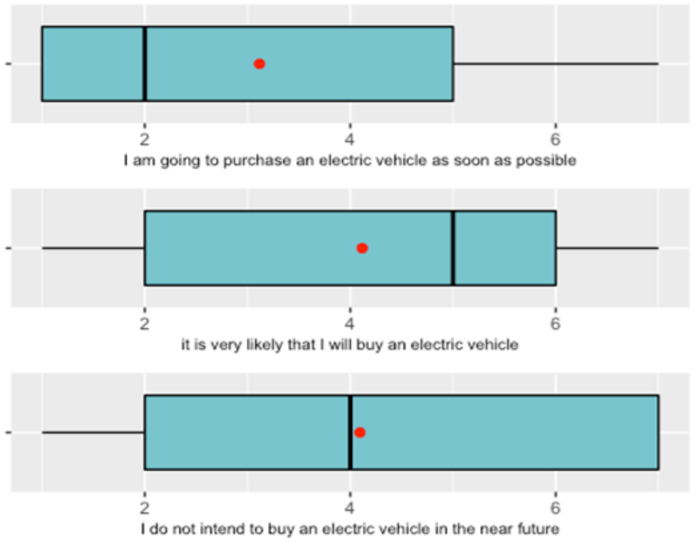


Figure 203 Non-users' Intention to buy an EV at the Grenoble demonstration area

Moreover, most respondents (60%) indicate they are mostly interested to buy an electric car. Out of these 11 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (7 respondents), an electric vehicle with range extender (1 respondent) or a plug-in hybrid electric vehicle (2 respondents). The remaining 2 respondents prefer a hybrid vehicle that combines a classic combustion engine.

Lastly, the most important motives for non-EV users to purchase an EV in the future is the environmental friendliness and the fact that EVs have more efficient technology in terms of energy consumption as 100% respectively 98% considers this moderately to extremely important. At the same time, the least important motive is the better image EVs could have towards other people as 37% of the respondents consider this not important at all to slightly important.

Key findings of the Grenoble report

The main reasons for electric car adoption are the green environmental footprint, and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, the big part of electric car owners' charges mostly at home. This can be seen in the chart of charging time, where the users charge overnight and in the evening. It is also clear that little charging takes place during the day, as the least frequent charging place is at the workplace, where more than half of the respondents (57.14%) indicate that they never charge at work. Respondents are not quite satisfied with the quality of service they receive from the charging stations of Grenoble-Alpes Métropole. More specific in terms of tangibility and reliability of the charging station, the responsiveness and compensation in case problems arise, and therefore are the scores on loyalty and customer satisfaction low. Fast charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use. Also, other future charging options receive high scores for the acceptance of new technologies, which means people are looking forward to the future charging options. Remarkable is that 75% of the respondents indicate they would only use the future charging options is when the price is similar or cheaper than the current charging options available. Especially for smart charging, where the respondents expect a high discount.

LEV users mainly bought their LEV because it is environmentally friendly, and because it is the fastest way of transportation. LEV users use their LEV often to go to work. In terms of charging behaviour, half of the LEV users charge their LEV when they are close to their usual place of charging. Smart charging is the most preferrable charging option in the future.

Lastly, most of the non- EV users (75%) states that they will buy an electric vehicle in the short-term horizon, with over 25% of the respondents' states that they will buy an electric vehicle as soon as possible. The respondents that would like to buy an EV in the future are mostly (60%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (100%) and more efficient technology in terms of energy consumption (98%) in comparison with non-EV. At the same time, the least important motive is the better image EVs could have towards other people as 37% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV car users.

Outcome from historical data

This section presents the quantitative data analysis for the Grenoble-Alpes Metropole. In this pilot, there are 31 unique CPs with a power of 22kW and the available dataset covers the time-window between 17/05/2019 to 04/11/2020. All the charging points are possessed and monitored by Grenoble-Alpes Metropole through its exploitation market with Bouygues Energies et Services. Users can have access to them by registering to the network or directly without registering through the application (in this case, tariffs are higher). Charging Points network is expected to develop, notably with DC charging points and different powers.

Descriptive Statistics

This section covers the descriptive statistics for the charging sessions data from Grenoble-Alpes Metropole. It provides a general idea on the metropole's electromobility situation.

- **Sessions geographical distribution**

Figure 204 shows the location of the CPs and heatmap of charging sessions that took place in Grenoble-Alpes Métropole's CPs in the timeframe of study. The territory covers the city of Grenoble, but also surrounding cities such as La Tronche, Seyssinet-Pariset, Gières or Meylan, where charging points are located. For the following analysis the division of sectors for the city of Grenoble is used.

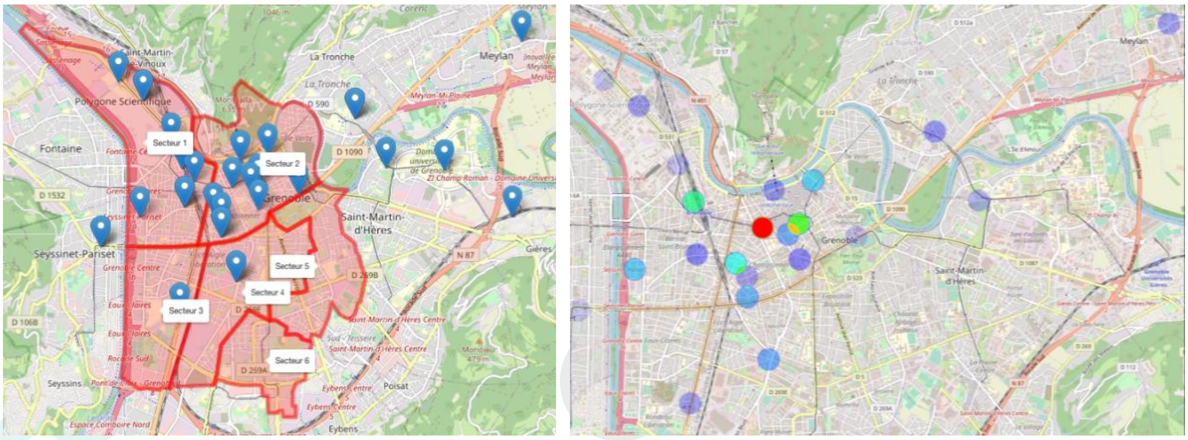


Figure 204. Heatmap of charging sessions in Grenoble

- **Usage distribution by sector**

In this section we analyse the number of CPs and their total number of charging sessions in each sector, Figure 205 represents the ratio of sessions divided by the number of CPs in the corresponding sector.

Sector 2, which is the city centre, with busy activity, is the one with the highest number of CPs and the highest number of sessions, on the contrary Sector 1, corresponding to residential and business districts, where companies may have their own private charging points for their fleet and employees, is the one showing the lowest ratio as the number of available CPs is high, but the number of sessions is lower. Finally, Sectors 3 and 4, which are residential areas with a part of low-income inhabitants higher, have low number of CPs and low number of sessions. In Annexe A3 can be found the session frequencies and the number of CPs per sector.

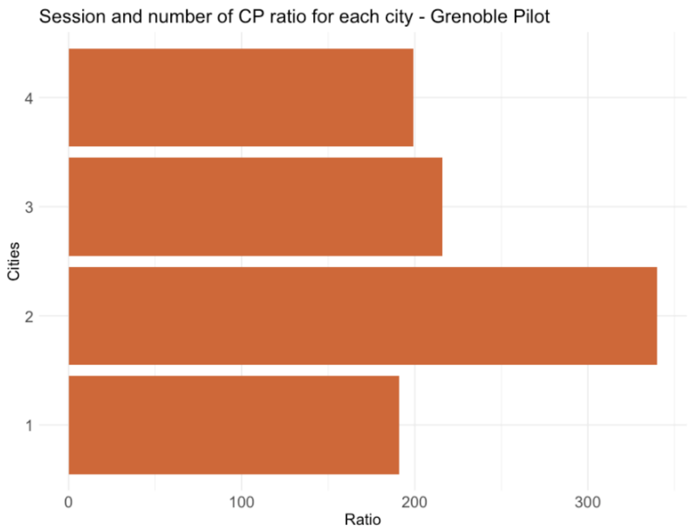


Figure 205. Ratio of sessions per CP in the Grenoble demonstration area

- **Sessions' temporal distribution**

Figure 206 shows the total number of sessions occurred in each day of the week. The frequency of sessions and patterns are similar for all the days of the week, except for Sunday which is the day with the lowest number of charging sessions.

From the figure it can be inferred that Tuesdays, Wednesdays, Thursdays and Fridays the starting time of the charging sessions have a morning peak from 8 am to 9 am, whereas on Mondays the peak shifts by one hour starting from 9 am to 10 am. On the other hand, the morning peak of the weekends is starting at 10 am. The noon peak starting from 12pm to 1 pm occurs in all working days, whereas Mondays, Tuesdays, and Wednesdays have a second peak with a lower level. In the evening, there's not a specific peak, we have different lower peaks from 5pm to 9 pm.

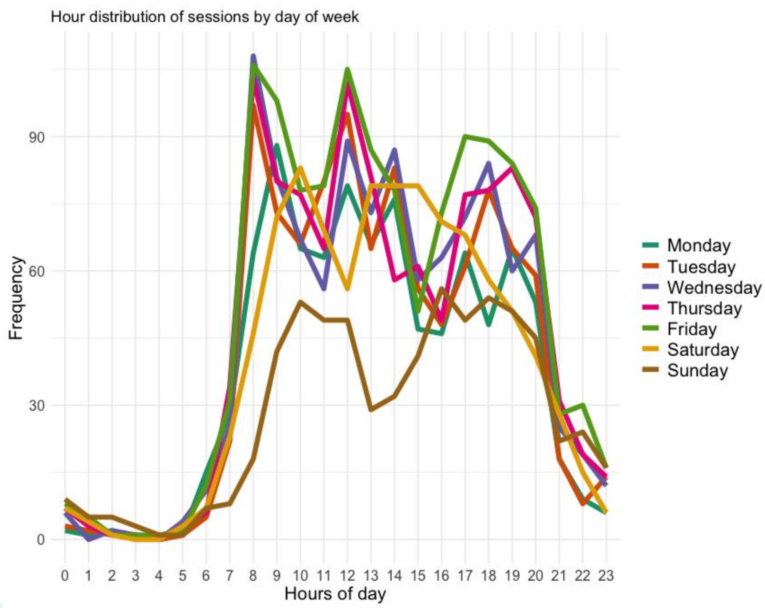


Figure 206. Session distribution by hour – Grenoble demonstration area

- **Sessions' duration**

The following boxplot provides a visual summary of the data enabling to quickly identify the mean and median values and the dispersion of the dataset. In this case, the dataset is very sparse as there are some really long sessions (up to 28 days). Therefore, the median is better choice to consider as the general average of duration, meaning that most of the users stay an average time of two hours in the public charging points. Table 43 presents a summary of the most meaningful values of the sessions' duration.

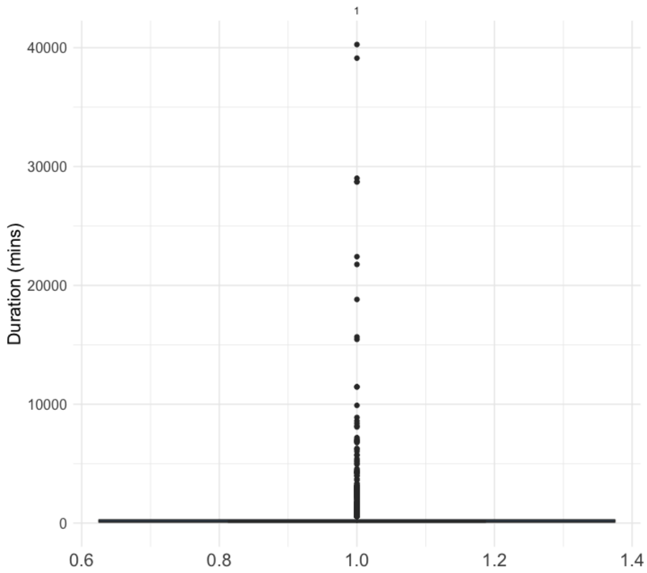


Figure 207. Boxplot of sessions duration – Grenoble demonstration area

Table 43. Summary of statistical values of sessions' duration – Grenoble demonstration area

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
4.05 min	72.77 min	131.13 min	313.73 min	273 min	40272.87 min (28 days)

- **Energy consumed per session**

The average energy consumed per session is 17.56 kWh. The individual dots represent the outliers; the algorithm detects the usages more than 50 kWh as outliers, meaning that a low number of sessions have an energy consumption above that number.

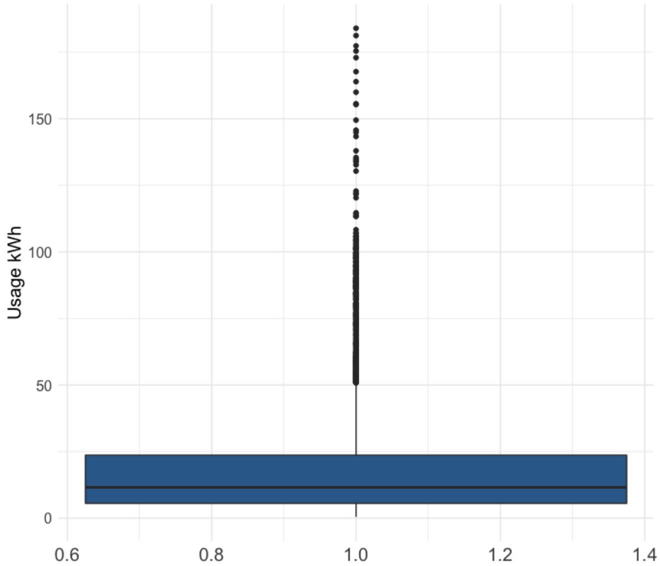


Figure 208. Boxplot for sessions' energy consumed – Grenoble demonstration area

Table 44. Summary of statistical values for sessions' energy consumed – Grenoble demonstration area

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
0.50 kWh	5.54 kWh	11.56 kWh	17.56 kWh	23.66 kWh	183.98 kWh

User Clustering

The user behaviours based on durations are used to obtain the real electromobility characteristics of the users. According to Annexe A1.2, the automated process with a predefined function in order to detect the optimal number of clusters and proper clustering method shows that the best option is *kmeans* method with 3 clusters.

Table 45 User clusters – Grenoble demonstration area

User Cluster 1	User Cluster 2	User Cluster 3
239 Users (47.9%)	95 Users (19%)	165 Users (33.1%)

Almost the half of the users from GAM belong to Cluster 1. In this cluster, users have low number of sessions (*n*), high energy and power consumed and low duration. On the contrary, users from Cluster 2, are the users with the highest number of sessions, highest number of different CPs visited and average energy consumed and duration similar to the overall average. Finally, users from Cluster 3 are the ones with highest duration, lowest power and low number of sessions.

The following diagram shows how each of the clusters compare to the average value of the studied parameters, a value above 0 means that this specific parameter is higher than the average, on the other hand a value below 0 means that the specific parameter is lower than the average.

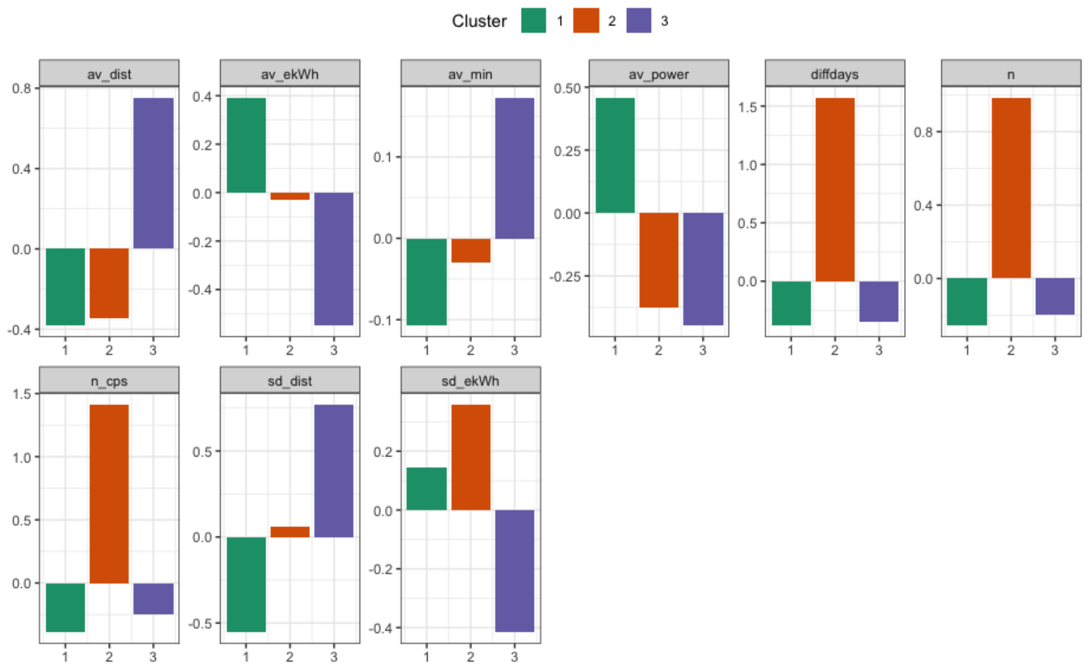


Figure 209. User clustering results – Grenoble demonstration area

Temporal Clustering

The charging stations are clustered based on their temporal behaviours. The optimal method for clustering the data is *kmeans* with 2 clusters.

Table 46 Temporal clusters – Grenoble demonstration area

Temporal Cluster 1	Temporal Cluster 2
18 CPs (58.1 %)	13 CPs (41.9 %)

Temporal Cluster 1 is the major cluster and contains 58 % of the CPs. This cluster comprises the CPs with a usage peak in the morning. Cluster 2 comprises the CPs with a higher occupancy (between 15% and 20%), and no pronounced usage peaks.

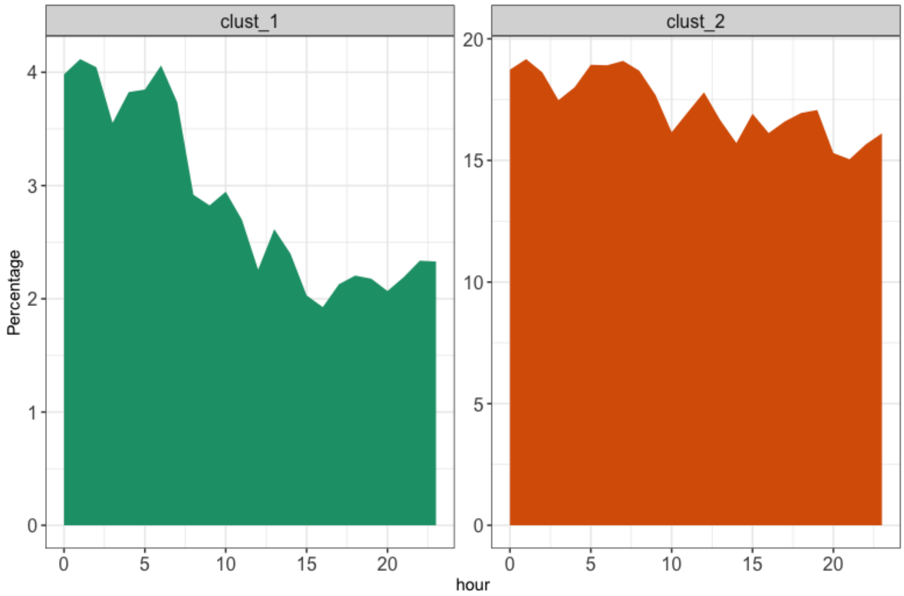


Figure 210. Charging Points' temporal clusters' hourly session distributions – Grenoble demonstration area

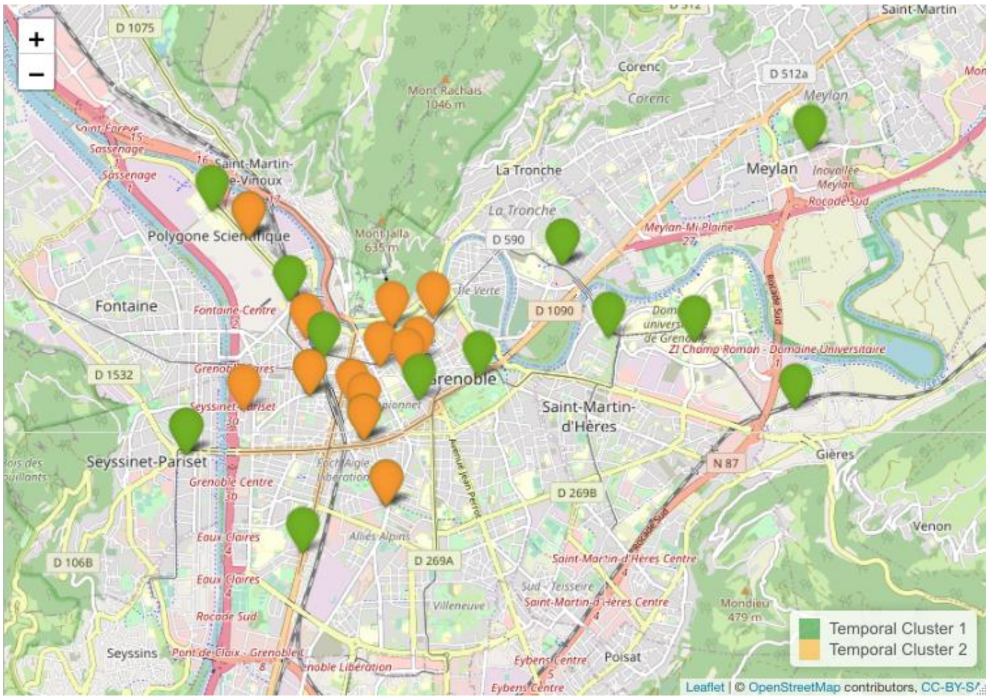


Figure 211. Charging Points temporal clustering geographical distribution – Grenoble demonstration

User mobility flows

In order to analyse the travel demands of the users and how the users charge in the city of Grenoble, the six geographical sectors from the city have been taken into account. Figure 212 depicts the flows between the sectors. In this case, there's a strong mobility flow between Sectors 2 and 1, this means that there's a high number of EV drivers that use the charging points located in both Sectors.

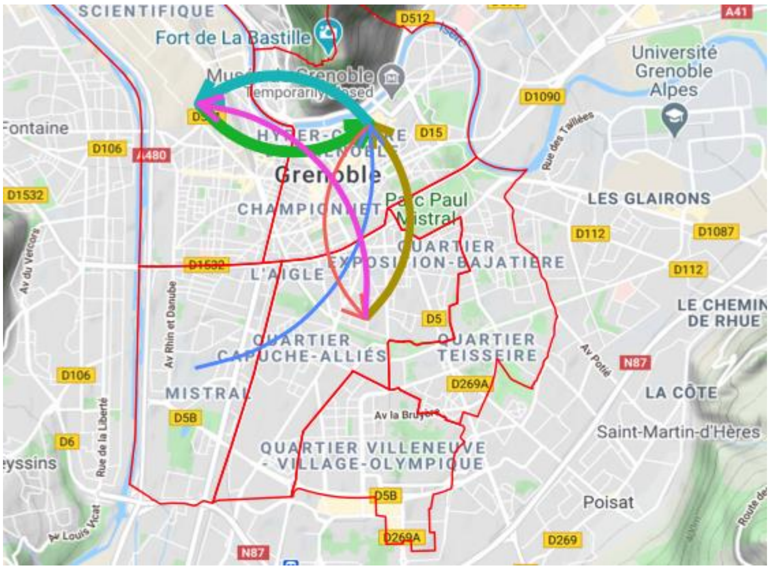


Figure 212. Inter-sector mobility flows in the Grenoble demonstration area

COVID-19 effect

The following time periods have been established for the analysis of the COVID-19 effect in the Grenoble demonstration area:

Pre-COVID-19: 2020-01-16 – 2020-03-16
Lockdown: 2020-03-17 – 2020-05-17
De-escalation: 2020-05-18 – 2020-06-21
New-normality: 2020-06-22 – 2020-09-01

The number of users, the number of sessions and the occupancy percentage dropped significantly when lockdown was imposed. The numbers start to recover during the de-escalation until new normality, where the number of users increases compared to the pre-COVID-19 period.

As regards the average duration and average daily energy consumed by user the numbers remain similar to the pre-covid situation, except for the New normality period where the average daily energy consumed by user decreased by 25%. It should be taken into account that the new normality period is during summer holidays where the usage patterns can also be different.

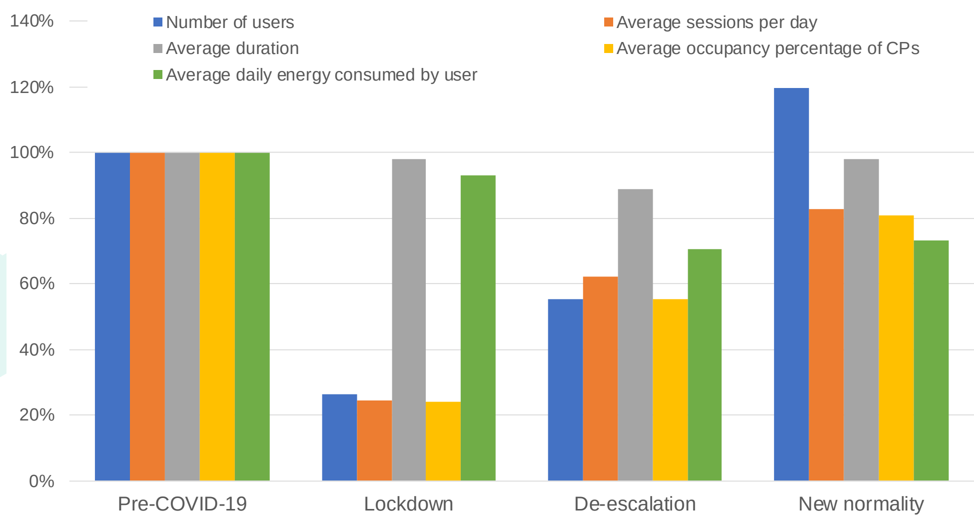


Figure 213. Variation of charging parameters with relation to the pre-COVID-19 period – Grenoble demonstration area

A priori assessment of the e-mobility charging infrastructure

The following KPIs have been calculated using data between 17/05/2019 and 31/10/2020.

Table 47. Usage KPIs – Grenoble demonstration area

Impact Area: Usage	Result
Loyalty to the same charging option	19% of users reused the same CP more than 5 times
Frequency of use of charging options	223 is the average of uses of each charging point
Vehicle's charging time	313.73 minutes
Availability rate (1)	42% of the charging options are occupied more than 10%.
Availability rate (2)	45% of the charging points are occupied less than 5%
Average usage ratio of charging options	9% is the average ratio.

Conclusions

The analysis performed for this pilot provides significant and useful information about the EV and charging point usage. The average consumed energy per session is 17.562 kWh with average duration of 5 hours and 20 minutes.
Another fact is that 77.15 % of the users use only CPs located in one sector, meaning that users tend to charge their vehicle always in the same area.
Created user clusters can be used in the future for the user related analyses and tailored recommendations to be applied for a specific group of users instead of all. The same clustering approach is applied also for the charging points in order to group them based on their occupancy distributions.

Demonstration area 6: Greece

Context

There is no official registry of charging infrastructure in Greece right now. An estimation of the charging network in Greece is less than 300 (in Aug 2020 the estimation was <200 EVSEs).
Sales in absolute numbers :

Table 48 Numbers of newly registered EV in Greece

Year	BEV	PHEV
2015	54	21
2016	41	55
2017	53	138
2018	88	211
2019	190	290

By the beginning of 2020, there were a total of 1141 electric cars (426 BEV - 715PHEV) registered in Greece. In 2020, an new e-mobility national boosting mechanism adopted by the government providing several incentives. Due to this reason, the overall number of electric vehicles rose to 2131 (679 BEV – 1452 PHEV). So, the national EV incentives adopted in 2020 resulted in an increase of 86.77% compared to the total EV sales in the previous 5 years (2015-2019). In 2020, an new e-mobility national boosting mechanism adopted by the government providing several incentives.

Table 49 Influence national EV incentives on EV sales

Type	Number of applications	Incentive percentage
Electric bikes:	7313	76%
Electric 2 wheels:	1709	18%
Electric vehicles:	663	2-4%

Incentives at national level

From 1-1-2021 until 31-12-2022, free parking at city level for vehicles with zero emissions or <50gr CO2/gr is provided. They included an environmental fee (additionally to registration fee): 3000 for Euro 4 EVs and 1000 Euro5a, and exemptions from income for expenses or concession of a vehicle of zero or < 50gr CO2/gr.

City eMobility initiatives:

Installation of limited numbers of EVSE from municipalities offering charging facilities for free.

Survey distribution

Since the launch of the survey in November 2020, ICCS has leveraged different means and communication channels for the dissemination of the survey to stakeholders and the public. Initially, an email was sent to the organization's internal mailing list, informing ICCS staff about the launch of the survey and inviting them to fill in the questionnaire, as well as to disseminate it to personal contacts and relevant stakeholders. Later and throughout December 2020, ICCS contacted 15 local organizations and authorities, comprising of research institutes, municipalities, CPOs/eMSPs, EV & mobility associations, environmental organizations, NGOs etc., through personalised emails that promoted the survey and asked for further distribution through their networks and channels. On December 5th, Mr. Angelos Amditis, the Research Director of ICCS, promoted the survey in an interview at the mainstream radio station Parapolitika. The survey was also widely promoted through the ICCS's social media. Several posts in Greek were advertised on LinkedIn and Twitter from early December until the end of the survey in mid-February. Two Facebook posts, which were also written in Greek, were promoted to reach a wider key audience, one in January reaching 3,252 people and one in February reaching 24,144 people. Finally, at the beginning of February, the survey was once again disseminated through the organization's internal mailing list.

Outcome from survey

After data cleaning, the data set contains 210 respondents in total. Of the respondents, 8.57% (18) use any type of electric vehicle, whereas 91.43% (192) does not. These percentages fully reflect the premature phase of transport electrification in Greece at this moment.

Figure 214 shows the type of electric vehicles the respondents use, where approximately half of them is in possession of a passenger electric car (55.56%) and the remaining half of the respondents uses light electric vehicles.

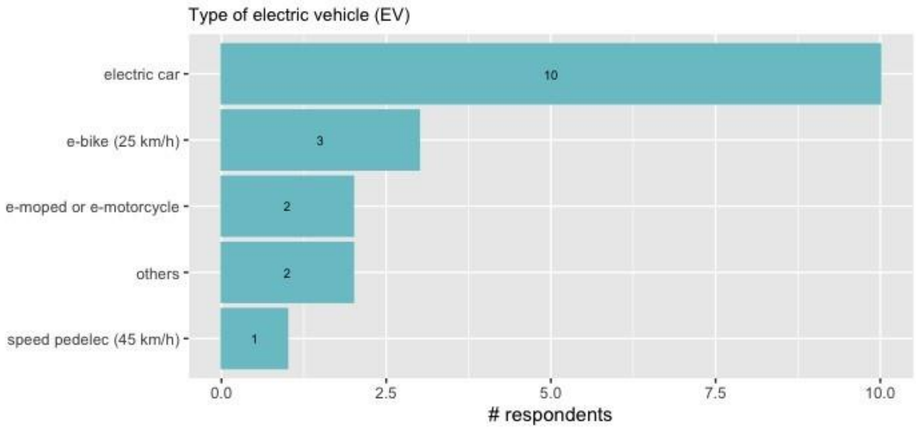


Figure 214 Type of EVs used out of 18 respondents at the Greece demonstration area

Out of the 10 respondents who use an electric car, 20.00% (2) indicated they drive a battery electric vehicle without an internal combustion engine, whereas 10.00% (1) respondents drive a plugin-hybrid electric vehicle. Also, 70.00% (7) of the respondents drive a hybrid vehicle that combines a classical internal combustion engine with an electric motor. The lack of an adequate public charging network at city and national level can justify user's choice for pure hybrid vehicles reflecting user's concerns, from one hand, as regards the environmental impact of road transport and, on the other hand, as regards the range anxiety.

In regard to the socio-demographic variables of the full sample, the majority of the respondents were men 65.24%. Most respondents (67.62%) have obtained a university degree or a higher non-university degree (11.43%). The majority is full time employed (70.95%), whereas 17% is retired. 52.38% of the respondents is married with or without children (34.76%, resp. 17.62%). The different socio-demographics are detailed in Table 50. Almost all respondents (97.14%) possess a driers licence. For most respondents, this concerns a drivers licence B (68.10%), followed by drivers licence A (36.19%). A small portion of the respondents possess a drivers licence C (9.05%), and a drivers licence G (0.95%).

Table 50 : Socio- demographics of the respondents at the Greece demonstration area

	N (%)
What is your gender?	
Female	73 (35%)
Male	137 (65%)
Indicate your highest obtained diploma or certificate:	
Higher non-university education	24 (11%)
Post-university education (PhD, Post-doc,…)	22 (11%)
Secondary education	21 (10%)
University education (Bachelor degree, Master degree, …)	142 (68%)
Which description best suits your residential situation? – Selected Choice	
I live alone	37 (18%)
I live with family	35 (17%)
I live with others: co-housing	17 (8%)
Married or in relationship with child(ren)	73 (35%)
Married or in relationship without children	37 (18%)
Other housing situation, namely:	1 (0%)
Single parent with child(ren)	10 (5%)
How can your professional situation best be described? – Selected Choice	
Currently unemployed	7 (3%)

Employed full time	149 (71%)
Housewife/Houseman	2 (1%)
Other profession, namely:	7 (3%)
Part-time employed	8 (4%)
Retired	35 (17%)
Student	1 (0%)
Temporary exemption (e.g. maternity leave, parental leave)	1 (0%)
What is your function within your company or institution?	
Blue collar worker	3 (2%)
Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	35 (21%)
Middle management	19 (11%)
Official / employed in a public service	16 (10%)
Own company, entrepreneur with employees	4 (2%)
Self-employed, entrepreneur without employees	19 (11%)
Senior management / management	11 (7%)
Teaching staff / employed in education	9 (5%)
White collar employee (administrative, executive or support/clerical function)	51 (31%)

EV car users

Out of 10 electric cars, 8 respondents privately own the vehicle, whereas 2 drive a company owned car. Less than half of the respondents (40.0%) enjoys a company fuel pass, whereas 20.0% indicated they enjoy a company charging pass. 40.0% does not enjoy any company benefits. Furthermore, 10% indicated they enjoy some other type of mobility benefit.

Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. The 2 BEV users, indicate a battery capacity between 20 and 50 kWh. At the same time, 2 respondents indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 100 and 299 km. In terms of battery range of the PHEV user, the respondent indicated this lies between 40 and 50 km. Lastly, 4 out of 10 EV users is driving their current vehicle for less than 1 year. More detailed information can be found in Table 51.

Table 51 EV characteristics at the Greece demonstration area

	N (%)	
Is your EV used as a taxi-cab?		
No.	10 (100%)	
		N (%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.		
20–30		1 (50%)
41–50		1 (50%)
What is the distance you can travel with a fully charged battery according to your experience?		
100–149		1 (50%)
250–299		1 (50%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.		
5 – 10		1 (100%)
What is the distance you can travel electrically with a fully charged battery according to your experience?		
40-50		1 (100%)
How long do you already use the EV you drive?		
< 1 year		4 (40%)
> 4 years		2 (20%)
1 year		2 (20%)

2 years	1 (10%)
3 years	1 (10%)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 215 shows an overview of reasons for EV usage or purchase, where "1" stands for not at all important and "5" for extremely important.

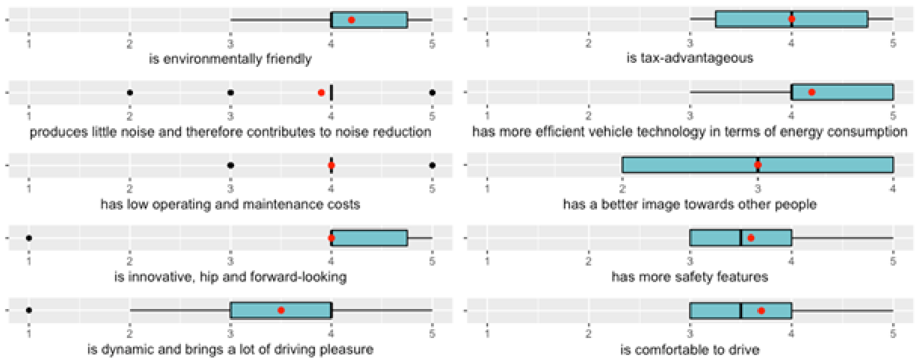


Figure 215 Reasons for EV usage or purchase at Greece demonstration area

From Figure 215, it is clear that the main reasons for using or purchasing an EV are the environmental friendliness, tax advantages, the low operation and maintenance costs, and the fact that EVs have more efficient technology in terms of energy consumption. More specific, the environmental friendliness was the most important factor as (90%) considered this factor to be very important to extremely important while the least important factor is the innovative and hip design an EV and the dynamic and driving pleasure and EV provides, where 10% resp. 10% considered this factor to be not important at all.

Respondents were asked to think about a specific day of the week before and indicate their driving profile, in terms of how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 49.44 km and the average time spent on the road was about 2 hours. The EV is mostly parked at a private parking at home for almost 13.86 hours a day on average. Figure 216 gives a more detailed overview of the parking time at different locations.

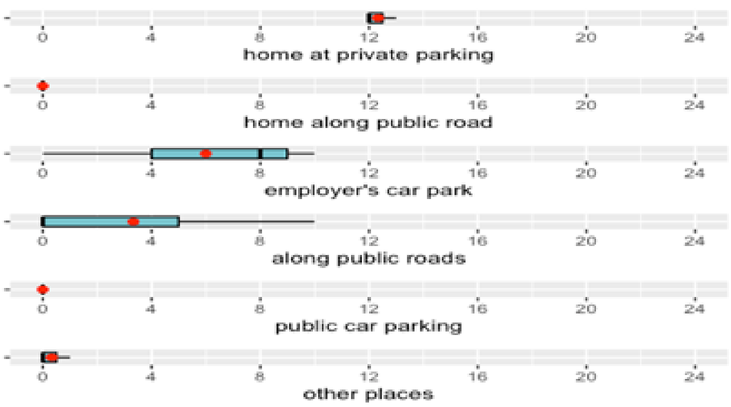


Figure 216 Respondents' EV parking time at different locations at the Greece demonstration area

The respondents' parking location at home was mostly the driveway or a privately-owned garage (70%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where “1” stands for strongly disagree and “7” for strongly agree. The majority of the respondents (75%) seem to charge when the battery falls below a certain level or based on their next trip. Also, 50% of the respondents charge regularly regardless of the battery level. For the other statements, the opinions are more divided (see Figure 217).

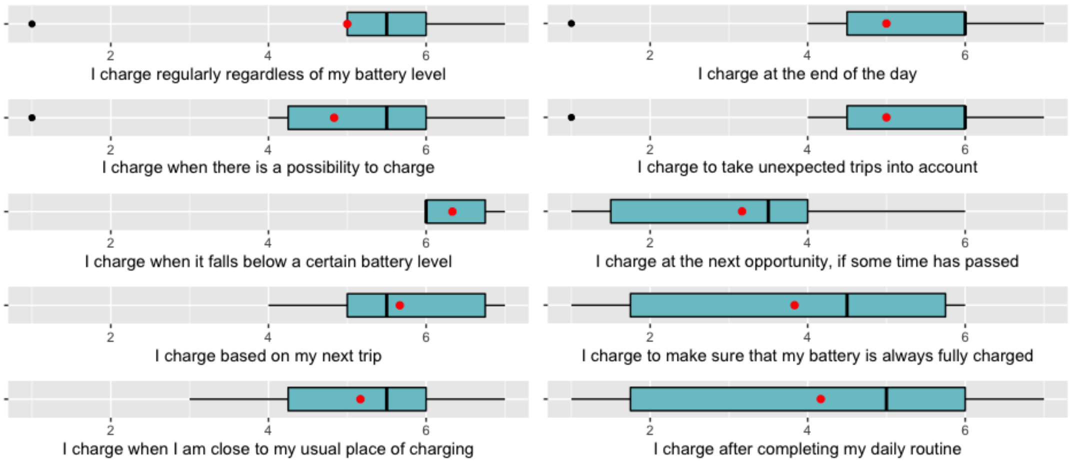


Figure 217 Respondents' charging behaviour at the Greece demonstration area

Regarding charging experience, 40.00% of the respondents indicated they have never charged their EV outside of their home socket station. At the same time, 40.00% charges often at a different location, whereas 20.00% sometimes charge at a different location. Respondents charge the EV most frequently at home, 50.00% of the respondents charges the EV at home daily and 33.33% does so several times a week (see Figure 218). The main charging option at home is a charging station (30.00%). Another third of the respondents indicate that they do not have a charging option at home. The least frequent charging place is at the workplace, where 33.33% of the respondents indicate that they never charge at work. Also, public fast chargers are more frequently used than non-fast chargers.

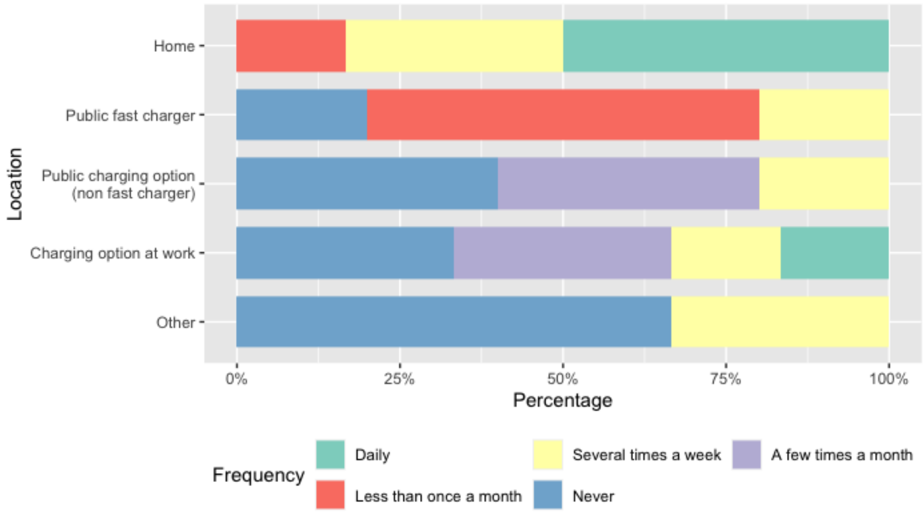


Figure 218 Respondents' charging behaviour per location at the Greece demonstration area

In terms of the most ideal charging session, the respondents indicated that the improvements need to be made are towards the operability of the charging cards and the implementation of faster charging stations (Figure 219).

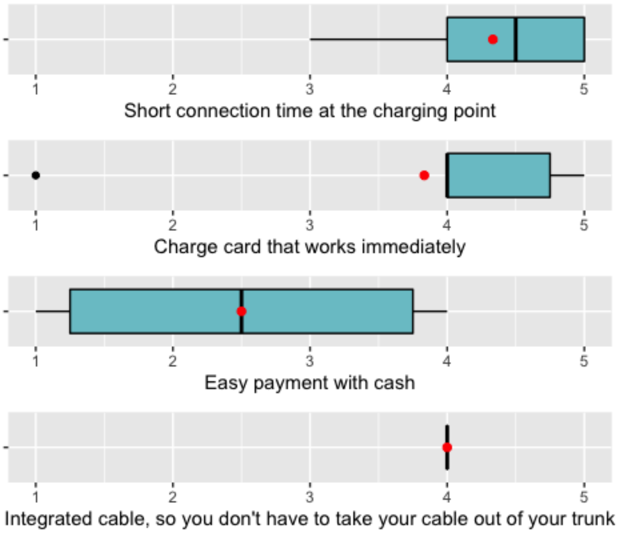


Figure 219 Respondents' most ideal charging session at the Greece demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last.

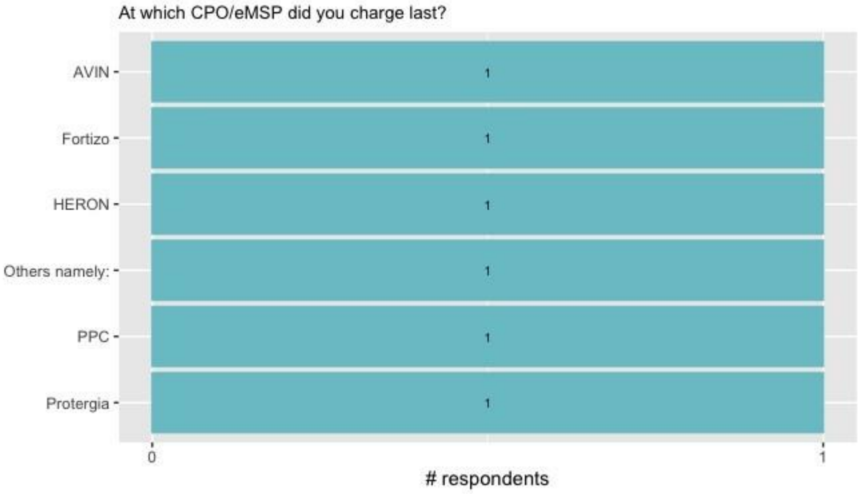


Figure 220 Last charging CPO/eMSP at the Greece demonstration area

The number of responses is not adequate to perform such an analysis since no reliable conclusions can be drawn.

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, Fast charging options are the most popular with 50% of respondents choosing they are most likely to use Fast charging options in the future. Furthermore, 20% of the respondents have the intention to use smart charging.

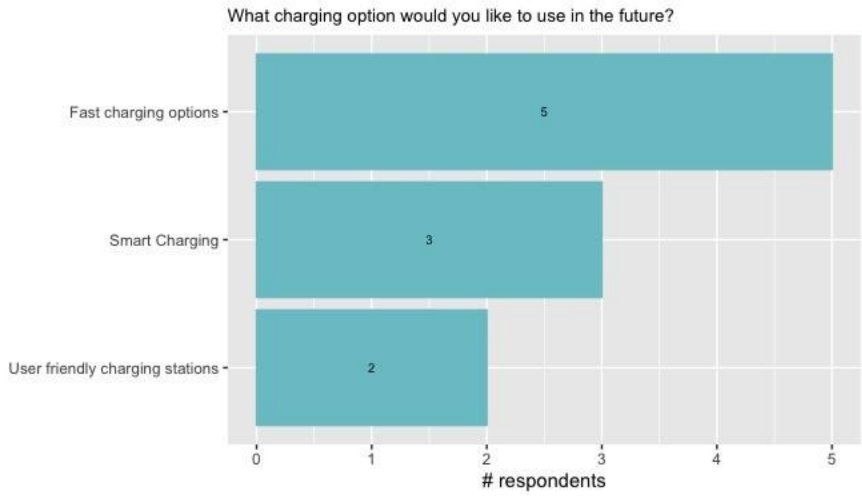


Figure 221 Most likely charging option in the future at the Greece demonstration area

Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration. All charging options score high in terms of behavioural intention. The fast charging is the option mostly selected by the users.

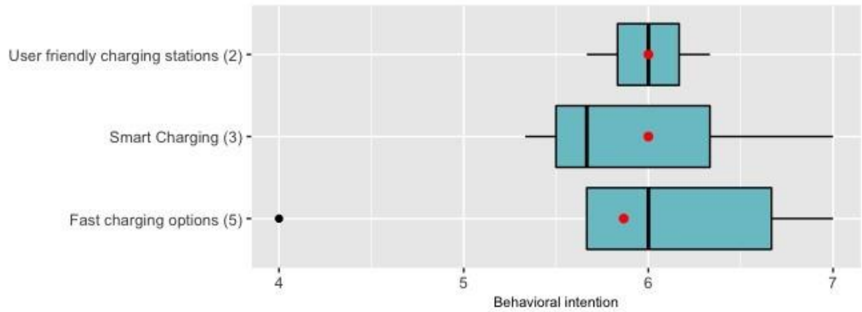


Figure 222 Behavioural intention of charging infrastructure at the Greece demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the smart charging scores highest on these criteria, aside from a few outliers (see Figure 223). But overall, the averages are high for the chosen charging options.

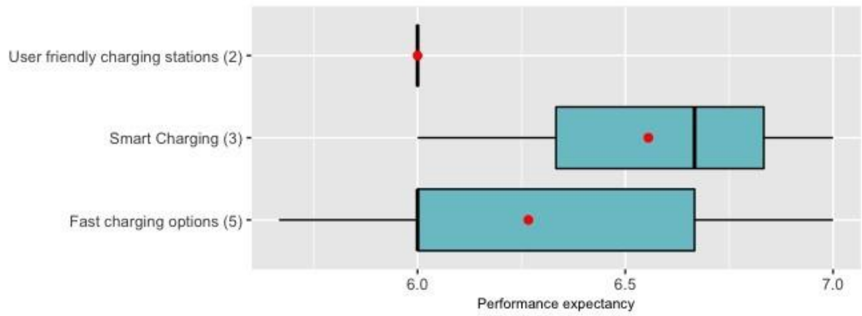


Figure 223 Performance expectancy of the charging infrastructure at the Greece demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. It is interesting to see that the scores for fast charging are higher than other charging options (see Figure 224). Less effort is expected for smart charging options, but smart charging also vary more than other charging options, indicating that respondents expect some effort into getting acquainted with this charging option compared to fast charging stations and user friendly charging stations.

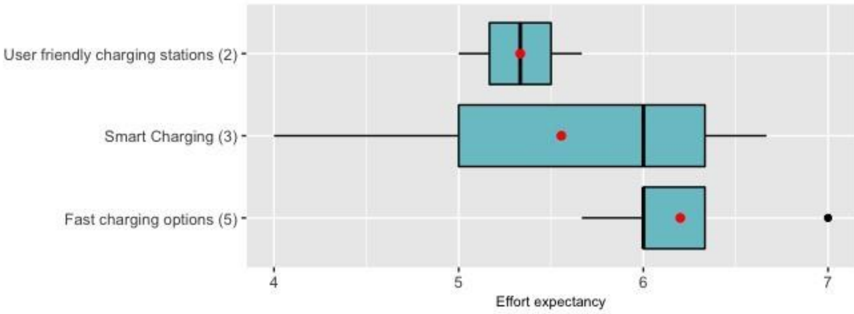


Figure 224 Effort expectancy of the charging infrastructure at the Greece demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 225). The averages and medians all lightly fluctuate between 4 and 5 on a scale of 7.

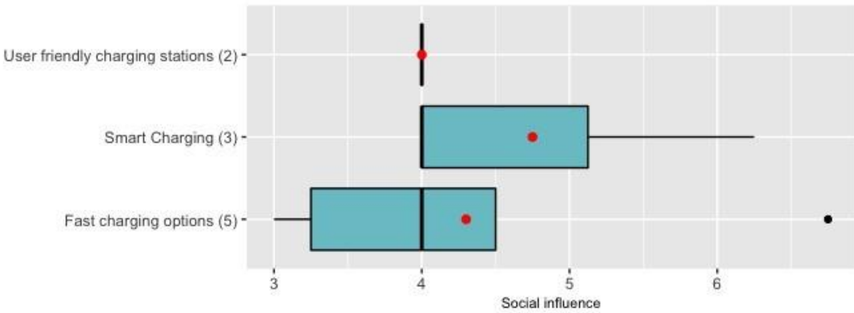


Figure 225 Social influence of the charging infrastructure at the Greece demonstration area

In terms of facilitating conditions, the charging options have more or less the same expectations around 5 out of 7. On average visibly higher than the other charging options is battery swapping (see Figure 226). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

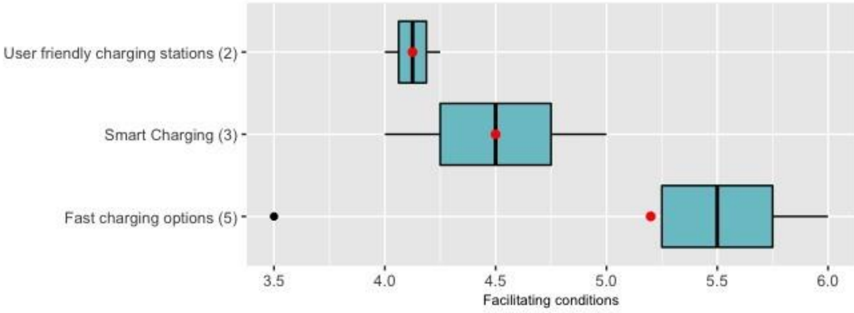


Figure 226 Facilitating conditions of the charging infrastructure at the Greece demonstration area

As for hedonic motivation, it is interesting to see that the scores for fast charging are quite lower compared to the different charging options (see Figure 227). Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable. Smart charging is seen as a fun and entertaining charging options, whereas the respondents are not that amused about the entertainment of fast charging.

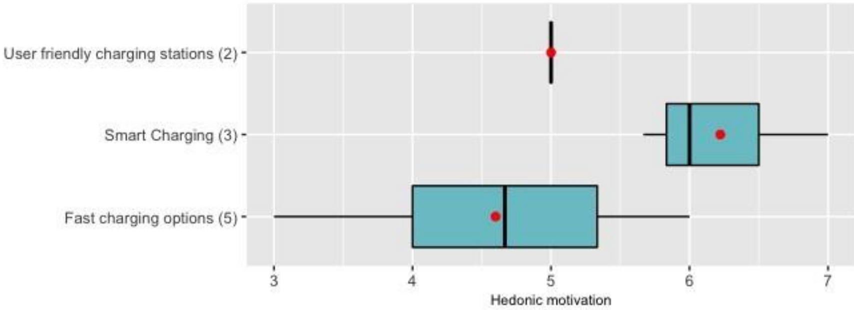


Figure 227 Hedonic motivation of the charging infrastructure at the Greece demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, it is interesting to note that the respondents mainly will use the charging options when prices are lower (see Figure 228).

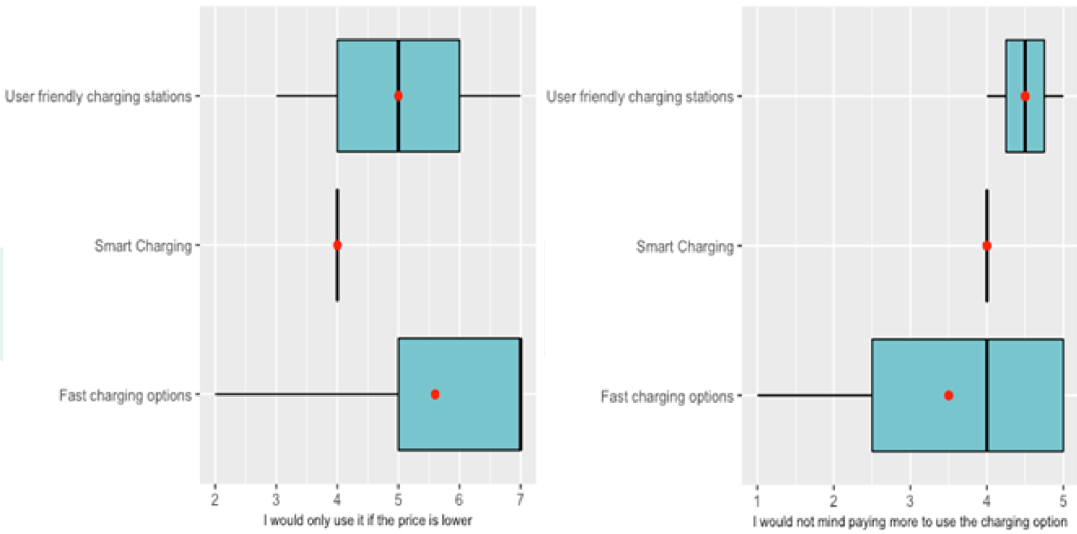


Figure 228 Price value of the charging infrastructure at the Greece demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. One third of the respondents, 30.0% (3 respondents) indicated they use app-based services, another 50.0% do not but intend to do. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, a third of the EV respondents has 4 or more apps on their phone. About 100.0% of the app-based service users, users this at least a few times a month, as can be seen in Figure 229.

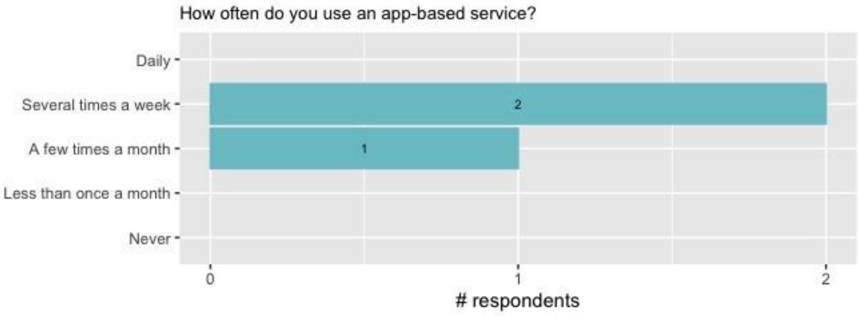


Figure 229 Usage of app-based services at the Greece demonstration area

App-based services are mostly used for commuting and work activities (2 respondents) and whereas 1 respondent use it for shop/errands. In terms of satisfaction with the used app-based services, Figure 230 shows that the respondents are very about the app-based services.

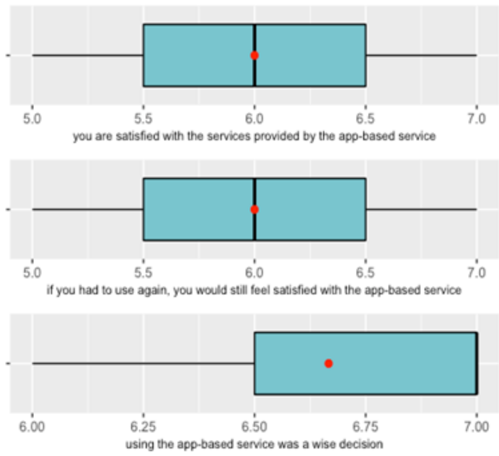


Figure 230 Satisfaction with the app-based services at the Greece demonstration area

LEV

In this section, we zoom in to the 6 respondents who use a light electric vehicle. The majority of the respondents (66.67%) owns the LEV they use and are responsible for the LEV maintenance costs (66.67%). At the same time, the majority (58%) of the respondents indicate that the battery capacity is lower than 3 kWh. Another 16.7% did not fill out this question. Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 52.

Table 52 LEV characteristics at the Greece demonstration area

	N (%)
Who is the owner of the LEV you normally drive?	
sharing company	1 (12%)

Company/Leasing company	2 (25%)
Private	5 (62%)
Who is responsible for the maintenance costs of the LEV you drive?	
Company	2 (29%)
Private	5 (71%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	
< 0,5	2 (29%)
1-3	2 (29%)
3-5	1 (14%)
5-7	1 (14%)
I do not know.	1 (14%)
How often do you use your LEV?	
A few times a month.	3 (43%)
Daily.	1 (14%)
Several times a week.	3 (43%)
Do you use a fixed car park or garage?	
I use a fixed car park which is my property.	2 (29%)
No.	5 (71%)

On average, the LEV users indicate they drive about 7.8 km each day. The majority of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 231).

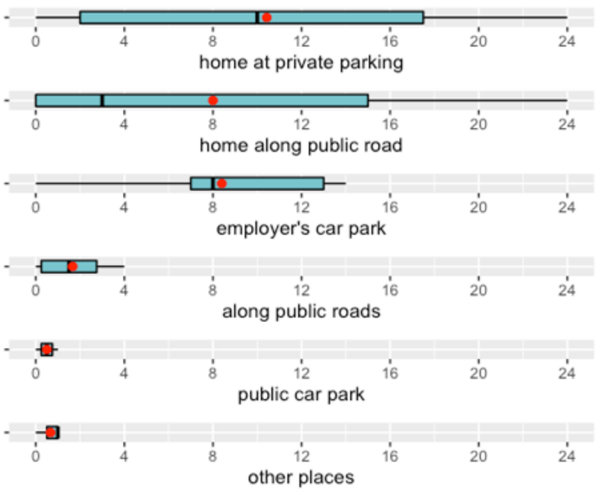


Figure 231 Parking space and duration of the LEV at the Greece demonstration area

Looking at the motives to use an LEV, it is clear that the most important motive is the environmental friendliness together with the advantages in taxes, whereas least important is the image towards other people.

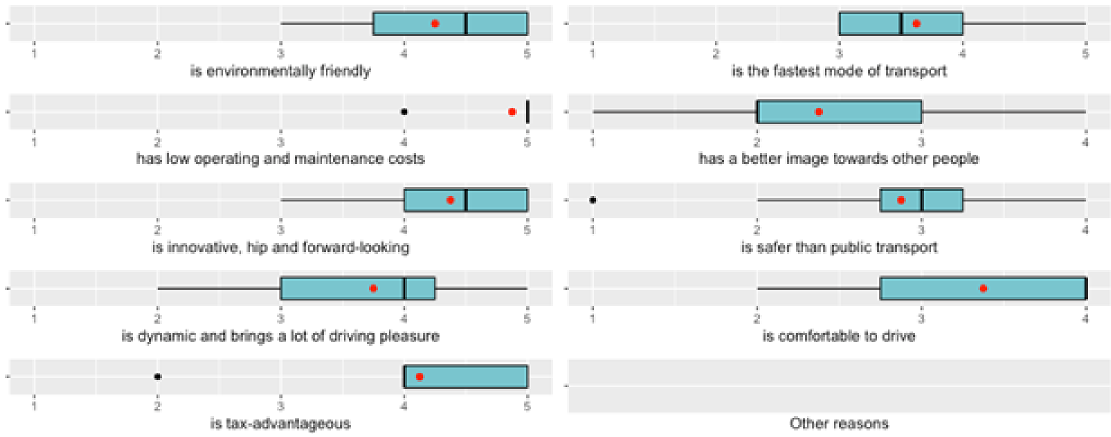


Figure 232 Motives to use LEVs at the Greece demonstration area

In terms of charging behaviour, almost all respondents seem to make sure that the battery is always fully charged. Also, 75% of the respondents charge when the battery falls below a certain level or based on their next trip. And, 50% of the respondents charge to take unexpected trips into account.

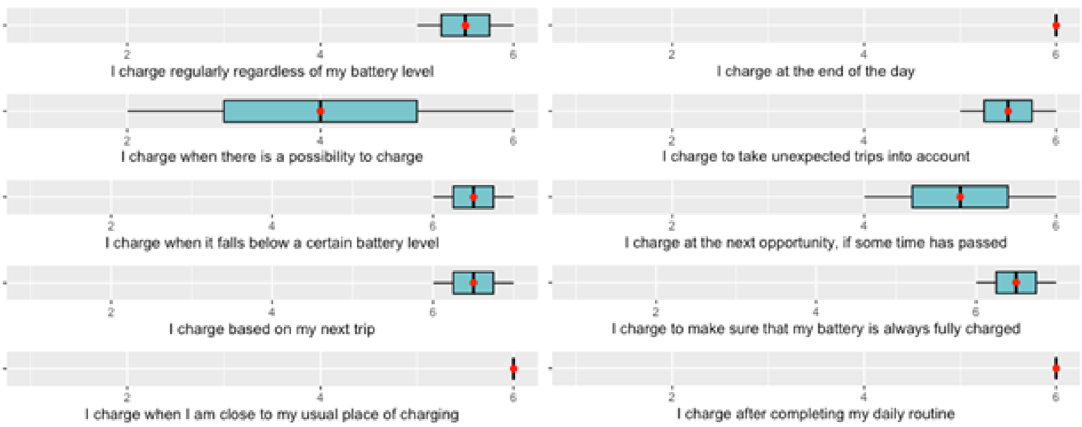


Figure 233 LEV charging behaviour at the Greece demonstration area

Quality of Experience

Out of 6 respondents, all the respondents indicated that they do not use the service of a CPO/eMSP. This number of responses is not adequate to perform such an analysis since no reliable conclusions can be drawn.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e. the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, smart charging options are the most popular with 66.67% of respondents choosing they are most likely to use fast charging options in the future. 33.33% of the respondents indicated that they would use fast charging stations in the future.

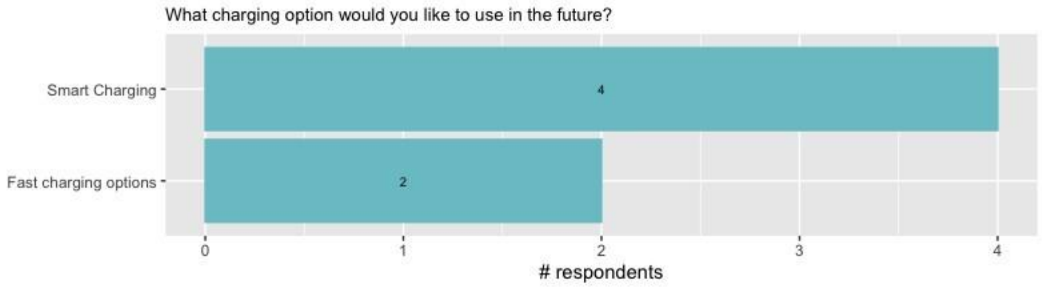


Figure 234 Preferred LEV charging option to use in the future at the Greece demonstration area

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 0.00% of the respondents, indicated they use app-based services. As such, this section will not be discussed.

Non-EV users

Lastly, we zoom into the non-EV users, a total of 192 respondents. Interestingly, most of the respondents (61.97%) states that they will not buy an electric vehicle in the short-term horizon.

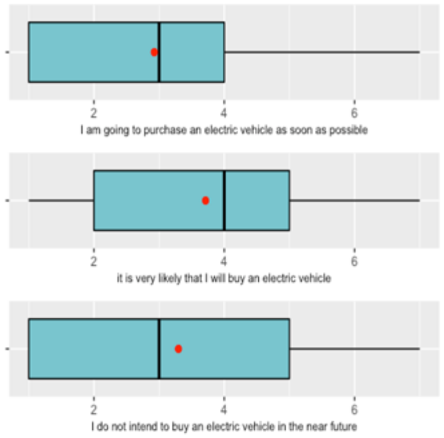


Figure 235 Non-users' Intention to buy an EV at the Greece demonstration area

Of the other 38% that would like to buy an EV in the future, most respondents (90.4%) indicate they are mostly interested in buying an electric car. Out of these 66 respondents, the opinions are quite divided as regards the preferable electric vehicle technology. Approximately, the two-thirds of the respondents prefer a (plug-in) hybrid electric vehicle feeling more comfortable with such a vehicle technology towards the transport sector transition to electrification. Pure battery electric vehicle is the second most preferable alternative technology with the percentage of 30%.

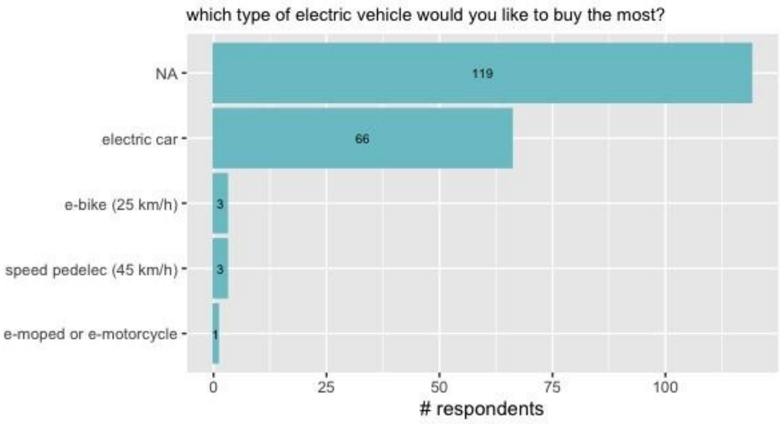


Figure 236 Type of EV that non-users intend to buy at the Greece demonstration area

Lastly, the most important motives for non-EV users to purchase an EV in the future are the green environmental footprint and the low operational costs as “environmental friendliness” and “more efficient technology in terms of energy consumption” are voted as the most important ones by 97% and 98% of responders, respectively. At the same time, the least important motive is the better image EVs could have towards other people as 52% of the respondents consider this not important at all to slightly important.

Key findings of the Greece report

While the e-mobility level in Greece still is in premature phase, some important indications towards the future of e-mobility become visible. The main reasons for electric car adoption are the green environmental footprint, and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, half of the electric car owners charge daily at home. Interesting to know is that 40% of the electric car owners indicates they never charged the EV outside of the charging option at home, while another 30% has no charging option at home. Fast charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use. Remarkable is that 75% of the respondents indicate they would only use is when the price is similar or cheaper than the current charging options available.

LEV users mainly bought their LEV because it is environmentally friendly, and because it is hip and innovative. In terms of charging behaviour, it is interesting to know most respondents seem to make sure that the battery is always fully charged. Half of the LEV users charge their LEV with unexpected trips in mind. Smart charging is the most preferrable charging option in the future.

Lastly, most of the non- EV users (61.97%) states that they will not buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (90.4%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (97%) and more efficient technology in terms of energy consumption (98%) in comparison with non-EV. At the same time, the least important motive is the better image EVs could have towards other people as 52% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV users.

Outcome from historical data

This section introduces the quantitative data analytics for the Greek demonstration area. In this demonstration area, there are 4 unique charging stations from the CPO BFS. BFS is responsible for the facility management, renovation plan and business extension plan of approximately 500 car service stations located around Greece. Those stations have been serving mobility in Greece for decades, mainly by providing conventional fuels (petrol and gas stations) and car caring services. From 2019, following the transformation of transportation services, an evolution plan is under deployment to provide also electromobility services form the already established network. The first stations equipped with fast charging stations were along the major Greek highways and started their initial test operation in 2019. The initial plan anticipated that the number of stations would have grown bigger by the end of 2020, but due to the health crisis, the installation planning has been adopted and most of the new stations will be installed within 2021. It is anticipated that by the end of the year about 50 electric charging stations will be operating, while in 2022 the charging network will grow bigger.

As for the electromobility in Greece, it should be mentioned that it remains in a pre-mature phase, with a few electric cars being in circulation, most of them being plug-in hybrids. Moreover, the legal framework deterring the operation conditions of such stations have been recently under establishment, and as a result for a long period the user was not charged for the usage of electricity consumed during charging by the operator of the station, but only for the time the car spent in the station and no other data were kept for the charging sessions. In addition, due to the restriction applied because of the health crisis, for a long period during the time of study, individuals were not allowed to travel away from their hometown and as a result the traffic was reduced in the highways, more than the reduction of traveling within the region. In Annexe A3, a graphic can be found showing the reduction of consumption of conventional fuels due to travelling restrictions. As a result, the dataset does not contain any user related information and that some subsections of the analysis could not be performed as they were not meaningful due to the low number of recorded sessions.

Descriptive Statistics

This subsection presents the descriptive statistics of the Greek Demonstration area, the sessions information come from four charging stations operated by BFS. The charging stations have CCS, CHAdeMO (50kW) and 43 kW AC connectors. The period of study is from 25/05/2020 to 08/10/2020.

- **Charging points geographical distribution**

The CPs are located in the A5 highway, that connects the cities of Ioannina and Athens. Figure 237 shows the exact location of the charging stations, having two charging stations in each blue bullet, one for each direction of the highway.

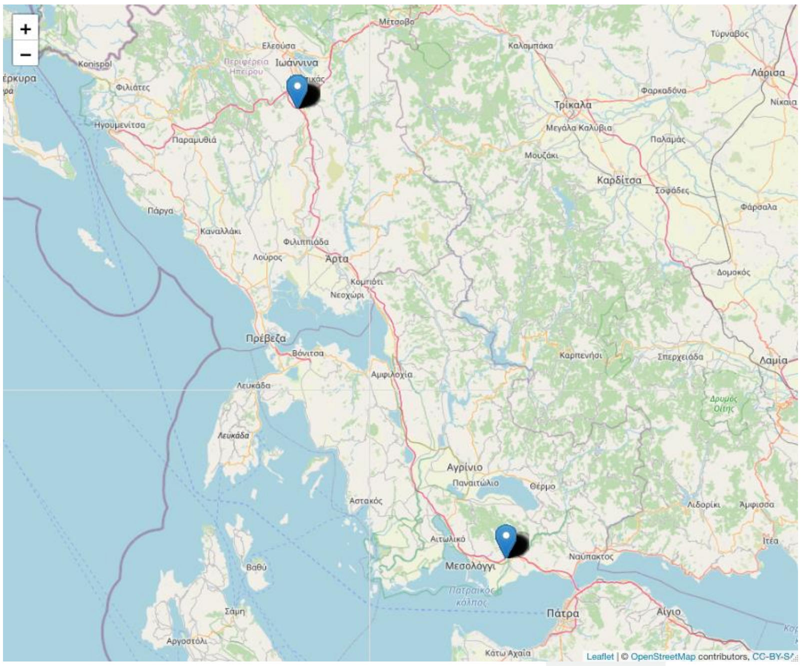


Figure 237. Charging Point locations in Greece demonstration area

- **Sessions’ temporal distribution**

With the limited number of charging stations in the data, and the low degree of usage, the session distribution is not significant to have clear interpretation. The only outcomes are as follows:

- Mondays have the peak from 1 pm to 2 pm with the highest overall peak in the dataset.
- Sundays have the peak from 3 pm to 4 pm.
- Fridays have the peak from 5 am to 6 am along with Mondays.
- Saturdays have the peak from 12 pm to 1 pm.

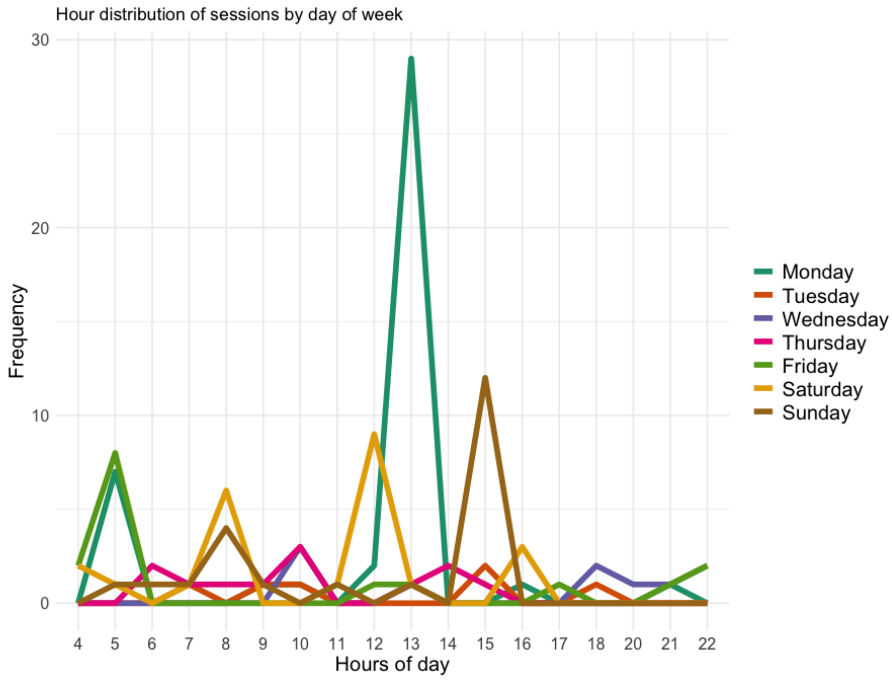


Figure 238. Sessions’ temporal distribution – Greece demonstration area

- **Sessions’ duration**

For the analysis of the duration of the sessions, Figure 239 represents the main statistical parameters for the interpretation of the duration for the case of AC charging (43kW) and DC charging (50kW). The sessions that are below 4 minutes and the sessions where energy consumed is 0 kWh have been removed for the analysis. In the case of 43kW CPs, the average duration is 43.86 minutes, and in the case of 50kW CPs the average duration is 51.43 minutes. In both cases the distribution of the data is almost symmetric, this means that the median is very similar to the mean.

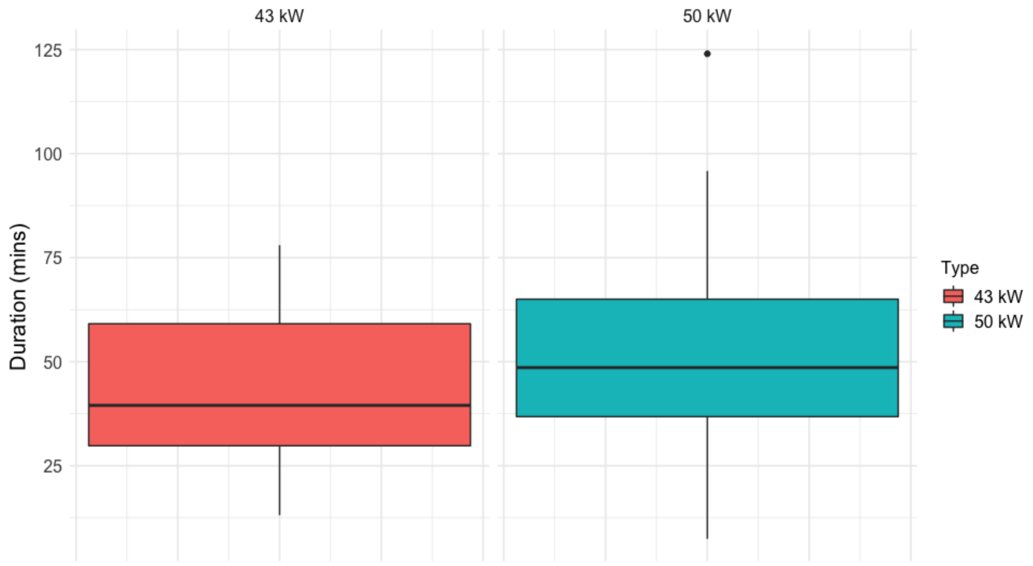


Figure 239. Boxplot of sessions duration – Greece demonstration area

Table 53. Summary of statistical values for sessions' duration – Greece demonstration area

43kW Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
13.12 min	29.80 min	39.50 min	43.86 min	59.12 min	78.0 min
50kW Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
7.43 min	36.79 min	48.58 min	51.43 min	65.03 min	124 min

- **Energy consumed per session**

Figure 240 shows the boxplot for the sessions' energy consumed. Table 54, presents the main statistical values to understand the boxplot. In the demonstration area of study, the mean of the energy consumed in the fast CPs is 25.88 kWh and in the case of the semi-fast CPs is 7.04 kWh. It can also be seen that in the case of the 50kW CPs the values are more disperse, but it is mostly due to the fact that most of the charging sessions are carried out with this connector.

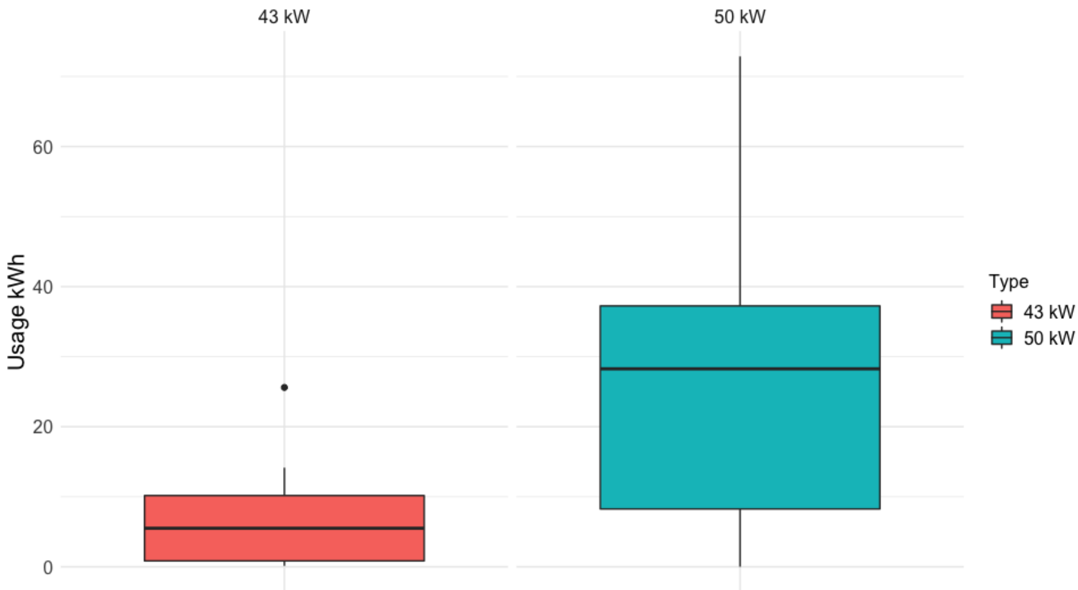


Figure 240. Boxplot for sessions' energy consumed – Greece demonstration area

Table 54. Summary of statistical values for sessions' energy consumed – Greece demonstration area

43kW Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.14 kWh	0.84 kWh	5.51 kWh	7.04 kWh	10.17 kWh	25.61 kWh
50kW Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.01 kWh	8.26 kWh	28.27 kWh	25.88 kWh	37.25 kWh	72.87 kWh

A priori assessment of the e-mobility charging infrastructure

The following KPIs have been calculated using data between 01/01/2019 and 31/08/2020.

Table 55. Usage KPIs – Greece demonstration area

Impact Area: Usage	Result
Frequency of use of charging options	35.25 is the average of uses of each charging point between 25/05/2020 and 08/10/2020
Vehicle's charging time	20.36 minutes
Availability rate (1)	25 % of the charging options are occupied more than 0.4 %.
Availability rate (2)	50 % of the charging points are occupied less than 0.35 %
Average usage ratio of charging options	0.34 % is the average ratio.

Conclusions

As already mentioned above due to the absence of an established legal framework for the electromobility in the country and because of the low market penetration of electric mobility, there is limited data availability, as the period of study is small, and the number of car charging sessions is low. Especially for the charging stations of the study, which are located along the A5 highway, the number of sessions were limited, as individuals were not allowed to travel outside their hometown region during lockdown and the highway were mainly used by conventional commercial vehicles.

Demonstration area 7 : Luxembourg

Context

With a revision of its subsidies scheme for the purchase of electric cars, bikes, pedelecs, electric quadricycles and motorcycles, following subsidies were introduced in May 2020:

- Battery electric vehicles: €8,000 subsidy (€5,000 EUR previously)
- Plug-in hybrid vehicles: €2,500 EUR (€2,500 EUR previously)

Ongoing discussions suggest that the subsidy for plug-in hybrids will be ended soon. The subsidy scheme's generosity is likely to be a significant factor, explaining the EV uptake that can be observed in Luxembourg (see below chart).

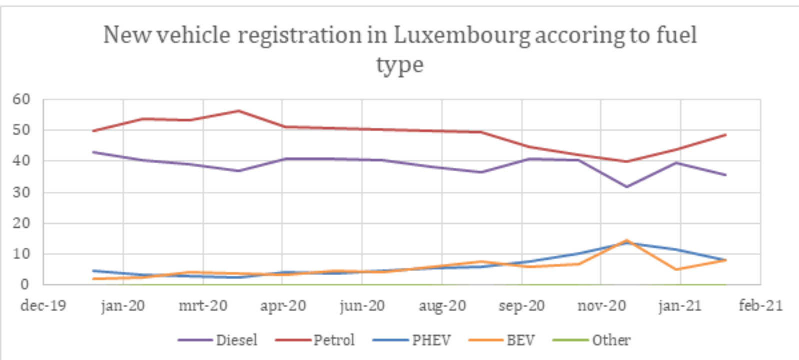


Figure 241 New vehicle registration in Luxembourg(Source : Statec)

Luxembourg's government had tasked the countries five DSOs to roll out a nationwide charging network, "Chargy", that is supposed to resolve the chicken-egg-problem of electric vehicles that would depend on the availability of charging infrastructure. The initial plan to roll out exclusively AC charging points (800 dual charging station of each 2 x 22 kW) had been adjusted recently. Some of the foreseen charging stations would be converted to DC fast charging of 160 or 320 kW, branded "SuperChargy". The price for charging at any public charging station within the "Chargy" network is comparably low, ranging from 0.24 €/kWh to 0.27 €/kWh in 2021, depending on the chosen EMSP.

A generous subsidy scheme targeting residential charging points has been established in 2020, which covers typically 50% of the cost for installing a private charging point. Another future subsidy scheme is in preparation which will target companies to provide "Charge@Work" infrastructure both for their clients and employees.

Data collection for survey

The data collection process in Luxembourg was off for a challenging start. That is because users are unknown to the project members, as there is no Luxembourgish EMSP involved in the project and no customer database accessible. The CPO did not grant permission to place stickers, e.g. with QR codes on charging points. Therefore, Nexxtlab used social media (LinkedIn and Facebook) to target the audience in Luxembourg. Nexxtlab had motivated participants to complete the survey by offering a prize ("Help us make e-mobility easy and have the chance to win an iPad"). Given the limited direct outreach of Luxembourg's project partner Nexxtlab, the national energy agency "myenergy" and the DSO and CPO Creos had published posts on Facebook that triggered each a steep rise in responses among predominantly male EV drivers that participated in the general survey. Trying to mitigate the gender gap, Nexxtlab had published a paid ("boosted") Facebook publication in January 2021 that had been shown to 10.000 + female users in the greater region (80 km radius around Luxembourg-City) that had expressed interest in environmental and automobile-related subjects. Unfortunately, only four female users had completed the questionnaire during the duration of that campaign.

The questionnaire had generally been conceived as far too long. In social media, people complained about that while others made it until the end just for the prize to be won.

Also, Luxembourg's contributor failed to reach taxi and delivery companies. After having contacted 17 taxi companies without any response, a phone interview with responsibility for Luxembourg's largest taxi company had been conducted by Christoph Emde of Nexxtlab. It was expressed taxi drivers dislike electric cars in general for the following reasons:

- The range (in real conditions) is often too low to allow serving on longer distances.
- Charging takes too long. It is working time, without earning.
- The purchase cost of electric cars is considered still too high.

Combining the first two issues: If a client requests a journey to an 80 km distant city in the Greater Region, the driver might find himself looking for a charging point to make his way back. Due to the personal commitment of the taxi company's management, one taxi driver had been appointed (to avoid saying forced) to take the survey, leading to a reduced expectation with regards to the quality of the answers given.

Outcome from survey

After data cleaning, the data set contains 258 respondents in total. Of the respondents, 53.88% (139) use any type of electric vehicle, whereas 46.12% (119) does not. Figure 242 shows the type of electric vehicles the respondents use, where the majority 75.54% (105) indicated they use an electric car. 15.1% (21) of the respondents make use of an e-bike.

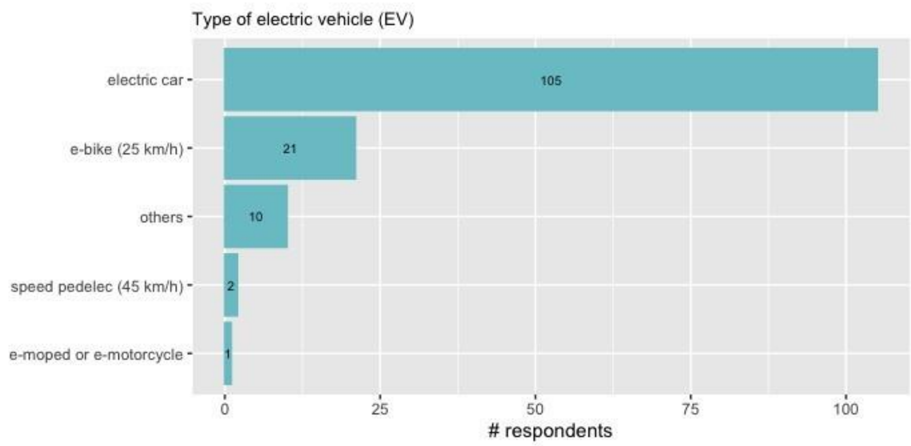


Figure 242 Type of EVs used out of 139 respondents at the Luxembourg demonstration area

Out of the 105 respondents who use an electric car, 84.76% (89) indicated they drive a battery electric vehicle without an internal combustion engine, whereas 13.33% (14) respondents drive a plugin-hybrid electric vehicle. Also, 1.90% of the respondents (2) drive an electric vehicle with a range extender.

In regards to the socio-demographic variables of the full sample, the majority of the respondents were men 78.29%, despite the efforts to balance the gender ratio. Most respondents (56.20%) have obtained a university degree or a higher non-university degree (18.99%). The majority is full time employed (72.87%), whereas 5.04% is retired. Almost 77.91% of the respondents is married with or without children (50.00% resp. 27.91%). The different socio-demographics are detailed in Table 56. Almost all respondents (98.84%) possess a drivers licence. For most respondents, this concerns a drivers licence B (86.05%), followed by drivers licence A (27.52%). A small portion of the respondents possess a drivers licence C (17.05%), a drivers licence D (5.43%) and a drivers licence G (1.16%).

Table 56 Socio-demographics of the respondents at the Luxembourg demonstration area

	N (%)
What is your gender?	
Female	55 (21%)
Male	202 (78%)
Other	1 (0%)
Indicate your highest obtained diploma or certificate:	
Higher non-university education	49 (19%)
Post-university education (PhD, Post-doc,…)	4 (2%)
Primary education	3 (1%)
Secondary education	56 (22%)
University education (Bachelor degree, Master degree, …)	145 (56%)
Unknown/Missing	1 (0.39%)
Which description best suits your residential situation? – Selected Choice	
I live alone	23 (9%)
I live with family	19 (7%)
I live with others: co-housing	13 (5%)
Married or in relationship with child(ren)	129 (50%)
Married or in relationship without children	72 (28%)
Single parent with child(ren)	2 (1%)
How can your professional situation best be described? – Selected Choice	
Currently unemployed	2 (1%)
Employed full time	188 (73%)
Housewife/Houseman	5 (2%)
Other profession, namely:	7 (3%)

Part-time employed	24 (9%)
Retired	13 (5%)
Student	17 (7%)
Temporary exemption (e.g. maternity leave, parental leave)	2 (1%)
What is your function within your company or institution?	
Blue collar worker	21 (9%)
Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	4 (2%)
Middle management	29 (12%)
Official / employed in a public service	47 (19%)
Own company, entrepreneur with employees	6 (2%)
Self-employed, entrepreneur without employees	10 (4%)
Senior management / management	13 (5%)
Teaching staff / employed in education	23 (9%)
White collar employee (administrative, executive or support/clerical function)	93 (38%)

EV car users

Out of 105 electric car (105) users, 72 respondents own the vehicle, whereas 33 drive a company owned car, and 0 a car owned by a car sharing company. Furthermore, 2 respondents indicated that they use their vehicle as a taxi-cab. The majority of the respondents (74.29%) does not enjoy any company benefits, 17.14% of the respondents indicated they enjoy a company charging pass, whereas 6.67% enjoys a company fuel pass. Furthermore, 1.90% receives a kilometre compensation and 1.90% indicated they enjoy some other type of mobility benefit.

In terms of the battery electric vehicles, the most popular cars are the Tesla Model 3 (16 respondents), followed by a Renault ZOE (13) and a Nissan LEAF (10 respondents). The Kia e-Niro (6 respondents) and the Mini Electric (5 respondents) close the top 5. The most popular plug-in hybrid electric vehicles are the Volkswagen Passat GTE (3 respondents) and the BMW 330e (2 respondents). Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity of more than 70 kWh, where the next most popular choice is between 31 and 40 kWh. At the same time, 89 respondents indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 250 and 299 km. Most PHEV users, indicate a battery capacity between 10 and 15 kWh. In terms of battery range, the majority (38%) indicates this lies between 40 and 50 km. Lastly, the majority of all EV users 42% is driving their current vehicle for less than 1 year. More detailed information can be found in Table 57.

Table 57 EV characteristics at the Luxembourg demonstration area

Is your EV used as a taxi-cab?	N (%)
No.	103 (98%)
Yes.	2 (2%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	**N (%)**
<20	3 (3%)
>70	22 (25%)
20–30	8 (9%)
31–40	20 (22%)
41–50	11 (12%)
51–60	5 (6%)
61-70	13 (15%)
I do not know.	7 (8%)
What is the distance you can travel with a fully charged battery according to your experience?	
< 100	3 (3%)
> 400	13 (15%)
100–149	13 (15%)
150–199	8 (9%)
200–249	16 (18%)
250–299	19 (21%)
300-400	17 (19%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	
>20	1 (7%)
10 – 15	7 (50%)
15 – 20	1 (7%)
5 – 10	3 (21%)
I do not know.	2 (14%)
What is the distance you can travel electrically with a fully charged battery according to your experience?	
> 50	3 (19%)
20-29	2 (12%)
30-39	5 (31%)
40-50	6 (38%)
How long do you already use the EV you drive?	
< 1 year	44 (42%)
> 4 years	8 (8%)
1 year	19 (18%)
2 years	19 (18%)
3 years	12 (11%)
4 years	3 (3%)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 243 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

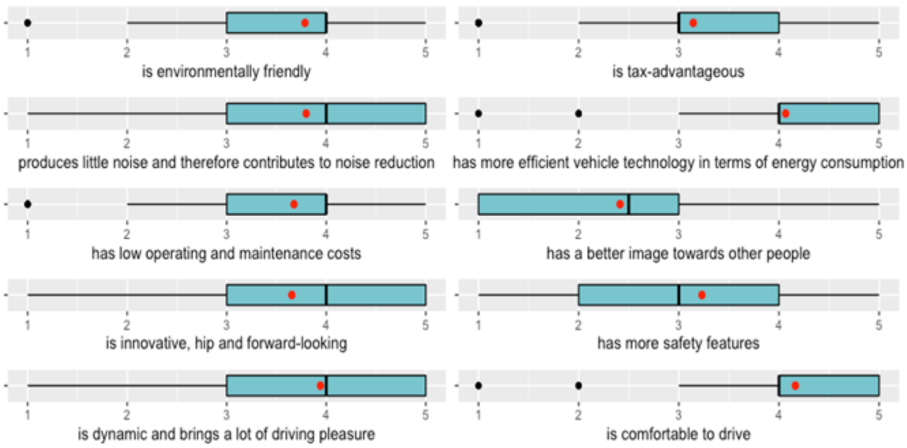


Figure 243 Reasons for EV usage or purchase at Luxembourg demonstration area

From Figure 243, it is clear that the main reasons for using or purchasing and EV are the fact that EVs have more efficient technology in terms of energy consumption, the driving comfort, and driving pleasure. More specific, the driving pleasure was the most important factor as 81% of the respondents considered this factor to be very important to extremely important, followed closely by the efficient technology in terms of energy consumption (80%). The least important factor is the better image an EV could have towards other people, where 66% considered this factor to be not important at all to slightly important.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 88.9 km, where the average time spent on the road was about 2 hours. The EV is mostly parked at a private parking at home for almost 12 hours a day on average. Figure 244 gives a more detailed overview of the parking time at different locations.

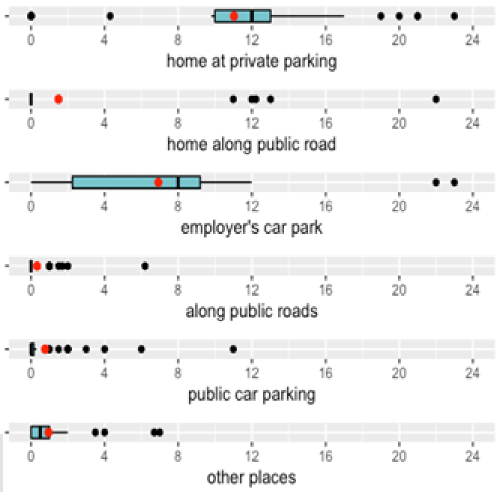


Figure 244 Respondents' EV parking time at different locations at the Luxembourg demonstration area

When EV users park at home, the majority does so in their driveway or in a privately-owned garage.

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 245).

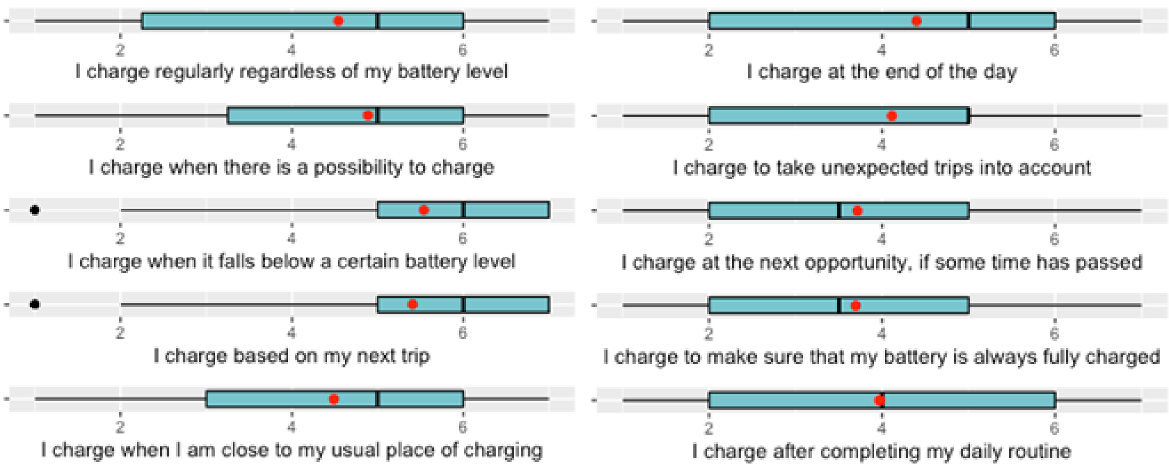


Figure 245 Respondents' charging behaviour at the Luxembourg demonstration area

In regards to charging experience, 14.29% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 57.14% charges often at a different location, whereas 28.57% sometimes does. Respondents charge the EV most frequently at home, 35% of the respondents charges the EV at home daily and 35% does so several times a week. The main charging option at home is the charging station (57.61%), followed by a socket (39.13%). The least frequent charging place is at the work place, where 50% of the respondents indicate that they never charge at work. Also, public non-fast chargers are more frequently used than fast chargers.

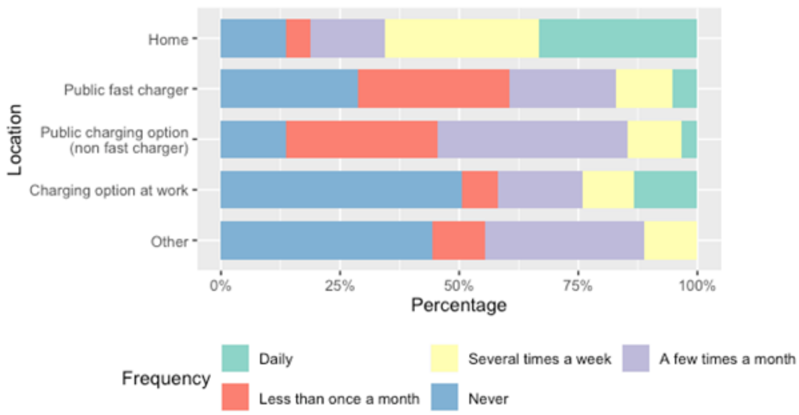


Figure 246 Respondents' charging behaviour per location at the Luxembourg demonstration area

The most popular charging time is in the evening between 6p.m. and midnight. The least popular time is during working hours between 6 a.m. and 5p.m. After 6 p.m. charging becomes more frequent again.

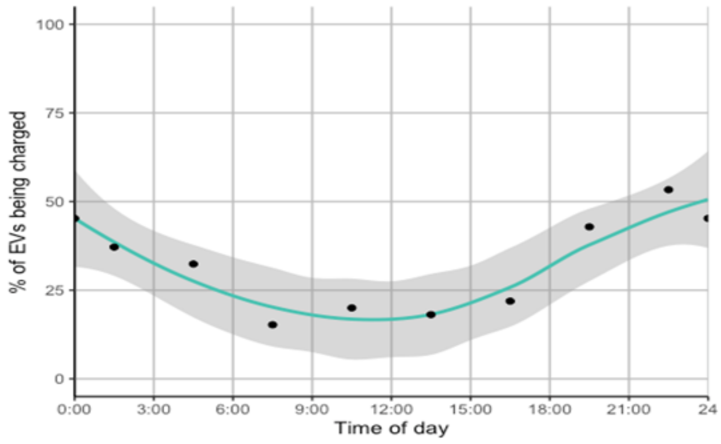


Figure 247 Respondents' charging schedule at the Luxembourg demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that Chargy (63 respondents) is the most popular. Respondents had been offered the choice between CPOs and MSPs based on the response options provided, although no clear distinction was made between these two categories.

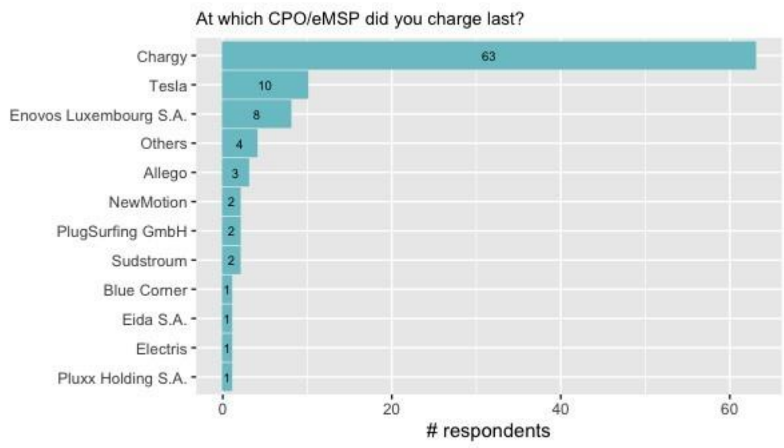


Figure 248 Last charging CPO/eMSP at the Luxembourg demonstration area

In what follows, we discuss the results and make comparisons for CPOs that were evaluated by at least 5 respondents.

Although Chargy is the most popular CPO, it appears to score good on tangibility as well as the other used CPOs (with at least 5 respondents). Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for Chargy are spread ranging from good to very good. The charging infrastructure for Enovos Luxembourg S.A. scores slightly higher with an average of more than 5 on 7, whereas the Tesla charging infrastructure scores highest overall in terms of tangibility (see Figure 249).

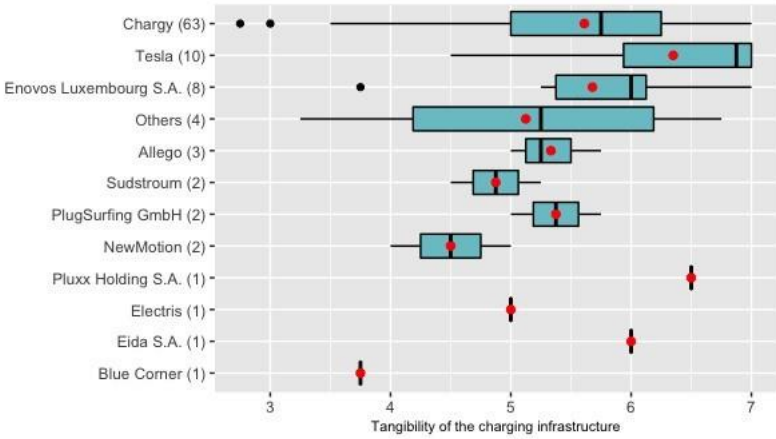


Figure 249 Tangibility of the charging infrastructure at the Luxembourg demonstration area

For availability of the charging infrastructure, similar scores can be observed (see Figure 250 and Figure 251). The availability captures whether the charging infrastructure is available for use, can start immediately, does not block and is not inadvertently interrupted. Both Tesla and Chargy score significantly high on average for these criteria, whereas Enovos Lux has still a good score, lower than the other CPOs. The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping. For reliability, these CPOs/eMSPs score all high on average.

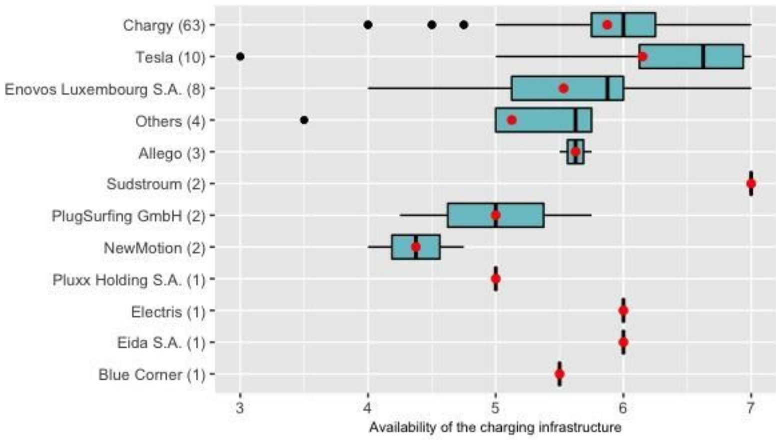


Figure 250 Availability of the charging infrastructure at the Luxembourg demonstration area

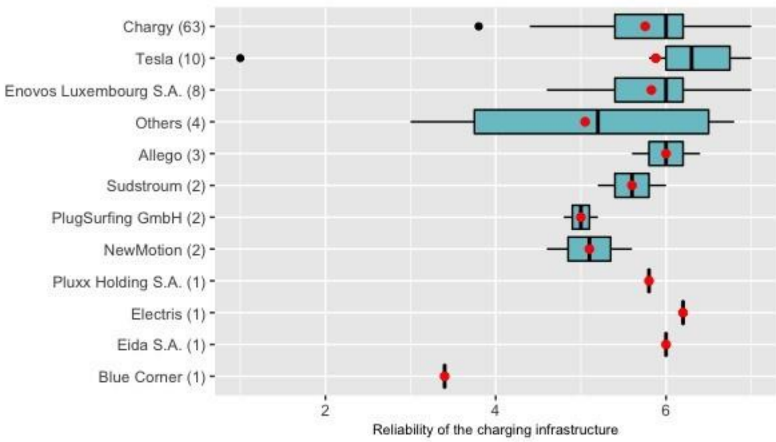


Figure 251 Reliability of the charging infrastructure at the Luxembourg demonstration area

Looking at the privacy of the charging infrastructure, it is clear that all CPOs receive similar scores. Except for Tesla, which scores slightly higher (see Figure 252). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other companies and payment credentials are protected.

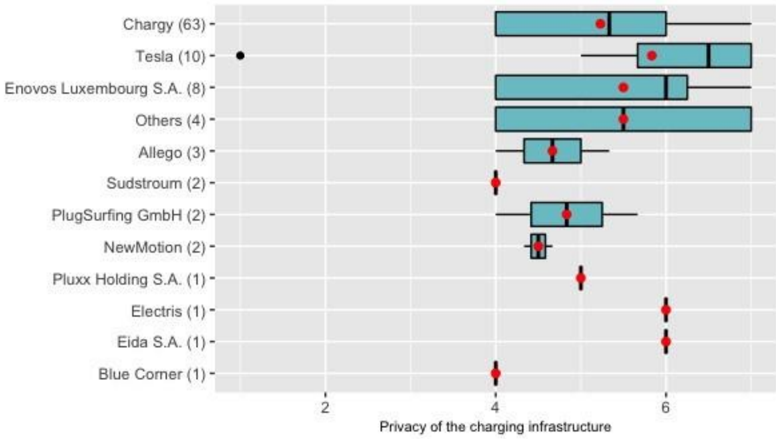


Figure 252 Privacy of charging infrastructure at the Luxembourg demonstration area

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 22 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 22 indicated they have not. Most charging infrastructure problems are experienced when using Chargy. Indeed, 28.57% (18 out of 63 respondents) indicated to have experienced problems with this CPO. Whereas for Tesla this is 20% (2 out of 10 respondents). For Enovos Luxembourg S.A. no respondents have indicated that problems did occur.

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For Chargy, it can be seen in Figure 253 that the scores for responsiveness varied a lot for the different respondents, ranging from bad to very good. Overall, the median and average are still quite average, between 4 and 5 out of 7. Tesla scores poorly, with the lowest average over the two CPOs in terms of responsiveness.

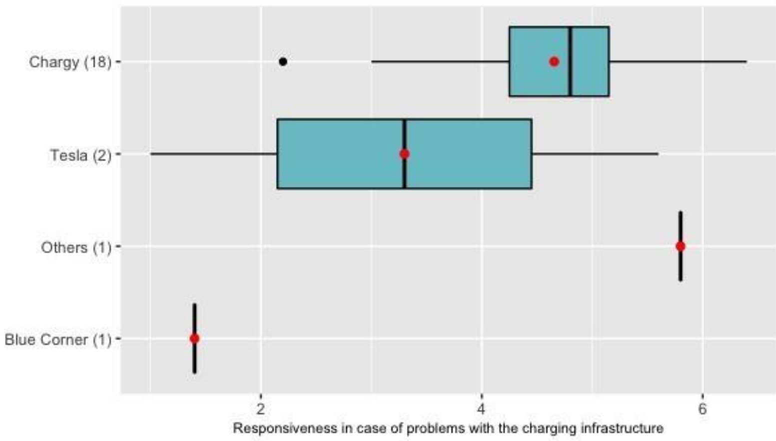


Figure 253 Responsiveness in case of problems with the charging infrastructure at the Luxembourg demonstration area

Compared to the responsiveness in case of problems, the scores on contact are clearly higher for Chargy. For contact, respondents had to indicated whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the ability is provided to speak to a person in case of problems. Although there is still a large spread in the scores, Chargy scores better with an average of 6 out of 7 for the contact criteria (see Figure 254). The lowest scoring CPO is now Tesla, with nearly a 4 out of 7.

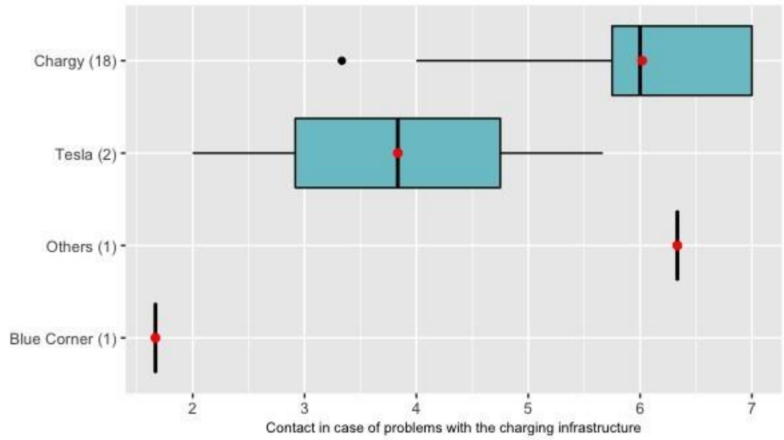


Figure 254 Contact in case of problems with the charging infrastructure at the Luxembourg demonstration area

Lastly, respondents had to score different criteria for compensation in case of problems. Respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. Figure 255 shows that all CPOs/eMSPs score rather poorly on the compensation criteria. A conclusion can be that the user seems to expect more in case of problems than what the CPO/eMSP currently offers. Both Chargy and Tesla score badly.

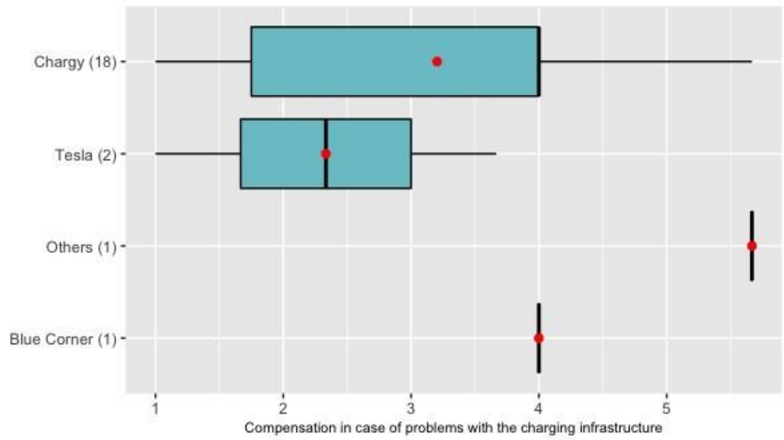


Figure 255 Compensation in case of problems with the charging infrastructure at the Luxembourg demonstration area

Finally, the last questions in this section probe for the respondents' opinions on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. Most CPOs/eMSPs score on average quite well on the perceived value criteria. Enovos and Tesla score on very well on average (see Figure 256). Chargy is a bit more distributed with an average of 5.5 out of 7.

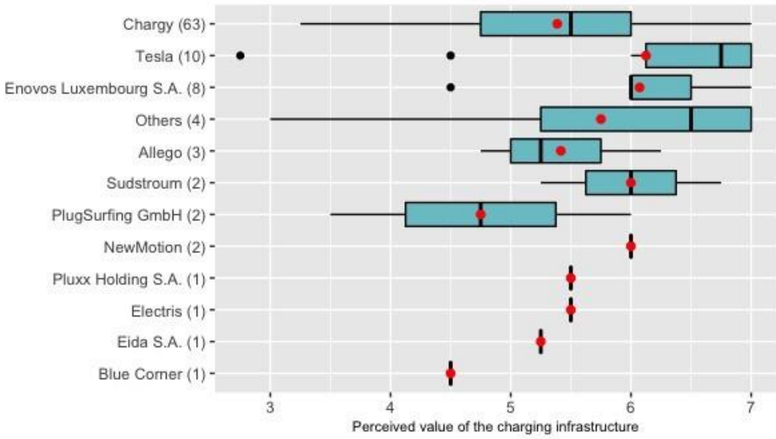


Figure 256 Perceived value of the charging infrastructure at the Luxembourg demonstration area

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. Aside from some outliers, Tesla scores clearly highest on the loyalty criteria (see Figure 257). Also Chargy and Enovos seem to have loyal customers overall, with an average of almost 5.5 out of 7.

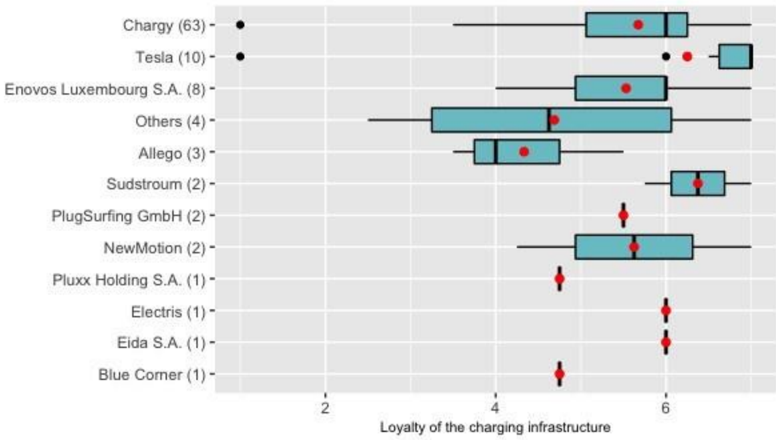


Figure 257 Loyalty of the charging infrastructure at the Luxembourg demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the general trend in the earlier questions, all three CPOs, Tesla, Chargy and Enovos are high scoring CPOs/eMSPs (see Figure 258).

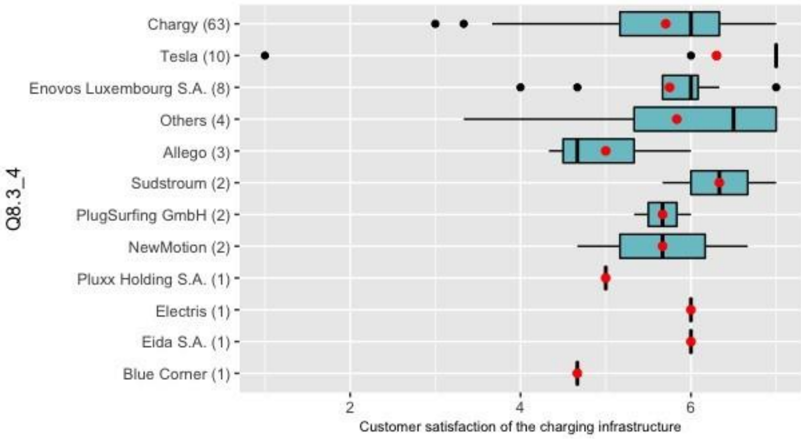


Figure 258 Customer satisfaction of the charging infrastructure at the Luxembourg demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e. the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, smart charging are the most popular with 79.04% of respondents choosing they are most likely to use smart charging in the future. In delving deeper into the respondents' answers, 9 of the 22 respondents who clicked 'Others' preferred fast charging, whereas 3 respondents preferred Plug & Charge. Other shared options were induction charging and user friendly charging stations for apartment buildings.

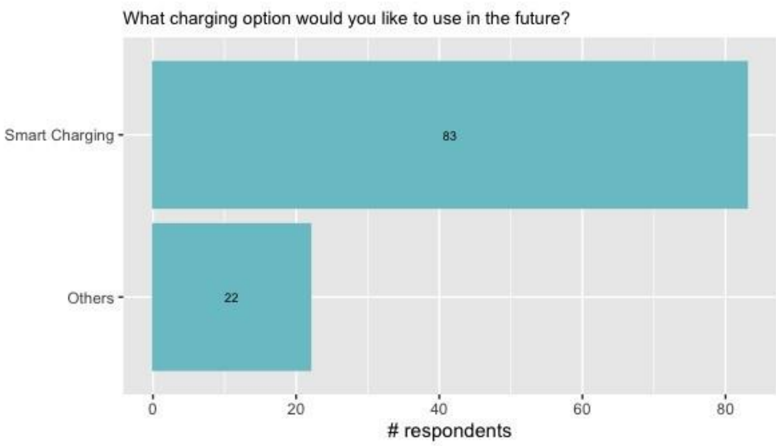


Figure 259 Most likely charging option in the future at the Luxembourg demonstration area

The smart charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration.

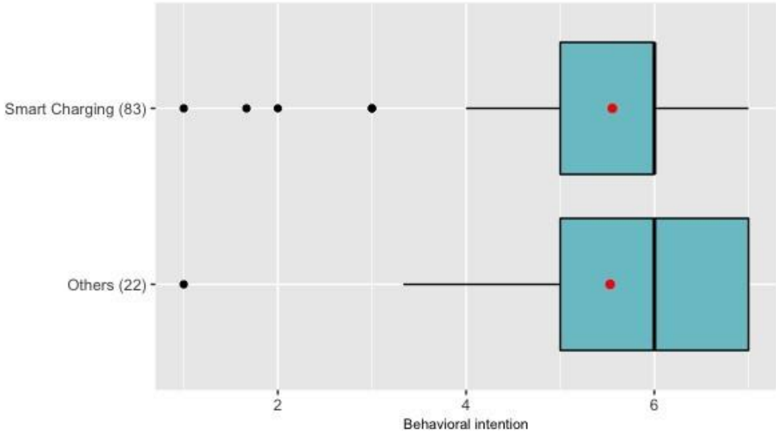


Figure 260 Behavioural intention of charging infrastructure at the Luxembourg demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the smart charging option scores high on these criteria with a score of 5.5 out of 7, aside from a few outliers (see Figure 261).

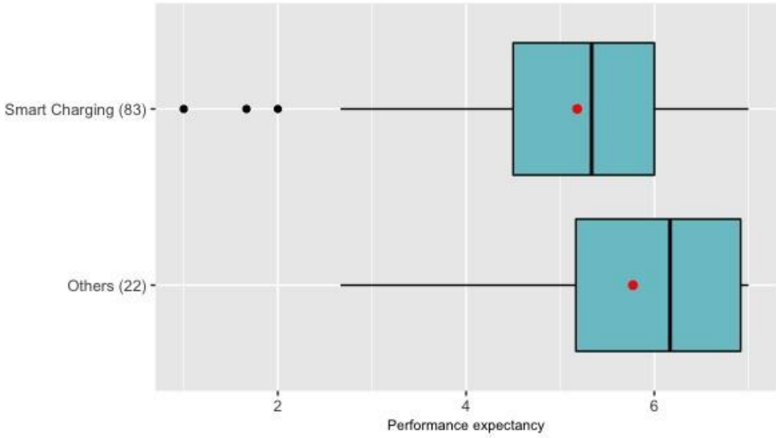


Figure 261 Performance expectancy of the charging infrastructure at the Luxembourg demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. Less effort is expected for smart charging options in the future (see Figure 262).

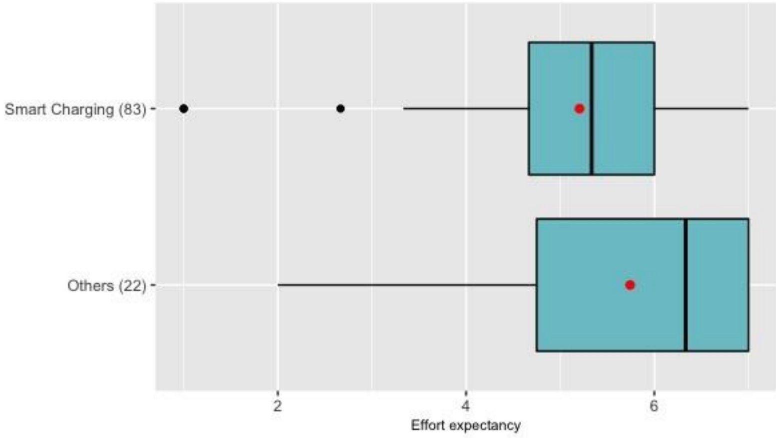


Figure 262 Effort expectancy of the charging infrastructure at the Luxembourg demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority? The average and median all lightly fluctuate around 4 on a scale of 7, but people do not seem to expert support from the authority (see Figure 263).

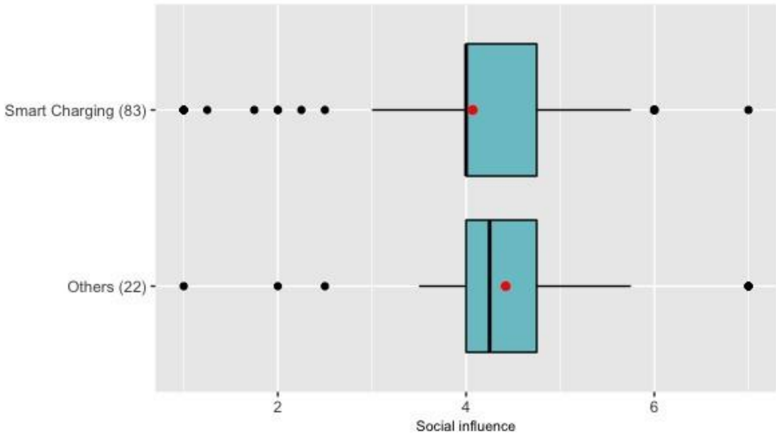


Figure 263 Social influence of the charging infrastructure at the Luxembourg demonstration area

In terms of facilitating conditions, the scores of the smart charging options are tend to evaluate a good score (see Figure 264). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

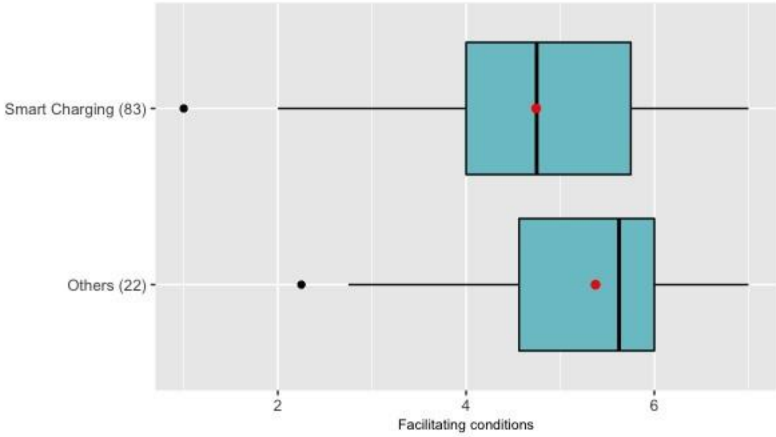


Figure 264 Facilitating conditions of the charging infrastructure at the Luxembourg demonstration area

As for hedonic motivation quite similar distributions as the social influence can be observed for the different charging options (see Figure 265). Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

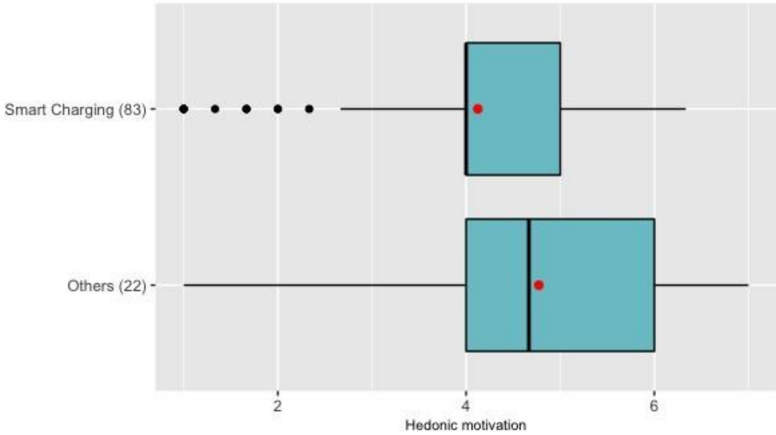


Figure 265 Hedonic motivation of the charging infrastructure at the Luxembourg demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. At the same time for smart charging, almost 75% indicates they would only use it if the price is lower (see Figure 266).

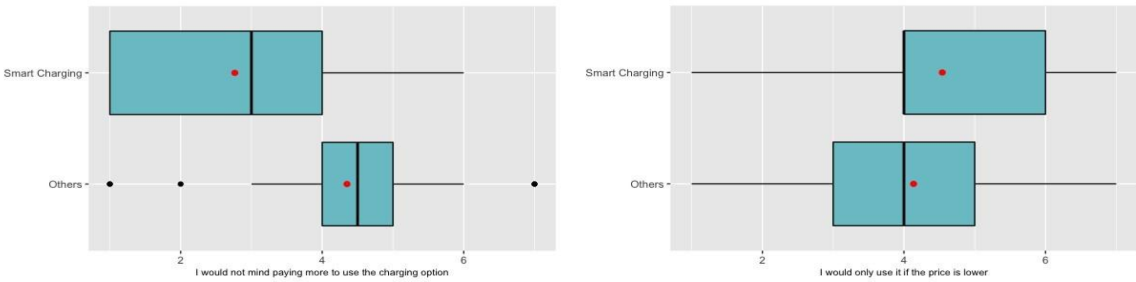


Figure 266 Price value of the charging infrastructure at the Luxembourg demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. The majority of the respondents, 57.14% (60 respondents) indicated they use app-based services, another 16.19% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, a third of the EV respondents has 4 or more apps on their phone. About 73.33% of the app-based service users, users this at least a few times a month, as can be seen in Figure 267.

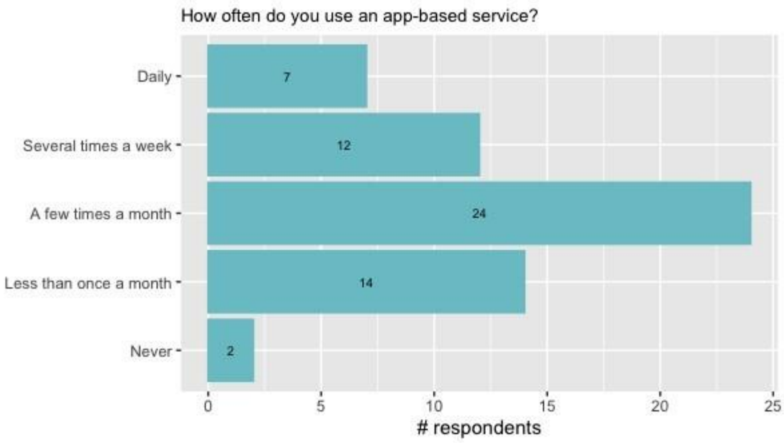


Figure 267 Usage of app-based services at the Luxembourg demonstration area

App-based services are mostly used for travel related to travel destinations on holiday (40 respondents), whereas 34 respondents use it for leisure activities. To a lesser extent, the app-based services are used for shop/errands (18 respondents) and commuting and work activities (15 respondents). In terms of satisfaction with the used app-based services, Figure 268 shows that more than 75% of the respondents are satisfied above average on a scale of 1 to 7.

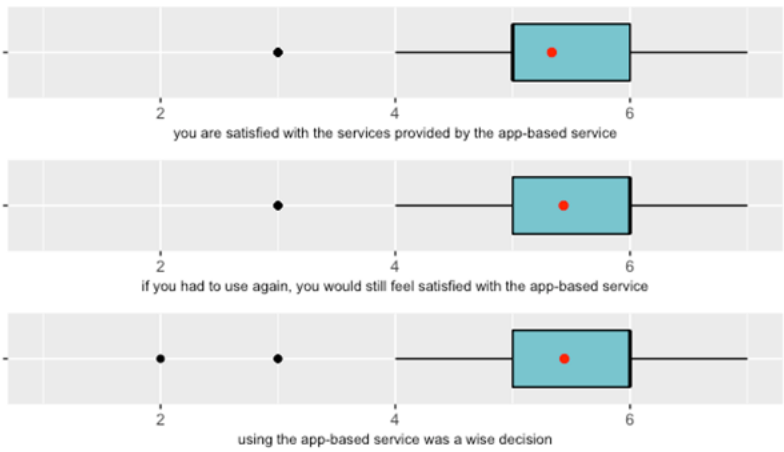


Figure 268 Satisfaction with the app-based services at the Luxembourg demonstration area

LEV

In this section, we zoom in to the 24 respondents who use a light electric vehicle. The majority of the respondents (60.0%) owns the LEV they use and are responsible for the LEV maintenance costs (100.0%). At the same time, the majority of the respondents does not know what the battery capacity is or did not fill out this question (54%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 58.

Table 58 LEV characteristics at the Luxembourg demonstration area

What is the capacity of the battery (in kWh)? Indicate it without looking it up.	N (%)
< 0,5	2 (8%)
> 7	1 (4%)
0,5 – 1	4 (17%)
1-3	4 (17%)
I do not know.	13 (54%)
Who is responsible for the maintenance costs of the LEV you drive?	
Private	24 (100%)
How long do you already own your LEV?	
< 1 year	7 (29%)
> 4 years	2 (8%)
1 year	9 (38%)
2 year	3 (12%)
3 years	3 (12%)
Do you use a fixed car park or garage?	
I use a garage that is my property or park on my driveway.	19 (79%)
No.	5 (21%)

On average, the LEV users indicate they drive about 22.89 km each day and spend more than 2 hours on the road. The majority of the time, the LEV is parked at home at a private parking or at the employer's car park (see Figure 269).

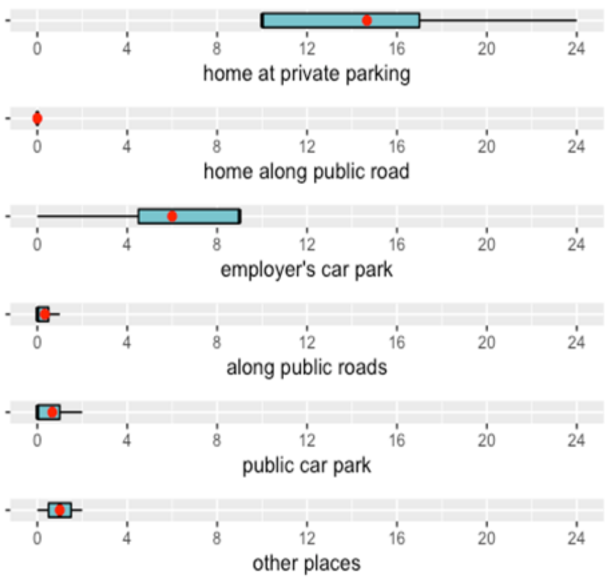


Figure 269 Parking space and duration of the LEV at the Luxembourg demonstration area

Looking at the motives to use an LEV, it is clear that the most important motives are the driving pleasure and the driving comfort, whereas least important is the image towards other people (Figure 270).

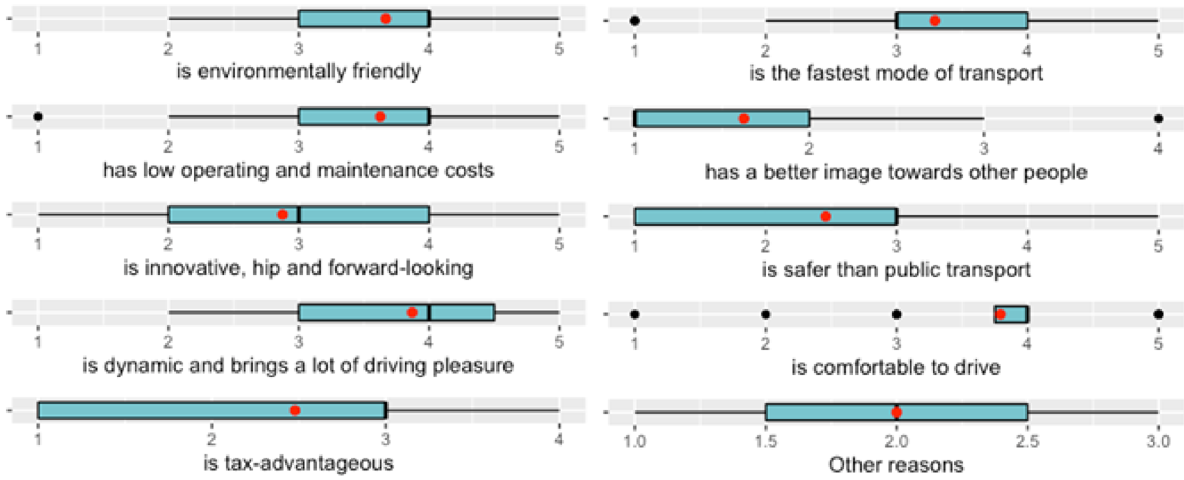


Figure 270 Motives to use LEVs at the Luxembourg demonstration area

In terms of charging behaviour, 75% of the respondents seem to charge when the battery falls below a certain level, or based on their next trip. Also, 50% of the respondents charge based on next trips.

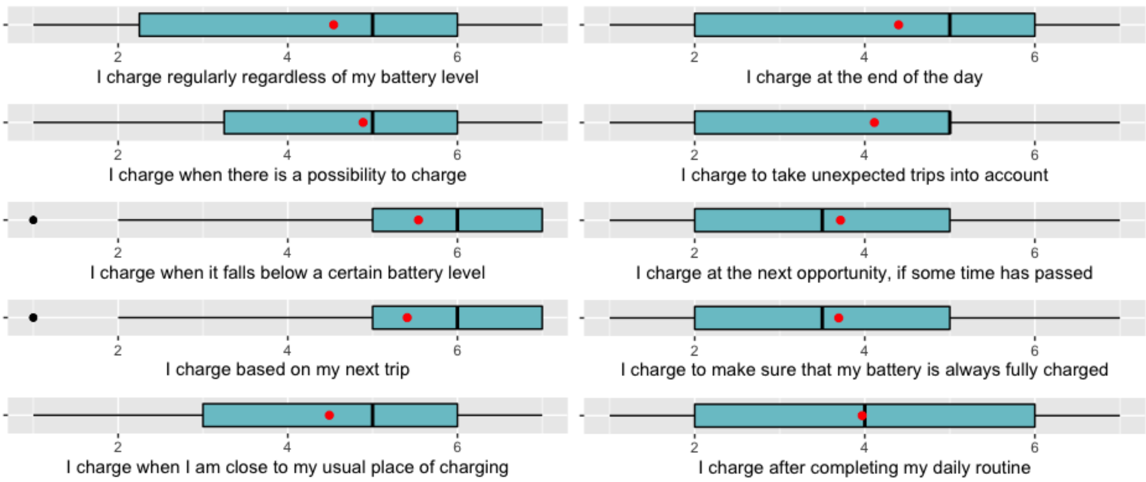


Figure 271 LEV charging behaviour at the Luxembourg demonstration area

Quality of Experience

Currently, there are no CPOs/eMSPs that serve LEVs in Luxembourg. As such, the Quality of Experience could not be measured and is therefore not discussed.

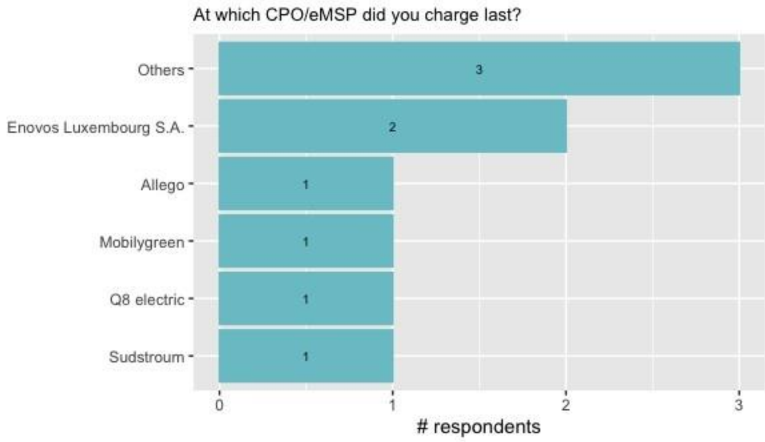


Figure 272 LEV last charging CPO/eMSP at the Luxembourg demonstration area

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e. the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, smart charging options are the most popular with 83.3% of respondents choosing they are most likely to use smart charging options in the future.

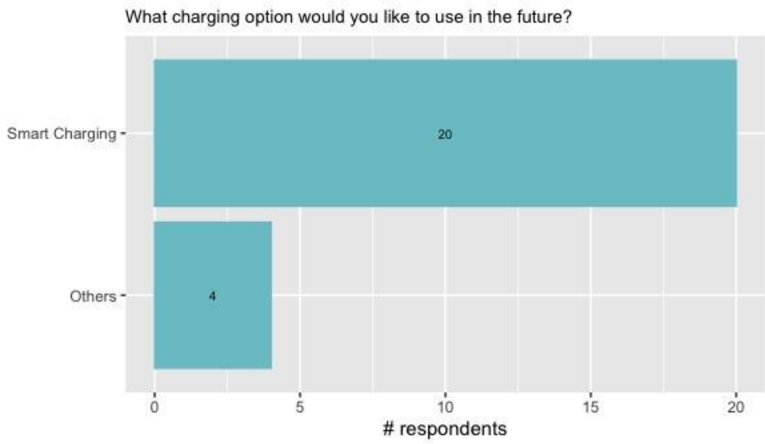


Figure 273 Preferred LEV charging option to use in the future at the Luxembourg demonstration area

Next, we take a closer look at the UTAUT constructs for the 2 biggest categories. Looking at behavioural intention, it can be seen in Figure 274 that the intention to use smart charging options is rather high (aside from some outliers).

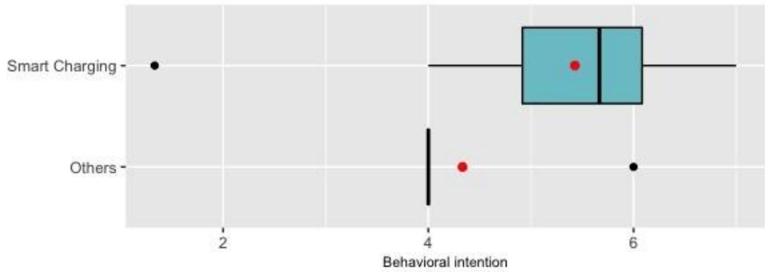


Figure 274 Behavioural intention for LEV charging options at the Luxembourg demonstration area

In terms of the performancy and effort expectancy (see Figure 275 and Figure 276), the respondents evaluate the smart charging solution well.

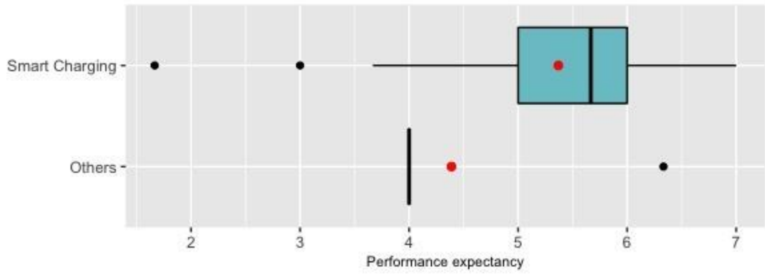


Figure 275 Performance expectancy of the LEV charging options at the Luxembourg demonstration area

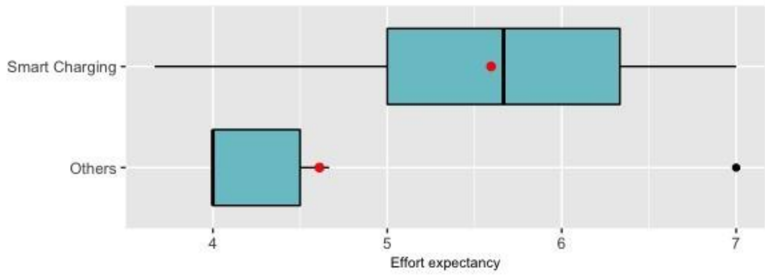


Figure 276 Effort expectancy of the LEV charging options at the Luxembourg demonstration area

In terms of facilitating conditions, 75% of the respondents ranges from neutral to completely agreeing with having the necessary resources and knowledge to use the charging option and having the charging option be compatible with other forms they use. This is the case for both fast charging options as well as user friendly charging options (see Figure 277).

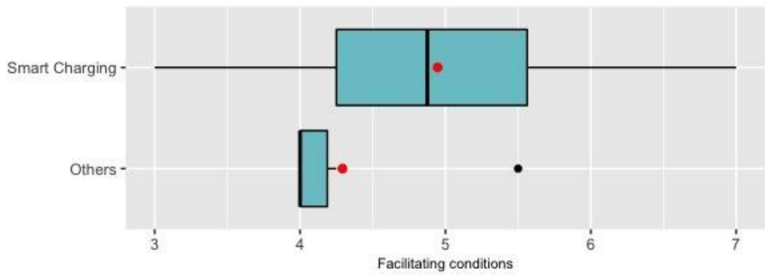


Figure 277 Facilitating conditions of the LEV charging options at the Luxembourg demonstration area

The social influence on using certain LEV charging options as well as the hedonic motivation are scored rather neutral on average (see Figure 278 and Figure 279). As such for social influence, respondents do not agree or disagree with the fact that people who are important or influence their behaviour think they should use this charging option. Neither are respondents influenced by whether a charging option is considered to be fun or entertaining, which is captured through the scores on hedonic motivation.

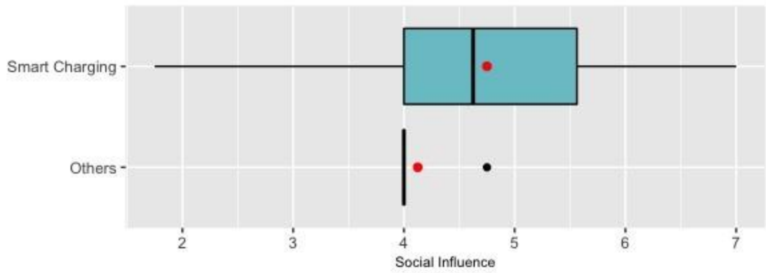


Figure 278 Social influence of the LEV charging options at the Luxembourg demonstration area

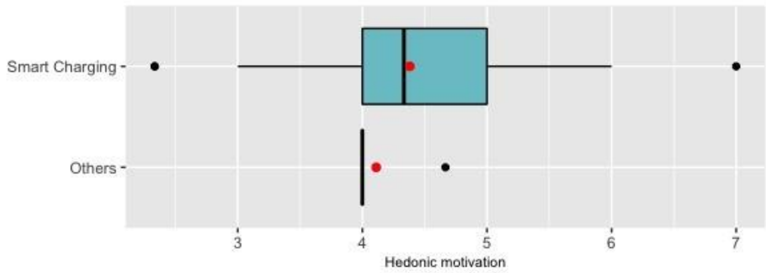


Figure 279 Hedonic motivation of the LEV charging options at the Luxembourg demonstration area

For the price value, LEV respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their LEV charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. At the same time for smart charging, almost 75% indicates they would only use it if the price is the same or lower (see Figure 280).

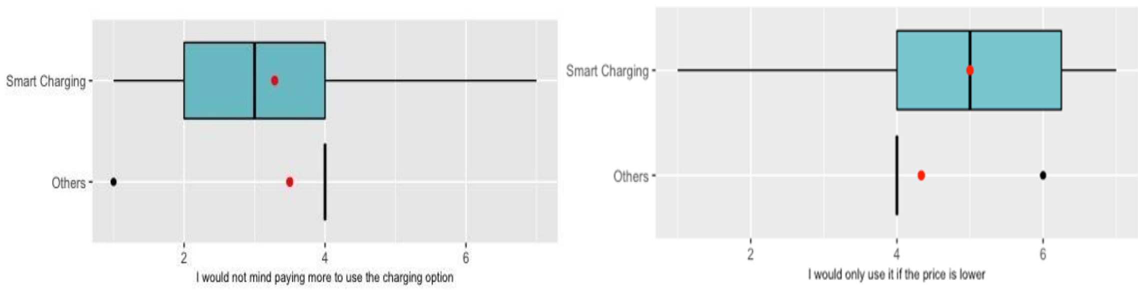


Figure 280 Price motivation of the LEV charging options at the Luxembourg demonstration area

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 16.67% of the respondents, indicated they use app-based services, another 16.19% do not but intend to. The remainder of the respondents have no intention to use an app in the near future. About 25.00% of the app-based service users, users this at least a few times a month, as can be seen in Figure 281.

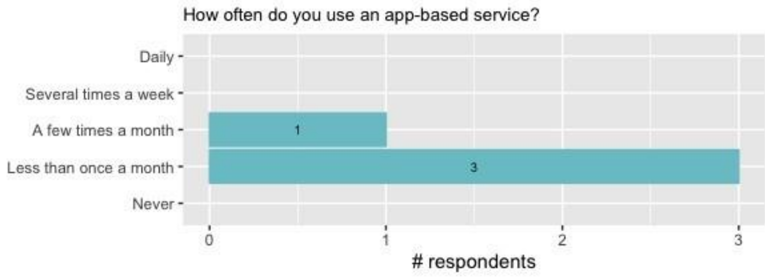


Figure 281 Usage of app-based LEV services at the Luxembourg demonstration area

While app-based services were most frequently used for leisure activities (4 respondents). The least frequent usage for LEV users is commuting and work activities with only 2 respondents. Shop/errands are in between with 3 respondents. In terms of satisfaction with the used app-based services, Figure 282 shows that more than 50% of the respondents are satisfied above average on a scale of 1 to 7.

Figure 282 Satisfaction of app-based LEV services at the Luxembourg demonstration area

Non-EV users

Lastly, we zoom into the non-EV users, a total of 119 respondents. Interestingly, more than half of the respondents (55.46%) states that will buy an electric vehicle as soon as possible or state that it is very likely they will buy an electric vehicle.

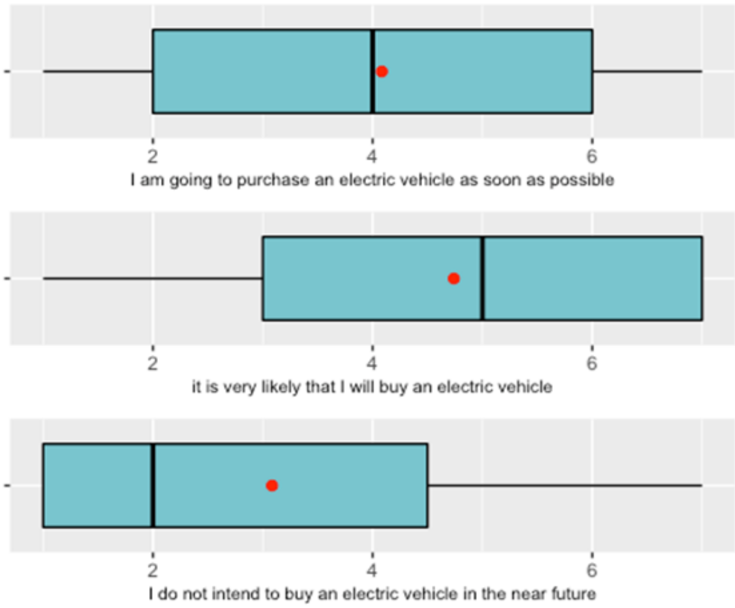


Figure 283 Non-users' Intention to buy an EV at the Luxembourg demonstration area

Moreover, 91.6% of the respondents indicate they are mostly interested to buy an electric car. Out of these 66 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (37 respondents), an electric vehicle with range extender (3 respondents) or a plug-in hybrid electric vehicle (14 respondents). The remaining 12 respondents prefer a hybrid vehicle that combines a classic combustion engine. 6 respondents indicated they are interested in buying a LEV.

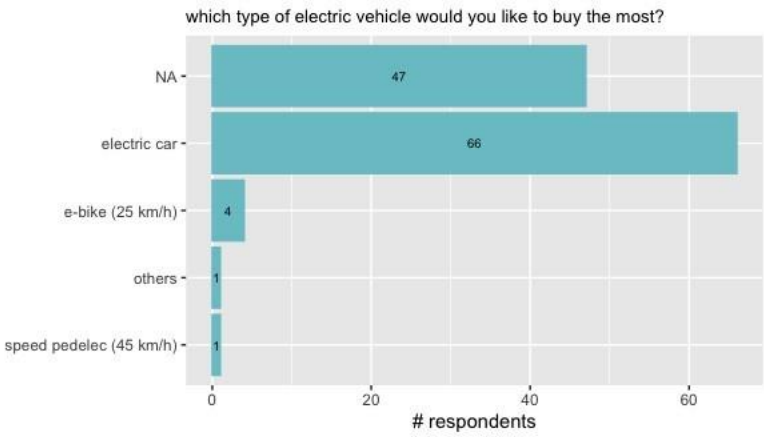


Figure 284 Type of EV that non-users intend to buy at the Luxembourg demonstration area

Lastly, the most important motives for non-EV users to purchase an EV in the future is the fact that EVs have more efficient technology in terms of energy consumption and the environmental friendliness as 78% respectively 67% considers this very to extremely important. At the same time, the least important motive is the better image EVs could have towards other people as 44% of the respondents consider this not important at all to slightly important.

Key findings of the Luxembourg report

The main reasons for electric car adoption are the driving pleasure of an EV, driving comfort and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, the big part of electric car owners' charges mostly at home, as 75% of the respondents charge daily to several times a week. This can be seen in the chart of charging time, where the users charge overnight and in the evening. Although the EV is parked for 7h a day at the employers parking, it is remarkable that little charging takes place during the day, and that the least frequent charging place is at the workplace, where more than half of the respondents (52%) indicate that they never charge at work. Respondents are really satisfied with the quality of service they receive from the CPOs/eMSPs. Tesla is the primus of the class and receive the highest overall satisfaction, followed by Chargy. Improvements can be made when problems arise at the charging station, as the responsiveness and compensation score low, except for Chargy, where customers are satisfied with the after sales-services. Smart charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use, which means people are looking forward to the future charging options. Remarkable is that 75% of the respondents indicate they would only use the future charging options is when the price is cheaper than the current charging options available.

LEV users mainly bought their LEV because it is pleasant and comfortable to drive. LEV users use their LEV often to go to work. In terms of charging behaviour, half of the LEV users charge their LEV based on their next trip. Smart charging is the most preferrable charging option in the future and users see this also as the charging option the easiest to use. Users don't want to pay more for smart charging in comparison with current charging options and expect a lower price.

Lastly, more than half of the non- EV users (55%) states that they will buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (91.6%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (78%) and more efficient technology in terms of energy consumption (67%) in comparison with non-EVs. At the same time, the least important motive is the better image EVs could have towards other people as 44% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV car users.

Outcome from historical data

The data analytics for the Luxembourg demonstration area covers the whole country, counting with the dataset from Chargy. The Chargy network includes public charging stations for electric cars and hybrid plug-in vehicles in Luxembourg, with nearly half of the stations located in park-and-ride car parks and the remaining in public municipal car parks. The rollout plan of the nationwide charging network "Chargy" foresees to have 400 dual charging (800 CPs) located on park-and-ride facilities and another 400 dual charging stations (800 CPS) scattered across municipalities. The infrastructure is set up and operated by Luxembourgish electric distribution network operators that also act as CPO.

It should be noted that, for this demonstration area, there is no charging power analysis since all the chargers have the same power (22 kW). Table 59 describes the data information obtained from the data set.

Table 59. General data information – Luxembourg demonstration area

Attribute	
Users	4115 users
Cantons	43 cities
Operators	Chargy
CPs	742 CPs
Sessions	75356 sessions
Time range	01/08/2019 – 07/08/2020
Power levels	22 kW

Descriptive Statistics

- **Sessions' geographical distribution**

In May 2020, Chargy had 79 out of the planned 400 dual charging stations for park-and-ride facilities installed, while they had installed 266 out of 400 planned dual charging stations in public parking sites run by local councils. Thereby 93 out of 102 communes in Luxembourg had at least one dual charging station operational. The network is most dense and widely used in the city of Luxembourg and the more populated areas in the South of the country. The charging sessions' analysis revealed a new finding: the concentration of charging activities along the highway A6/E25 connecting Luxembourg to Belgium's Arlon.

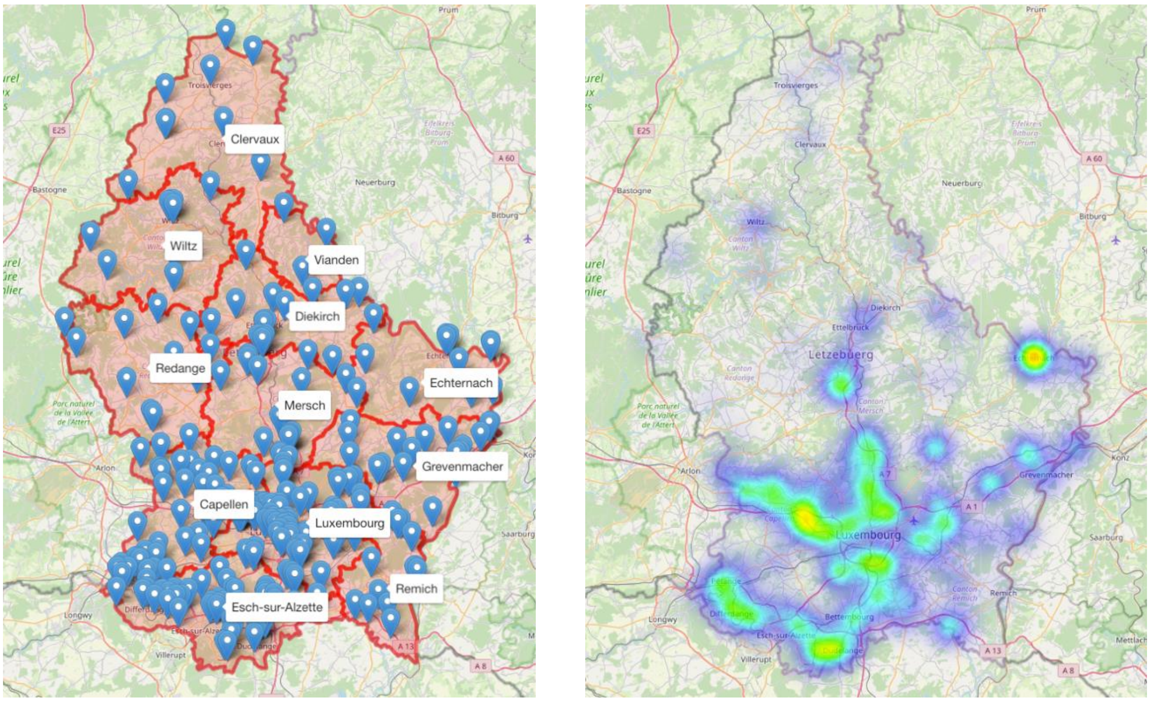


Figure 285. Location of CPs (right) and Heatmap of sessions happened in Luxembourg (left)

- **Usage distribution by city**

As for the CP coverage in the different cantons in Luxembourg, the number of CPs and sessions in each canton have been analysed in order to see the ratio that represents the division of the total number of sessions by the total number of CPs in each canton. This ratio is shown in Figure 286. The canton of Luxembourg has the highest usage activity, since it has the highest number of sessions and installed CPs. In Annexe A3, figures can be found representing the number of sessions per canton and the number of CPs per canton.

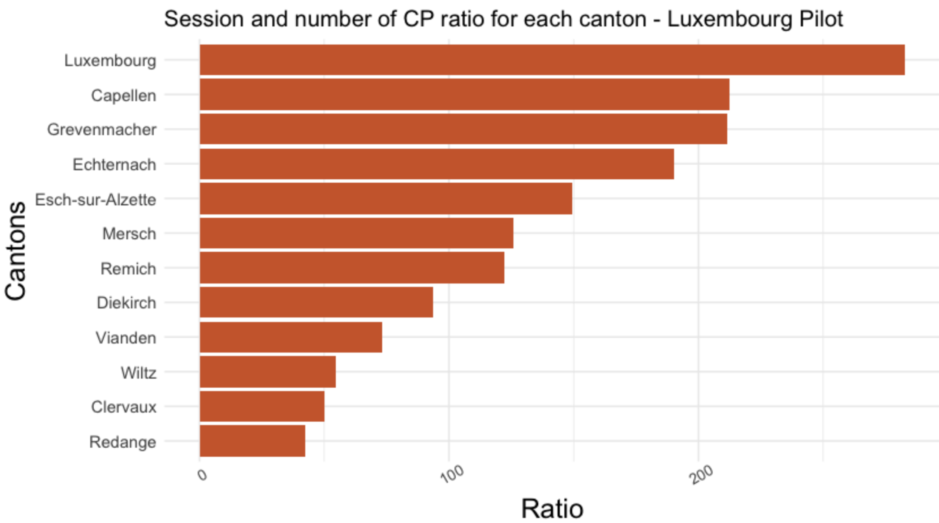


Figure 286. Ratio of sessions and CPs – Luxembourg demonstration area

- **Sessions' temporal distribution**

When looking at the time of the day preferred by the users, it is very helpful to plot the session time distribution. From Figure 287, which shows the hourly distribution of sessions per day of the week, the following insights can be drawn:

- There is a first significant peak during the weekday mornings, from 8 to 9 AM, and at noon between 12 and 1 PM, these peaks are higher on Thursdays and lower on Mondays. The noon peak is also present during the weekends, but with a lower frequency than the weekdays.
- With a lower frequency than the two previous peaks, there is a peak during the evenings, from 6 to 7 PM. This peak only appears during the weekdays.
- Finally, the weekends have always lower session values than the weekdays.

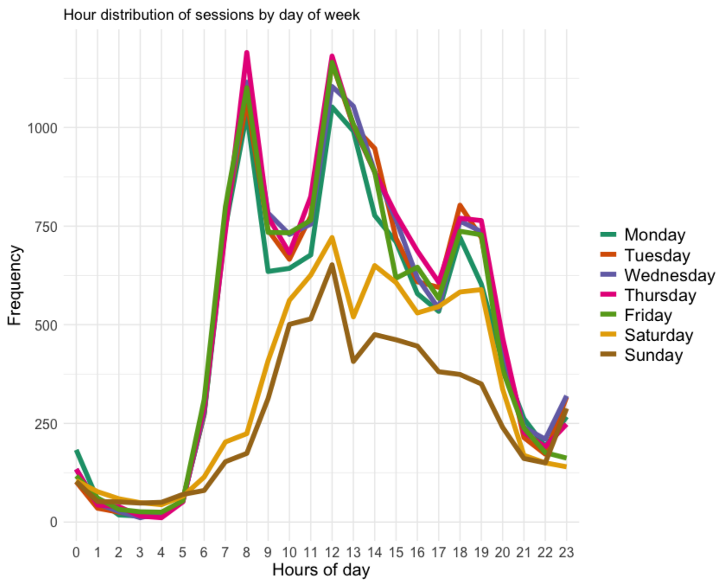


Figure 287. Sessions' temporal distribution – Luxembourg demonstration area

- **Sessions' duration**

Figure 288 shows the box plot of the duration of the sessions for the Luxembourg pilot. It can be inferred that there are a lot of outliers that park for extremely long periods of time (the maximum value is 58 days), which are unrealistic in terms of charging session. These outliers affect the value of the average, which is of 377 minutes, whereas the median is 163 minutes. In this case, the median is a more realistic value to consider as a general duration average of users that perform a charging session. Table 60 shows the minimum, 1st quartile, median, mean, 3rd quartile and maximum values.

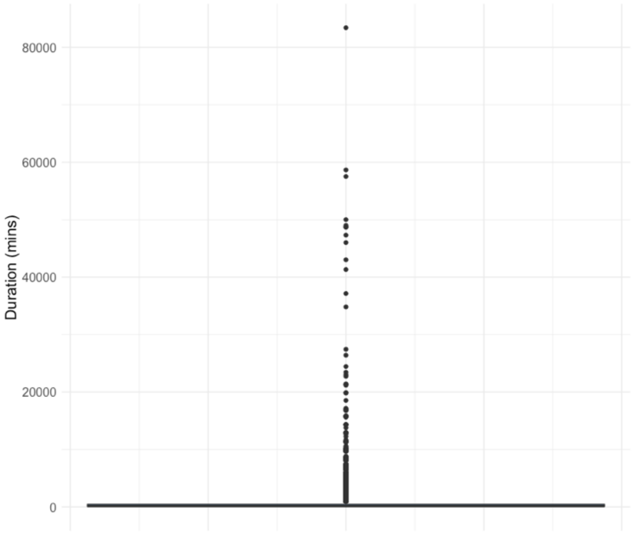


Figure 288. Boxplot for sessions' duration – Luxembourg demonstration area

Table 60. Summary of statistical values of sessions' duration – Luxembourg demonstration area

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
0.04 min	69.76 min	163.38 min	376.56 min	448.77 min	83416.58 min

- **Energy consumed per session**

To graphically represent the energy consumed per session, a boxplot is shown in Figure 289. In this case, the number of outliers is lower, which leads to more realistic conclusions. The algorithm detects usages with more than 37.5 kWh as outliers, and the average usage is 13.48 kWh, which implies that Luxembourg users tend to perform short sessions. On a side-note, above 50% of Luxembourg's residents live in single-family houses, enabling the installation of private charging points. Therefore, it is safe to assume that most of the charging happens at home and less on public charging stations.

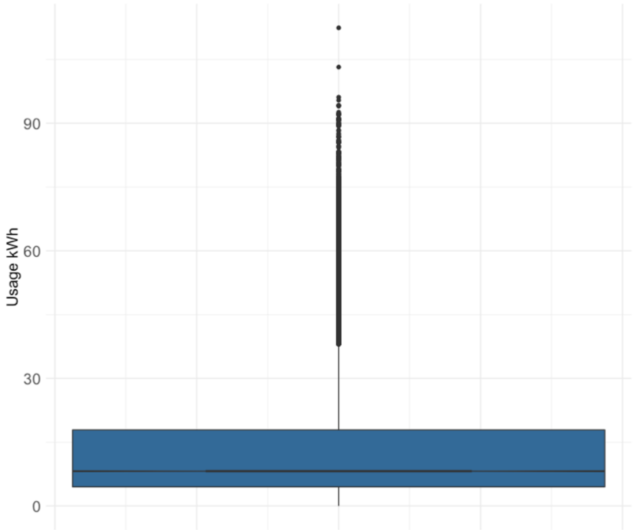


Figure 289. Boxplot for sessions' energy consumed – Luxembourg demonstration area

Table 61. Summary of statistical values for sessions' energy consumed – Luxembourg demonstration area

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
0.001 kWh	4.5 kWh	8.2 kWh	13.48 kWh	17.9 kWh	112.43 kWh

User Clustering

The user clustering has also been performed for the Luxembourg demonstration area. The methodology explained in Annexe A1.2 has been followed and the outcome for the best option is the *kmeans* method with 3 clusters. Even though there is only one type of power level for this demonstration area (22 kW), the *average power* parameter has been used considering the actual power level of the CPs.

Table 62 User clusters – Luxembourg demonstration area

User Cluster 1	User Cluster 2	User Cluster 3
1639 (59%)	393 (14.1%)	746 (26.9%)

Almost 60% of the users belong to Cluster 1, is the cluster closest to the average values. Moreover, Cluster 1 is the cluster with the lowest number of sessions per user, an average energy consumption of 7 kWh and an average charging session duration of 3 hours.

Cluster 2 users have the most different patterns of behaviour to the average, with the longest session duration (8.5 hours), highest number of sessions, highest number of different CPs visited and lowest actual power. Finally, users that belong to Cluster 3 are characterised by high energy consumption per charging session and high actual power.

The following diagram in Figure 290 shows how each of the clusters compare to the average value of the studied parameters, a value above 0 means that this specific parameter is higher than the average, on the other hand a value below 0 means that the specific parameter is lower than the average.

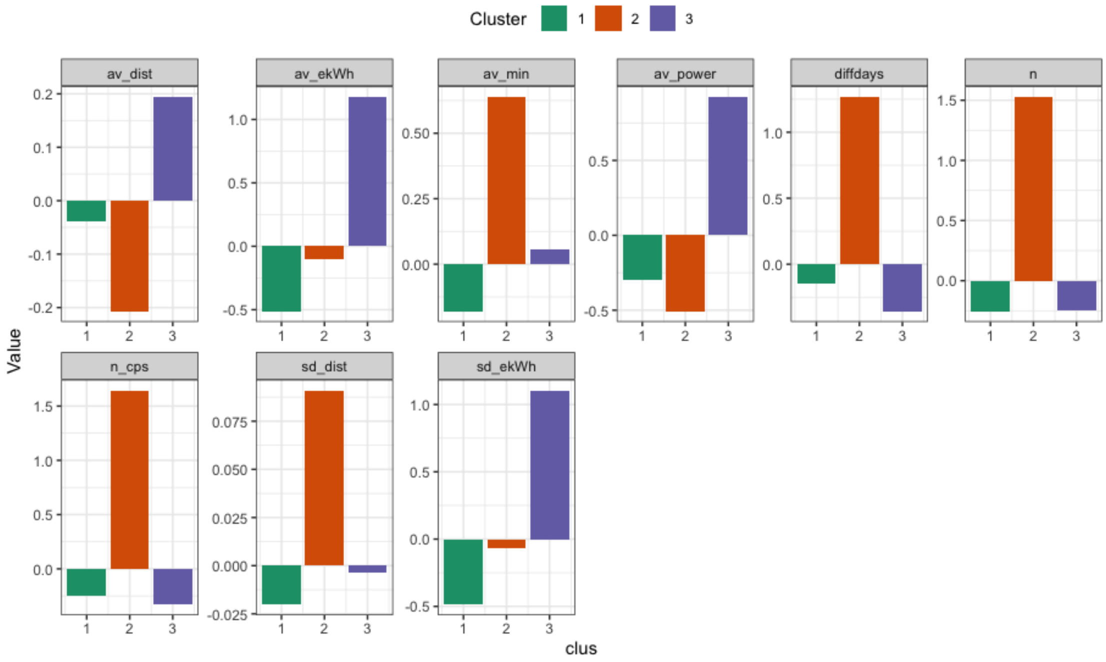


Figure 290. User clustering results – Luxembourg demonstration area

Temporal Clustering

According to the results of the method explained in Annexe A1.2, the best clustering option is “kmeans” with 2 clusters.

Table 63 Temporal clusters – Luxembourg demonstration area

Temporal Cluster 1	Temporal Cluster 2
669 CPs (90.2 %)	73 CPs (9.8 %)

Temporal Cluster 1 CPs (90% of the CPs) have one significant peak, from 3 am to 8 am, this Cluster includes the CPs with lower occupancy (between 2.2% and 5.8%). Temporal Cluster 2 (90% of the CPs) has a 40% occupancy peak between 3 am and 8 am and then the occupancy progressively decreases up to 25%.

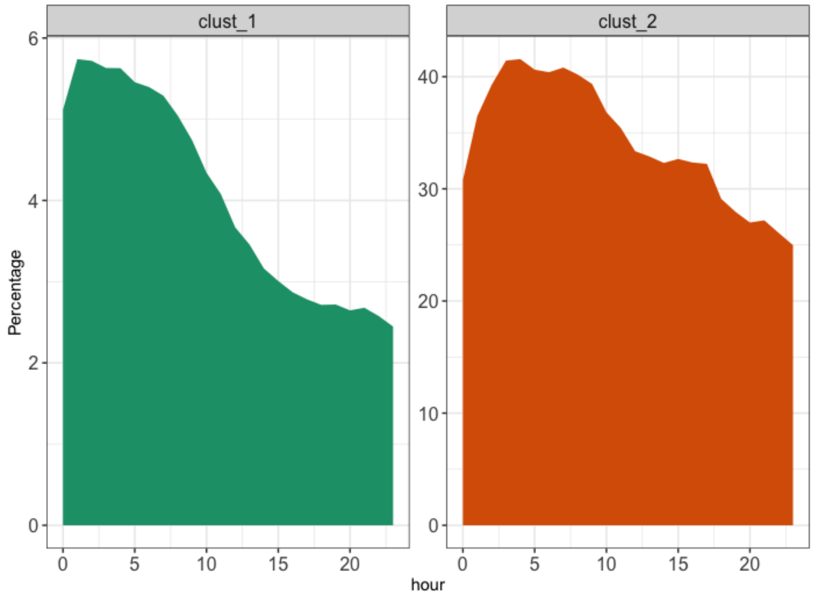


Figure 291. Charging Points' temporal clusters' hourly session distributions – Luxembourg demonstration area

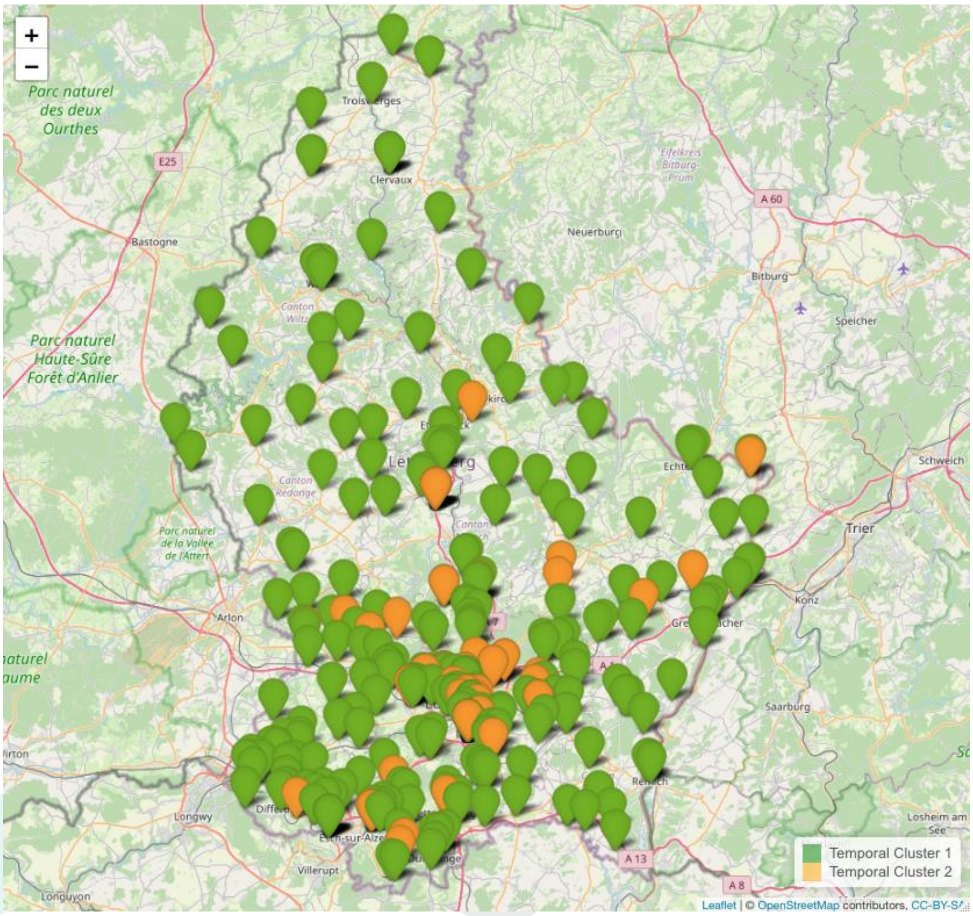


Figure 292. Charging Points temporal clustering geographical distribution – Luxembourg demonstration area

User Mobility Flows

The results of user mobility flows analysis for the Luxembourg demonstration area are based on 159 canton pairs detected in the dataset. The predefined threshold to select the significant flows based on the number of trips occurred is 25 trips, as shown in Annexe A3. The canton with the highest mobility flows is Luxembourg, being the main origin and destination, then it's followed by Capellen and Grevenmacher. The top-three mobility flows are Luxembourg – Capellen (309 trips), Luxembourg-Echternach (110 trips) and Luxembourg-Mersch (88 trips). Again, it is safe to assume that charging on private charging points is missing in that picture. Also, charging abroad is not taken into account, which might be an essential factor too, given the fact that more than 200,000 cross-border workers are employed in the Grand Duchy (Source: Statec 2019), with almost half of them coming from France, where electricity prices are even below the Luxembourgish level.

Figure 293. Inter-cantons mobility flows – Luxembourg demonstration area

COVID-19 effect

The following time periods have been established for the analysis of the COVID-19 effect in the Luxembourg demonstration area:

Pre-COVID-19: 2020-01-15 – 2020-03-13
Lockdown: 2020-03-14 – 2020-05-17
De-escalation: 2020-05-18 – 2020-06-21
New-normality: 2020-06-22 – 2020-09-01

The number of users, the average sessions per day and the average occupancy percentage of the CPs decreased considerably during the lockdown period and these attributes increase during the se-escalation and achieving similar values to the pre-covid period in the new normality.
The average duration increases a 73% in the lockdown period compared to the pre-COVID 19 period, the increase is probably caused by users leaving their car parked at the CPs due to the mobility limitations.
Overall, the number of users, average sessions per day, average duration, average occupancy percentage of CPs and average daily energy consumed by user recover similar values to the pre-covid situation in the new normality.

Moreover, in Annexe A3 a comparison can be found between the conventional fuel sales in Luxembourg's petrol stations and the energy consumed in Chargy CPs during the COVID-19 period. It is clearly noted that the consumption of the three energy sources decreased during lockdown.

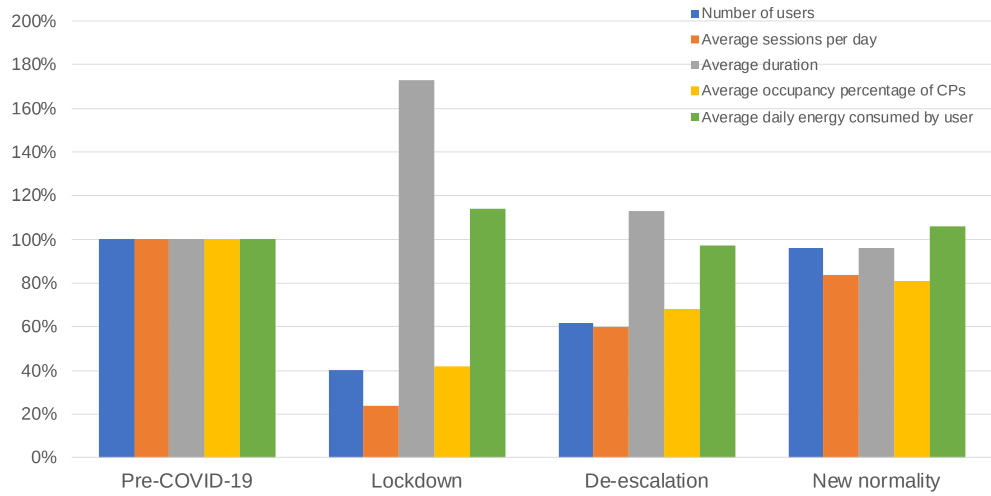


Figure 294. Variation of charging attributes with relation to the pre-COVID-19 period – Luxembourg demonstration area

A priori assessment of the e-mobility charging infrastructure

The following KPIs from the Usage Impact Area have been calculated as defined in D1.1 using data between 01/08/2019 and 01/08/2020.

Table 64. Usage KPIs – Luxembourg demonstration area

KPI	Result
Loyalty to the same charging option	26 % of users reused the same CP more than 5 times
Frequency of use of charging options	196 is the average of uses of each CP
Vehicle's charging time	383 minutes
Availability rate (1)	39% of the charging options are occupied more than 10%.
Availability rate (2)	50% of the charging points are occupied less than 5%
Average usage ratio of charging options	14%

Conclusions

The analyses that are done for this pilot gave significant and useful information about the EV and charging point usage. The average consumed energy is 13 kWh with average duration of 377 minutes (median is 163 minutes). All CPs are with 22 kW power, whereas the actual average power is 5.10 kW. 61.43% of the users perform their charging sessions inside the same canton. Luxembourg, Capellan and Grevenmacher are the cantons with the highest mobility flows, having users that use CPs from all three cantons; the most significant flow OD pair is from Luxembourg to Capellen. The cantons of Luxembourg, Capellen, Grevenmacher and Echternach are the cantons with a higher usage level in terms of sessions per CP.

Demonstration area 8: Northern Italy

Context

Electric mobility is starting to experience interesting growth volumes also in Italy (comparing them to the volumes of other European countries such as France, Germany, Netherlands,…). In 2018, about 20,000 electric vehicles were registered in Italy while the new registrations counted 13,000 new vehicles in 2019, 30,000 new vehicles in 2020 and an estimation of over 60,000 new registrations in 2021. The country has about 15,000 charging points for electric vehicles and the number is constantly increasing also thanks to the presence of a few large national players and many other small CPO operators active mainly locally. There are also about ten main EMPs on the national territory. 95% of the available charging stations are interoperable and this makes it possible for the end users to choose one or more EMP operators through which experience recharges regardless of the CPO that manages the charging points.

The charging tariff tends to be homogeneous at national level for recharging on public spaces for AC and DC charging stations. There are free recharging possibilities for example at shopping centres or at some accommodation facilities such as restaurants, hotels or museums / cinemas.

Data collection process

Route220 disseminated the questionnaire to all its end users: private, business, and corporate. The process of collecting data by users was mainly finalised by sending a direct communication explaining the project and asking to answer the questionnaire. The main tool used was the newsletter. A first newsletter was sent on middle of November and subsequently a second newsletter with a reminder for the answer to the questionnaire was sent on the first days of December and a third one during the last days of the month.

Other methodologies used to collect the responses were contact of groups of users for specific areas (for example user groups by city or region), direct communication to taxi driver associations which also include electric cars, communication and dissemination of the questionnaire through local municipalities and authorities, communication via e-mail also to local associations close to the world of sustainability and electric mobility for issues of interest, and communication to universities in the area of relevance.

Outcome from survey

After data cleaning, the data set contains 308 respondents in total. Of the respondents, 85.71% (264) use any type of electric vehicle, whereas 14.29% (44) does not. Figure 295 shows the type of electric vehicles the respondents use, where the majority 93.18% (246) indicated they use an electric car.

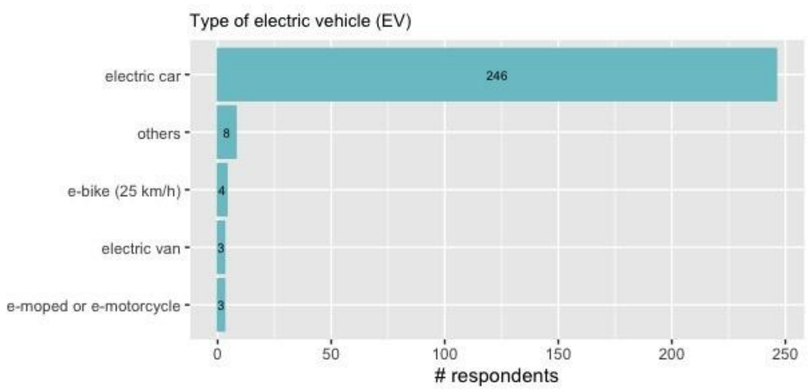


Figure 295 Type of EVs used out of 264 respondents at the Northern Italy demonstration area

Out of the 246 respondents who use an electric car, 90.65% (223) indicated they drive a battery electric vehicle without an internal combustion engine, whereas 6.50% (16) respondents drive a plugin-hybrid electric vehicle. Also, 2.03% (5) respondents drive an electric vehicle with a range extender, whereas no respondents drive a hybrid vehicle that combines a classical internal combustion engine with an electric motor.

In regard to the socio-demographic variables of the full sample, the majority of the respondents were men 88.64%. Most respondents (40.26%) have obtained a university degree or a higher non-university degree (35.71%). The majority is full time employed (73.05%), whereas 9.42% is retired. Almost 65.91% of the respondents is married with or without children (44.48% resp. 21.43%). The different socio-demographics are detailed in Table 65. Almost all respondents (99.68%) possess a drivers licence. For most respondents, this concerns a drivers licence B (92.86%), followed by drivers licence A (29.22%). A small portion of the respondents possess a drivers licence C (4.22%), a drivers licence D (1.30%), no respondents have a drivers licence G.

Table 65 Socio-demographics of the respondents at the Northern Italy demonstration area

Socio demographics	Categories	N (%)
Gender	Female	35 (11)
	Male	273 (89)
Degree	Primary education	5 (2)
	Secondary education	42 (14)
	Higher non-university education	110 (36)
	University education (Bachelor degree, Master degree, …)	124 (40)
	Post-university education (PhD, Post-doc,…)	27 (9)
Residential situation	I live alone	31 (10)
	I live with family	44 (14)
	I live with others: co-housing	13 (4)
	Married or in relationship with child(ren)	137 (44)
	Married or in relationship without children	66 (21)
	Other housing situation, namely :	3 (1)
	Single parent with child(ren)	14 (5)
Professional situation	Currently unemployed	5 (2)
	Employed full time	225 (73)
	Housewife/Houseman	3 (1)
	Other profession, namely :	31 (10)
	Part-time employed	10 (3)
	Retired	29 (9)
	Student	4 (1)
	Temporary exemption (e.g. maternity leave, parental leave)	1 (0)
Function	Blue collar worker	23 (8)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	27 (9)
	Middle management	13 (4)
	Official / employed in a public service	18 (6)
	Own company, entrepreneur with employees	42 (14)
	Self-employed, entrepreneur without employees	53 (18)
	Senior management / management	15 (5)
	Teaching staff / employed in education	20 (7)

White collar employee (administrative, executive or support/clerical function)	90 (30)

EV car users

Out of 249 electric car (246) and van users (3), 189 respondents own the vehicle, whereas 58 drive a company owned car, and 2 a car owned by a car sharing company. Furthermore, 6 respondents indicated that they use their vehicle as a taxi-cab. The majority of the respondents (75.90%) does not enjoy any company benefits, 7.63% of the respondents indicated they enjoy a company charging pass. Furthermore, 5.62% receives a kilometre compensation and 4.42% indicated they enjoy some other type of mobility benefit. Only 0.40% enjoys a company fuel pass. In terms of the battery electric vehicles, the most popular cars are the Renault ZOE (44 respondents), followed by a Tesla Model 3 (39) and a Hyundai Kona EV (25 respondents). The Nissan LEAF (22 respondents) and the VW e-Golf (10 respondents) close the top 5. The most popular plug-in hybrid electric vehicles are the BMW 225xe (4 respondents) and the BMW i3 Range Extender (3 respondents). Out of the 3 electric van users, 1 drive a Citroen Berlingo Electric, 1 drives a Nissan e-NV200 and 1 drives a Peugeot e-Partner. Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity of more than 70 kWh, where the next most popular choice is between 31 and 40 kWh. At the same time, 6 respondents indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 300 and 400 km. Most PHEV users think the battery capacity of their vehicle is between 10 and 15 and 5 and 10. In terms of battery range, the majority indicates this lies between 40 and 50 or higher than 50 km. Lastly, the majority of all EV users 51% is driving their current vehicle for less than 1 year. More detailed information can be found in Table 66.

Table 66 EV characteristics at the Northern Italy demonstration area

Vehicle characteristics	Categories	N (%)
Battery Capacity – kWh (BEV) according to respondents	<20	9 (4)
	20–30	16 (7)
	31–40	44 (19)
	41–50	38 (17)
	51–60	34 (15)
	61-70	29 (13)
	>70	50 (22)
	I do not know.	6 (3)
Battery Range – km (BEV) according to respondents	100–149	21 (9)
	150–199	26 (12)
	200–249	39 (17)
	250–299	42 (19)
	300-400	55 (24)
	> 400	41 (18)
	I do not know.	2 (1)
Battery Capacity – kWh (PHEV) according to respondents	2 – 5	1 (6)
	5 – 10	5 (31)
	10 – 15	6 (38)
	>20	1 (6)
	I do not know.	3 (19)

Battery Range – km (PHEV) according to respondents	10-19	1 (5)
	20-29	1 (5)
	30-39	7 (35)
	40-50	6 (30)
	> 50	5 (25)
Respondent usage of the vehicle in years	< 1 year	125 (50)
	1 year	43 (17)
	2 years	53 (21)
	3 years	11 (4)
	4 years	5 (2)
	> 4 years	12 (5)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 296 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

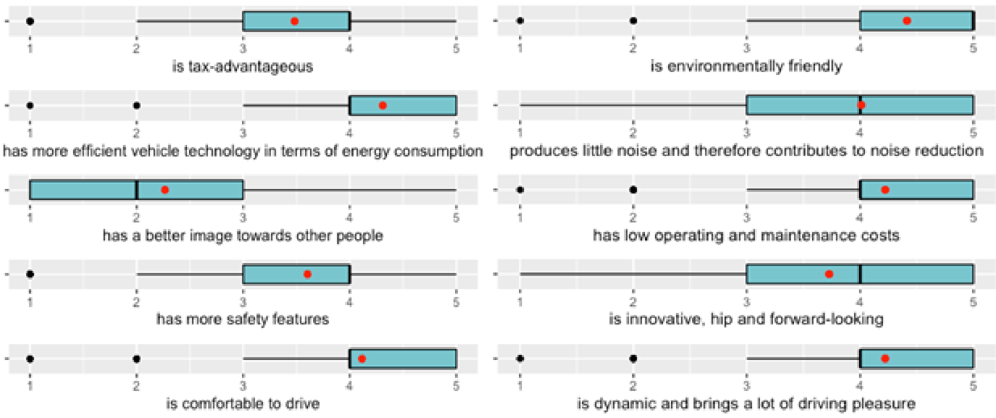


Figure 296 Reasons for EV usage or purchase at Northern Italy demonstration area

From Figure 296, it is clear that the main reasons for using or purchasing and EV are the environmental friendliness, the low operating and maintenance costs, the fact that Evs have more efficient technology in terms of energy consumption and the comfort of driving. More specific, the environmental friendliness was the most important factor as 93.57% considered this factor to be very important to extremely important. The least important factor is the better image an EV could have towards other people, where 36.14% considered this factor to be not important at all.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 102.66 km, where the average time spent on the road was about 1 hours and 54 minutes. The EV is mostly parked at a private parking at home for almost 12 and a half hours per day on average. Figure 297 gives a more detailed overview of the parking time at different locations.

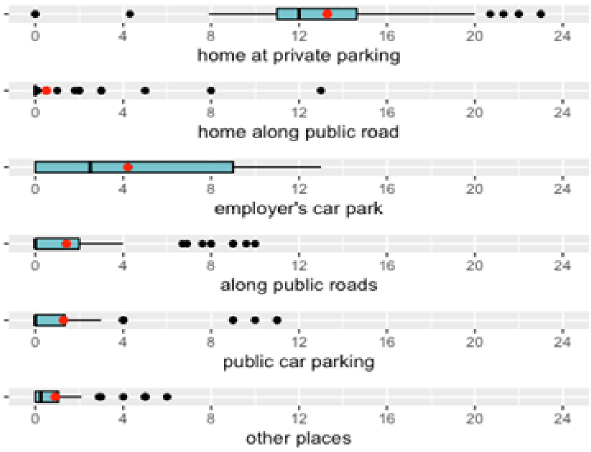


Figure 297 Respondents' EV parking time at different locations at the Northern Italy demonstration area

When EV users park at home, the majority does so in their driveway or in a privately-owned garage (59.11%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 298).

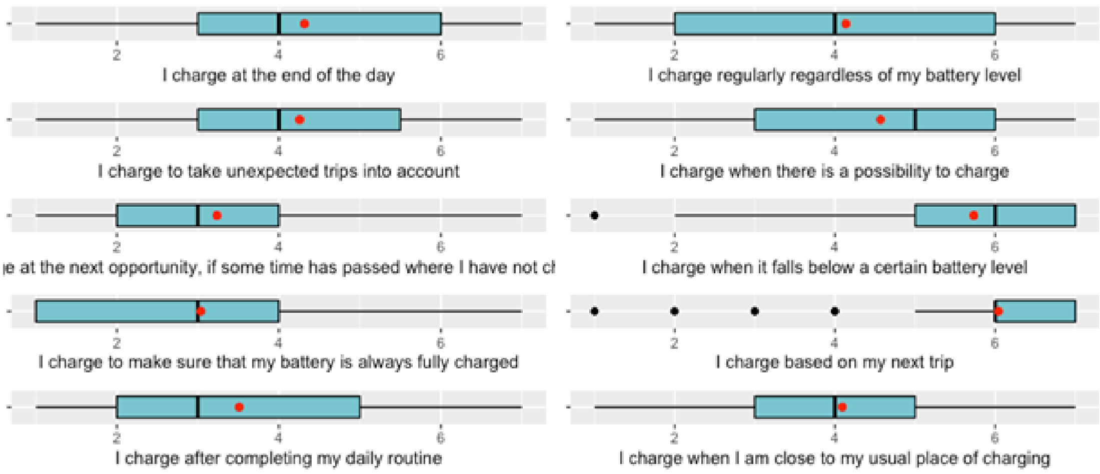


Figure 298 Respondents' charging behaviour at the Northern Italy demonstration area

In regard to charging experience, 7.32% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 63.41% charges often at different locations, whereas 28.86% sometimes does. Respondents charge the EV most frequently at home, 22.03% of the respondents charges the EV at home daily and 34.80% does so several times a week. The main charging option at home is the charging station (52.27%, followed by a socket (43.64%). The least frequent charging place is at the workplace, where 61.67% of the respondents indicate that they never charge at work. Also, public non-fast chargers are more frequently used than fast chargers (see Figure 299).

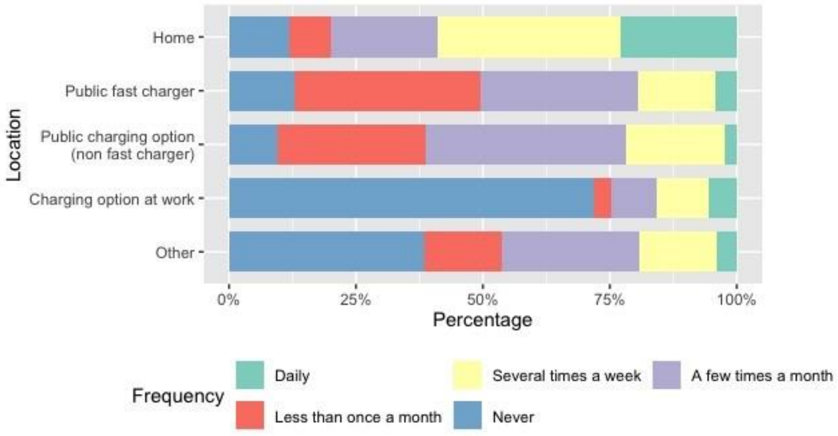


Figure 299 Respondents' charging behaviour per location at the Northern Italy demonstration area

The most popular charging time is between midnight and 3a.m., followed closely by 3a.m-6a.m. The least popular time is between 6 a.m. and 9 p.m. After 6 p.m. charging becomes more frequent again.

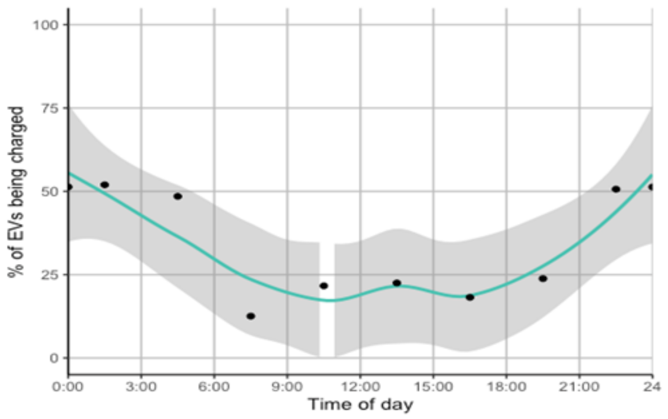


Figure 300 Respondents' charging schedule at the Northern Italy demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that ENEL X is the most popular.

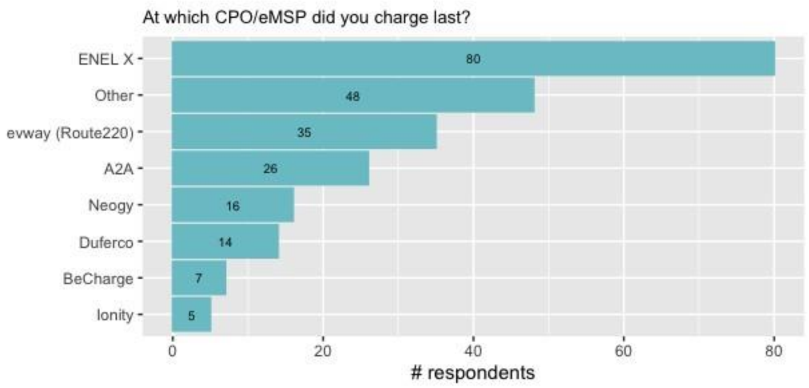


Figure 301 Last charging CPO/eMSP at the Northern Italy demonstration area

Although ENEL X is the most popular CPO, it appears to score lower on tangibility than some other less frequently used CPOs. Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for ENEL X are spread ranging from very poor to very good. The charging infrastructure for evway (Route 220) scores higher with an average of more than 5 on 7. Ionity has the highest average overall in terms of tangibility, although it is also the least frequently used CPO (see Figure 302). At the same time, A2A and Neogy show a similar distribution to ENEL X in terms of tangibility.

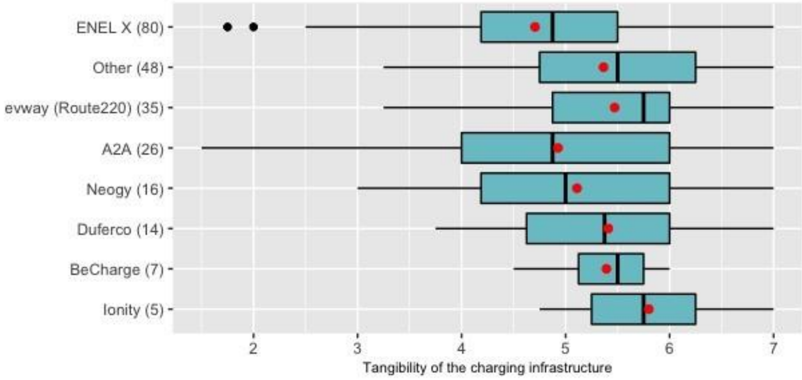


Figure 302 Tangibility of the charging infrastructure at the Northern Italy demonstration area

For availability and reliability of the charging infrastructure, similar scores can be observed (see Figure 303 and Figure 304). The availability captures whether the charging infrastructure is available for use, can start immediately, does not block and is not inadvertenly interrupted. Top scorers are evway, BeCharge and Duferco, which score highest on average for these criteria, whereas A2A is again comparable to ENEL X. These CPOs/eMSPs score rather neutral on average. The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping.

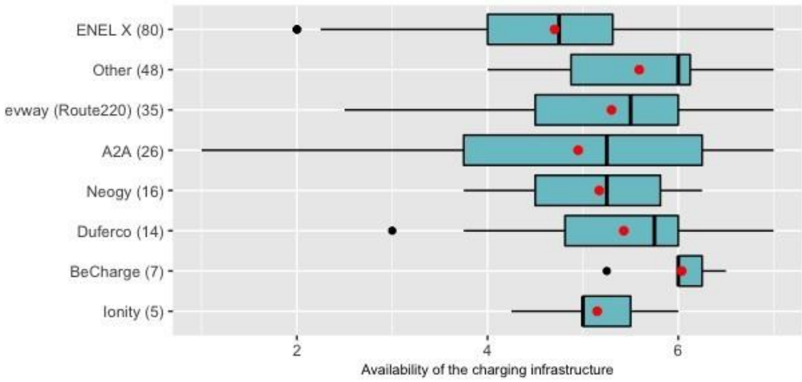


Figure 303 Availability of the charging infrastructure at the Northern Italy demonstration area

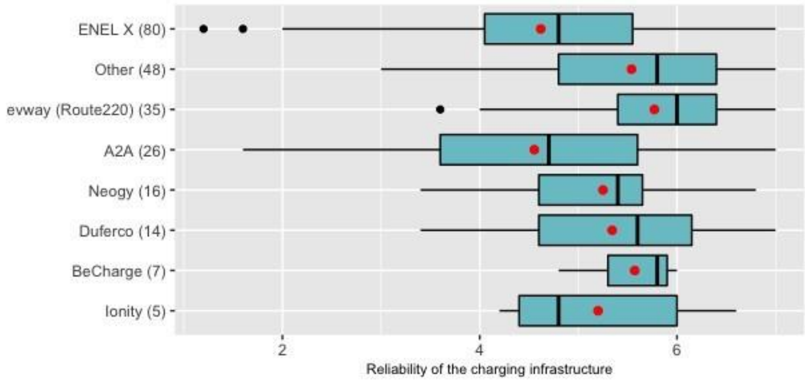


Figure 304 Reliability of the charging infrastructure at the Northern Italy demonstration area

Looking at the privacy of the charging infrastructure, it is clear that all CPOs receive similar scores. Except for evway, which scores significantly higher (see Figure 305). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other companies and payment credentials are protected.

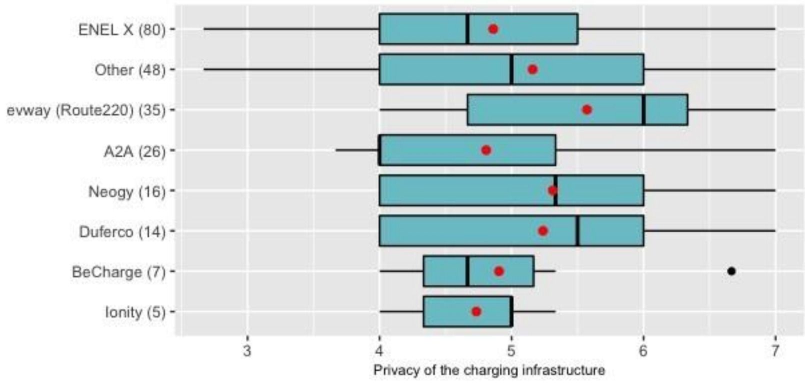


Figure 305 Privacy of charging infrastructure at the Northern Italy demonstration area

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 66 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 66 indicated they have not. Most charging infrastructure problems are experienced when using ENEL X. Indeed, 43.75% (35 out of 80 respondents) indicated to have experienced problems with this CPO. A2A has a similar problem rate with 42.31 (11 out of 26 respondents, whereas for evway this is only 17.14% (6 out of 35 respondents).

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For ENEL X, it can be seen in Figure 306 that the scores for responsiveness varied a lot for the different respondents, ranging from very bad to good. Overall, the median and average are still quite low, with less than 4 out of 7. A2A scores poorly, with the lowest average overall, and evway scores highest in terms of responsiveness.

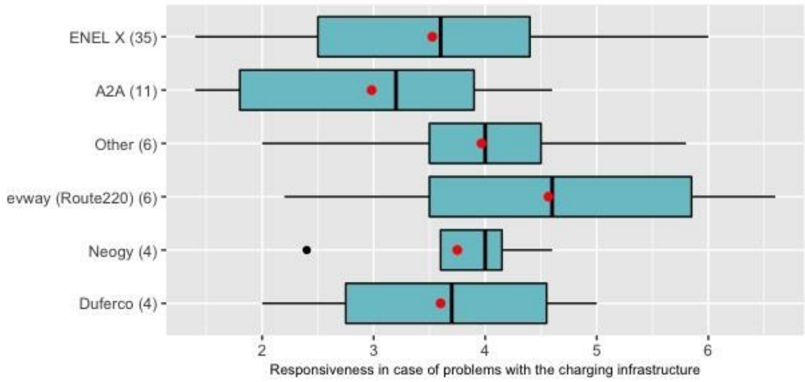


Figure 306 Responsiveness in case of problems with the charging infrastructure at the Northern Italy demonstration area

Compared to the responsiveness in case of problems, the scores on contact are clearly higher. For contact, respondents had to indicated whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the ability is provided to speak to a person in case of problems. Although there is still a large spread in the scores, ENEL X scores better with an average of more than 5 out of 7 for the contact criteria (see Figure 307). The lowest scoring CPO is now A2A. Neogy and Duferco score best.

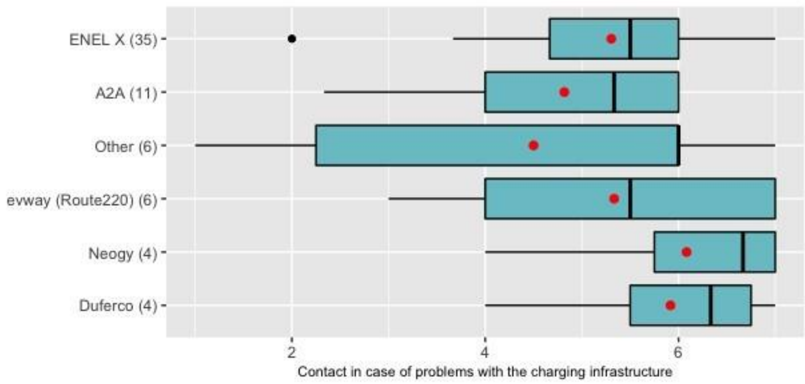


Figure 307 Contact in case of problems with the charging infrastructure at the Northern Italy demonstration area

Lastly, respondents had to score different criteria for compensation in case of problems. Respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. Figure 308 shows that all CPOs/eMSPs score rather poorly on the compensation criteria. A conclusion can be that the user seems to expect more in case of problems than what the CPO/eMSP currently offers. The one that scores best on average is evway.

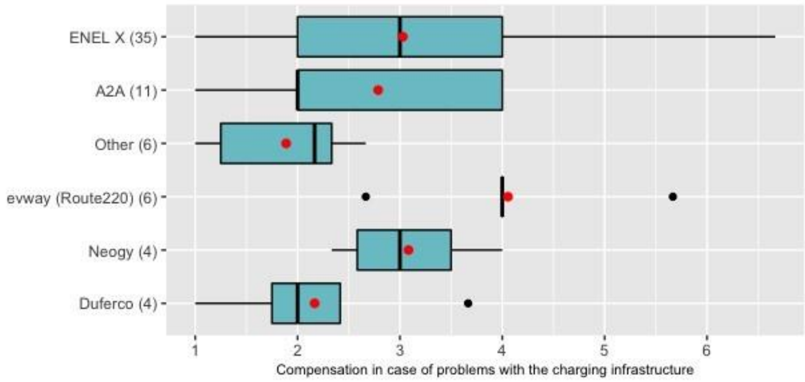


Figure 308 Compensation in case of problems with the charging infrastructure at the Northern Italy demonstration area

Finally, the last questions in this section probe for the respondents opinions on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. Most CPOs/eMSPs score on average quite well on the perceived value criteria. ENEL X and Neogy score on average lower clearly than the others (see Figure 309).

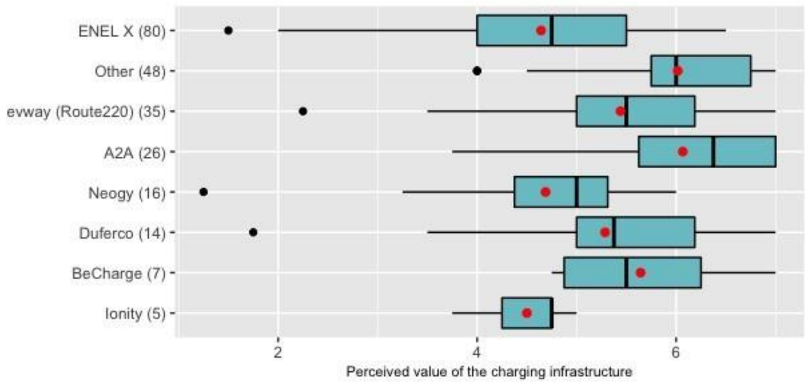


Figure 309 Perceived value of the charging infrastructure at the Northern Italy demonstration area.

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. Most CPOs/eMSPs score rather high (see Figure 310) ENEL X, again, receives a wide range of scores, resulting in an average of almost 4.5 out of 7. A2A, Neogy and Duferco seems to have loyal customers overall, with almost 100% of the respondents (aside from some outliers) ranging from neutral to strongly agree.

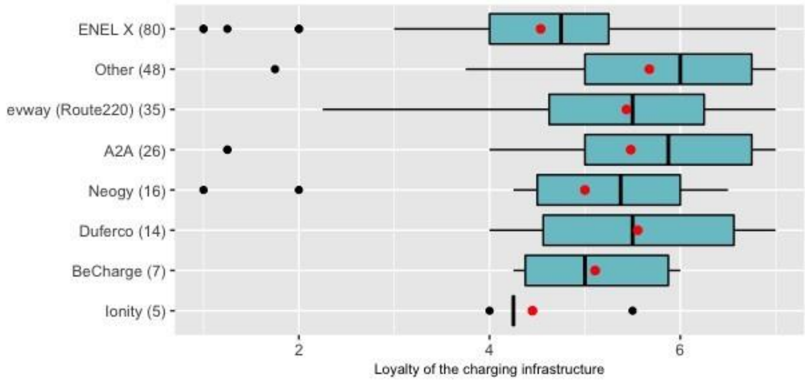


Figure 310 Loyalty of the charging infrastructure at the Northern Italy demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the general trend in the earlier questions, the highest scoring CPOs/eMSPs are evway and Duferco. ENEL X receives both low and high scores, resulting in an average of almost 5 out of 7 (see Figure 311). Overall, the Northern Italy respondents are quite satisfied with the service by CPO/eMSPs and give them a score of 5.2 on 7 (SD=1.34).

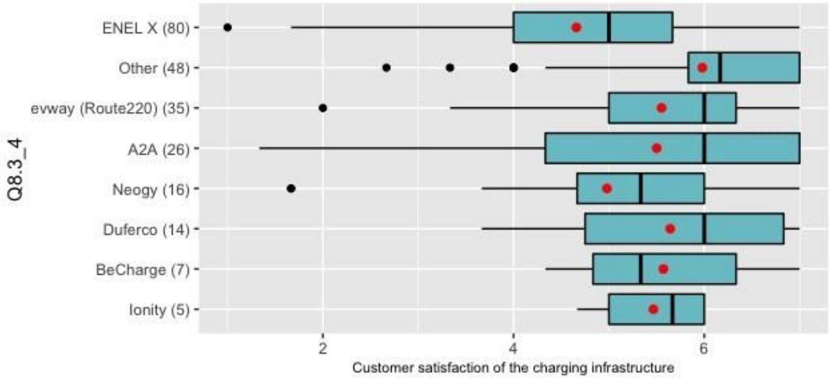


Figure 311 Customer satisfaction of the charging infrastructure at the Northern Italy demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, Fast charging options are the most popular with 55% of respondents choosing they are most likely to use Fast charging options in the future.

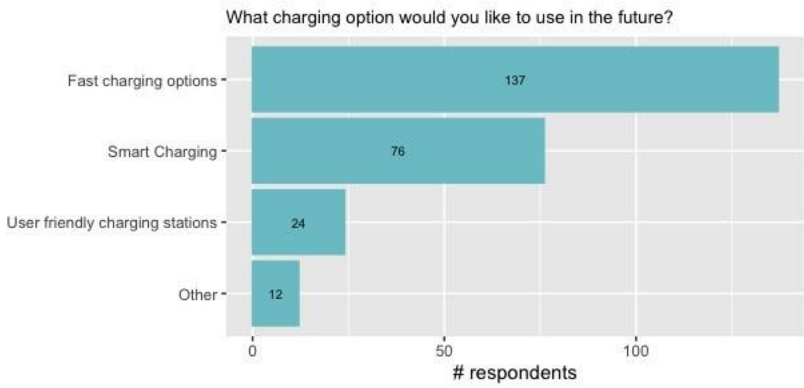


Figure 312 Most likely charging option in the future at the Northern Italy demonstration area.

The fast charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration.

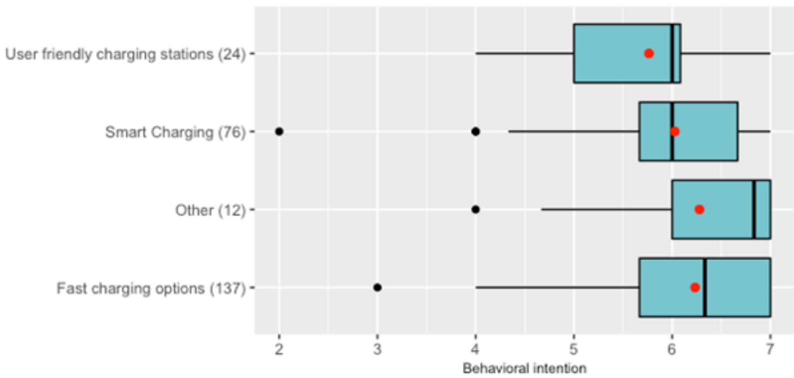


Figure 313 Behavioural intention of charging infrastructure at the Northern Italy demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the fast charging option and smart charging score highest on these criteria, aside from a few outliers (see Figure 314).

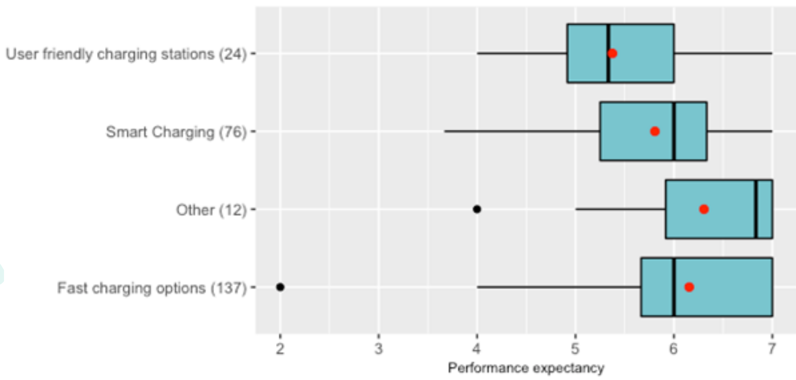


Figure 314 Performance expectancy of the charging infrastructure at the Northern Italy demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. It is interesting to see that the scores user friendly charging stations score better on this criterion, indicating that respondents expect less effort into getting acquainted with this charging option (see Figure 315). The other charging options score rather similar.

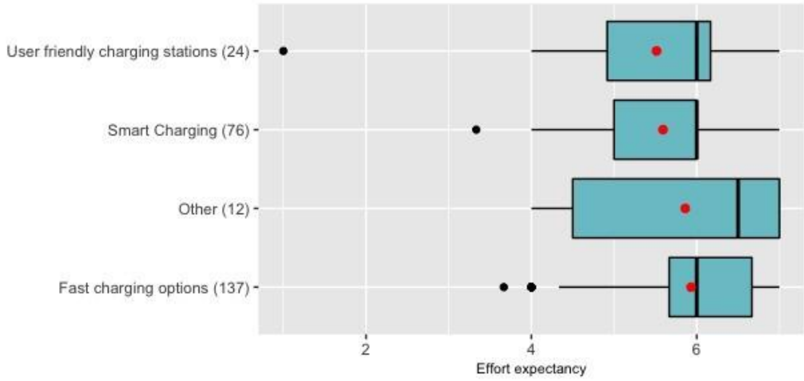


Figure 315 Effort expectancy of the charging infrastructure at the Northern Italy demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 316). The averages and medians all lightly fluctuate between 4 and 5 on a scale of 7.

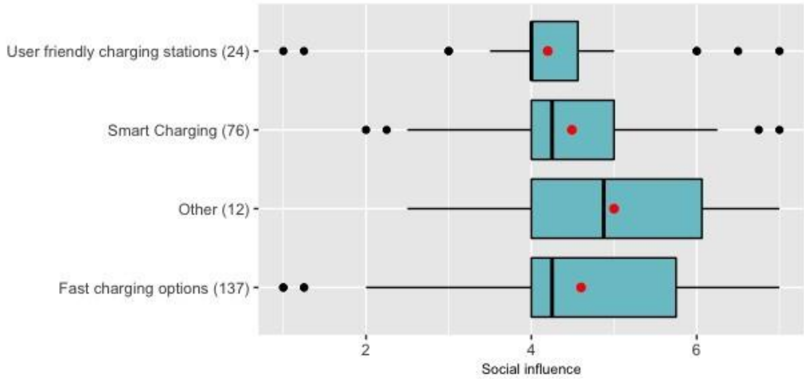


Figure 316 Social influence of the charging infrastructure at the Northern Italy demonstration area

In terms of facilitating conditions, the scores of the fast charging options are more skewed towards a 7 than the other charging options (see Figure 317). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

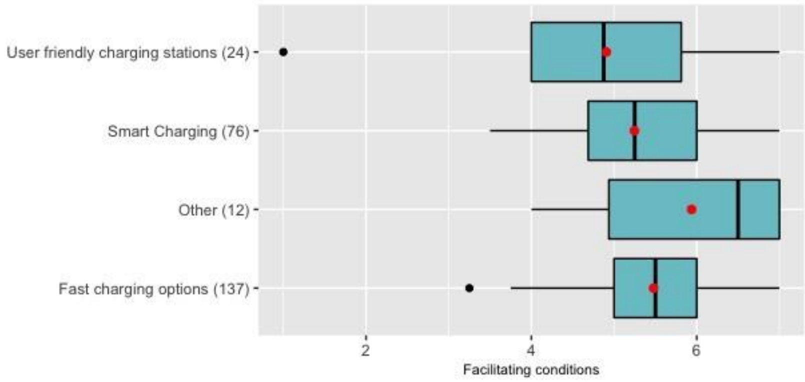


Figure 317 Facilitating conditions of the charging infrastructure at the Northern Italy demonstration area

As for hedonic motivation, rather similar distributions can be observed for user friendly charging stations and smart charging (see Figure 318). The scores for fast charging options range from strongly disagree to strongly agree. Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

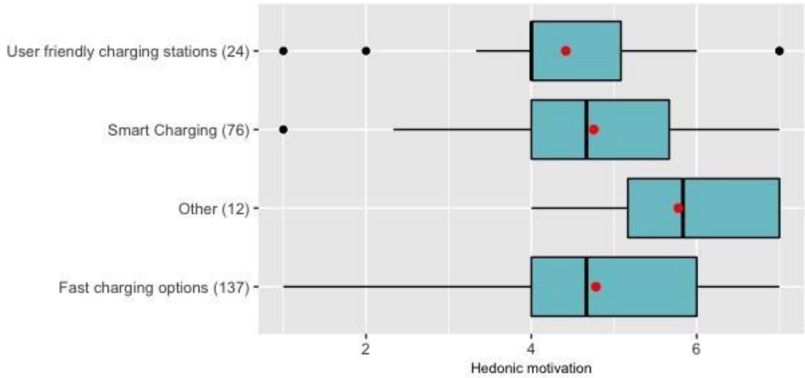


Figure 318 Hedonic motivation of the charging infrastructure at the Northern Italy demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, it is interesting to note that 50% of the respondents would not seem to mind to pay more for fast charging options (see Figure 319). At the same time for smart charging, almost 75% indicates they would only use it if the price is lower.

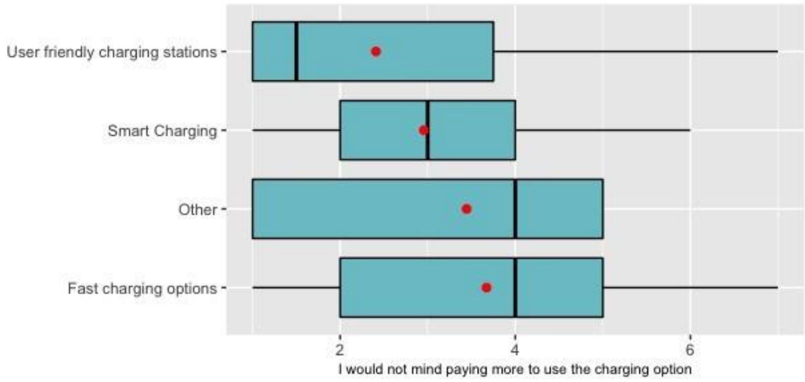


Figure 319 Price motivation of the charging infrastructure at the Northern Italy demonstration area

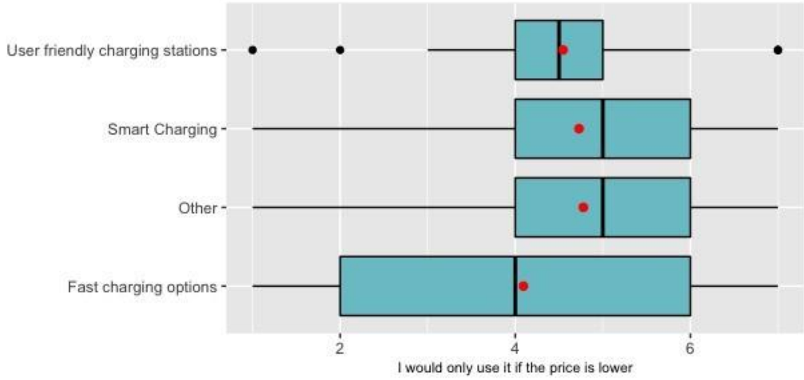


Figure 320 Price value of the charging infrastructure at the Northern Italy demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. The majority of the respondents, 79.92% (199 respondents) indicated they use app-based services, another 16.87% does not but intends do. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, over 60% of the EV respondents has 4 or more apps on their phone. About 68.34% of the app-based service users, users this at least a few times a month, as can be seen in Figure 321.

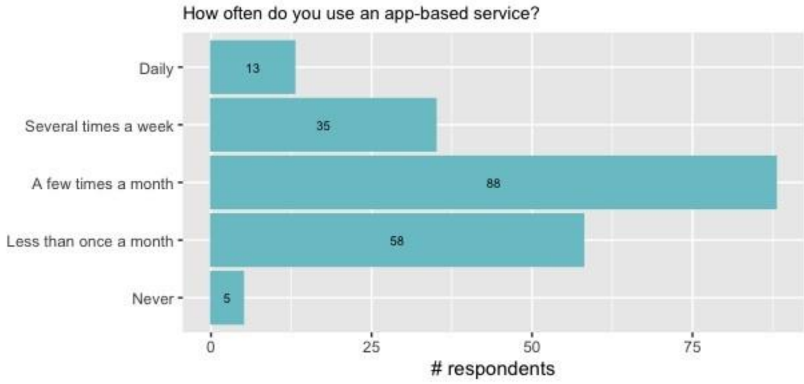


Figure 321 Usage of app-based services at the Northern Italy demonstration area

App-based services are mostly used for travel related to travel destinations on holiday (131 respondents), whereas 106 respondents use it for leisure activities. To a lesser extent, the app-based services are used for shop/errands (44 respondents) and commuting and work activities (76 respondents). In terms of satisfaction with the used app-based services, Figure 322 shows that 75% of the respondents are satisfied above 4 on a scale of 1 to 7.

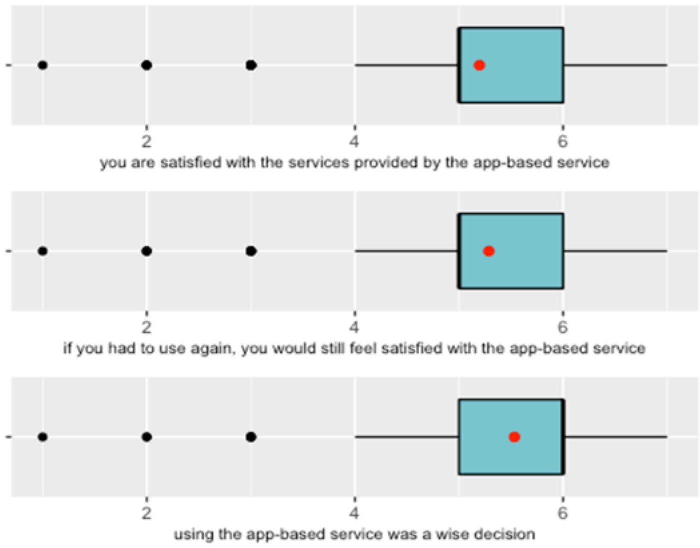


Figure 322 Satisfaction with the app-based services at the Northern Italy demonstration area.

LEV

In this section, we zoom in to the 7 respondents who use a light electric vehicle. The majority of the respondents (57.14%) owns the LEV they use and are responsible for the LEV maintenance costs (71.43%). At the same time, the majority of the respondents does not know what the battery capacity is thinks it is between 0.5 and 1. The detailed responses can be seen in Table 67.

Table 67 LEV characteristics at the Northern Italy demonstration area

Vehicle characteristics	Categories	N (%)
Owner of the LEV	Private	4 (57)
	Sharing company	2 (14)
	Company/Leasing company	1 (29)
Responsible LEV maintenance costs	Private	5 (83)
	Company	1 (17)
	NA	1
Battery Capacity – kWh according to respondents	< 0.5	0
	0.5-1	3 (43)
	1-3	0
	3-5	0
	5-7	0
	>7	1 (14)
	I do not know.	3 (43)
How often do they use the LEV	Daily	1 (14)
	Several times a week	2 (39)
	A few times a month	1 (14)
	Less than once a month	3 (43)
LEV parking	I use a garage that is my property or park on my driveway	2 (29)
	I use a fixed rente parking space	1 (14)

I use a fixed car park which is my property	3 (43)
I use a rented garage	0
I do not use a fixed parking	1 (14)

On average, the LEV users indicate they drive about 39.33 km each day. The majority of the time, the LEV is parked at home at a private parking or at the employer's car park (see Figure 323).

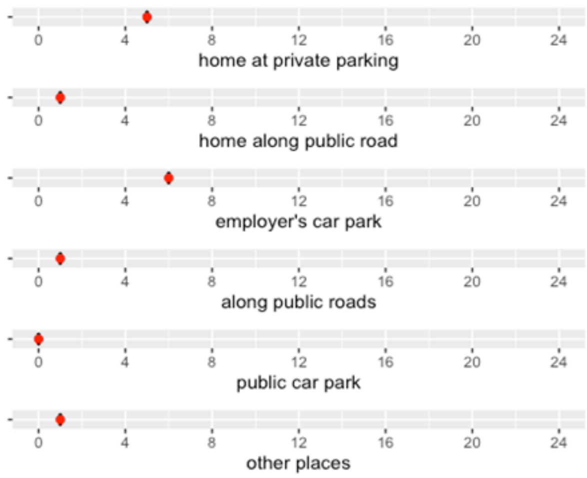


Figure 323 Parking space and duration of the LEV at the Northern Italy demonstration area

Looking at the motives to use an LEV, it is clear that the most important motives are the environmental friendliness and the low operating and maintenance costs, whereas least important is the image towards other people.

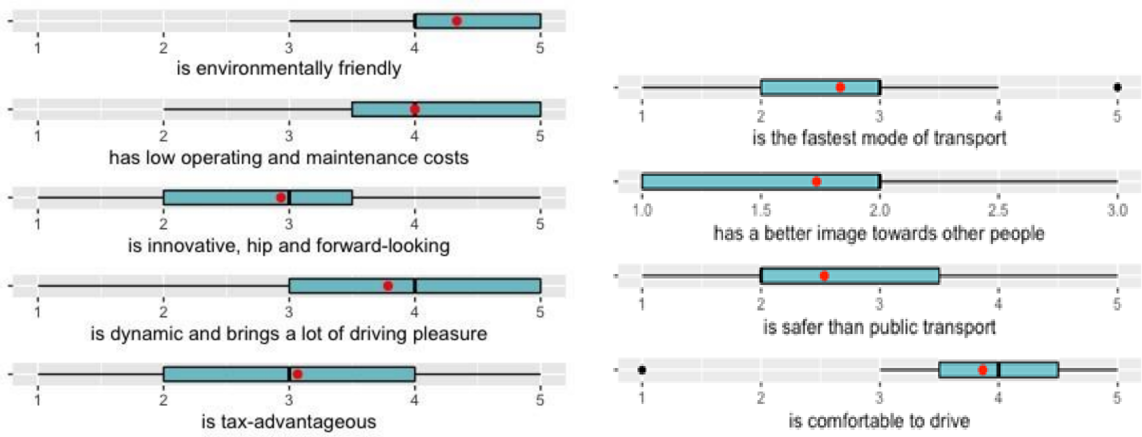


Figure 324 Motives to use LEVs at the Northern Italy demonstration area

In terms of charging behaviour, over 75% of the respondents seem to charge when the battery falls below a certain level, or 50% based on their next trip.

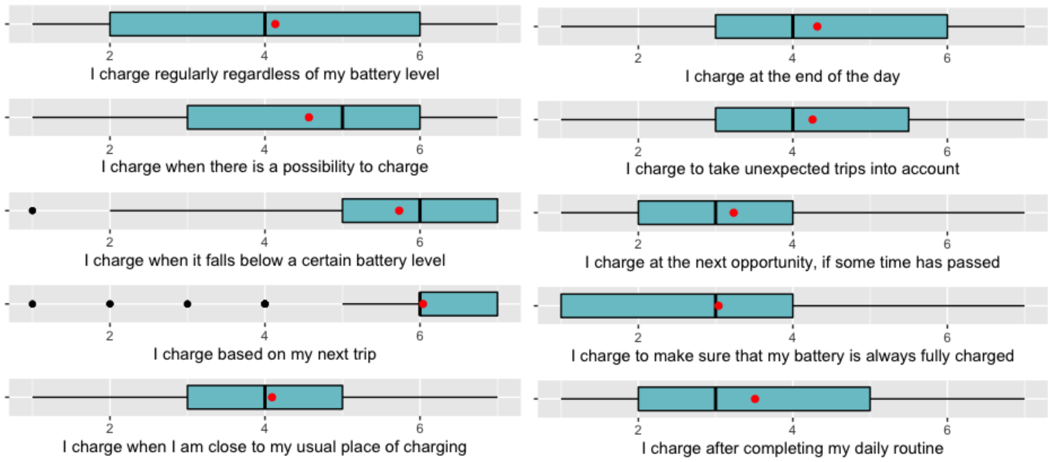


Figure 325 charging behaviour at the Northern Italy demonstration area

Quality of Experience

Out of 7 respondents, only 1 respondent indicated that they used the service of a CPOs/eMSPs, which was ENEL X. As such, the quality of experience will not be discussed in this section.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. The fast charging options are the most popular with 5 respondents choosing they are most likely to use fast charging options in the future.

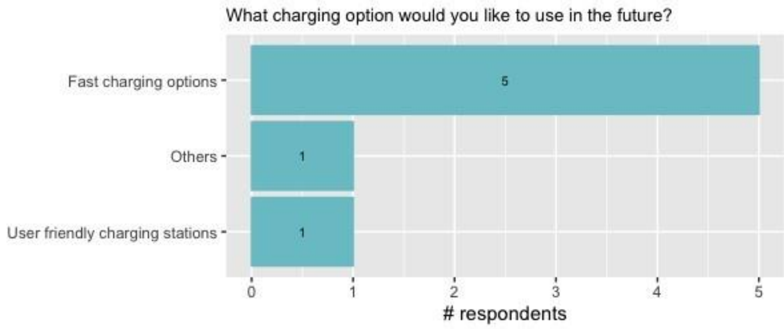


Figure 326 Preferred LEV charging option to use in the future at the Northern Italy demonstration area

The UTAUT constructs are not further investigated in detail as there are not enough observations for LEV users.

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 28.57% of the respondents, indicated they use app-based services, another 16.87% does not but intends do. The remainder of the respondents have no intention to use an app in the near future. As only 2 respondents use app-based services. No further aspects will be investigated in this section.

Non-EV users

Lastly, we zoom into the non-EV users, a total of 44 respondents. Interestingly, over 50% of the respondents' states that will buy an electric vehicle as soon as possible or state that it is very likely they will buy an electric vehicle.

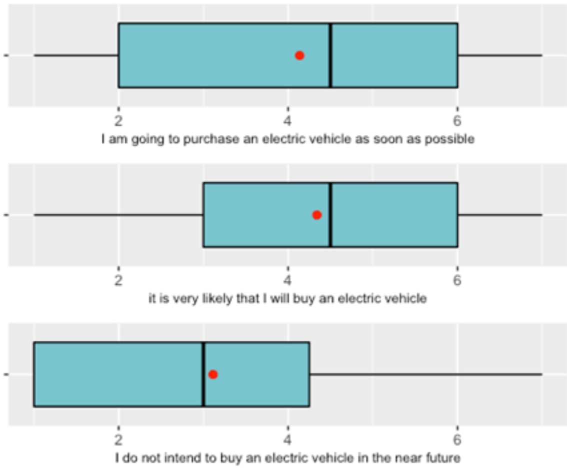


Figure 327 Non-users' Intention to buy an EV at the Northern Italy demonstration area

Moreover, most respondents (50.00%) indicate they are mostly interested to buy an electric car. Out of these 22 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (13 respondents), an electric vehicle with range extender (1 respondents) or a plug-in hybrid electric vehicle (2 respondents). The remaining 6 respondents prefer a hybrid vehicle that combines a classic combustion engine.

Lastly, the most important motives for non-EV users to purchase an EV in the future is the environmental friendliness and the fact that EVs have more efficient technology in terms of energy consumption as 95% considers this moderately to extremely important. At the same time, the least important motive is the better image EVs could have towards other people as 59% of the respondents consider this not important at all to slightly important.

Key findings of the Northern Italy report

The main reasons for electric car adoption the environmental friendliness, the low operating and maintenance costs, the fact that Evs have more efficient technology in terms of energy consumption and the comfort of driving. In terms of charging behaviour, the big part of electric car owners' charges mostly at home, as 75% of the respondents charge daily to several times a week. This can be seen in the chart of charging time, where the users charge overnight and in the evening. It is remarkable that little charging takes place during the day, therefore is the least frequent charging place at the workplace, where almost two third of the respondents (61.67%) indicate that they never charge at work. Respondents are really satisfied with the quality of service they receive from the CPOs/eMSPs. Especially tangibility and reliability of the charging stations scores well. Improvements can be made when problems arise at the charging station, as the responsiveness and compensation score low, meaning that where customers are not quite satisfied with the after sales-services.

Fast charging is the most preferrable charging option to use in the future and users see this, together with smart charging, also as the charging option the easiest to use, which means people are looking forward to the future charging options. Respondents would only use smart charging and user friendly charging station when prices are lower than the prices of current charging options. For fast charging they expect a similar price than current charging options.

LEV users mainly bought their LEV because the environmental friendliness and the low operating and maintenance costs. LEV users use their LEV often to go to work. In terms of charging behaviour, 75% of the LEV users charge their LEV based on their next trip, and when the battery level falls below a certain level.

Lastly, more than half of the non- EV users states that they will buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (91.6%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (95%) and more efficient technology in terms of energy consumption in comparison with non-EVs. At the same time, the least important motive is the better image EVs could have towards other people as 59% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV car users.

Outcome from historical data

This section will cover the Data Analytics for the Northern Italy demonstration area, which covers a total of 43 municipalities, including Milan and Turin, and includes the Trentino Alto-Adige autonomous region, located at the border with Switzerland and Austria, with a significant tourist activity. The operator and data provider for this demonstration area is Route 220. Table 68 describes the information contained in the dataset.

Table 68. General information for the Northern Italy demonstration area

Attribute	
Users	1145 users
Cities	43 cities
Operators	Route 220
CPs	238 CPs
Sessions	20704 sessions
Time range	28/06/2017 – 02/09/2020
Power levels	7.4 kW, 11 kW, 22 kW, 50 kW

Descriptive Statistics

- **Sessions' geographical distribution**

Figure 328 shows the geographical distribution of the charging sessions from the Northern Italy demonstration area, the charging sessions mostly take place in the main cities of study: Torino, Milano and Trento.

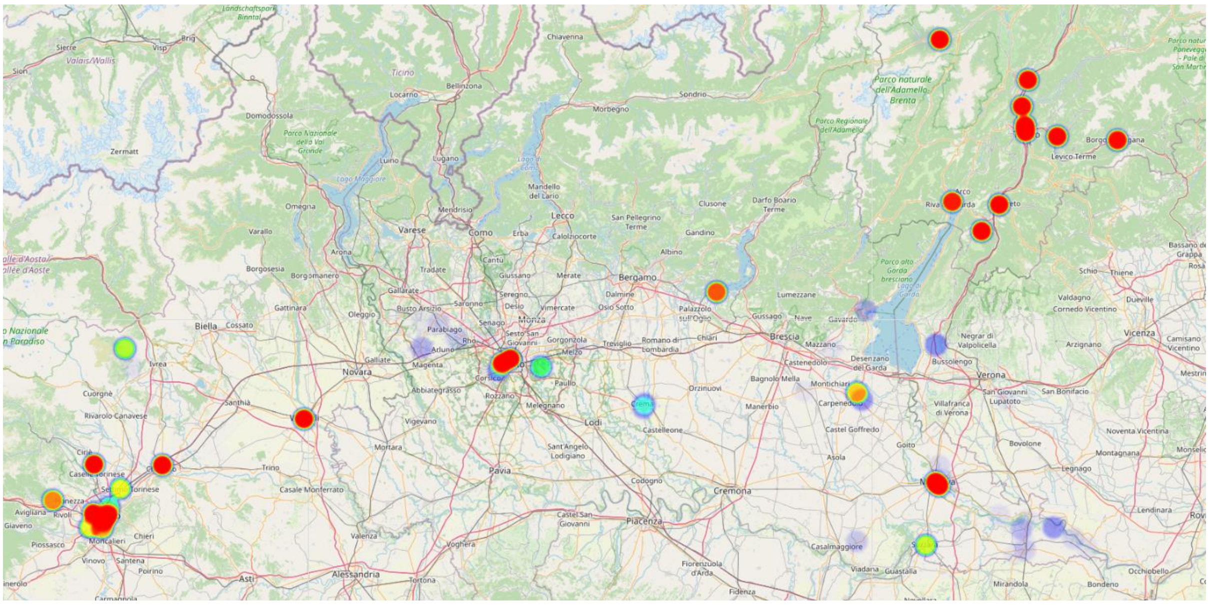


Figure 328. Heatmap of charging sessions in Northern Italy demonstration area

- **Charging Power analysis**

For this demonstration area, the different power levels have been classified as follows: 7.4 kW, 11 kW and 22 kW chargers are considered as semi-fast chargers, and 50 kW chargers are considered as fast.

Figure 329 shows the ratio between the number of existing rated powers coming from unique CPs and the usage frequency for those rated power levels. The result shows that fast chargers (i.e. 50 kW) have a higher usage ratio than the 11 kW and 7.4 kW Semi-Fast chargers even with the lower number of installed CPs. The most popular choice is 22 kW (Semi-Fast) chargers with the highest number of sessions and highest number of installed CPs. In Annexe A3, Figure 485 shows, on the left, the total number of sessions happened with each power level, revealing a fairly higher usage for 22 kW power chargers. On the right, the number of chargers for each power level indicate that 22 kW chargers are the most common ones, followed by the 11 kW ones.

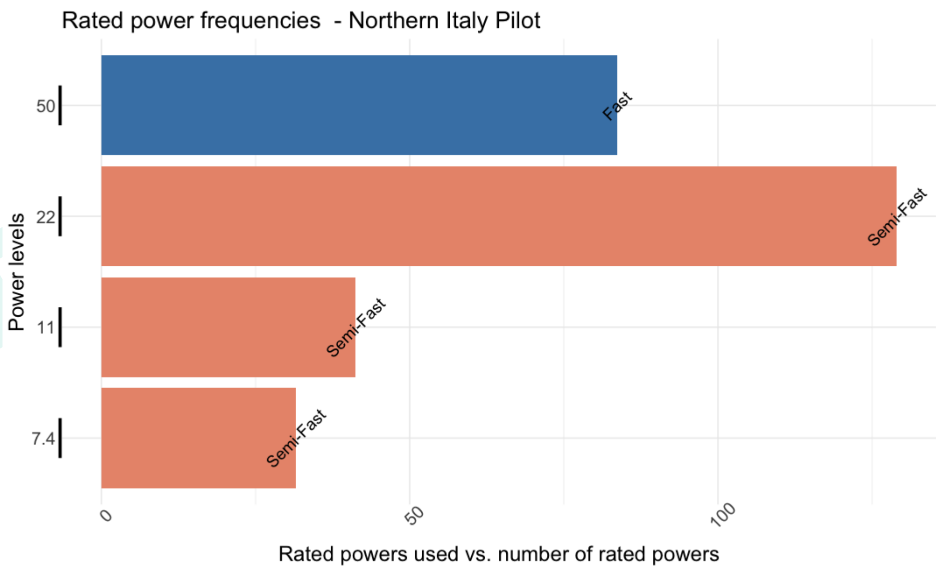


Figure 329. Ratio of total sessions per connector power level divided by the total number of connector power types – Northern Italy demonstration area

- **Sessions' temporal distribution**

In order to understand how the charging sessions are distributed temporarily during the week, Figure 330 shows the session distribution by hour for the Northern Italy demonstration area. On one hand, the weekdays (from Monday to Friday) have 3 peaks: (i) from 7 am to 8 am, (ii) from 10 am to 11 am, (iii) from 3 pm to 4 pm. On the other hand, the weekend has 2 peaks: (i) from 8 am to 11 am, (ii) 3 pm to 4 pm, with generally more sessions happened on Saturday than on Sunday.

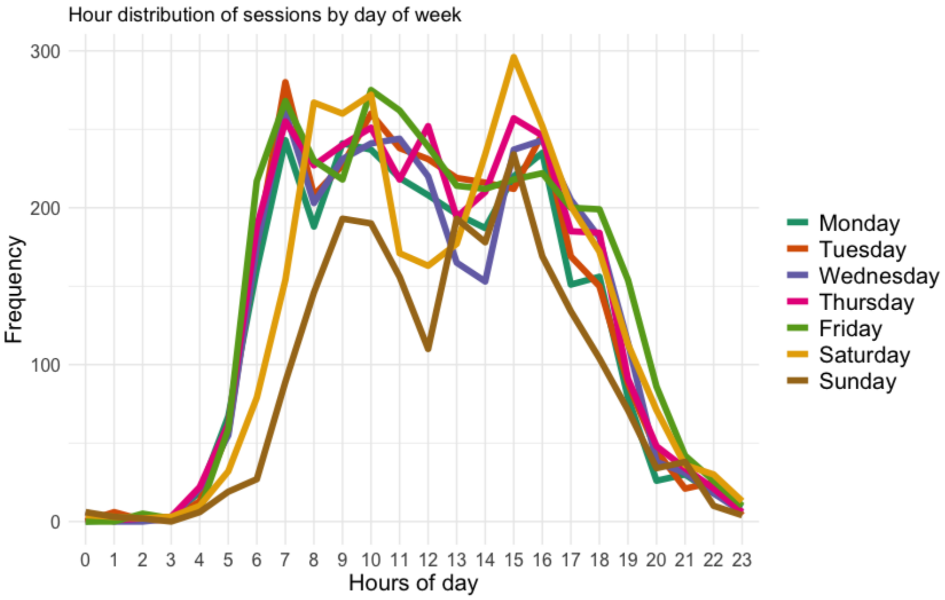


Figure 330. Hourly distribution for each day of the week – Northern Italy demonstration area

- **Sessions' duration**

Figure 331 shows the boxplot for the sessions' duration. It can be inferred that there is a noticeable number of outliers in the semi-fast CPs that perform really long charging sessions (with a maximum of 8 days).

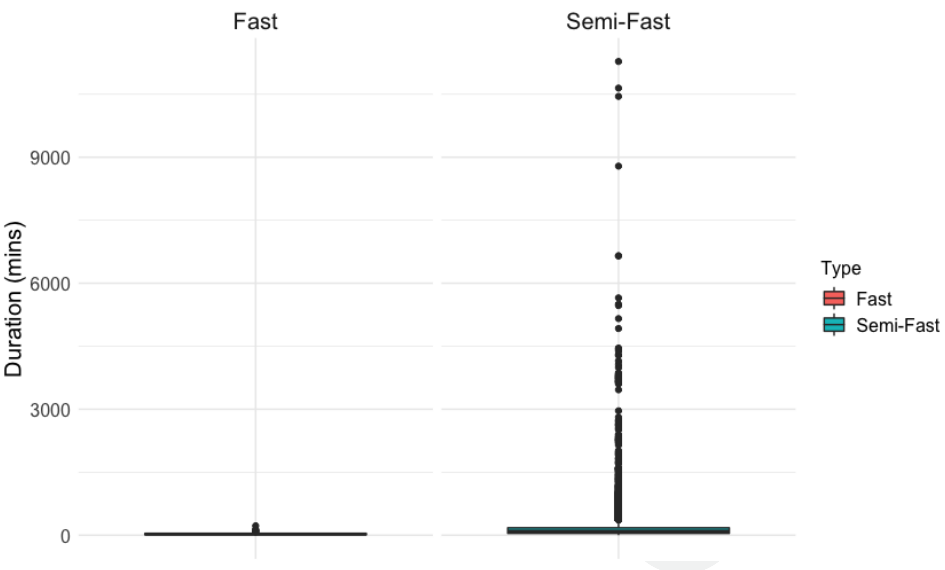


Figure 331. Boxplot for sessions' duration – Northern Italy demonstration area

Therefore, the average duration in the case of the fast-charging points is 31 minutes, and in the case of the semi-fast CPs is 153 minutes, but due to the presence of outliers the median can be considered as a more realistic number for the general average, with 95 minutes (Table 69).

Table 69. Summary of statistical values of sessions' duration – Northern Italy demonstration area

Fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.6 min	13.32 min	26.33 min	31.11 min	39.98 min	223.65 min
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.5 min	44.39 min	95.45 min	153.31 min	177.2 min	11280.28 min

- **Sessions' energy consumed**

As for the energy consumed during the sessions, the boxplot (Figure 332) also shows outliers, especially in the case of semi-fast CPs. As shown in Table 70, the mean of the energy consumed in the fast CPs is 15.69 kWh and in the case of the semi-fast CPs is 11.79 kWh.

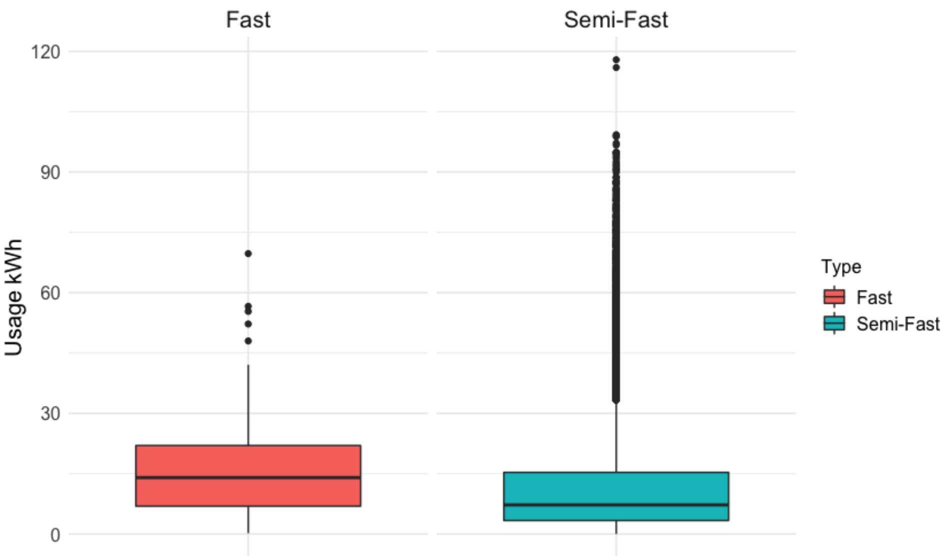


Figure 332. Boxplot for sessions' energy consumed – Northern Italy demonstration area

Table 70. Summary of statistical values of sessions' energy consumed – Northern Italy demonstration area

Fast Charging Points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.2 kWh	6.92 kWh	14.02 kWh	15.69 kWh	22.0 kWh	69.71 kWh
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.001 kWh	3.35 kWh	7.23 kWh	11.79 kWh	15.32 kWh	117.9 kWh

- **Usage and CP distribution by city**

Figure 333 displays in a clear manner which power levels are present in each municipality. It can be inferred that most of the cities have only one type of power level for their CP connectors, whereas only

Trento, Torino, San Maurizio Canavese, Rovereto, Milano, Mantova and Borgo Mantovano have different power level CPs installed.

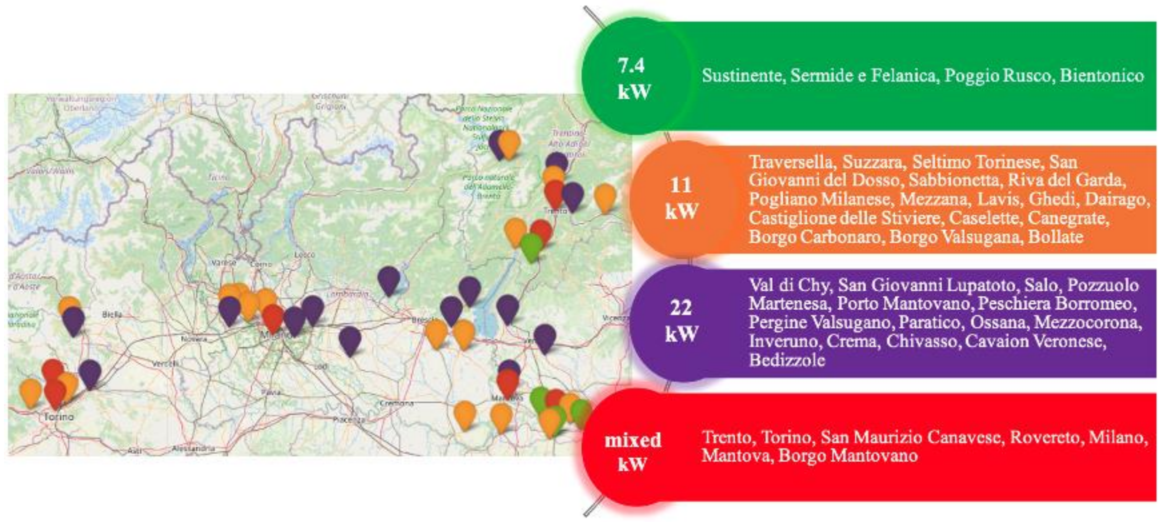


Figure 333. CPs and Power levels for the cities of the Northern Italy demonstration area

For the cities with mixed power levels, Figure 334 shows the distribution of the number of sessions for each power level type. It can be noted that the only city with fast chargers is San Maurizio Canavese, in the Metropolitan City of Turin, very close to the Turin Airport.

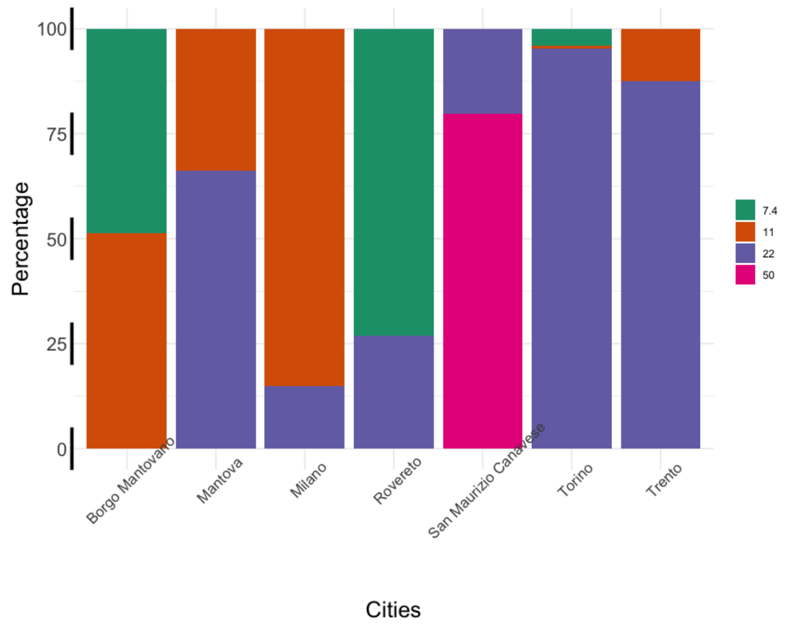


Figure 334. Percentage distribution of rated power usage in different cities– Northern Italy demonstration area

The number of CPs and their total number of sessions happened in data for each city are analysed in order to see the ratio that represents the division of the total number of sessions in the corresponding city by total number of CPs in the corresponding city. The higher ratio represents the higher usage level of the CPs in the city. Figure 486 (available in Annexe A3) shows the value of this ratio for the cities in the Northern Italy demonstration area.

User Clustering

As per the methodology defined in Annexe A1.2, the user clustering has been performed for the Northern Italy demonstration area, indicating the *kmeans* algorithm with 3 clusters as the most convenient clustering method.

Table 71 User clusters – Northern Italy demonstration area

User Cluster 1	User Cluster 2	User Cluster 3
191 users (25.6%)	144 users (19.3%)	410 users (55%)

Figure 335 shows the results for the user clusters resulting from the application of the algorithm to the Northern Italy demonstration area. The following conclusions can be drawn from the charts:

Users belonging to Cluster 1 have always values lower than the mean, especially in the case of the number of sessions, the usage period and the number of CPs visited. Cluster 2 includes users with longer session duration (almost 4 hours in average), high energy consumption and low number of sessions. Cluster 3 is the most crowded cluster (55% of the users) and consists of the users that have the highest number of sessions, highest number of CPs used, low average energy consumption and lowest duration (1h 38 mins in average).

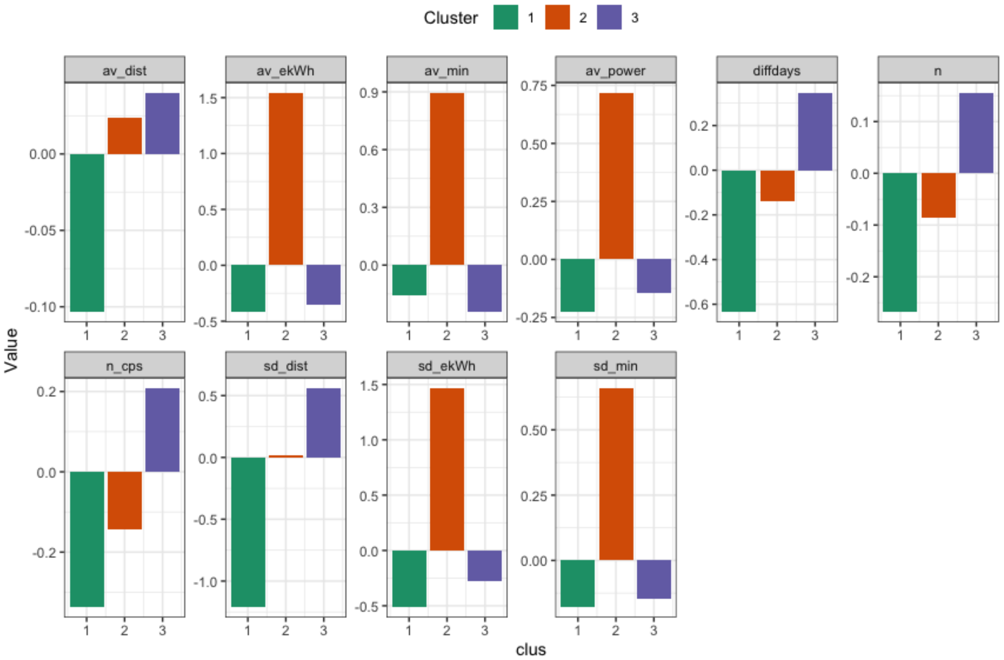


Figure 335. User clustering results and normalised attribute values – Northern Italy demonstration area

Temporal Clustering

The Charging Points are clustered based on their temporal behaviours. The automated clustering method and optimal number of cluster detection is done, and the results shows that the best option is *kmeans* method with 3 clusters.

Table 72 Temporal clusters – Northern Italy demonstration area

Temporal Cluster 1	Temporal Cluster 2
9 CPs (3.8 %)	229 CPs (96.2%)

The two clusters have a similar hourly occupancy distribution, however, CPs belonging to Cluster 1 present a higher average occupancy than those belonging to Cluster 2. Most of the CPs from the Northern Italy demonstration area belong to Cluster 2 (96.2%). Figure 336 presents the hourly occupancy distribution and Figure 337 presents the geographical location of the CPs belonging to both clusters.

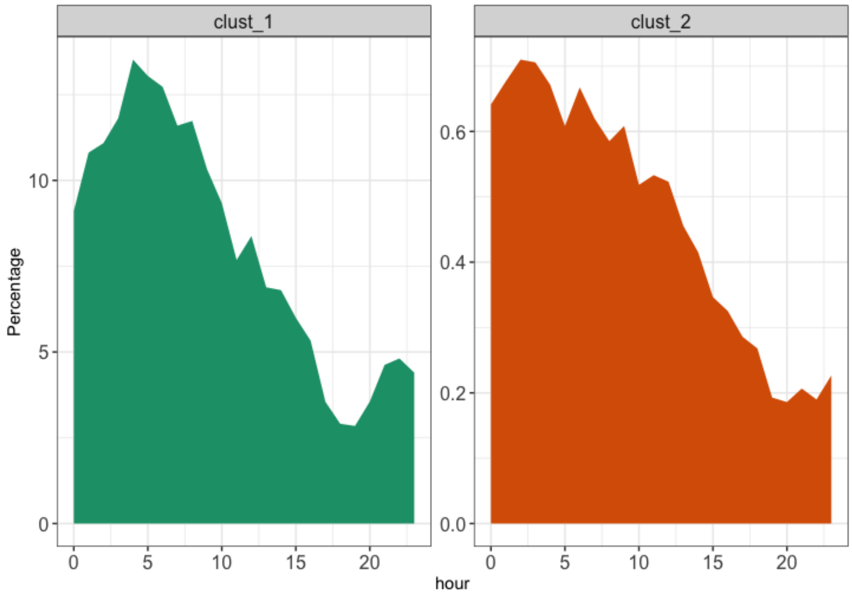


Figure 336. Charging Points' temporal clusters' hourly session distributions – Northern Italy demonstration area

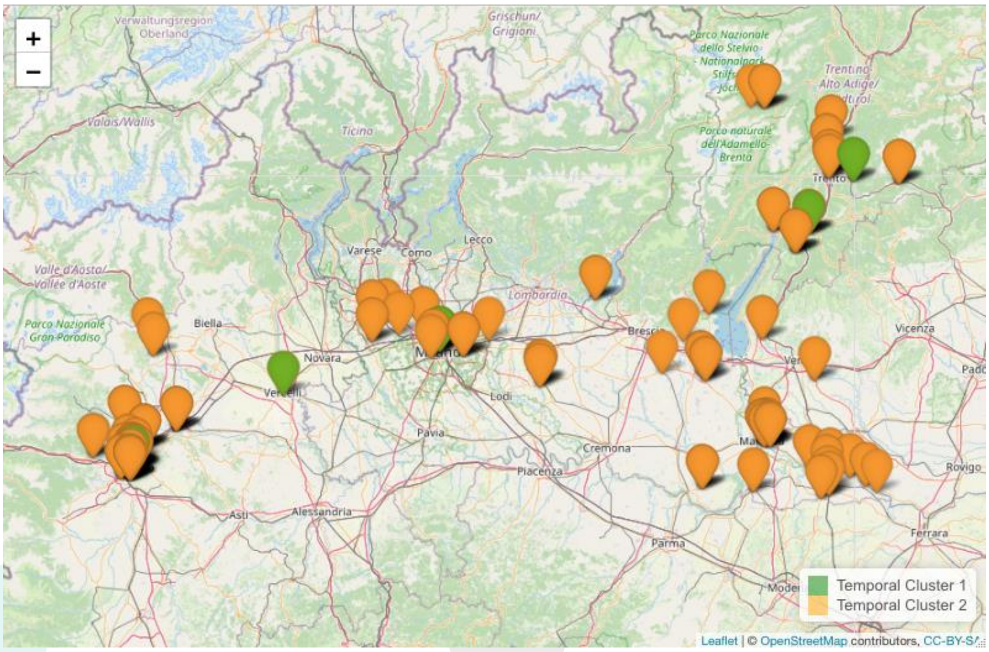


Figure 337. Charging Points temporal clustering geographical distribution – North Italy demonstration area

User mobility Flows

Within the Northern Italy demonstration area's analysis, a series of origin and destination (OD) trips have been created to evaluate how EV users charge on long-distance trips. Hence, sessions happened by unique users are grouped and the consecutive sessions happened in different cities are filtered and considered as one single trip. Considering a predefined minimum threshold of 5 trips, a total of 159 city pairs have been detected in the Northern Italy demonstration area. The most popular trips are plotted in Figure 338, with the thickness of the arrows representing the density of that corridor. In Annexe can be found more detail of the most significant trips for the Northern Italy demonstration area

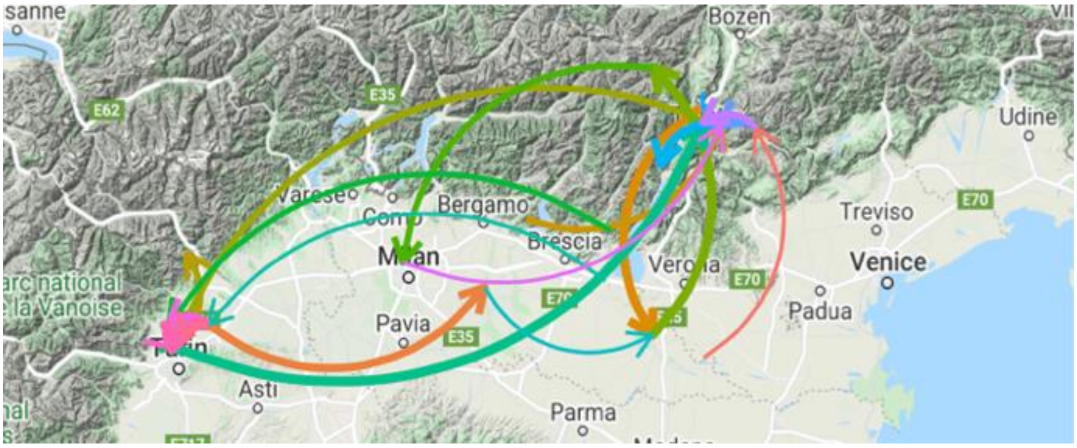


Figure 338. Inter-city trips flows in the Northern Italy demonstration area

COVID-19 effect in electomobility usage

The following time periods have been established for the COVID-19 effect analysis in the Northern Italy demonstration area:

Pre-COVID-19:	2020-01-16 – 2020-03-08
Lockdown:	2020-03-09 – 2020-05-17
De-escalation:	2020-05-18 – 2020-06-21
New-normality:	2020-06-22 – 2020-09-01

It should be noted that the new normality period corresponds to July-September 2020, which should not be considered as a fully "standard" new normality period since it covers the summer period, where the mobility action is normally reduced due to holidays. Figure 339 shows the variation of significant parameters related to charging activity (a more detailed explanation of the analysis is contained in Annexe A1.2). The conclusions of this analysis are as follows:

- The number of users dropped significantly when the lockdown was imposed in Italy, with a drop of 60% of users. After the lockdown, it increases during the de-escalation period and reaches an 89% of the pre-COVID-19 period in the new normality. Likewise, the average sessions per day and the average occupancy also show a noticeable reduction during the lockdown. In the same way as the number of users, the average sessions per day recover a 95% of the value shown at the pre-COVID-19 period.
- As for the duration of the sessions, a slight decrease of 9% is noted in the time the users spent on each charging station. During the de-escalation, the value increases to almost the same as during the pre-COVID-19 effect and decreases a 15% during the new normality.
- With regard to the average daily energy consumed by user, there is a 17% increase during the lockdown period, which is probably related with the increase in the sessions' duration. The increase of the daily energy consumed per user could be caused by users parking their vehicle at a CP strictly for charging, whereas before COVID-19, some users might have parked at a CP just because they needed a parking spot. Afterwards, the value slightly decreases but without a large variation, always close to the pre-COVID-19 period.

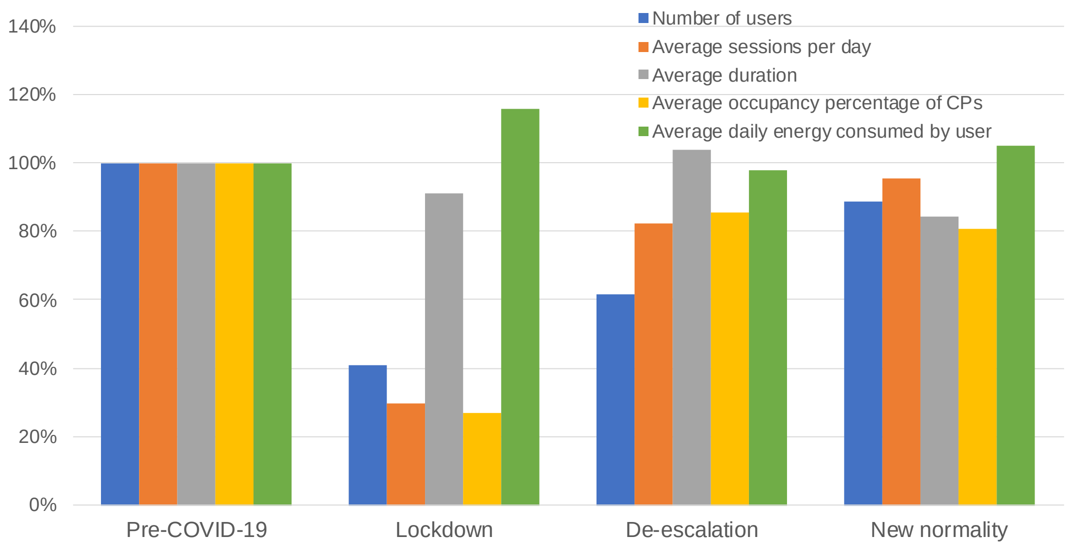


Figure 339. Variation of charging attributes with relation to the pre-COVID-19 period

A priori assessment of the e-mobility charging infrastructure

The following KPIs from the Usage Impact Area have been calculated as defined in D1.1 using data between 01/07/2020 and 31/08/2020.

Table 73. Usage KPIs – Northern Italy demonstration area

Impact Area: Usage	Result
Loyalty to the same charging option	22% of users reused the same CP more than 5 times
Frequency of use of charging options	87 is the average of uses of each CP
Vehicle's charging time	Semi-fast: 161 minutes Fast: 33 minutes
Availability rate (1)	1% of the CPs are occupied more than 10%.
Availability rate (2)	96% of the charging points are occupied less than 5%
Average usage ratio of charging options	1%
Frequency of use of app-based services	2019: 36 2020: 61 2021 (Q1): 107
App users	2019: 8900 2020: 16100 2021 (Q1): 2700
Users uninstalling the app	2019: 800 2020: 2800 2021 (Q1): 700
App-based services and total charging ratio	
App-based payments per charging station	87 (All charging sessions are paid by the app)
App-based payments per user	

Conclusions

The analyses carried out for this pilot gave significant and useful information about the EV and charging point usage. The following conclusions are drawn from the analysis:

- The average consumed energy is 12 kWh with average duration of 152 minutes. 79.04 % of the users perform charging sessions inside the same city.

- Torino and Trento are the most popular cities to be an origin or destination point for intercity trips; the most significant flow OD pairs are from Chivasso to Torino and from Torino to Trento.
- Most of the CP are Semi-Fast along with limited number of Fast chargers. Even with the limited number of Fast chargers, their usage is quite high, whereas the least preferred charging points are the 7.4 kW CPs. It highlights the fact that in the public CPs the EV users tend to use the faster options, even though these are not the most available group. The cities of Pergine Valsugana, Chivasso and Mantova have the highest usage levels with a low number of CPs.
- Created user clusters can be used in the future for user related analyses and tailored recommendations to be applied for a specific group of users instead of all. The same clustering approach is applied also for the charging points in order to group them based on their hourly occupancy distributions.

Demonstration area 9: Istanbul and Western Turkey

Current context of electromobility

At the end of 2020, there were around 3.000 EV registered in Turkey and almost half of it in Istanbul. With the launching of the first electric vehicle brand of Turkey (TOGG, or Turkey's Automobile Joint Venture Group) at the end of 2022, rapid increase in the number of electric vehicles is expected in the near future. In order to meet this capacity, ZES is already giving service in all 81 cities of Turkey. ZES is operating 26 fast charging stations and providing service in 481 different locations. In the current situation, with another CPs of different CPOs, there are approximately 2 electric vehicles per 1 public AC charging point in Turkey. And for the public DC charging points, this rate is around 17:1 (EV/DC).

Data collection process

ZES has established contacts with some stakeholders, universities, and companies that have an important role in the sector in order to make the surveys reach the large masses. In this direction, survey was shared with the relevant companies to ensure the participation of these companies and to make the survey popular by using the wide networks of the companies. In addition, some incentives were applied to ZES employees and customers of the company which are active EV users during mailing distribution. The distribution strategy in more detail:

- Survey was shared with academic staff in some universities due to their interest in the subject. They were asked to share the survey with their other academic colleagues and students within the university
- Survey was shared with the most influential/known associations in Turkey and survey was asked to be published and disseminated in their networks
- In addition, survey was shared with some DSOs. DSOs have disseminated the survey to their staff with internal mailing. The main purpose here was to ensure the participation of employees who are electric vehicle users and to get the opinions of potential users who are knowledgeable in EV and energy sector
- In parallel, survey was shared with the Zorlu Energy employees with internal mailing and some incentives were applied in order to increase participation. Finally, survey has been published with ZES customer (Electrical vehicle users) with some incentives in order to focus on active EV users and increase participation.

Outcome from survey

After data cleaning, the data set contains 254 respondents in total. Of the respondents, 23.62% (60) use any type of electric vehicle, whereas 76.38% (194) does not. Figure 340 shows the type of electric vehicles the respondents use, where the majority 53.33% (32) indicated they use an electric car.

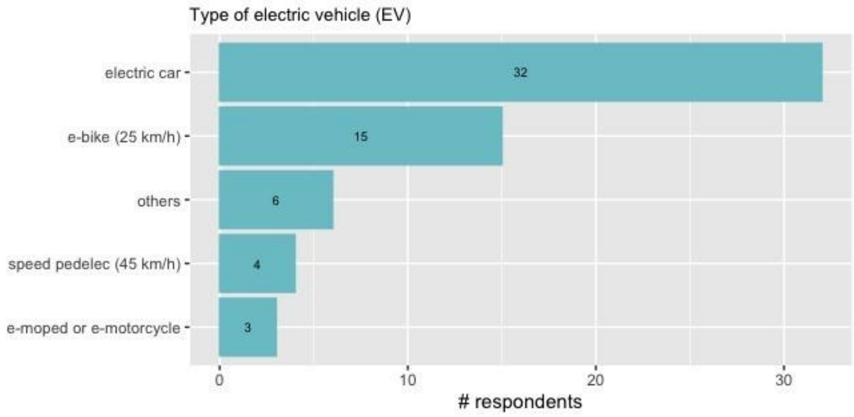


Figure 340 Type of EVs used out of 60 respondents at the Turkey demonstration area

Out of the 32 respondents who use an electric car, 78.12% (25) indicated they drive a battery electric vehicle without an internal combustion engine, whereas no respondents drive a plugin-hybrid electric vehicle. Also, 3.12% (1) respondents drive an electric vehicle with a range extender and 18.75% (6) a hybrid vehicle that combines a classical internal combustion engine with an electric motor.

In regards to the socio-demographic variables, the majority of the respondents were men 83.86%. Most respondents (78.74%) have obtained a university degree. The majority is full time employed (94.88%), whereas 0.79% is retired. Also, 46.46% of the respondents is married with or without children (37.01% resp. 9.45%). The different socio-demographics are detailed in Table 74. Almost all respondents (96.06%) possess a driving licence. For most respondents, this concerns a driving licence B (87.01%), followed by driving licence A (11.42%). A small portion of the respondents possess a driving licence C (3.94%), a driving licence D (5.51%) and a driving licence G (1.57%).

Table 74 Socio-demographics of the respondents at the Turkey demonstration area

Socio demographics	Categories	Answers number N (%)
Gender	Female	41 (16)
	Male	213 (84)
Degree	None	2 (1)
	Secondary education	25 (10)
	Higher non-university education	14 (6)
	University education (Bachelor degree, Master degree, …)	200 (79)
	Post-university education (PhD, Post-doc,…)	12 (5)
Residential situation	I live alone	46 (18)
	I live with family	76 (30)
	I live with others: co-housing	7 (3)
	Married or in relationship with child(ren)	94 (37)
	Married or in relationship without children	24 (9)
	Other housing situation, namely :	1 (0)
	Single parent with child(ren)	6 (2)
Professional situation	Currently unemployed	2 (1)
	Employed full time	241 (95)
	Other profession, namely :	4 (2)
	Part-time employed	2 (1)
	Retired	2 (1)
	Student	3 (1)
Function	Blue collar worker	22 (9)
	Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	6 (2)
	Middle management	55 (22)
	Official / employed in a public service	9 (4)
	Own company, entrepreneur with employees	10 (4)
	Self-employed, entrepreneur without employees	3 (1)
	Senior management / management	8 (3)
	Teaching staff / employed in education	3 (1)
	White collar employee (administrative, executive or support/clerical function)	134 (54)

EV car users

Out of 32 electric car users, 16 respondents own the vehicle, whereas 15 drive a company owned car, and 1 a car owned by a car sharing company. Furthermore, 1 respondent indicated that he/she uses the vehicle as a taxi-cab. Half of the respondents (50.00%) indicated they enjoy a company charging pass, where 43.75% does not enjoy any company benefits. Another 9.38% enjoys a company fuel pass.

In terms of the battery electric vehicles, the most popular cars are the Renault ZOE (13 respondents), followed by a BMW i3 (5) and a Mercedes EQC (2 respondents). 347240

Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity between 41 and 50 kWh or higher than 70 kWh. In terms of battery range, the BEV users, mostly indicate this lies between 250 and 400 km. Lastly, the majority of all EV users 56% is driving their current vehicle for less than 1 year. More detailed information can be found in Table 75.

Table 75 EV characteristics at the Turkey demonstration area

Vehicle characteristics	Categories	N (%)
Battery Capacity – kWh (BEV) according to respondents	20–30	1 (4)
	31–40	4 (16)
	41–50	7 (28)
	51–60	2 (8)
	61-70	1 (4)
	>70	6 (24)
	I do not know.	4 (16)
Battery Range – km (BEV) according to respondents	100–149	2 (8)
	150–199	3 (12)
	200–249	5 (20)
	250–299	8 (32)
	300-400	6 (24)
	I do not know.	1 (4)
Respondent usage of the vehicle in years	< 1 year	18 (56)
	1 year	6 (19)
	2 years	7 (22)
	3 years	1 (3)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time EVs are used as well as the activities they are used for. Figure 335 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

From Figure 341, it is clear that the main reasons for using or purchasing and EV are the fact EVs are dynamic and bring driving pleasure, that they are hip and forward looking, the environmental friendliness, the noise reduction and the fact that EVs have more efficient technology in terms of energy consumption. More specific, the fact that EVs are dynamic and bring driving pleasure was the most important factor as all respondents considered this factor to be very important to extremely important. The least important factor is the better image an EV could have towards other people, although only 6% considered this factor to be not important at all.

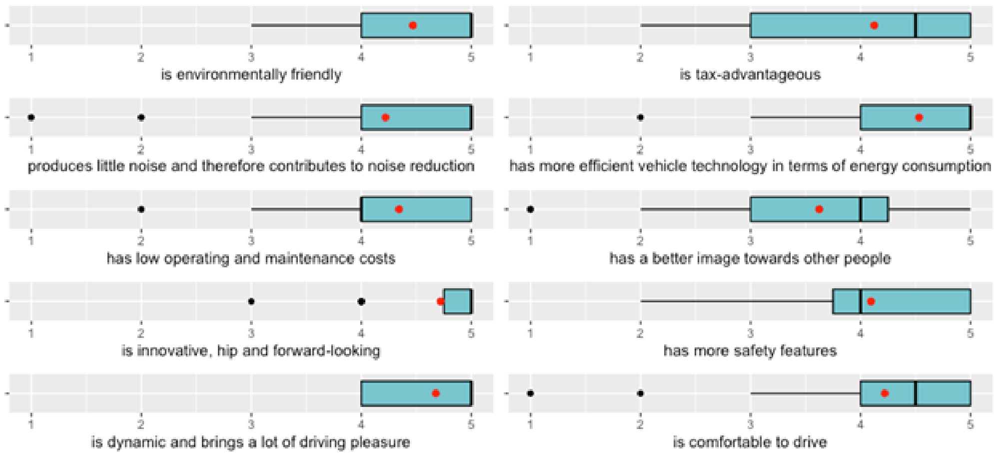


Figure 341 Reasons for EV usage or purchase at Turkey demonstration area

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 147.58 km, where the average time spent on the road was about 2 hours and 10 minutes. The EV is mostly parked at a private parking at home for about 8 hours a day on average. Figure 342 gives a more detailed overview of the parking time at different locations.

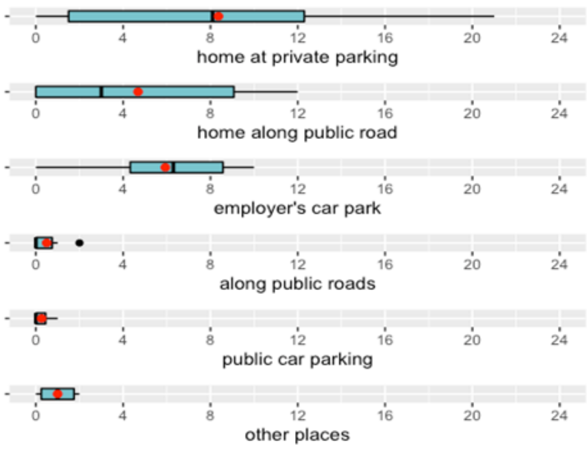


Figure 342 Respondents' EV parking time at different locations at the Turkey demonstration area

When EV users park at home, the majority does so in their driveway or in a privately-owned garage.

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or based on their next trip. For the other statements, the opinions are more divided (see Figure 343).

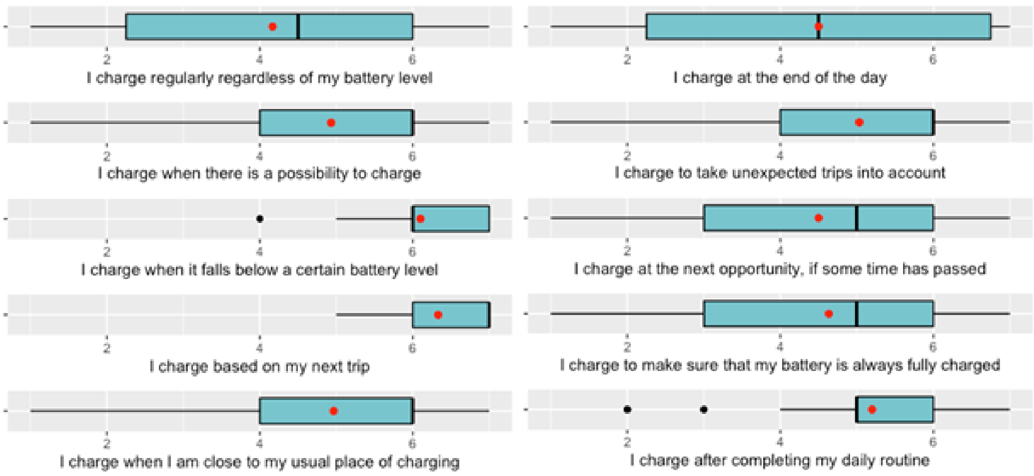


Figure 343 Respondents' charging behaviour at the Turkey demonstration area.

In regards to charging experience, 56.25% charges often at a different location, whereas 37.50% sometimes does. Respondents charge the EV most frequently at work. 27.0% of the respondents charges the EV at work daily and 14.0% does so several times a week. The least frequent charging place is at home, where 26.67% of the respondents indicate that they never charge at home. In terms of charging experience at home, 6.25% of the respondents indicated they have never charged the EV outside of their home socket station. The main charging option at home is the charging station (37.50%). Also, public fast chargers are more frequently used than non-fast chargers.

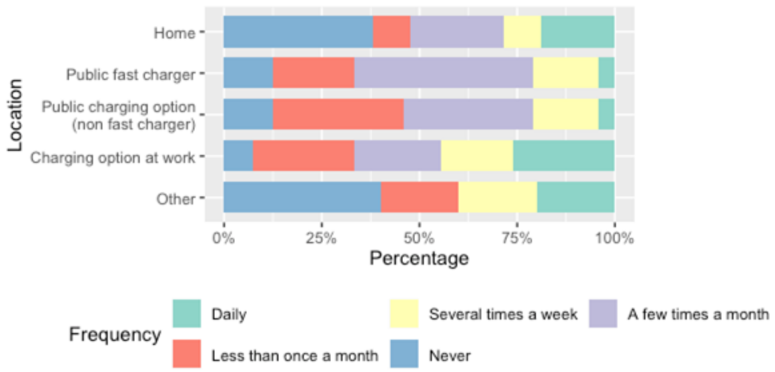


Figure 344 Respondents' charging behaviour per location at the Turkey demonstration area

As for the most popular charging time, no conclusions can be drawn as a steady percentage of 25% of the EVs are charged throughout the day.

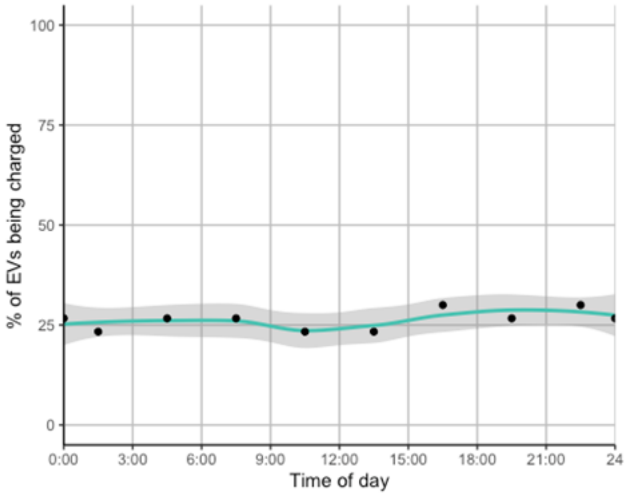


Figure 345 Respondents' charging schedule at the Turkey demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that ZES is the most popular.

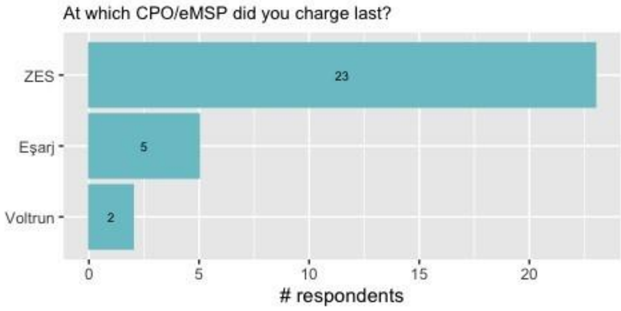


Figure 346 Last charging CPO/eMSP at the Turkey demonstration area

In what follows, we discuss the results and make comparisons for CPOs that were evaluated by at least 5 respondents. ZES is the most popular CPO, and it appears to score higher on tangibility than the other less frequently used CPOs. Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for ZES are spread ranging from rather good to very good.

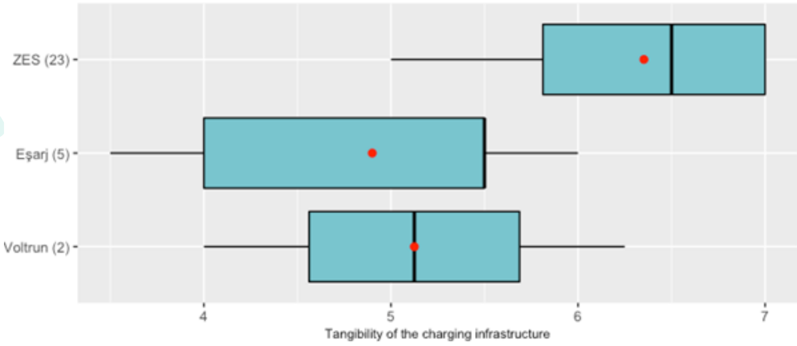


Figure 347 Tangibility of the charging infrastructure at the Turkey demonstration area

For availability and reliability of the charging infrastructure, similar scores can be observed (see Figure 348 and Figure 349). The availability captures whether the charging infrastructure is available for use, can start immediately, does not block and is not inadvertently interrupted. Again, ZES scores high on average for these criteria, whereas Esarj performs worse. The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping.

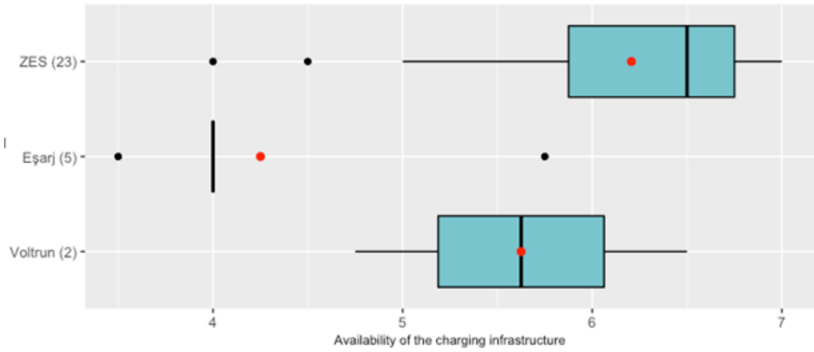


Figure 348 Availability of the charging infrastructure at the Turkey demonstration area

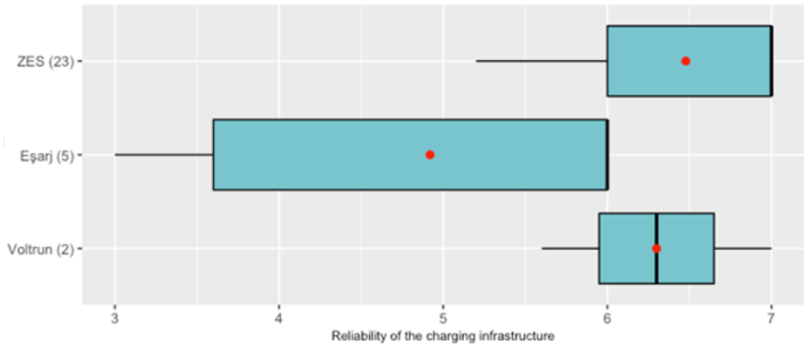


Figure 349 Reliability of the charging infrastructure at the Turkey demonstration area

Looking at the privacy of the charging infrastructure, again, ZES scores significantly higher than Esarj (see Figure 350). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other companies and payment credentials are protected.

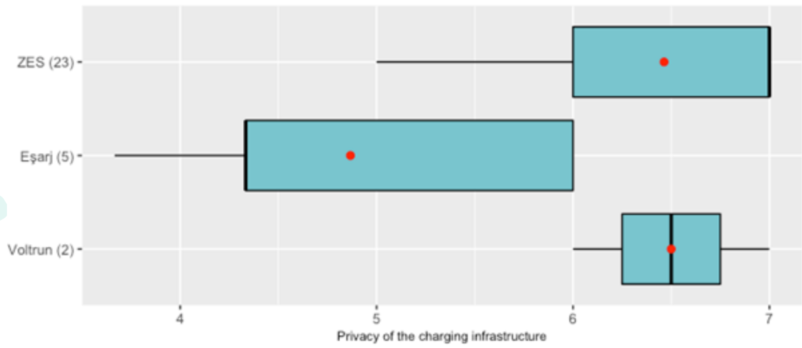


Figure 350 Privacy of charging infrastructure at the Turkey demonstration area

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 6 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 6 indicated they have not. The charging infrastructure problems were experienced when using ZES.

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For contact, respondents had to indicated whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the ability is provided to speak to a person in case of problems. For compensation in case of problems, respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. ZES scores on average high for both responsiveness and contact. For compensation, the opinions are more divided, and the average is noticeably lower. It appears that respondents expect more from ZES in terms of compensation when a problem arises.

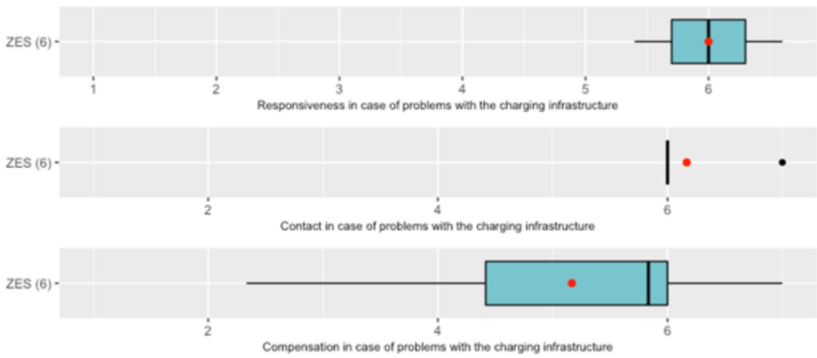


Figure 351 Problems with the charging infrastructure at the Turkey demonstration area.

Finally, the last questions in this section probe for the respondents' opinions on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. Again, ZES scores on average very good the perceived value criteria. All respondents are in agreement to a certain extent with the perceived value criteria.

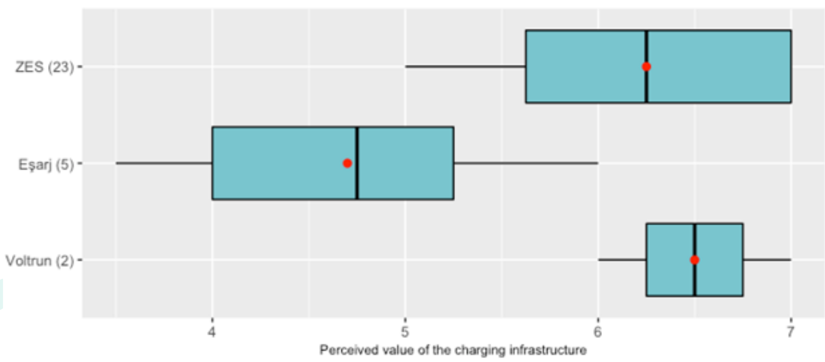


Figure 352 Perceived value of the charging infrastructure at the Turkey demonstration area

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. ZES scores high on the loyalty criteria (see Figure 353), with all respondents agreeing to a certain extent with the loyalty criteria.

Figure 353 Loyalty of the charging infrastructure at the Turkey demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the general trend in the earlier questions, ZES receives an excellent score on average of more than 6.5 out of 7 (see Figure 354).

Figure 354 Customer satisfaction of the charging infrastructure at the Turkey demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. In this survey, the respondents could either choose user friendly charging stations or others. The other option that was specified was fast charging.

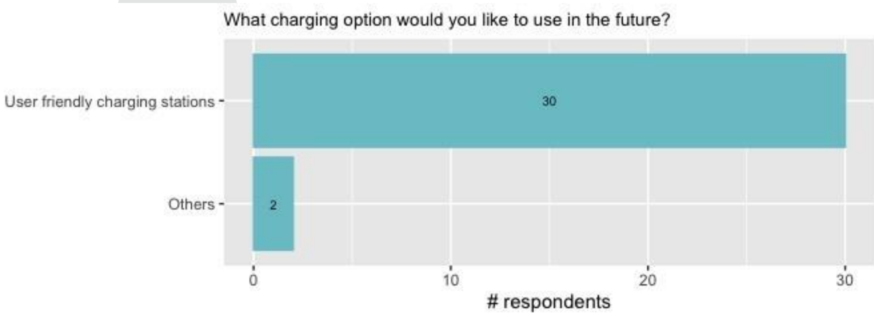


Figure 355 Most likely charging option in the future at the Turkey demonstration area

The user-friendly charging stations further score high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration. Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it. Lastly, hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable. The distributions for all constructs are rather similar and skewed towards the right, less important appear to be the social influence, the facilitating conditions and the hedonic motivation.

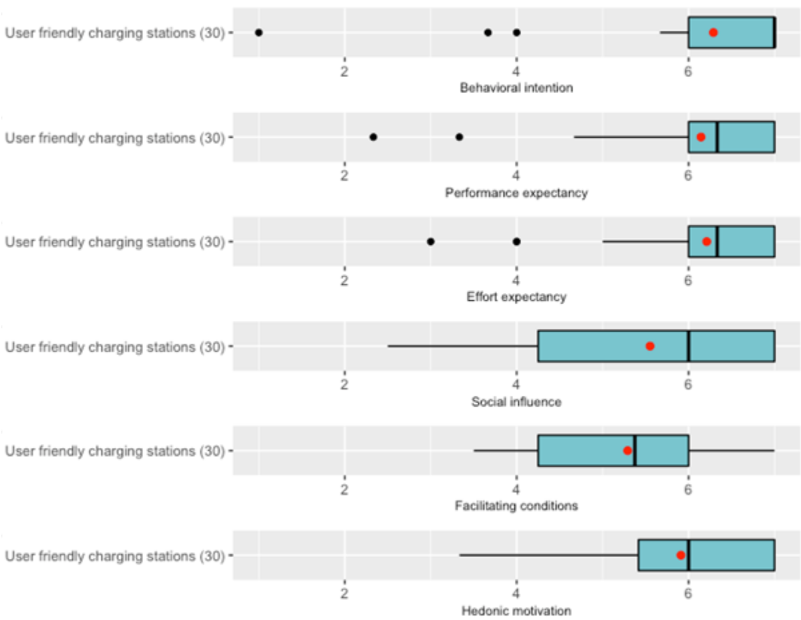


Figure 356 Acceptance of future charging infrastructure at the Turkey demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, it is interesting to note that 75% of the respondents does not to pay more the user-friendly charging options. Even more so, 75% of the respondents agree with the statement that they would only use it if the price is lower.

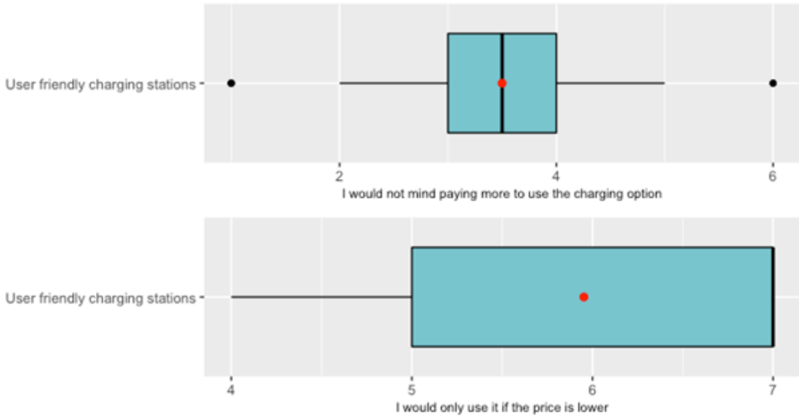


Figure 357 Price value of the charging infrastructure at the Turkey demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. Of the respondents, 46.88% (15) indicated they use app-based services, another 46.88% does not but intends do. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, half of the EV respondents has 4 or more apps on their phone. Of the app-based service users, all of them use the apps at least a few times a month.

App-based services are mostly used for travel related to commuting and work activities (10 respondents) and travel destinations on holiday (9 respondents), whereas 4 respondents use it for leisure activities. To a lesser extent, the app-based services are used for shop/errands (3 respondents). In terms of satisfaction with the used app-based services, Figure 358 shows that minimum 75% of the respondents are satisfied above 4 on a scale of 1 to 7.

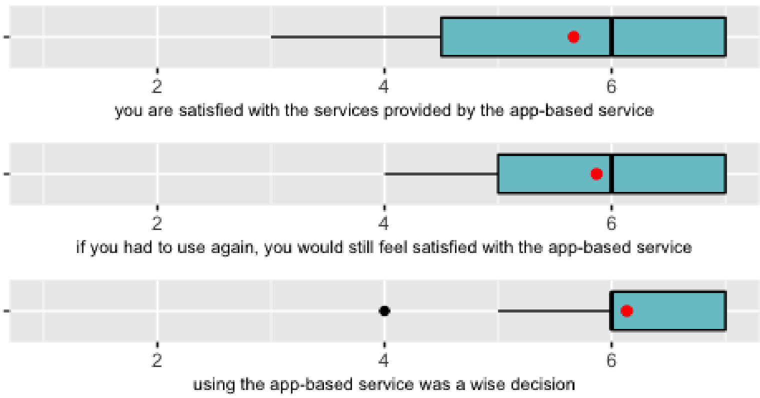


Figure 358 Satisfaction with the app-based services at the Turkey demonstration area

LEV

In this section, we zoom in to the 22 respondents who use a light electric vehicle. The majority of the respondents (86.36%) owns the LEV they use and are responsible for the LEV maintenance costs (81.82%). At the same time, the majority of the respondents does not know what the battery capacity is or did not fill out this question (72.73%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 76.

Table 76 LEV characteristics at the Turkey demonstration area

Vehicle characteristics	Categories	Answers number N (%)
Owner of the LEV	Private	19 (86)
	Sharing company	2 (9)
	Company/Leasing company	1 (5)
Responsible LEV maintenance costs	Private	18 (95)
	Company	1 (5)
	NA	3
Battery Capacity – kWh according to respondents	< 0.5	1 (5)
	1-3	2 (10)
	3-5	3 (14)
	I do not know.	15 (71)
How often do they use the LEV	Daily	7 (33)
	Several times a week	9 (43)
	A few times a month	4 (19
	Less than once a month	1 (5)
LEV parking	I use a garage that is my property or park on my driveway	4 (19)
	I use a fixed car park which is my property	7 (33)
	I do not use a fixed parking	10 (48)

On average, the LEV users indicate they drive about 23.85 km each day and spend about 2 hours and 10 minutes on the road. The majority of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 359).

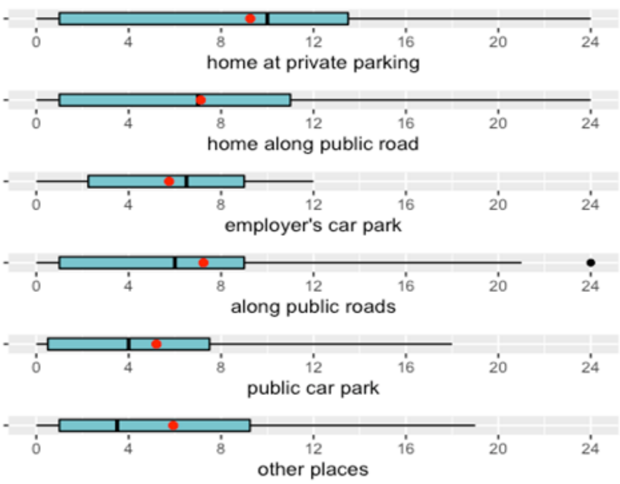


Figure 359 Parking space and duration of the LEV at the Turkey demonstration area

Looking at the motives to use an LEV, it is clear that the most important motive is the environmental friendliness and the fact that it is tax-advantageous, whereas the least important is the image towards other people.

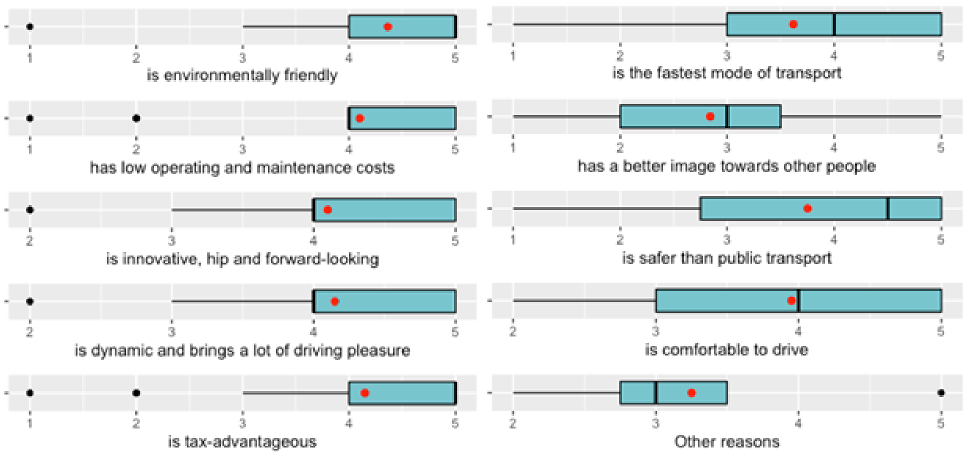


Figure 360 Motives to use LEVs at the Turkey demonstration area

In terms of charging behaviour, 75% of the respondents seem to charge at the end of the day, or when they have the possibility to charge.

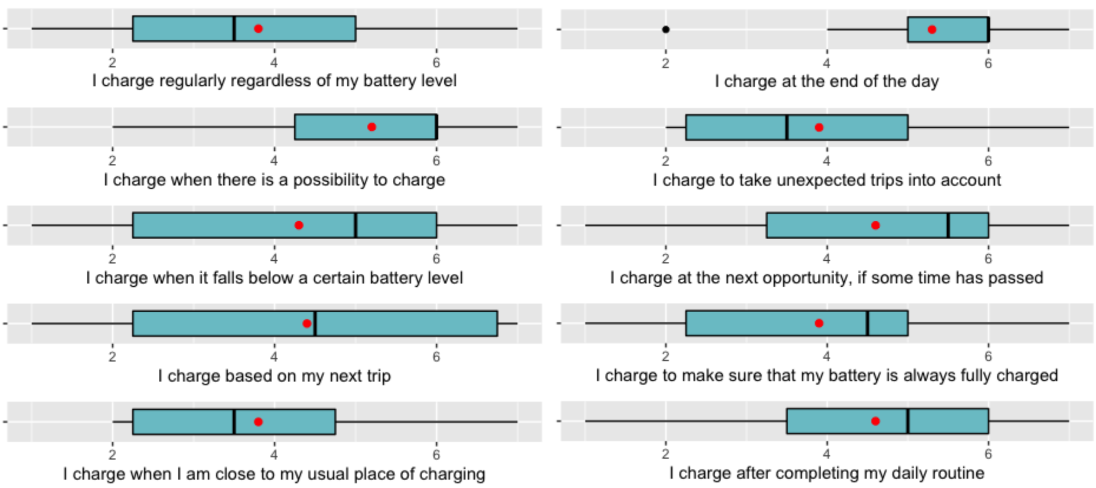


Figure 361 LEV charging behaviour at the Turkey demonstration area

Quality of Experience

Out of 22 respondents, only 3 respondents indicated that they used the service of a CPOs/eMSPs. They all made use of ZES. Due to the limited sample, the charging experience will not be further investigated in this section.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging options are the most popular with 45.45% of respondents choosing they are most likely to use fast charging options in the future.

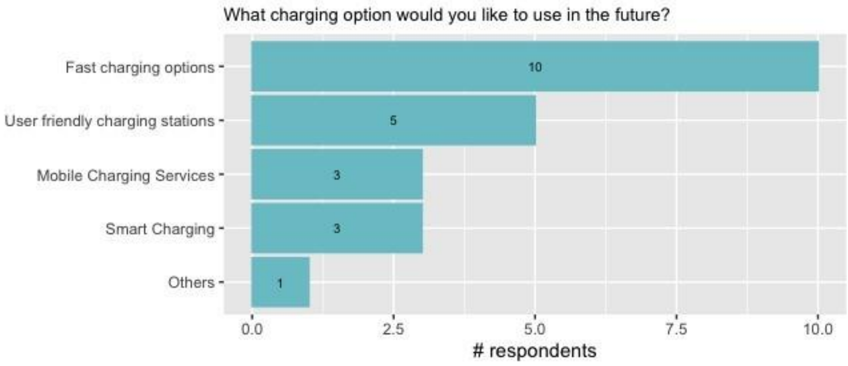


Figure 362 Preferred LEV charging option to use in the future at the Turkey demonstration area.

Due to the limited sample, the acceptance will not be further investigated in this section.

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 36.36% (8 respondents) of the respondents, indicated they use app-based services, another 46.88% does not but intends do. The remainder of the respondents have no intention to use an app in the near future. About 87.50% of the app-based service users, users this at least a few times a month.

In terms of satisfaction with the used app-based services, Figure 363 shows that almost all respondents are satisfied above 5 on a scale of 1 to 7.

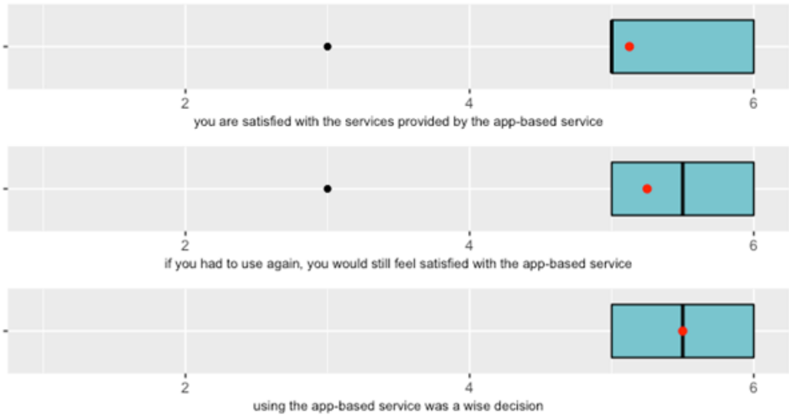


Figure 363 Usage of app-based LEV services at the Turkey demonstration area

Non-EV users

Lastly, we zoom into the non-EV users, a total of 194 respondents. Interestingly, over 50% state that it is very likely they will buy an electric vehicle.

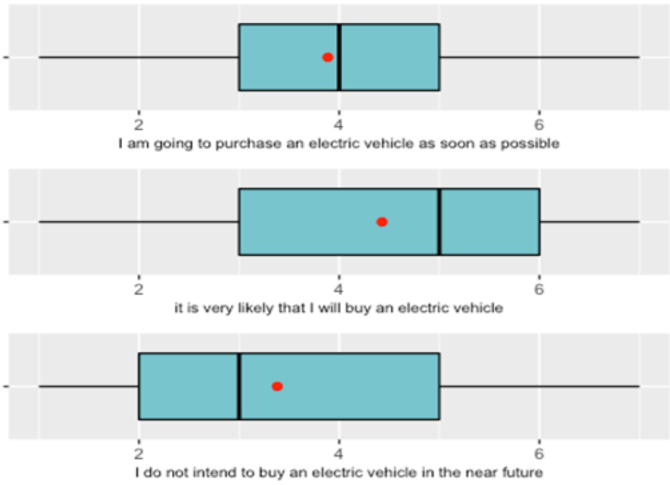


Figure 364 Non-users' Intention to buy an EV at the Turkey demonstration area

Moreover, most respondents (89,69%) indicate they are mostly interested to buy an electric car. Out of these 174 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (101 respondents) or a hybrid vehicle that combines a classic combustion engine (54 respondents). The remaining prefer an electric vehicle with range extender (9 respondents) or a plug-in hybrid electric vehicle (9 respondents) and 1 does not prefer any of the above.

Lastly, the most important motives for non-EV users to purchase an EV in the future is the environmental friendliness and the fact that EVs have low operating and maintenance costs, as in both cases 97% considers this moderately to extremely important. At the same time. The least important motive is the better image EVs could have towards other people as 29% of the respondents consider this not important at all to slightly important.

Key findings of the Turkey report

The main reasons for electric car adoption are the fact that EVs have more efficient technology in terms of energy consumption, and the dynamic driving pleasure. In terms of charging behaviour, it is interesting that electric car users charge most frequently at work, where 41.0% of the respondents charge more than several times a week. The least frequent charging place is at home, where 26.67% of the respondents indicate that they never charge at home. Interesting to know is the time when users charge. No real conclusions can be drawn as a steady percentage of 25% of the EVs are charged throughout the day. User friendly charging options are the most preferrable charging options to use in the future and users see this also as the charging option the easiest to use. Respondents expect to pay less for future charging option compared with the current charging options.

LEV users mainly bought their LEV because it is environmentally friendly, and because of the tax advantageous. In terms of charging behaviour, 75% of the respondents seem to charge at the end of the day, or when they have the possibility to charge. Fast charging is the most preferrable charging option in the future.

Lastly, more than half of the non- EV states that they will buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (89.69%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (97%) and the fact that EVs have low operating and maintenance costs (97%) in comparison with non-EV. At the same time, the least important motive is the better image Evs could have towards other people as 29% of the respondents consider this not important at all to slightly important.

Outcome from historical data

This section contains the Data Analytics for the Istanbul and Western Turkey demonstration area. During the last years the number of registered electric vehicles has increased. At the end of 2018, there were around 1.200 EV registered, at the end of 2019 this number was around 2.000 and by the end of 2020, there were around 3.000 EV registered in Turkey and almost half of it in Istanbul. With the launching of the first electric vehicle brand of Turkey (TOGG, or Turkey's Automobile Joint Venture Group) at the end of 2022, rapid increase in the number of electric vehicles is expected in the near future. Considering this situation, it is expected to have approximately 30,000 electric vehicles in Istanbul at the end of the project and more than 100.000 by the end of 2025.

In order to meet this capacity, ZES is already giving service in 81 cities of Turkey. ZES is operating 26 fast charging stations and providing service in 481 different locations. In the current situation, with another CPs of different CPOs, there are approximately 2 EVs per 1 public AC CP in Turkey. And for the public DC charging points, this rate is around 17:1 (EV/DC).
The following table describes the information contained in the dataset provided by ZES:

Table 77 General information for the Turkey demonstration area

Attribute	
Users	785 users
Cities	13 cities (Balıkesir, Bolu, Bursa, Çanakkale, Edirne, İstanbul, İzmir, Kırklareli, Kocaeli, Manisa, Sakarya, Tekirdağ, Yalova)
Operators	ZES
CPs	164 CPs
Sessions	3418 sessions
Time range	01/03/2020 – 13/10/2020
Power levels	22 kW, 43 kW, 60 kW, 100 kW, 120 kW

Descriptive Statistics

The following section covers some general statistics that describe the electromobility paradigm of the Istanbul and Western Turkey demonstration area. These statistics will cover the type of charging powers available, the duration of the sessions, the energy consumed and the usage distribution by city.
This specific demonstration area covers the CPs operated by ZES in the cities of Balıkesir, Bolu, Bursa, Çanakkale, Edirne, İstanbul, İzmir, Kırklareli, Kocaeli, Manisa, Sakarya, Tekirdağ and Yalova. Figure 365 shows the specific location of the CPs.

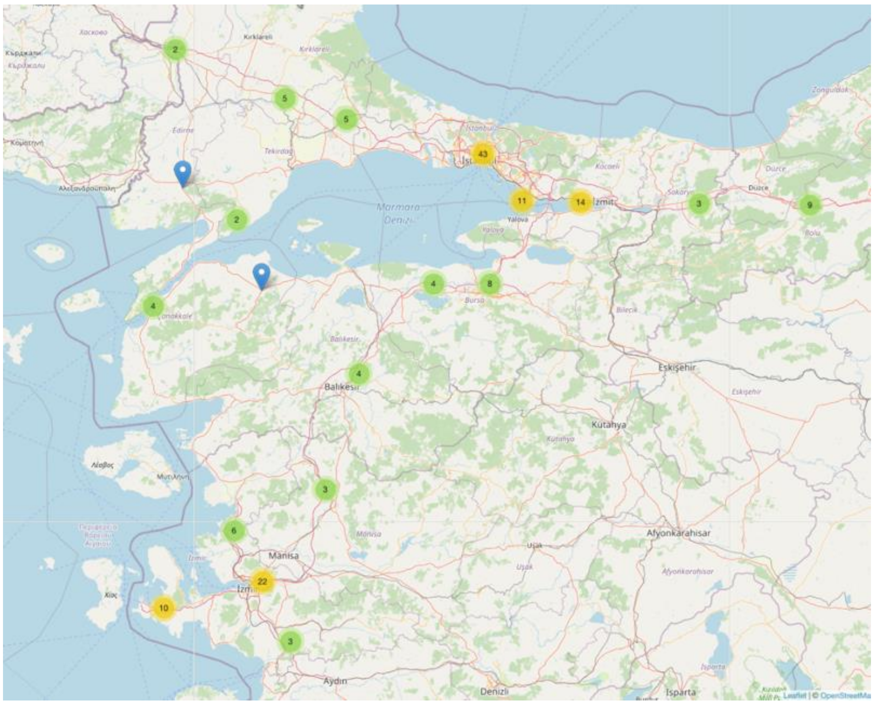


Figure 365. CP locations in the Istanbul and Western Turkey demonstration area

- **Charging Power analysis**

Figure 366 shows the ratio between the number of existing CP power levels and the usage frequency for those rated power levels, in order to provide the average number of usages for each rated power level for unique CPs.

The result shows that fast chargers (i.e. 100 kW and 120 kW) are the most commonly used, although the total number is low. On the other hand, the most common CP power level, 22 kW has the lowest ratio. In Annexe A3, Figure 488 shows the total number of sessions charging sessions per power type are plotted and the plot shows a predominance in the charging sessions of slow chargers (22 kW) and also a significant number of sessions in fast chargers (100 kW and 120 kW). Moreover, the figure shows the number of CPs of each power level, showing that the majority of chargers in this demonstration area are of 22 kW.

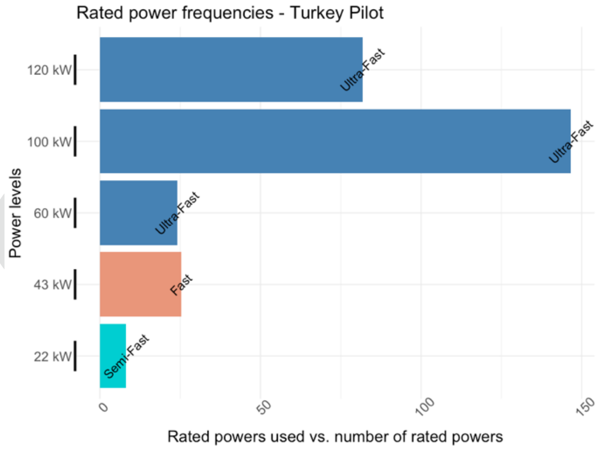


Figure 366. Ratio between the number of rated powers and the number of sessions

- **Sessions' temporal distribution**

The following Figure shows the distribution of the sessions' starting time, it can be inferred that starting from 5 am, until the 4 pm the number sessions keeps increasing. Then it starts to decrease again. The highest peak occurs on Sunday at 4 pm.

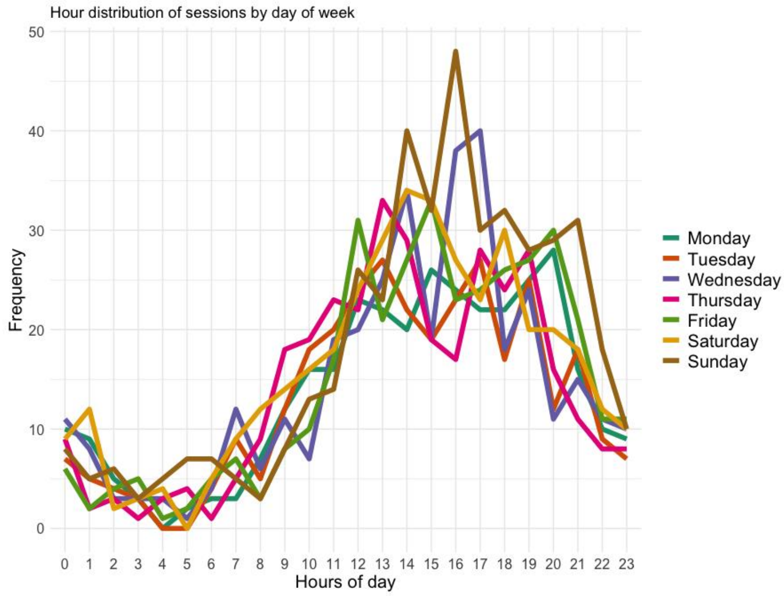


Figure 367. Hourly distribution for each day of the week – Istanbul and Western Turkey demonstration area

- **Sessions' duration**

With regard to the duration of the sessions, Figure 368 shows the boxplot of this parameter for the three types of CPs.

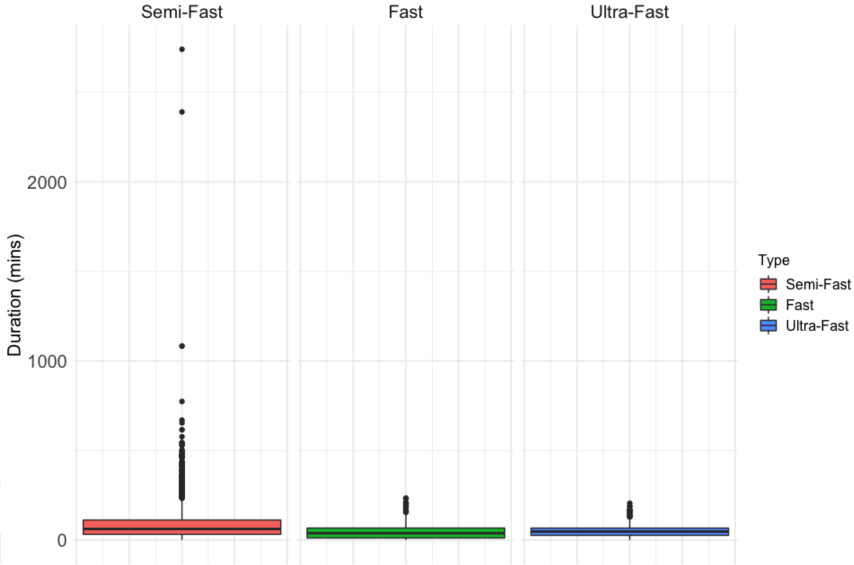


Figure 368. Boxplot for sessions' duration – Istanbul and Western Turkey demonstration area

As it can be inferred from Table 78, the average and the median is higher for the case of semi-fast CPs, as in this type of charging points the user needs to spend more time to have a full recharge. In the case of the fast and ultra-fast charging points, the presence of outliers is low, which means that the mean can be a good measure to know the average time spent in these CPs. It is inferred that in both types of CPs the average duration of the session is longer than expected, meaning that some users spend more time than necessary. A zoomed version of the box plots for ultra-fast chargers can be found in Annexe A3, providing more detail on the time spent by users in the 60kW, 100 kW and 120 kW CPs.

Table 78. Summary table of session duration – Istanbul and Western Turkey demonstration area

Semi-fast charging points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.08 min	32.85 min	63.08 min	103.05 min	116.22 min	2741.02 min
Fast charging points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.02 min	11.60 min	38.57 min	49.52 min	68.52 min	233.60 min
Ultra-fast charging points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.02 min	26.55 min	47.70 min	49.22 min	66.56 min	206.03 min

- **Energy consumed per session**

As for the energy consumed in the sessions, Figure 369 shows few outliers only in the case of semi-fast CPs, with the rest of the energy consumed data fitting into the IQR boundaries. The lowest average energy consumed takes place in fast CPs (10.9 kWh) whereas in ultra-fast CPs have the highest average (37 kWh). On the other hand, the highest values achieved are for the case of the semi-fast CPs, having some values between 60kWh and 115 kWh.

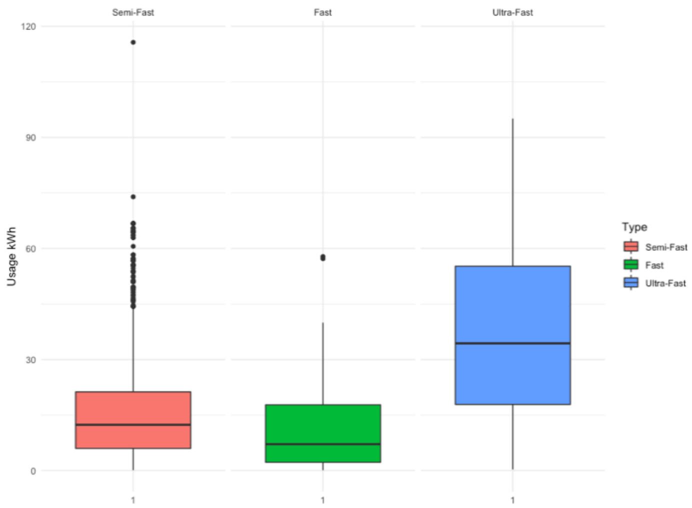


Figure 369. Boxplot for sessions' energy consumed – Istanbul and Western Turkey demonstration area

Table 79. Summary of statistical values of sessions' energy consumed – Istanbul and Western Turkey demonstration area

Semi-fast charging points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.11 kWh	5.99 kWh	12.37 kWh	16.01 kWh	21.25 kWh	115.68 kWh
Fast charging points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.10 kWh	2.24 kWh	7.13 kWh	10.91 kWh	17.78 kWh	57.82 kWh
Ultra-fast charging points					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.30 kWh	17.86 kWh	34.38 kWh	36.99 kWh	55.21 kWh	95.08 kWh

- **Usage distribution by city**

Figure 370 shows the distribution of the usage of the different charging points distinguishing them according to their power in each of the cities in the study.

- Çanakkale, Edirne, İzmir, Sakarya, Tekirdağ and Yalova cities have only charging sessions in CPs with a power level of 22 kW.
- Only Bursa, İstanbul, Kırklareli and Manisa have 120 kW charging sessions.
- Balıkesir, Bolu and Kocaeli cities have more than half of their sessions in 100 kW CPs, and they are followed by Bursa and Manisa. These cities are on the specific corridor between İstanbul and İzmir.
- In all cities, the usage of 43 kW and 60 kW is not highly preferred.

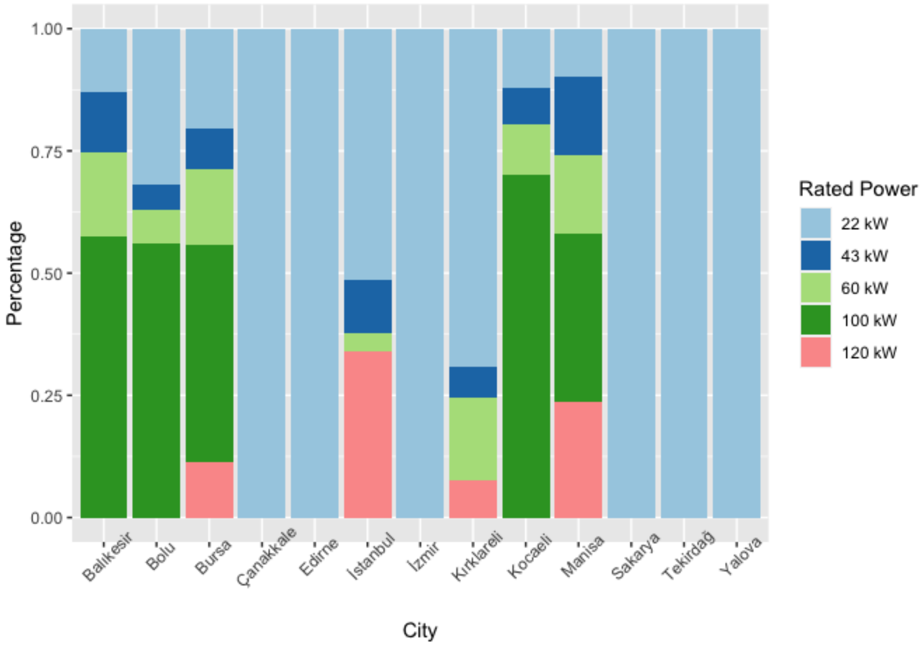


Figure 370. Percentage distribution of rated power usage in different cities

It is of relevance to this analysis to understand how well covered the demand for charging EV is for every city of the Turkish demonstration area. Hence, the number of CPs and the total of number of sessions have been evaluated. The ratio between the total number of sessions in a city and the number of CPs in the corresponding city has been calculated to represent the level of coverage of a city with regard to CP offer.

Figure 371 shows the ratio between the sessions and the CPs. It can be inferred that Balıkesir has a very low number of CPs for the relatively high number of sessions, with a ratio of 105 sessions per CP. Manisa, Bursa, Kocaeli and İstanbul also show a high ratio of sessions per CP. On the other side, there are cities like Sakarya, Çanakkale and Edirne that show a low ratio of session per CP, meaning a low usage of the city's CPs. In Annexe A3, the total number of CPs in each city can be found as well as the number of sessions performed by users in each of the cities of study.

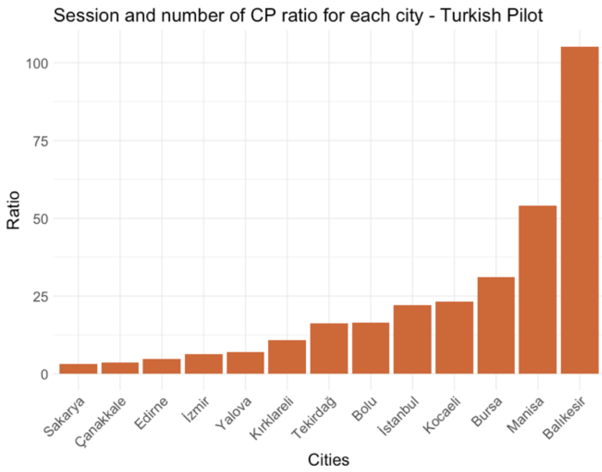


Figure 371. Ratio of sessions and CPs – Istanbul and Western Turkey demonstration area

User Clustering

Following the methodology explained in Annexe A1.2, the user clustering was performed for the Istanbul and Western Turkey demonstration area. The outputs showed that the most convenient method is “kmeans” with 3 clusters.

Table 80 User clusters – Istanbul and Western Turkey demonstration area

User Cluster 1	User Cluster 2	User Cluster 3
241 users (43.82%)	85 users (15.45%)	224 users (40.73%)

In Figure 372, the charts display the multivariate data, for each variable the mean is represented by 0, and the distance to the mean is represented by a bar chart to ease the view of differences between all the clusters at a glance. The users from Cluster 1 are characterised by low energy consumption per charging session, longest average duration (82 minutes), lowest actual power (26 kW) and are sporadic users, as the number of sessions is low. The Cluster 2 is the least crowded cluster (15% of the users), users belonging to Cluster 2 are regular users, with the highest number of sessions, longest memebership period and highest number of CPs visited. In average, users from Cluster 2 and Cluster 3 have similar session duration. Users from Cluster 3 are the closest to the average, and present high energy consumption per charging session, and low number of sessions.

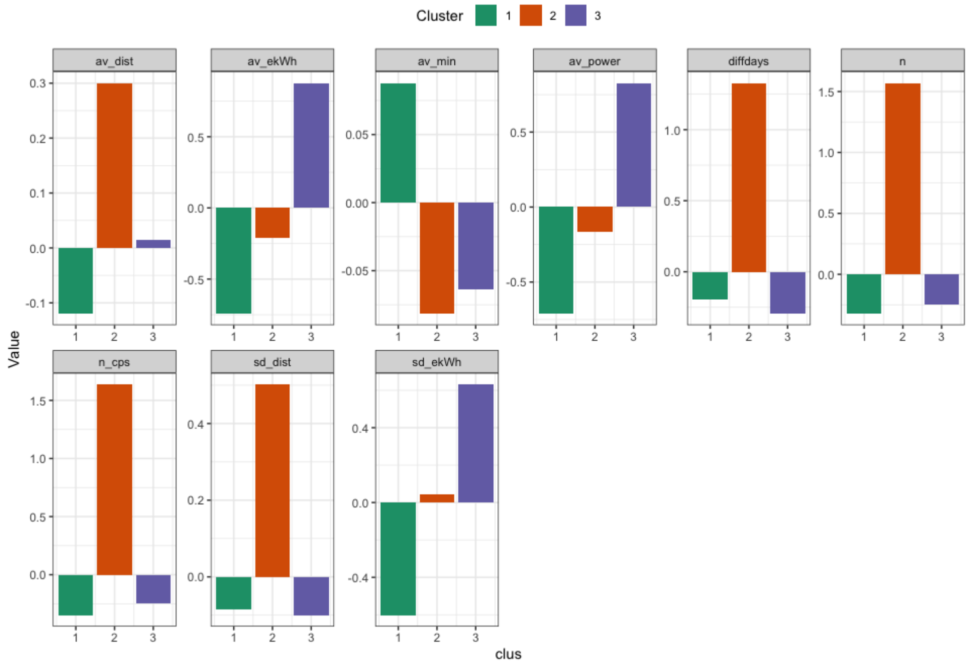


Figure 372. User clustering results – Istanbul and Western Turkey demonstration area

Temporal Clustering

As stated in Annexe A1.2, the selection of the clustering algorithm and the optimal number of clusters for the CPs is chosen automatically. The function gave the output as “kmeans” with 3 clusters.

Table 81 Temporal clusters – Istanbul and Western Turkey demonstration area

Temporal Cluster 1	Temporal Cluster 2
13 CPs (8 %)	150 CPs (92%)

The occupancy percentage in both Clusters is low, nevertheless Cluster 1 includes the charging stations with the highest number of sessions. On one hand, Cluster 1 presents one peak at 12pm, another at 3pm and at 8 pm, on the other hand Cluster 2 Charging stations present a peak between 3pm and 5pm.

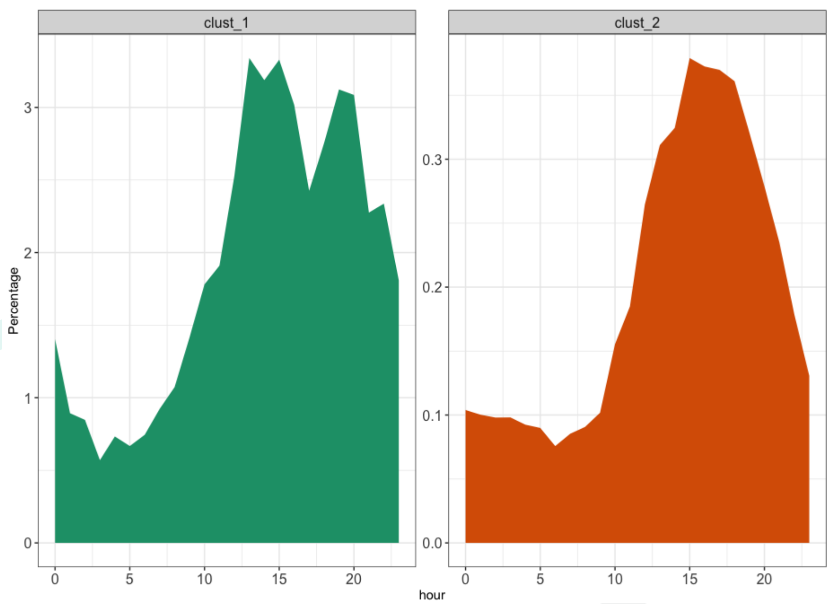


Figure 373. Charging Points' temporal clusters' hourly session distributions – Istanbul and Western Turkey demonstration area

User mobility flows

The Turkey demonstration area's charging sessions data have also been analysed in order to create origin and destination (OD) trips to investigate in what manner are the EV drivers doing long-distance trips such as from a city to another. For that, sessions happened by unique users are grouped and the consecutive sessions happened in different cities are filtered considering the ordered data frame by time attribute. This way, OD trips are created and used to detect the corridors in this demonstration area. Annexe A3 details the number of users that have charging sessions in more than one city.

The corridor analysis took attention to see the density of the electric vehicles (EVs) on these corridors. 110 combinations for OD city pairs are detected among 13 cities in the session data. For the plotting purposes, only the most significant (i.e., dense) ones have been plotted to provide the most popular OD city pairs in Turkey as follows:

Figure 374. Inter-city mobility flows in the Istanbul and Western Turkey demonstration area

It can be noted that most of the trips happened between İstanbul and İzmir highway and the intermediary cities between them. We conclude that the main corridor between İzmir and İstanbul needs to be deeply analysed in order to ensure the demand and supply balance for today and the future.

The intermediary cities in the main corridor are Kocaeli, Bursa, Balıkesir and Manisa. In Figure 371 the top four cities with a high ratio (the average number of sessions per total CP in the corresponding city) are the intermediary cities that are detected in the corridor analyses. This means that the CP capacity needs to be increased in order to meet the current and future demand and promote EV users to have long-distance trips on the main corridor detected.

A priori assessment of the e-mobility charging infrastructure

The following KPIs have been calculated using data between 01/07/2020 and 31/08/2020.

Table 82. Usage KPIs – Istanbul and Western Turkey demonstration area

Impact Area: Usage	Result
Loyalty to the same charging option	8% of users reused the same CP more than 5 times
Frequency of use of charging options	21 is the average of uses of each CP
Vehicle's charging time	Semi-Fast (22 kW): 103 min Fast (43 kW): 49 min

	Ultra-Fast (60 kW, 100 kW, 120 kW): 49 min • 60 kW: 54.87457 mins • 100 kW: 46.3135 mins • 120 kW: 50.93577 mins
Availability rate (1)	25% of the charging options are occupied more than 1.5%.
Availability rate (2)	64% of the charging points are occupied less than 1%
Average usage ratio of charging options	3% is the average ratio.
Frequency of use of app-based services	Between the 01/03/21 and 31/03/21 average number of daily usages of the service is around 34.1
App users	Between the 01/03/21 and 31/03/21 average number of daily usages of the service is around 24.9

Conclusions

The analyses carried out for this pilot gave significant and useful information about the EV drivers and CP usage in the Istanbul and Western Turkey demonstration area. More than half of the EV users show charging sessions in the same city without charging in other cities, whereas the rest, 41.7% of the users, use also the CPs from other cities. This shows the initial output, which is the fact that the intercity trips are happening and will likely increase in the future in case that the necessary conditions are met. According to the analyses, these conditions are (i) installation of fast chargers for intracity and intercity trips, (ii) installation of more charging points in the cities that are located on the corridor between İstanbul and İzmir.

Although there is a huge number of slow chargers (i.e., 22 kW) the ratio for the average session per charging point is quite low, whereas the ratio is quite high for the fastest chargers (i.e., 100 kW, 120 kW).

The user clustering approach shows two major groups (Cluster 1 and Cluster 3) with low number of sessions and with high energy consumed with low duration sessions. Cluster 2 shows a longer usage period with the highest number of sessions.

The same clustering approach is applied also for the charging points in order to group them based on their hourly occupancy distributions. This clustering shows two clusters for the CPs. All clusters show an increase of activity after 11 am and have the highest activity at the afternoon and early evening.

Lastly, the corridor analysis shows that the main corridor between Istanbul and Izmir generates more charging activity compared to the rest of the cities in the demonstration area.

Demonstration area 10 : Zellik

Context

The demonstration area in the Green Energy Campus is located in an industrial zone at the border between Brussels and Flanders very close to the TEN-T network, where 70 companies from different sectors are active. The site accommodates 199 parking spots. The site will provide the possibility to use and charge 100 electric bicycles for transit. The parking will serve the dayshift of an adjacent hospital (1,000 people per week) and as a carpool parking in the weekends. The Green Energy Park will operate 100 charging stations for electric bikes, 15 chargers are at 7 companies in the industrial zone (semi-private) to be doubled by 2020. Forty charging stations for cars are planned by 2021.

As of 2020, there were estimated that the number of registered EVs in Belgium would be around 105, 000. There are around 30,000 battery electric cars and 75,000 plugin-hybrid electric cars. Sales are expected to increase over the next few years due to the increased offer of EV models and government subsidies.

Currently, in Belgium there's a total of 8482 CPs, more in detail 4200 public charge points and 4282 private charge points. More specific, there are 476 public slow charging stations, and 476 public fast charging stations. Key players in the implementation of public charging infrastructure are Allego, EVBox, Blue Corner, Ionity, Fastned, GreenFlux, ChargePoint.

Data collection strategy

The three surveys of T1.2 of eC4Drivers project (general users, taxi and fleet owners), have been widespread on social media, emails, and forums. More specific for the general survey, a direct approach through emails of CPOs, car sharing companies, and e-bike and LEV companies (17 in total). A mail was sent to the Department of Environment of Brussels (Governmental organization). The survey was disseminated through social media (LinkedIn, Facebook, twitter), and via paid ads through Facebook and LinkedIn. Personal contacts were addressed. University students were approached through announcements, mails, and messages in existing whatsapp groups, and the use of the Prolific platform, a professional paid service to guarantee 150 responses.

Outcome from survey

After data cleaning, the data set contains 309 respondents in total. Of the respondents, 35.28% (109) use any type of electric vehicle, whereas 64.72% (200) does not. Figure 375 shows the type of electric vehicles the respondents use, where the majority is divided between electric car (44.04%) and e-bikes (42.20%).

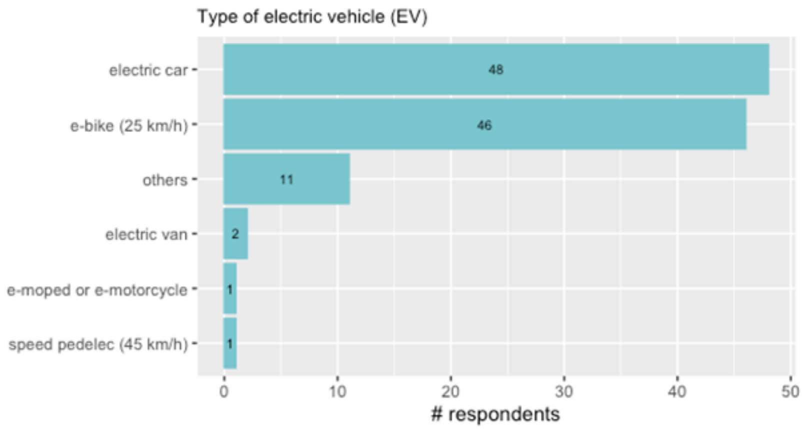


Figure 375 Type of EVs used out of 109 respondents at the Zellik demonstration area

Out of the 48 respondents who use an electric car, 47.92% (23) indicated they drive a battery electric vehicle without an internal combustion engine, whereas 37.50% (18) respondents drive a plugin-hybrid electric vehicle. Also, 2.08% (1) of the respondents drive an electric vehicle with a range extender and 10.42% (5) a hybrid vehicle that combines a classical internal combustion engine with an electric motor.

In regards to the socio-demographic variables, the majority of the respondents were men 66.02%. Most respondents (53.40%) have obtained a university degree or a higher non-university degree (16.50%). The majority is full time employed (66.67%), whereas 66.67% is retired. Almost 53.07% of the respondents is married with or without children (28.16% resp. 24.92%). The different socio-demographics are detailed in Table 83. Almost all respondents (96.12%) possess a driving licence. For most respondents, this concerns a driving licence B (94.17%), followed by driving licence A (13.92%). A small portion of the respondents possess a driving licence C (1.62%), and a driving licence G (1.29%).

Table 83 Socio-demographics of the respondents at the Zellik demonstration area

What is your gender?	N(%)
Female	104 (34)
Male	204 (66)
Other	1 (0)
Indicate your highest obtained diploma or certificate:	
Higher non-university education	51 (17)
None	1 (0)
Post-university education (PhD, Post-doc,…)	42 (14)
Primary education	1 (0)
Secondary education	49 (16)
University education (Bachelor degree, Master degree, …)	165 (53)
Which description best suits your residential situation? – Selected Choice	
I live alone	42 (14)
I live with family	69 (22)
I live with others: co-housing	18 (6)
Married or in relationship with child(ren)	87 (28)
Married or in relationship without children	77 (25)
Other housing situation, namely:	4 (1)
Single parent with child(ren)	12 (4)
How can your professional situation best be described? – Selected Choice	
Currently unemployed	6 (2)
Employed full time	206 (67)
Housewife/Houseman	2 (1)
Independent	14 (5)
Other profession, namely:	1 (0)
Part-time employed	18 (6)
Retired	1 (0)
Student	56 (18)
Temporary exemption (e.g. maternity leave, parental leave)	5 (2)
What is your function within your company or institution?	
Blue collar worker	6 (3)
Liberal profession (lawyers, architects, pharmacists, doctors, notaries, accountants and paramedics, for example)	15 (7)
Middle management	24 (10)
Official / employed in a public service	21 (9)
Own company, entrepreneur with employees	1 (0)
Self-employed, entrepreneur without employees	4 (2)
Senior management / management	14 (6)

Teaching staff / employed in education	23 (10)
White collar employee (administrative, executive or support/clerical function)	122 (53)

EV car users

Out of 50 electric car (48) and van users (2), 19 respondents own the vehicle, whereas 30 drive a company owned car, and 1 a car owned by a car sharing company. Furthermore, only 1 respondent indicated that they use their vehicle as a taxi-cab. The majority of the respondents 36.0%indicated they enjoy a company charging pass, whereas 22.0% enjoys a company fuel pass. 34.0% does not enjoy any company benefits. Furthermore, 12.0% receives a kilometre compensation and 4.0% indicated they enjoy some other type of mobility benefit.

In terms of the battery electric vehicles, the most popular cars are the Tesla Model 3 (7 respondents), followed by a Nissan LEAF (4) and a Audi e-Tron (3 respondents). The Tesla Model S (2 respondents) and the Hyundai IONIQ (1 respondents) close the top 5. The most popular plug-in hybrid electric vehicles are the Mercedes GLE 500e (2 respondents) and the Volvo XC40 (2 respondents). Out of the 2 electric van users, 1 drive a Mercedes eVito, whereas 1 drives a Nissan e-NV200.

Respondents were further asked to indicate the vehicle capacity as well as the battery range without looking it up. Most BEV users, indicate a battery capacity of more than 70 kWh, where the next most popular choice is between 31 and 40 kWh. At the same time, 23 respondents indicate that they do not know the battery capacity. In terms of battery range, the BEV users, mostly indicate this lies between 300 and 400 km. Most PHEV users do not know the battery capacity of their vehicle. In terms of battery range, the majority indicates this lies between 20-39 km. Lastly, the majority of all EV users 50% is driving their current vehicle for less than 1 year. More detailed information can be found in Table 84.

Table 84 EV characteristics at the Zellik demonstration area

	N (%)
Is your EV used as a taxi-cab?	
No.	46 (98%)
Yes.	1 (2%)
Is your [QID3-ChoiceGroup-SelectedChoices] used as a delivery van?	
No.	2 (100%)
Which brand (+model) do you have as a van? – Selected Choice	
Mercedes eVito	1 (50%)
Nissan e-NV200	1 (50%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	**N(%)**
>70	9 (38%)
20–30	2 (8%)
31–40	6 (25%)
41–50	3 (12%)
61-70	1 (4%)
I do not know.	3 (12%)
What is the distance you can travel with a fully charged battery according to your experience?	
> 400	4 (17%)
100–149	1 (4%)
150–199	3 (12%)
200–249	4 (17%)

250–299	3 (12%)
300-400	9 (38%)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	
>20	2 (12%)
10 – 15	4 (24%)
5 – 10	1 (6%)
I do not know.	10 (59%)
What is the distance you can travel electrically with a fully charged battery according to your experience?	
> 50	2 (11%)
20-29	6 (33%)
30-39	6 (33%)
40-50	4 (22%)
How long do you already use the EV you drive?	
< 1 year	24 (49%)
> 4 years	3 (6%)
1 year	9 (18%)
2 years	7 (14%)
3 years	5 (10%)
4 years	1 (2%)

Usage

In this section, we provide an overview of how the charging infrastructure is utilised. Before doing so, we zoom into the reasons for purchasing or using an EV, the average time Evs are used as well as the activities they are used for. Figure 376 shows an overview of reasons for EV usage or purchase, where 1 stands for not at all important and 5 for extremely important.

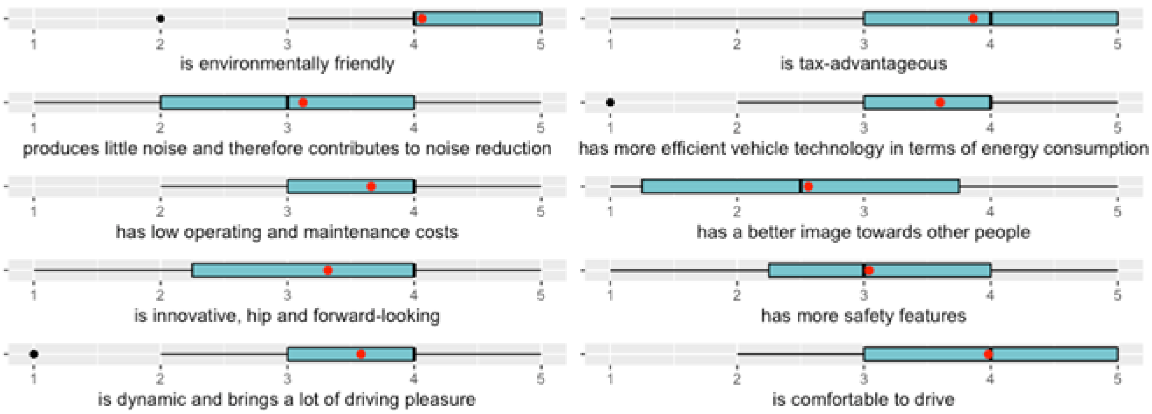


Figure 376 Reasons for EV usage or purchase at Zellik demonstration area

From Figure 376, it is clear that the main reasons for using or purchasing and EV are the environmental friendliness, tax-advantageous, the driving comfort and the fact that Evs have more efficient technology in terms of energy consumption. More specific, the *“environmental friendliness”* was the most important factor as (78%) considered this factor to be very important to extremely important, the least important factor is the *“better image an EV could have towards other people”*, where 26% considered this factor to be not important at all.

Respondents were asked to think about a specific day of the week before and indicate how many kilometres they drove that day, how many hours they parked at specific parking spots and how many hours they were on the road. The average number of kilometres driven on a specific day was 89.6 km, where the average time spent on the road was about 1.5 hours. The EV is mostly parked at a private parking at home for almost 10.71 hours a day on average. Figure 377 gives a more detailed overview of the parking time at different locations.

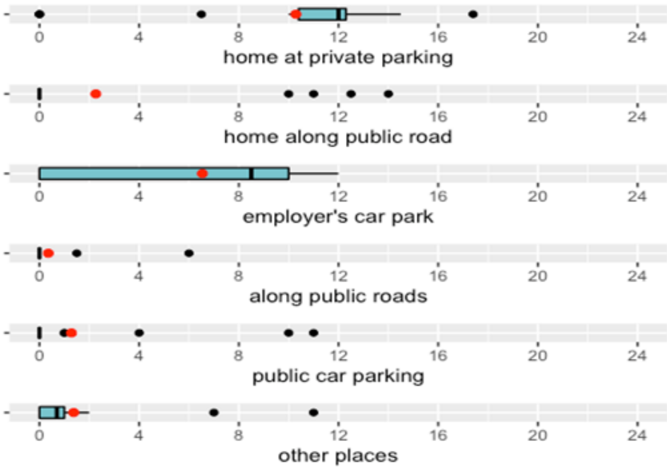


Figure 377 Respondents' EV parking time at different locations at the Zellik demonstration area

When EV users park at home, the majority does so in their driveway or in a privately-owned garage (77.08%).

Next, the respondents were asked to describe their charging behaviour, on a scale of 1 to 7, where 1 stands for strongly disagree and 7 for strongly agree. Most respondents agree with the statements that they charge their EV when their battery falls below a certain level or when there is a possibility to charge. For the other statements, the opinions are more divided (see Figure 370). In regards to charging experience, 8.33% of the respondents indicated they have never charged the EV outside of their home socket station. At the same time, 70.83% charges often at a different location, whereas 25.00% sometimes does.

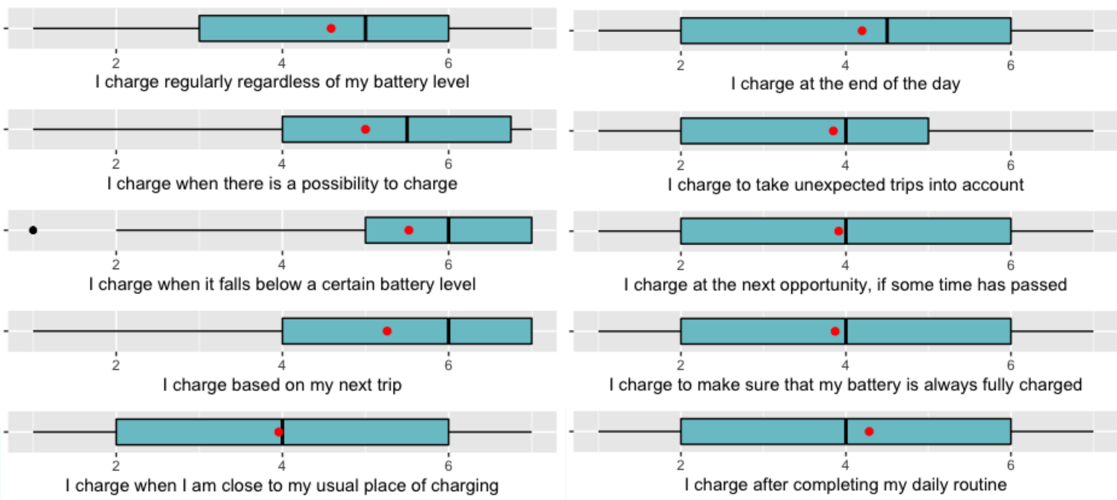


Figure 378 Respondents' charging behaviour at the Zellik demonstration area

Respondents charge the EV most frequently at work, 20% of the respondents charges the EV at work daily and 42.5% does so several times a week. Another popular charging option is charging at home, 28.26% of the respondents charges the EV at home daily and 28.26% does so several times a week. The main charging option at home is a charging station (56.82%), followed by a socket (38.64%). The other 4.54% does not have a charging option at home. The least frequent charging place is at a public charging option (non fast charger), where 37.5% of the respondents indicate that they never charge at work. Also, public fast chargers are more frequently used than non-fast chargers.

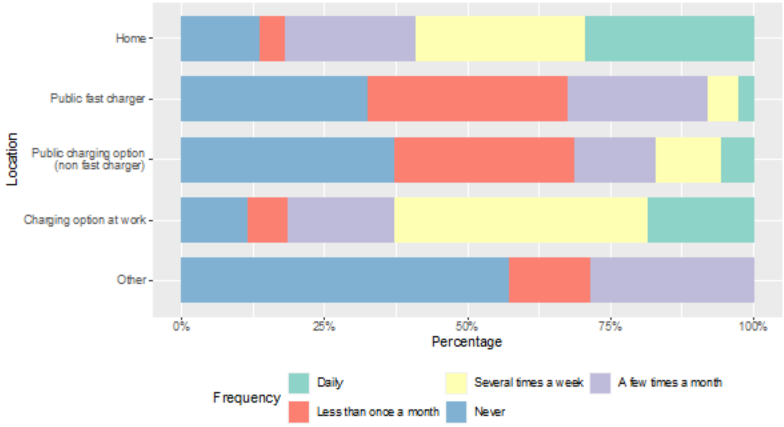


Figure 353 Respondents' charging behaviour per location at the Zellik demonstration area

The most popular charging time is in the evening, after working hours, between 6p.m. and midnight, followed closely by midnight and 3a.m. The least popular time is between 6a.m. and 9a.m. When people arrive at work (9a.m.), they also start charging their EV.

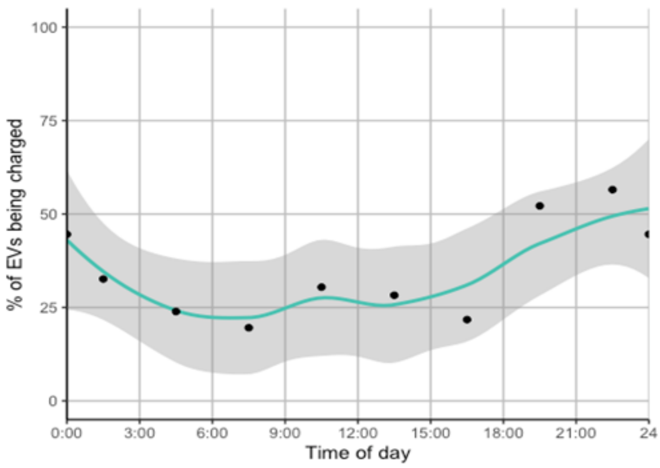


Figure 379 Respondents' charging schedule at the Zellik demonstration area

Quality of Experience

In this section, we look at the user satisfaction and perceptions of the different aspects of the charging experience. If we look at the Charge Point Operator (CPO)/ eMobility Service Provider (eMSP) that the respondents charged at last, it is clear that EV Point is the most popular.

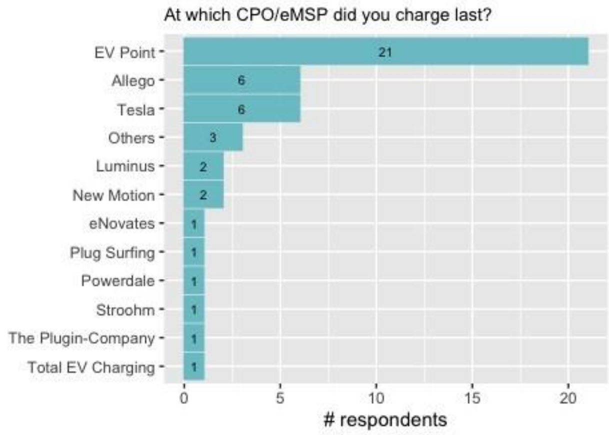


Figure 380 Last charging CPO/eMSP at the Zellik demonstration area

In what follows, we discuss the results and make comparisons for CPOs that were evaluated by at least 5 respondents. Although EV Point is the most popular CPO, it appears to score slightly lower on tangibility than some other less frequently used CPOs. Tangibility takes into account whether the charging infrastructure is considered up to date, is considered to have a pleasant design, tells the customer what service to expect and is in line with the service provided. The tangibility scores for EV Point are spread ranging from very poor to very good. Tesla's charging infrastructure scores highest overall in terms of tangibility (see Figure 381). At the same time, Allego shows a larger distribution to EV Point in terms of tangibility.

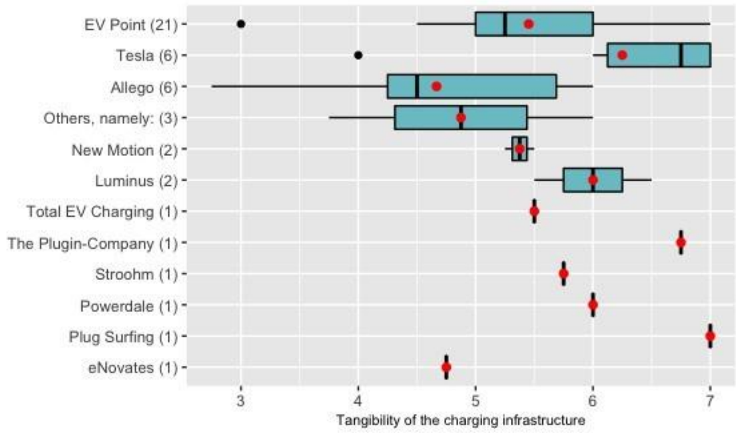


Figure 381 Tangibility of the charging infrastructure at the Zellik demonstration area

For availability of the charging infrastructure, similar scores can be observed (see Figure 382 and Figure 383). The availability captures whether the charging infrastructure is available for use, can start immediately, does not block and is not inadvertently interrupted. Tesla scores significantly high on average for these criteria, whereas Allego, on average, is comparable to EV Point. These CPOs/eMSPs score quite good on average (5 on 7). The reliability captures whether agreements in the area of service provision are kept, whether actions in case of problems are sympathetic and reassuring, the dependability, the timely provision of services and accurate record keeping. EV Point can be placed as average (5 on 7), lying between Allego (4.5 on 7) and Tesla (6 on 7).

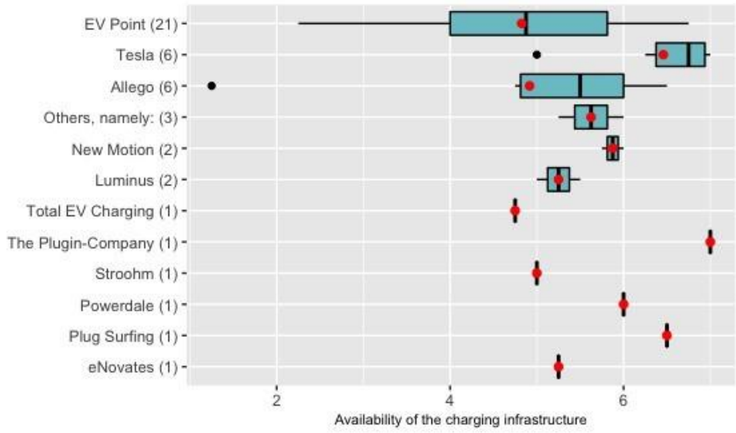


Figure 382 Availability of the charging infrastructure at the Zellik demonstration area

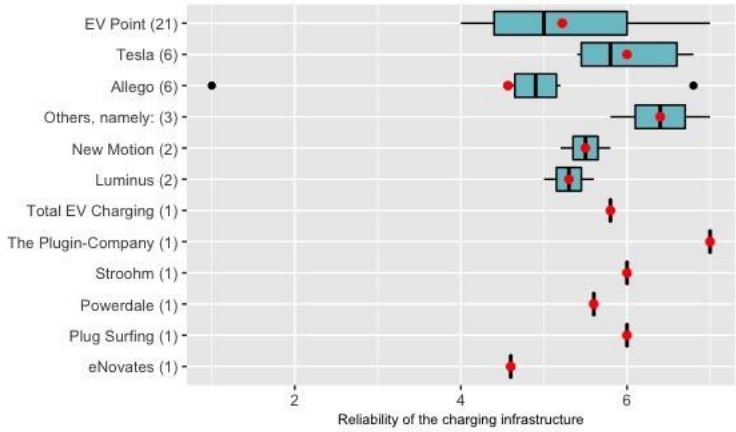


Figure 383 Reliability of the charging infrastructure at the Zellik demonstration area

Looking at the privacy of the charging infrastructure, it is clear that the most reviewed CPOs receive on average similar scores (Between 4.5 and 5.5). Except for Tesla (6.5 on 7), which scores significantly higher (see Figure 384). The privacy construct captures whether the information about charging behaviour is protected, as well as whether personal information is shared with other company's and payment credentials are protected.

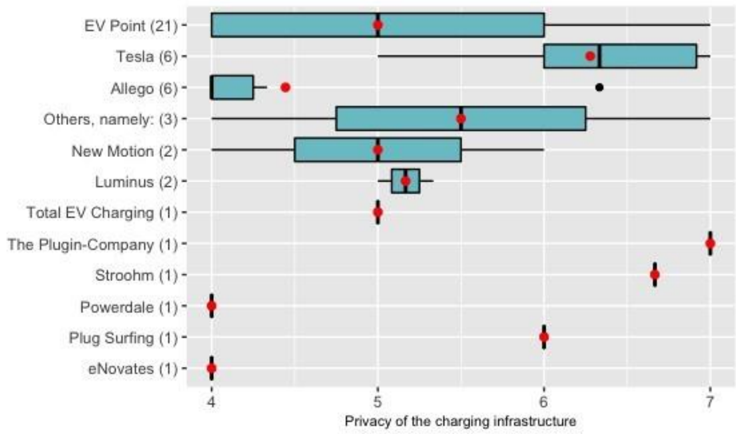


Figure 384 Privacy of the charging infrastructure at the Zellik demonstration area

Aside from general usage of the charging infrastructure, respondents were inquired on their satisfaction in case of problems arising with the charging infrastructure. A total of 11 respondents indicated that they have experienced problems in the past with the chosen CPO/eMSP, whereas 11 indicated they have not. Most charging infrastructure problems are experienced when using EV Point. Indeed, 38.1% (8 out of 21 respondents) indicated to have experienced problems with this CPO. Whereas for Allego and Tesla this is only 16.7% (1 out of 6 respondents) and 33.3% (2 out of 6 respondents) respectively.

The CPO/eMSP is next evaluated in terms of responsiveness, contact and compensation in case of problems. For responsiveness, respondents had to indicate whether they receive an immediate solution, whether the charging infrastructure problems are handled well, if a meaningful guarantee is offered that the charging infrastructure will work, whether they are informed what to do if a charging session does not start and if problems are taken care of promptly. For EV Point, it can be seen in Figure 385 that the scores for responsiveness varied a lot for the different respondents, ranging from bad to very good. Overall, the median and average are still quite low, with slightly more than 4 out of 7. Allego scores very bad, with the lowest average overall, and Tesla scores highest in terms of responsiveness.

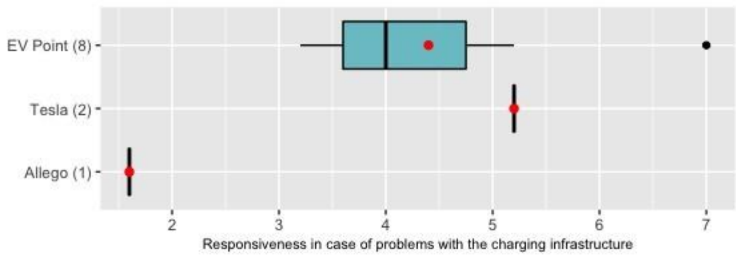


Figure 385 Responsiveness in case of problems with the charging infrastructure at the Zellik demonstration area

Compared to the responsiveness in case of problems, the scores on contact are clearly higher. For contact, respondents had to indicated whether a phone number was provided to reach the CPO, whether a contact person or online customer service is available and whether the ability is provided to speak to a person in case of problems. Although there is still a large spread in the scores, EV Point scores better with an average of almost 5.2 out of 7 for the contact criteria (see Figure 386). The other CPOs scores slightly less but still good, with a score of 5 out of 7.

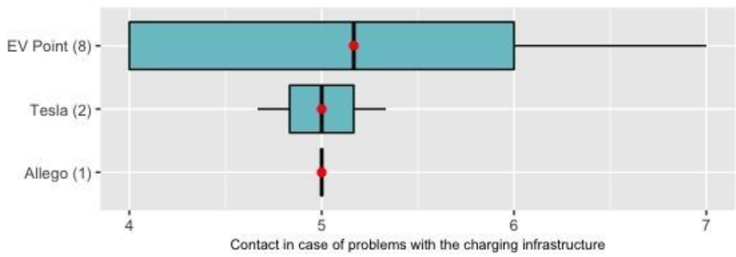


Figure 386 Contact in case of problems with the charging infrastructure at the Zellik demonstration area

Lastly, respondents had to score different criteria for compensation in case of problems. Respondents had to score whether a compensation is offered for the problems, if a compensation is provided if the promised services do not work or if someone comes to help out when a problem occurs. Figure 387 shows that all CPOs/eMSPs score rather poorly on the compensation criteria. A conclusion can be that the user seems to expect more in case of problems than what the CPO/eMSP currently offers. Again, Allego scores very bad, with the lowest average overall. The ones that score best on average are Tesla.

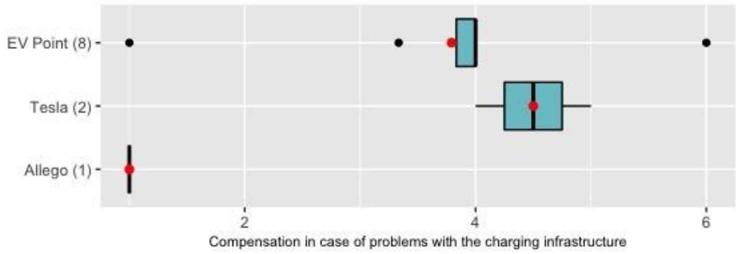


Figure 387 Compensation in case of problems with the charging infrastructure at the Zellik demonstration area

Finally, the last questions in this section probe for the respondents' opinions on the perceived value of the CPO/eMSP, the loyalty to the CPO/eMSP and the general customer satisfaction. In terms of perceived value, respondents had to indicate whether prices are clearly displayed or easy to find, whether the charging infrastructure is easy to use, whether the respondents feel in control over the charging service and whether they get the impression to get value for money. Most CPOs/eMSPs score on average quite well on the perceived value criteria (see Figure 388). Again, Tesla scores the best.

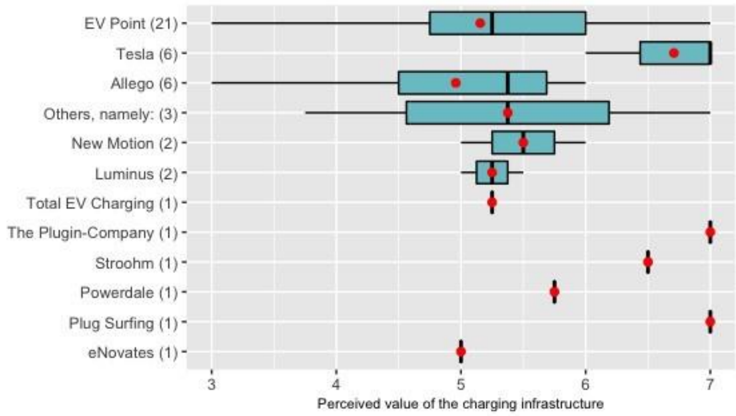


Figure 388 Perceived value of the charging infrastructure at the Zellik demonstration area.

In terms of loyalty, respondents had to indicate whether they are positive about the CPO/eMSP towards other e-drivers, whether they would recommend it, whether they encourage other companies or colleagues to work with the CPO/eMSP and whether it will remain their first choice in the future. Aside from some outliers, Tesla scores clearly highest on the loyalty criteria (see Figure 389). Allego, again, receives a wide range of scores, resulting in an average of almost 4.2 out of 7. EV Point seems to have loyal customers overall, with an average of almost 5 out of 7.

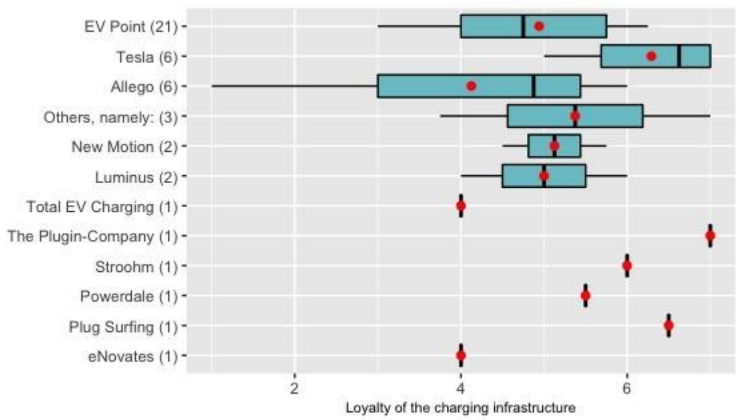


Figure 389 Loyalty of the charging infrastructure at the Zellik demonstration area

To close this section on quality of experience, we look at the customer satisfaction of the respondents. Confirming the general trend in the earlier questions, the highest scoring CPOs/eMSPs is Tesla. EV Point receives good scores, resulting in an average of 5.2 out of 7 (see Figure 390). Allego scores just a fraction less, with a score of 4.8 out of 7.

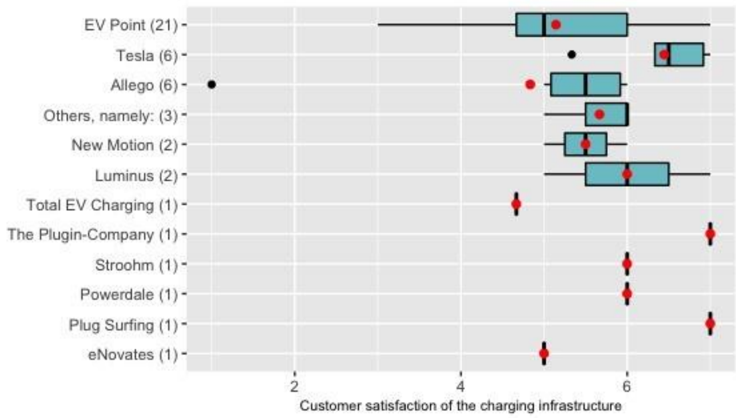


Figure 390 Customer satisfaction of the charging infrastructure at the Zellik demonstration area

Acceptance

The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging options are the most popular with 50% of respondents choosing they are most likely to use fast charging options in the future. Furthermore, 26% of the respondents have the intention to use user friendly charging stations, and 22% of the respondents would use smart charging in the future. One respondent indicated to use battery swapping in the future.

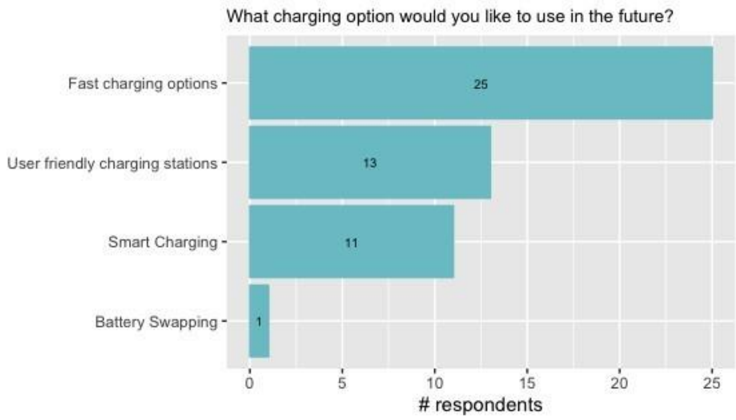


Figure 391 Most likely charging option in the future at the Zellik demonstration area

The fast charging is the option mostly selected by the users and scores high in terms of behavioural intention. Behavioural intention captures whether respondents predict they will choose the charging option in the future, whether they plan to use it if it becomes permanently available and whether they intend to use it again during the demonstration. The behavioural intention to use smart charging is slightly higher than the behavioural intention to use user friendly charging stations.

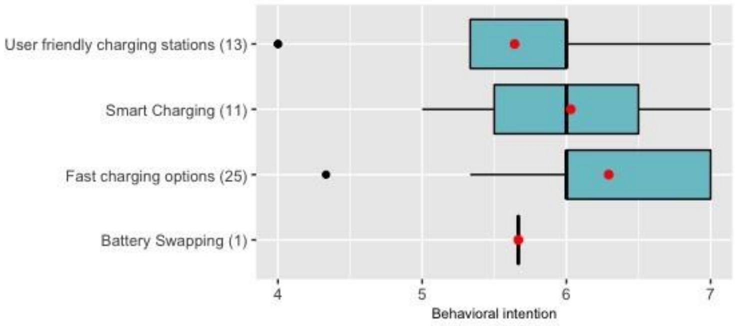


Figure 392 Behavioural intention of charging infrastructure at the Zellik demonstration area

Performance expectancy captures whether the chosen charging option is considered to be a useful mode of charging, whether it will help the respondents achieve things that are important to them and whether it would help to reach the preferred state of charge more quickly. Cleary, the fast charging option scores highest on these criteria, aside from a few outliers (see Figure 393).

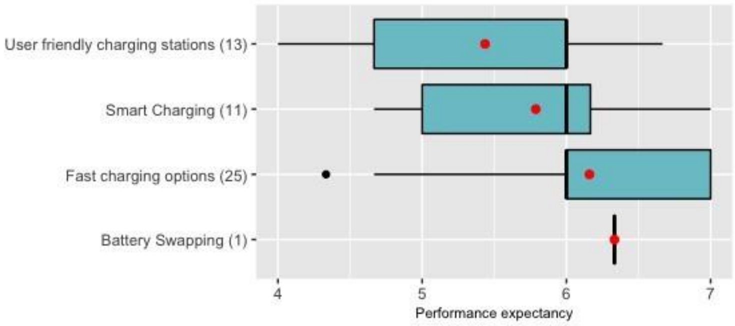


Figure 393 Performance expectancy of the charging infrastructure at the Zellik demonstration area

The next construct that was investigated, is the effort expectancy. This captures whether the respondents expect the charging infrastructure to be clear and understandable, whether it will be easy to use, and easy to learn. It is interesting to see that the scores for battery swapping are higher than other charging options (see Figure 394). Less effort is expected for fast charging options, but fast charging also varies more than other charging options, indicating that respondents expect some effort into getting acquainted with this charging option compared to smart charging stations and user friendly charging stations.

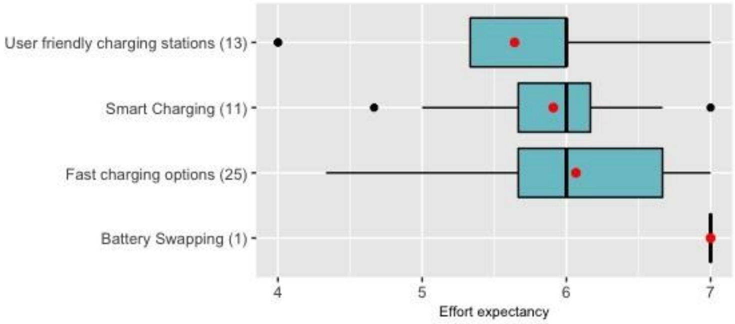


Figure 394 Effort expectancy of the charging infrastructure at the Zellik demonstration area

The construct social influence captures whether respondents believe that people who are important to them or influence their behaviour think they should use the charging infrastructure, whether people whose opinions they value think they should use it and whether support is expected from the authority. There are no clear discrepancies between the different charging infrastructures that can be noted in terms of this construct (see Figure 395). The averages and medians all lightly fluctuate between 4 and 5 on a scale of 7.

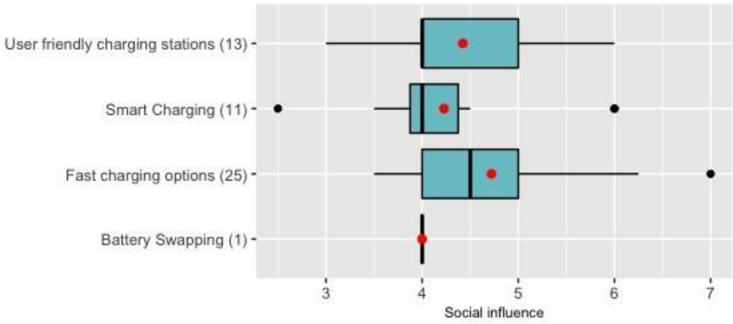


Figure 395 Social influence of the charging infrastructure at the Zellik demonstration area

In terms of facilitating conditions, the charging options have more or less the same expectations around 5 out of 7. On average visibly higher than the other charging options is battery swapping (see Figure 396). Facilitating conditions measures whether the respondents believe they have the necessary resources to use the chosen charging option, whether they have the necessary knowledge to use it, whether it is compatible with the other forms of charging they use and whether they could get help from others when they use it.

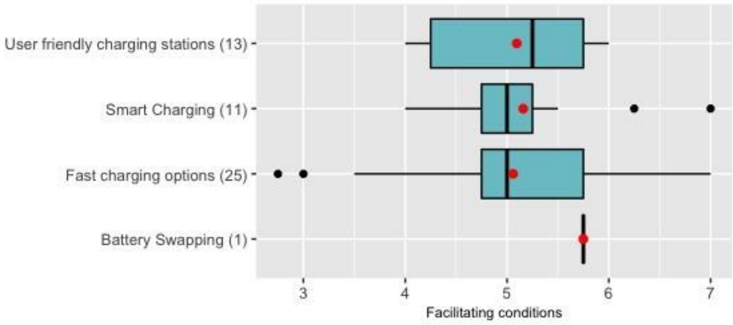


Figure 396 Facilitating conditions of the charging infrastructure at the Zellik demonstration area

As for hedonic motivation, quite similar distributions can be observed for the different charging options (see Figure 397). Hedonic motivation captures whether the chosen charging option is considered to be fun, entertaining or enjoyable.

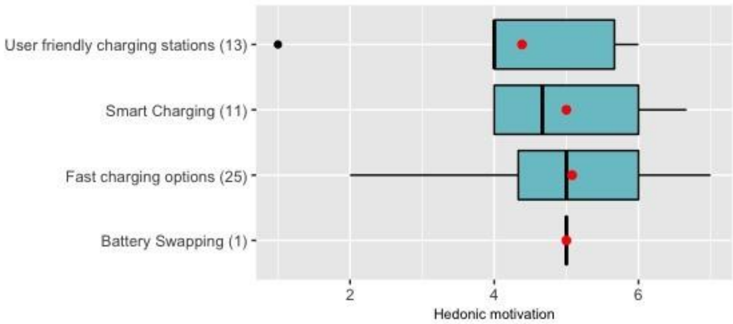


Figure 397 Hedonic motivation of the charging infrastructure at the Zellik demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their car charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, it is interesting to note that half of the respondents would not seem to mind to pay more for fast charging options (see Figure 398). At the same time for smart charging, almost 75% indicates they would only use it if the price is lower.

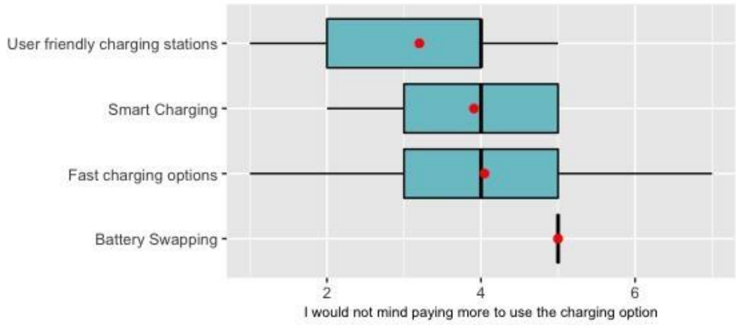


Figure 398 Price value of the charging infrastructure at the Zellik demonstration area

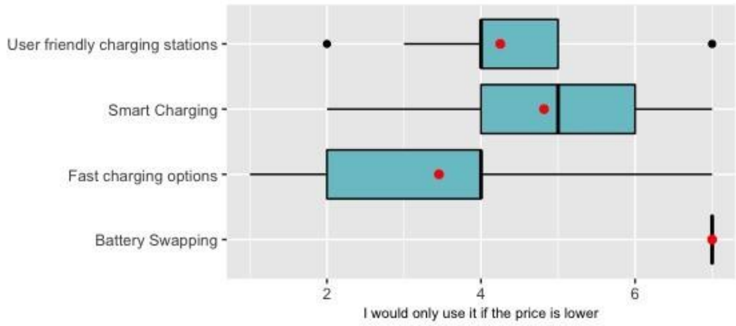


Figure 399 Price motivation of the charging infrastructure at the Zellik demonstration area

App-based services

Lastly, EV users were inquired on the use of app-based services. Less than half of the respondents, 48.0% (24 respondents) indicated they use app-based services, another 22.0% does not but intends do. The remainder of the respondents have no intention to use an app in the near future. In terms of the app usage, a third of the EV respondents has 4 or more apps on their phone. About 75.0% of the app-based service users, users this at least a few times a month, as can be seen in Figure 400.

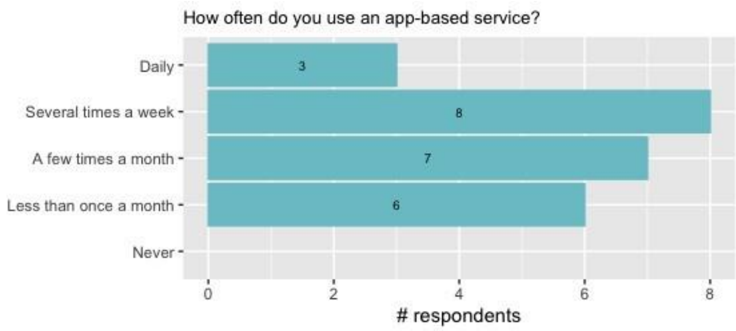


Figure 400 Usage of app-based services at the Zellik demonstration area

App-based services are mostly used for travel related to travel destinations on holiday (14 respondents), whereas 14 respondents use it for leisure activities. To a lesser extent, the app-based services are used for commuting and work activities (9 respondents) and shop/errands (6 respondents). In terms of satisfaction with the used app-based services, Figure 401 shows that the respondents are satisfied above average on a scale of 1 to 7.

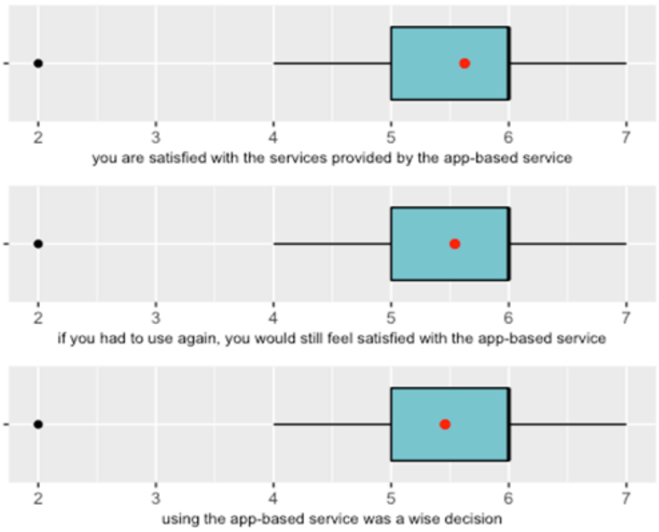


Figure 401 Satisfaction with the app-based services at the Zellik demonstration area

LEV

In this section, we zoom in to the 48 respondents who use a light electric vehicle. The majority of the respondents (89%) owns the LEV they use and are responsible for the LEV maintenance costs (91.67%). At the same time, the majority of the respondents does not know what the battery capacity is or did not fill out this question (68.75%). Most respondents use their LEV daily or several times a week. The detailed responses can be seen in Table 82.

Table 85 LEV characteristics at the Zellik demonstration area

	N (%)
Who is the owner of the LEV you normally drive?	
sharing company	5 (8)
Company/Leasing company	6 (10)
Private	48 (81)
Who is responsible for the maintenance costs of the LEV you drive?	
Company	6 (11)
Private	48 (89)
What is the capacity of the battery (in kWh)? Indicate it without looking it up.	
> 7	1 (2)
0,5 – 1	3 (6)
1-3	5 (9)
3-5	6 (11)
5-7	2 (4)
I do not know.	37 (69)
How often do you use your LEV?	
A few times a month.	13 (24)
Daily.	8 (15)
Less than once a month.	2 (4)
Several times a week.	31 (57)
Do you use a fixed car park or garage?	
I use a fixed car park which is my property.	7 (13)

I use a fixed, rented parking space.	4 (7)
I use a garage that is my property or park on my driveway.	23 (43)
I use a rented garage.	3 (6)
No.	17 (31)

On average, the LEV users indicate they drive about 20.46 km each day and spend about a half hour on the road. The majority of the time, the LEV is parked at home at a private parking or at home along a public road (see Figure 402).

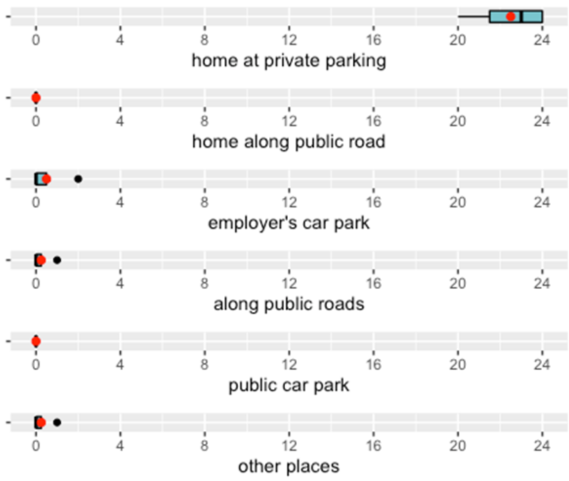


Figure 402 Parking space and duration of the LEV at the Zellik demonstration area

Looking at the motives to use an LEV, it is clear that the most important motive is the *"environmental friendliness"* together with *"driving pleasure and comfort"*, whereas least important is the *"image towards other people"*.

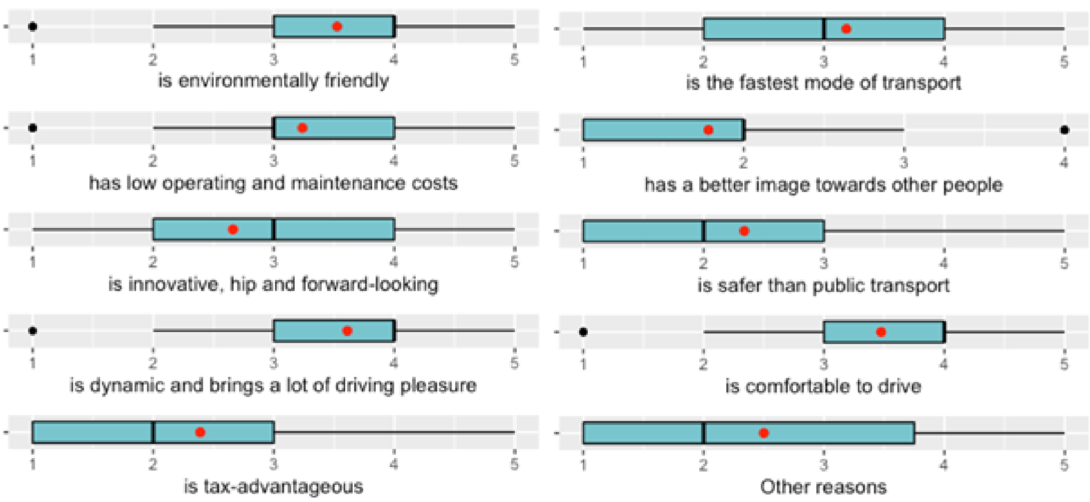


Figure 403 Motives to use LEVs at the Zellik demonstration area

In terms of charging behaviour, the majority of the respondents (75%) seem to charge when the battery falls below a certain level, or based on their next trip. Also, 50% of the respondents charge to take unexpected trips into account and 50% of the respondents seem to make sure that the battery is always fully charged.

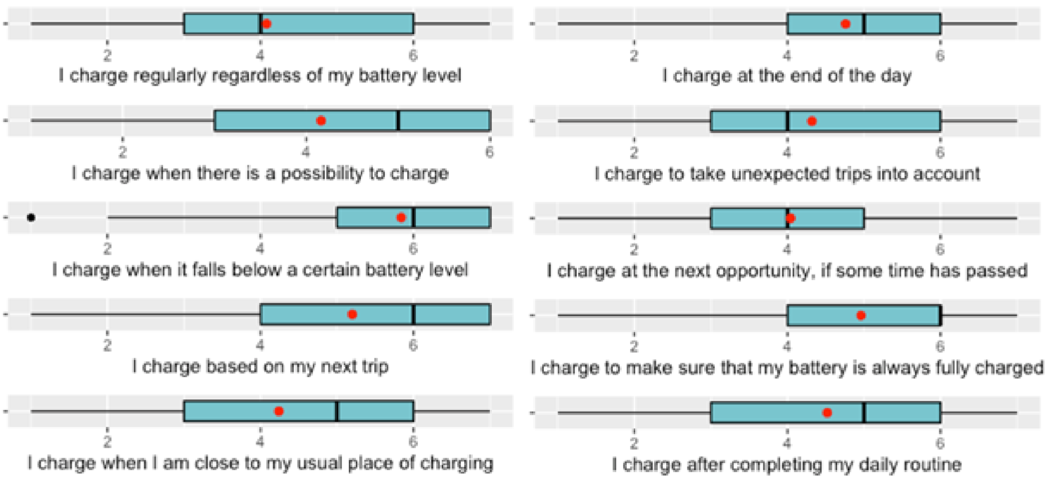


Figure 404 LEV charging behaviour at the Zellik demonstration area

Quality of Experience

Out of 48 respondents, all the respondents indicated that they do not use the service of a CPO/eMSP. As such, the quality of experience will not be discussed in this section.

Acceptance

In this section, the acceptance of charging infrastructure of users is investigated as well as their intentions to certain charging infrastructure options in the future. The survey implemented the Unified Theory of Acceptance and Use of technology (UTAUT), where the users had to express to which extent they agree with different statements. The statements form different constructs within the UTUAT model, performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation. These independent variables have been shown to predict behavioural intention, i.e., the intention to use this technology in the future. First, respondents had to indicate which charging option they were most likely to use in the future. Clearly, fast charging options are the most popular with 43,75% of respondents choosing they are most likely to use fast charging options in the future. 18.75% of the respondents indicated that they would use battery swapping, 16,67% smart charging and 14.75% would like to use user friendly charging stations in the future.

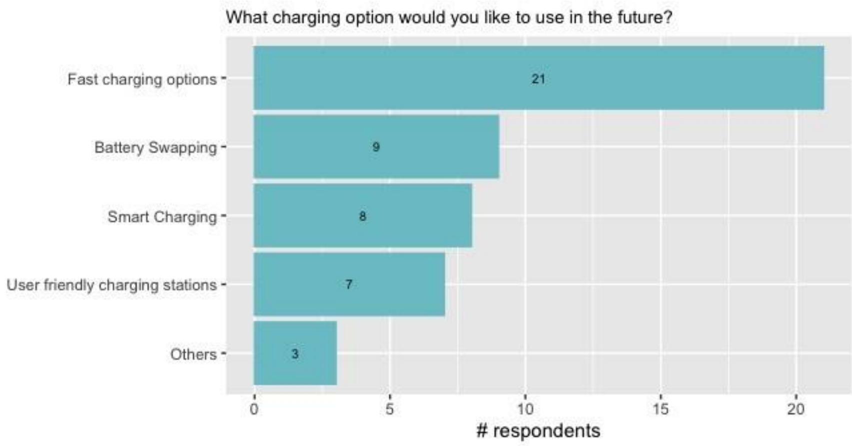


Figure 405 Preferred LEV charging option to use in the future at the Zellik demonstration area

Next, we take a closer look at the UTAUT constructs for the 2 biggest categories. Looking at behavioural intention, it can be seen in Figure 406 that the intention to use user friendly charging stations as well as fast charging options is rather high (aside from some outliers), where user smart charging stations and battery swapping score somewhat higher than the other two charging options.

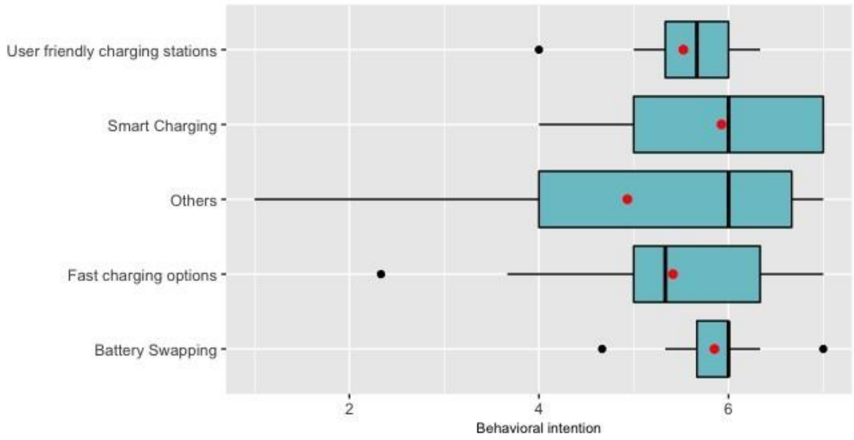


Figure 406 Behavioural intention for LEV charging options at the Zellik demonstration area

In terms of the performance and effort expectancy (see Figure 407 and Figure 408) , the respondents evaluate all the solutions well. Again, battery swapping and smart charging perform slightly better.

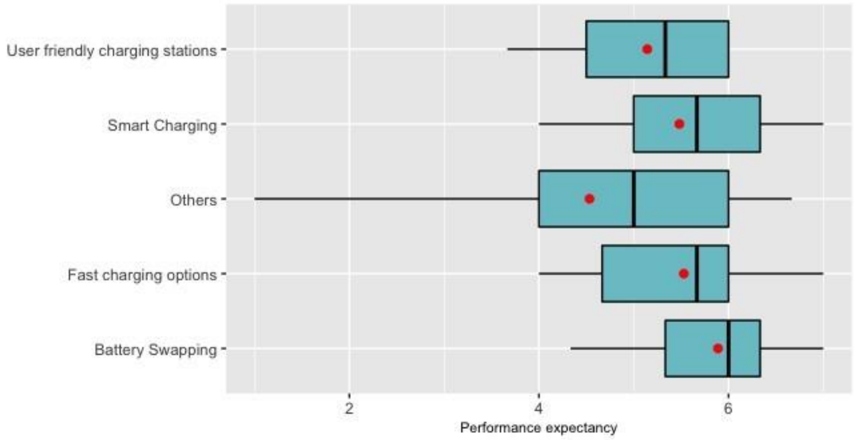


Figure 407 Performance expectancy of the LEV charging options at the Zellik demonstration area

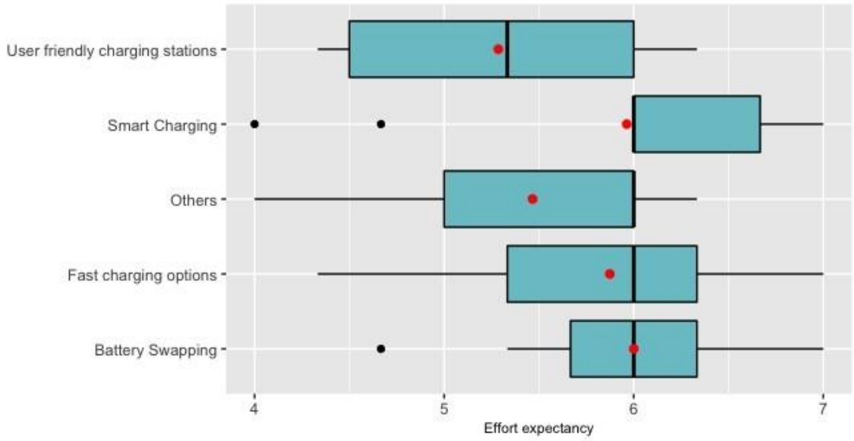


Figure 408 Effort expectancy of the LEV charging options at the Zellik demonstration area

In terms of facilitating conditions, more than 75% of the respondents ranges from neutral to well agreeing with having the necessary resources and knowledge to use the charging option and having the charging option be compatible with other forms they use (see Figure 409).

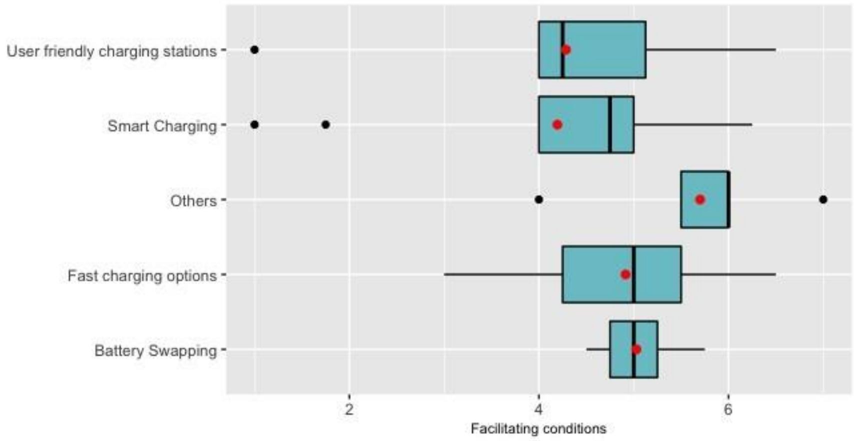


Figure 409 Facilitating conditions of the LEV charging options at the Zellik demonstration area

The social influence on using certain LEV charging options as well as the hedonic motivation are scored rather neutral on average (see Figure 410 and Figure 411). As such for social influence, respondents do not agree or disagree with the fact that people who are important or influence their behaviour think they should use this charging option. Neither are respondents influenced by whether a charging option is considered to be fun or entertaining, which is captured through the scores on hedonic motivation.

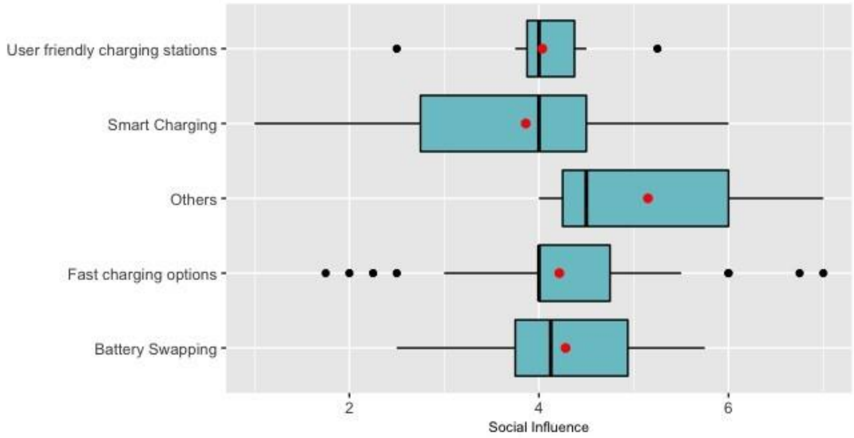


Figure 410 Social influence of the LEV charging options at the Zellik demonstration area

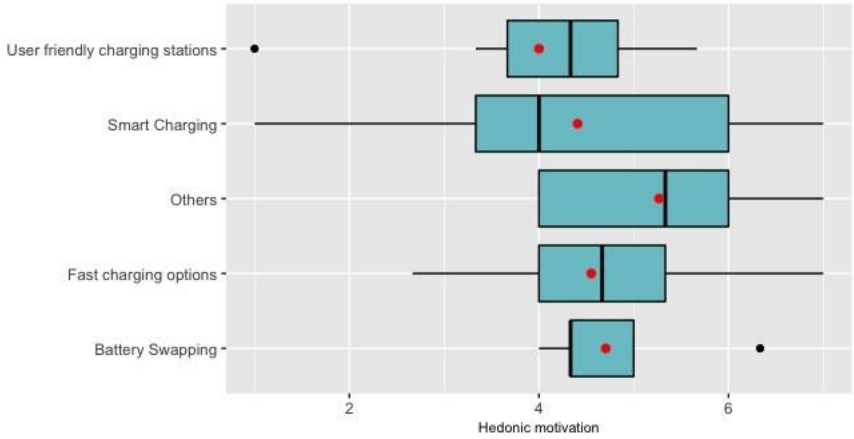


Figure 411 Hedonic motivation of the LEV charging options at the Zellik demonstration area

For the price value, respondents had to indicate whether they would not mind paying more to use the charging option, whether they would not mind spending a lot of money for getting their LEV charged by the charging option, whether they would only use it if the price is the same or whether they would only use it if the price is lower. Here, the respondents indicate they want to pay less for future charging options in comparison with current charging options (see Figure 412). At the same time for user friendly charging stations, the respondents indicate they would only use it if the price is lower.

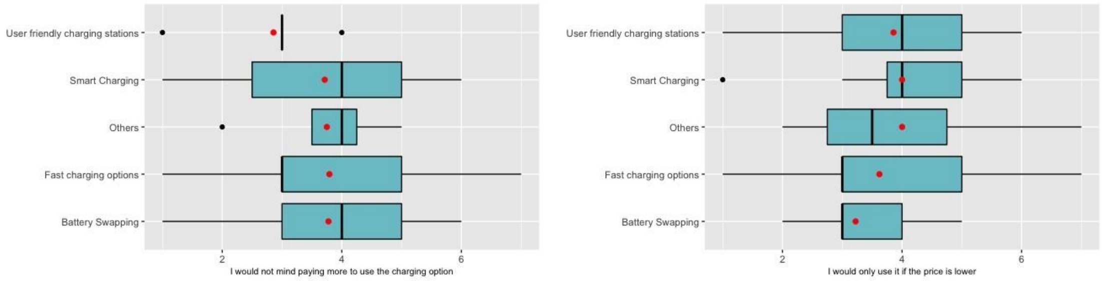


Figure 412 Price value of the LEV charging options at the Zellik demonstration area

App-based services

Lastly, LEV users were inquired on the use of app-based services. Here, 29.17% of the respondents, indicated they use app-based services. The remainder of the respondents have no intention to use an app in the near future. About 92.9% of the app-based service users, users this at least a few times a month, as can be seen in Figure 413.

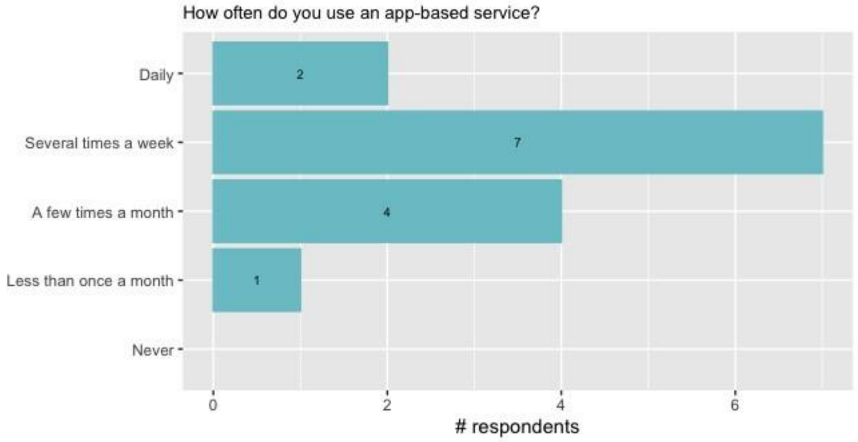


Figure 413 Usage of app-based LEV services at the Zellik demonstration area

While app-based services were most frequently used for travel related for shop/errands with the EV users, this is the least frequent usage for LEV users (only 8 respondents). LEV users use app-based services mostly for leisure activities (13 respondents), next for commuting and work activities (10 respondents), followed by to travel destinations on holiday (10 respondents). In terms of satisfaction with the used app-based services, Figure 414 shows that all the respondents are satisfied above average on a scale of 1 to 7.

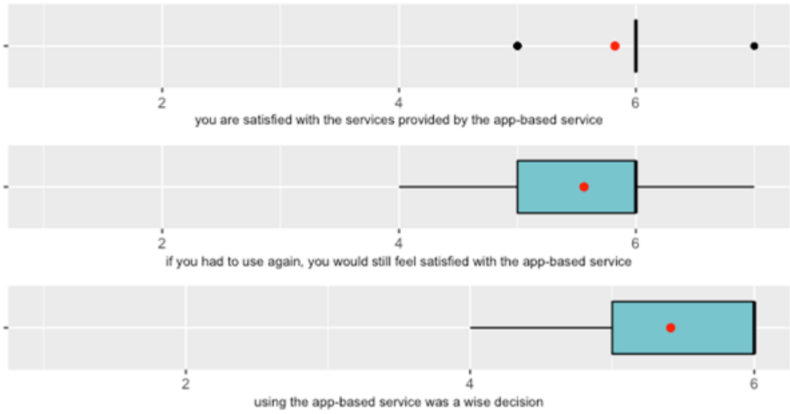


Figure 414 Satisfaction with the LEV app-based services at the Zellik demonstration area

Non-EV users

Lastly, we zoom into the non-EV users, a total of 200 respondents. Interestingly, less than 50% of the respondents' states that will buy an electric vehicle as soon as possible or state that it is very likely they will buy an electric vehicle.

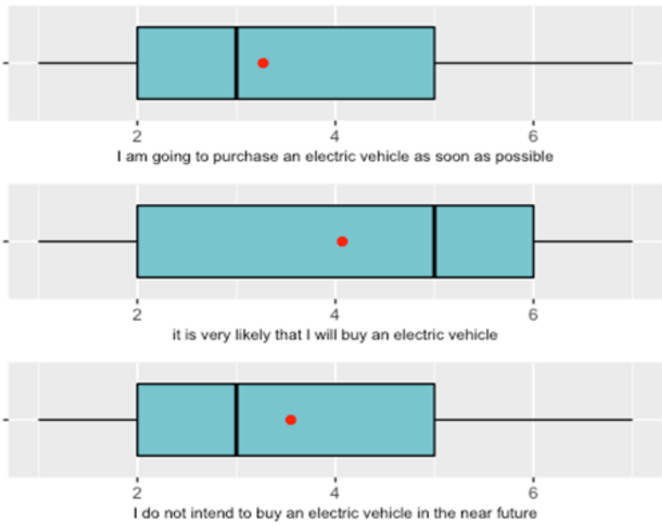


Figure 415 Non-users' Intention to buy an EV at the Zellik demonstration area

Moreover, most respondents (78.57%) indicate they are mostly interested to buy an electric car. Out of these 77 respondents, the opinions are quite divided on whether they prefer a battery electric vehicle (34 respondents), an electric vehicle with range extender (11 respondents) or a plug-in hybrid electric vehicle (15 respondents). The remaining 17 respondents prefer a hybrid vehicle that combines a classic combustion engine.

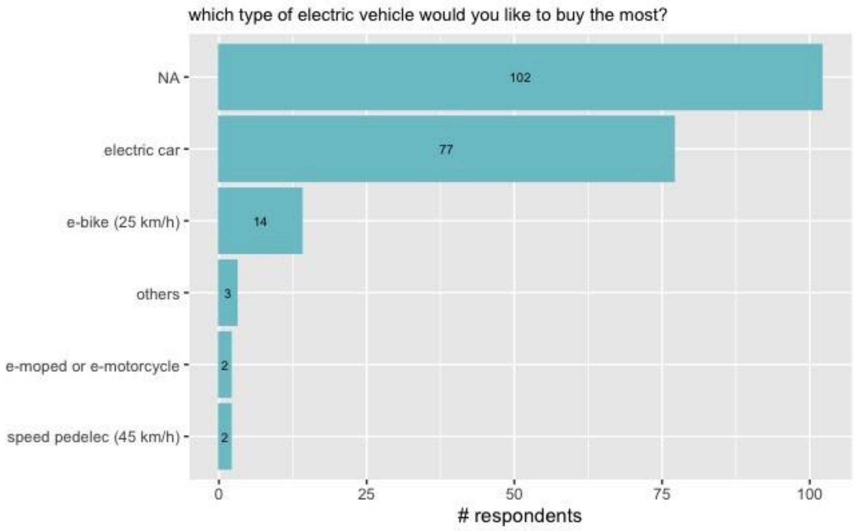


Figure 416 Type of EV that non-users intend to buy at the Zellik demonstration area

Lastly, the most important motives for non-EV users to purchase an EV in the future is the *"environmental friendliness"* and the fact that EVs have "*more efficient technology in terms of energy consumption"* as 89% respectively 74% considers this moderately to extremely important. At the same time, the least important motive is the better image EVs could have towards other people as 87% of the respondents consider this not important at all to slightly important.

Key findings of the Zellik report

The main reasons for electric car adoption are the green environmental footprint, and the fact that EVs have more efficient technology in terms of energy consumption. In terms of charging behaviour, it is interesting that electric car users charge most frequently at work, where 62.5% of the respondents charge more than several times a week. Charging at work is followed closely by charging at home. Remarkably, the least frequent charging place is the public charging option (non-fast charger), where 37.5% of the respondents indicate that they never charge public. Overall, the electric car users are happy with the quality of service that the CPO/eMSP provide. The most popular charging time is in the evening, after working hours, between 6p.m. and midnight, followed closely by midnight and 3a.m. This could be an important incentive for smart charging. Fast charging is the most preferrable charging option to use in the future and users see this also as the charging option the easiest to use. Respondents expect a similar price for future charging option compared with the current charging options.

LEV users mainly bought their LEV because it is environmentally friendly, and because of the driving pleasure. Half of the LEV users charge their LEV with unexpected trips in mind and make sure that the battery is always fully charged. Smart charging is the most preferrable charging option in the future and respondents expect a similar price compared to current charging options.

Lastly, less than half of the non- EV states that they will not buy an electric vehicle in the short-term horizon. The respondents that would like to buy an EV in the future are mostly (78.54%) interested in buying an electric car. The most important motives for non-EV users to purchase an EV in the future are the environmental friendliness (89%) and more efficient technology in terms of energy consumption (74%) in comparison with non-EV. At the same time, the least important motive is the better image EVs could have towards other people as 87% of the respondents consider this not important at all to slightly important. These results are similar to the results of EV users.

Outcome from historical data

Given that there were no chargers yet installed in the demonstration area of Zellik, no data was provided to analyse.

Social Media Analysis Results

ENGLISH

The following section presents the results for the social media analysis of the English tweets.

Charging Infrastructure

The following diagram shows the top 20 most frequent terms for the charging infrastructure topic.

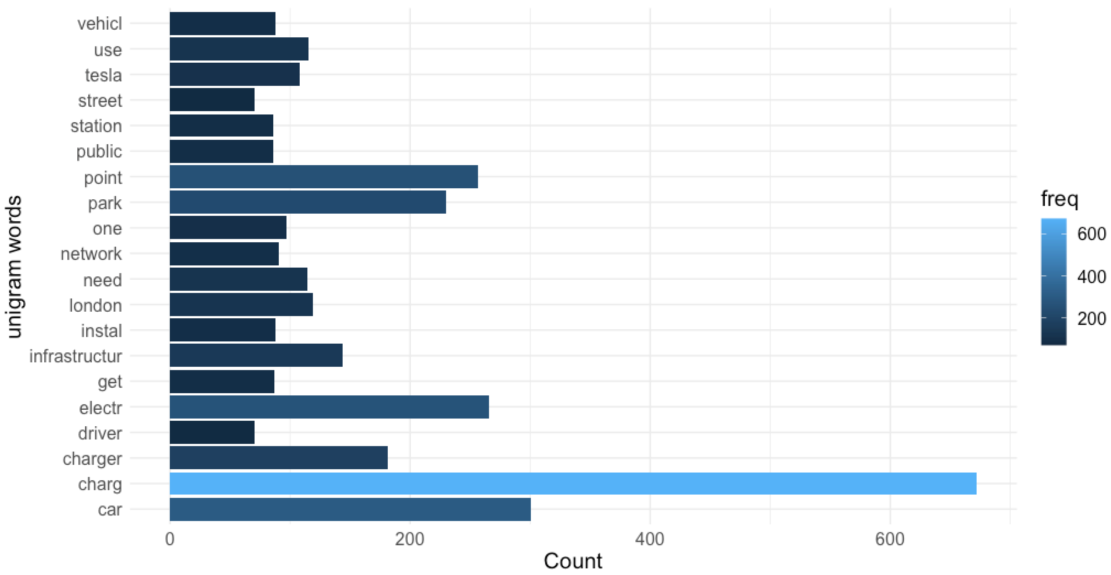


Figure 417. Unigram Term frequencies - top 20 plot - Charging Infrastructure – English

The following figure presents the network of words.

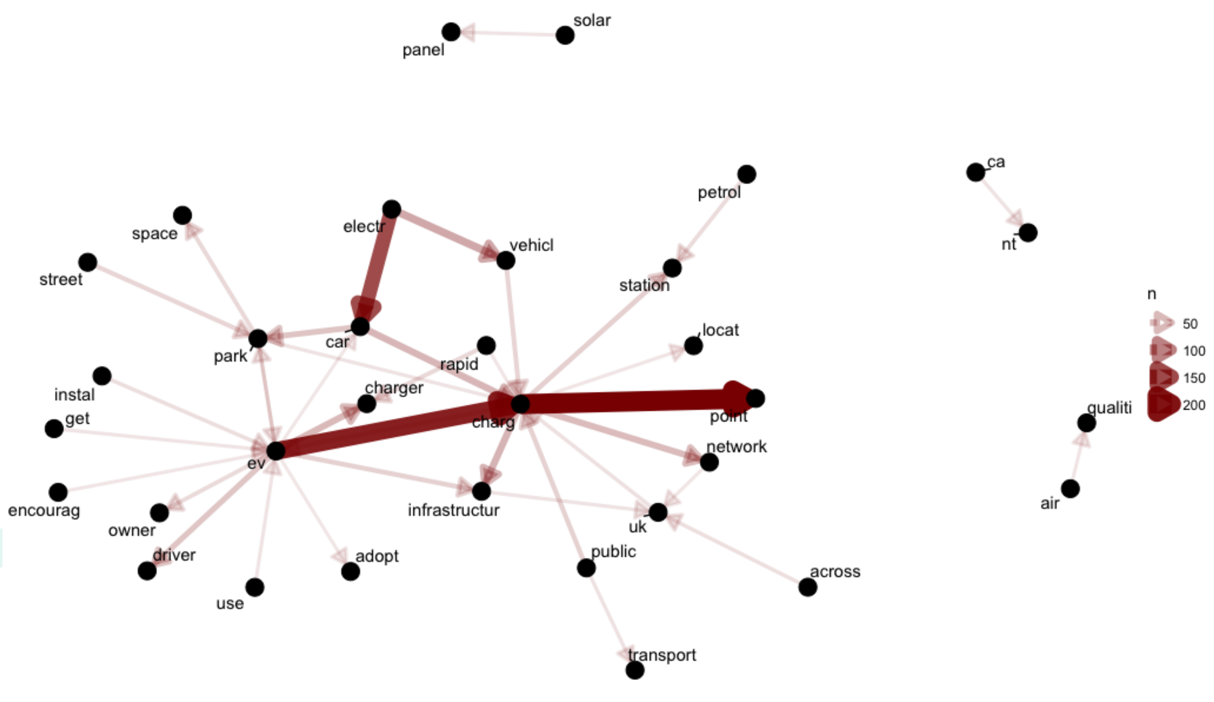


Figure 418. Network of words - bigram - Charging infrastructure - English

Then, the most frequent bigrams have been analysed and plotted in the following figure.

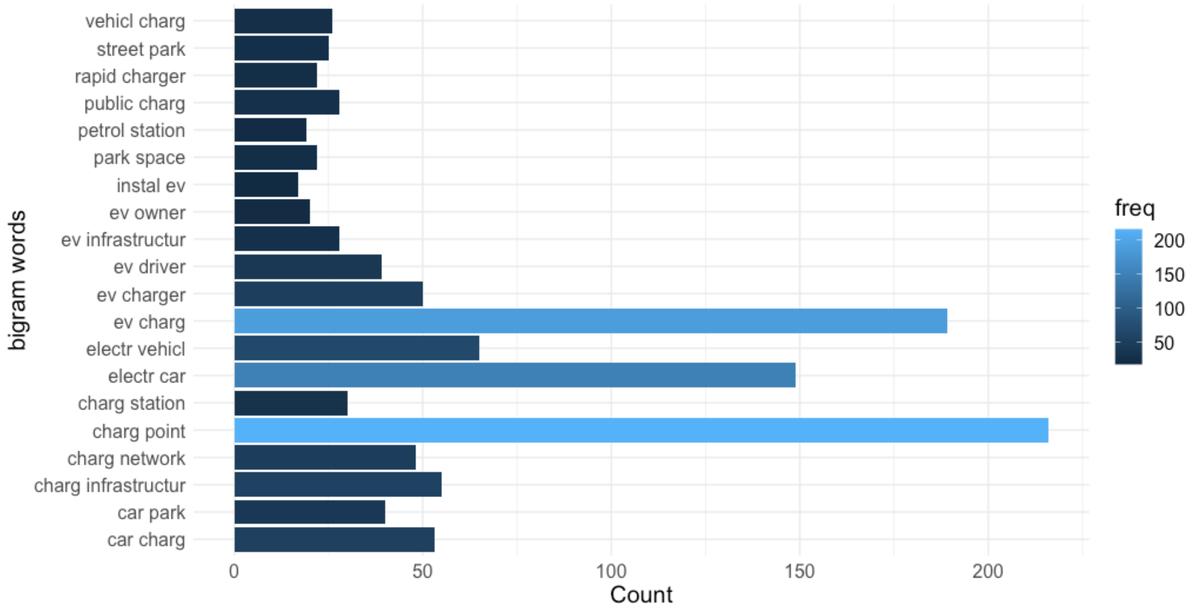


Figure 419. Bigram Term frequencies - top 20 plot - Charging Infrastructure – English

74% of the tweets from this topic are classified as positive and 26% as negative. Then, the following figure presents the emotion distribution for the charging infrastructure topic.

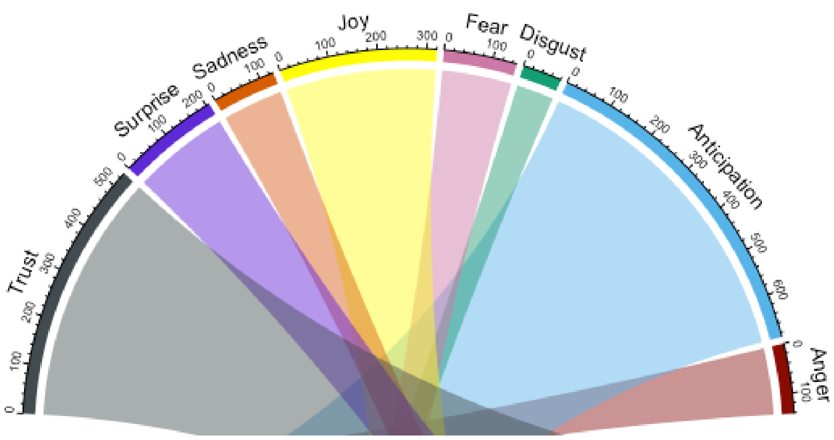


Figure 420. Emotion distribution for tweets of Charging Infrastructure Topic - English

Environment

The following diagram shows the top 20 most frequent terms for the environment topic.

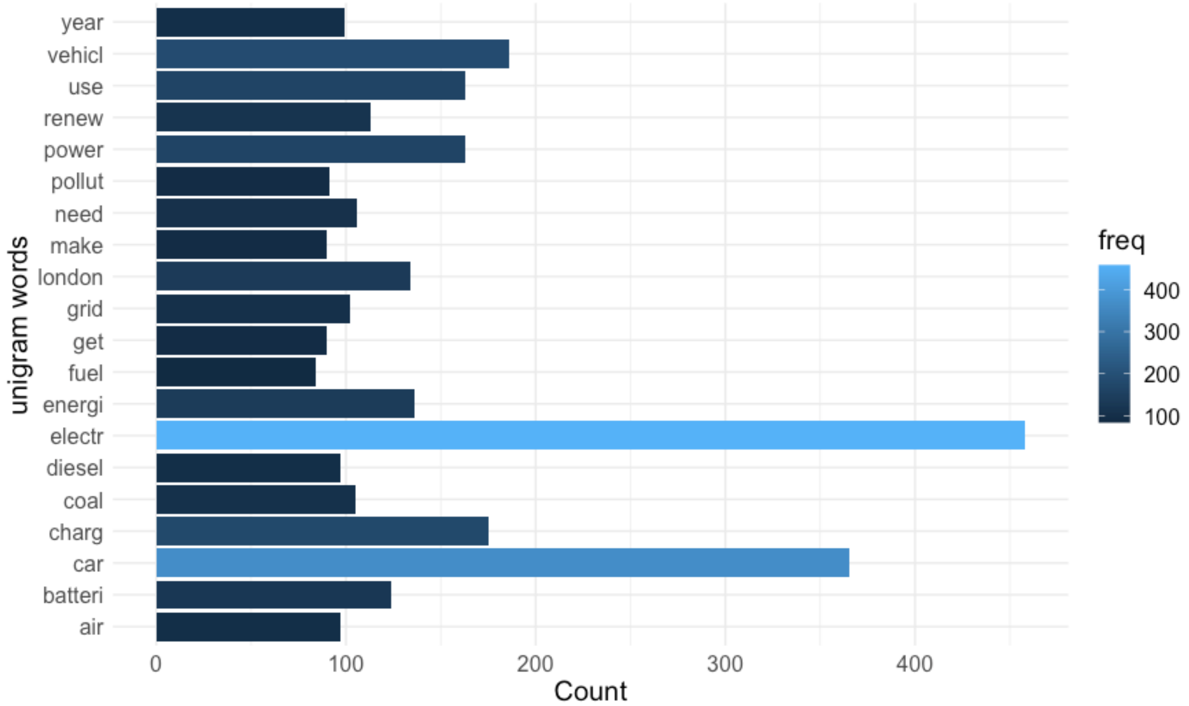


Figure 421. Term frequencies - top 20 plot – Environment – English

Figure 422 presents the network of words.

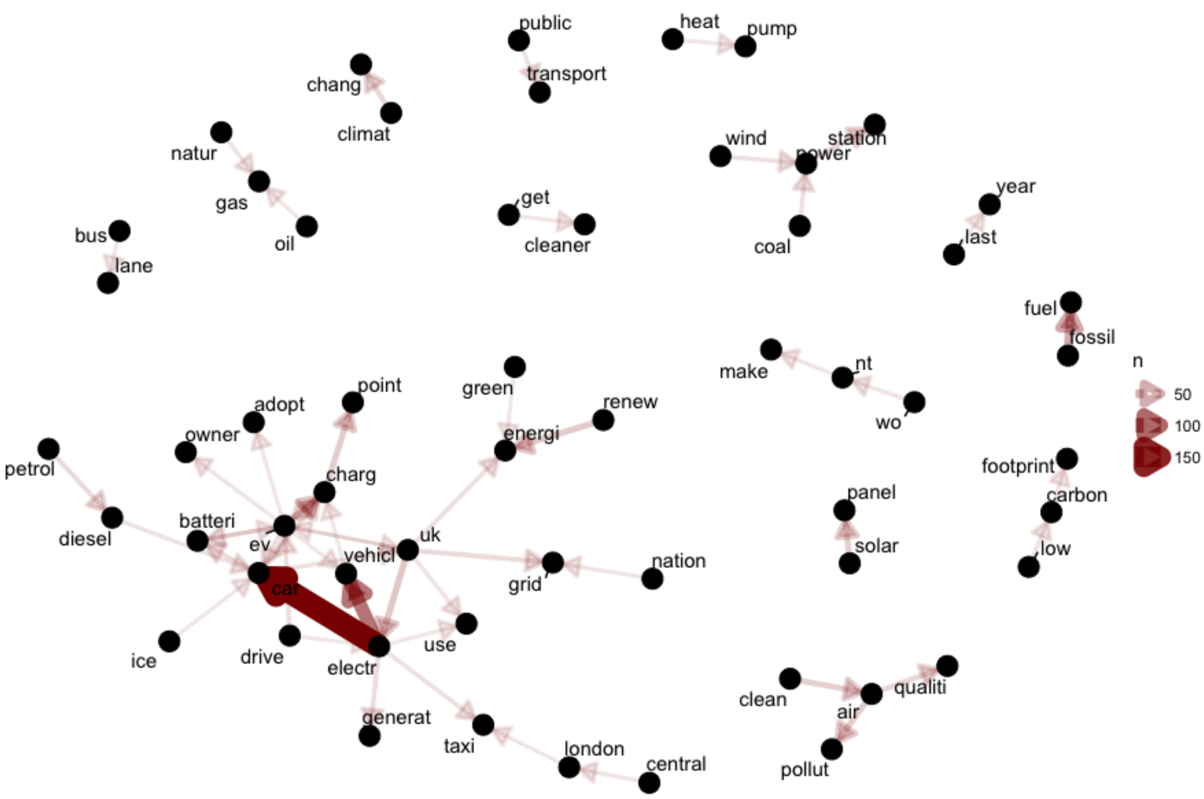


Figure 422. Network of words - bigram – Environment – English

Then, the most frequent bigrams have been analysed and plotted in the following figure.

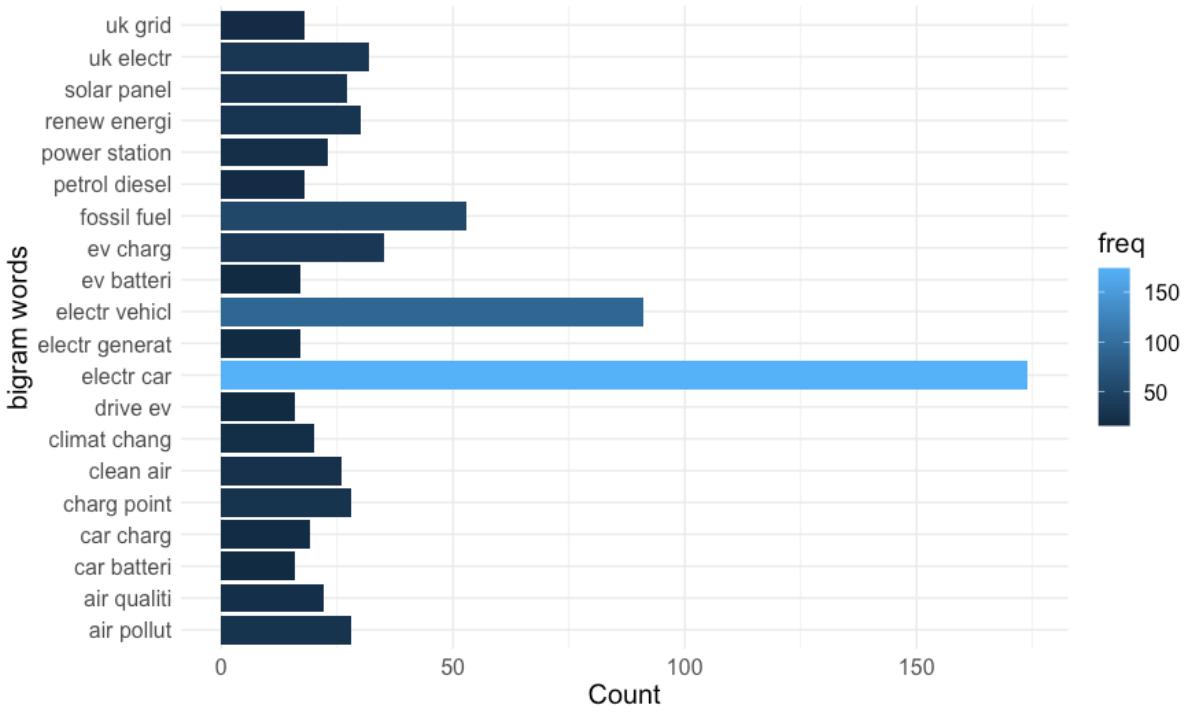


Figure 423. Bigram Term frequencies - top 20 plot – Environment - English

70% of the tweets from this topic are classified as positive and 30% as negative.

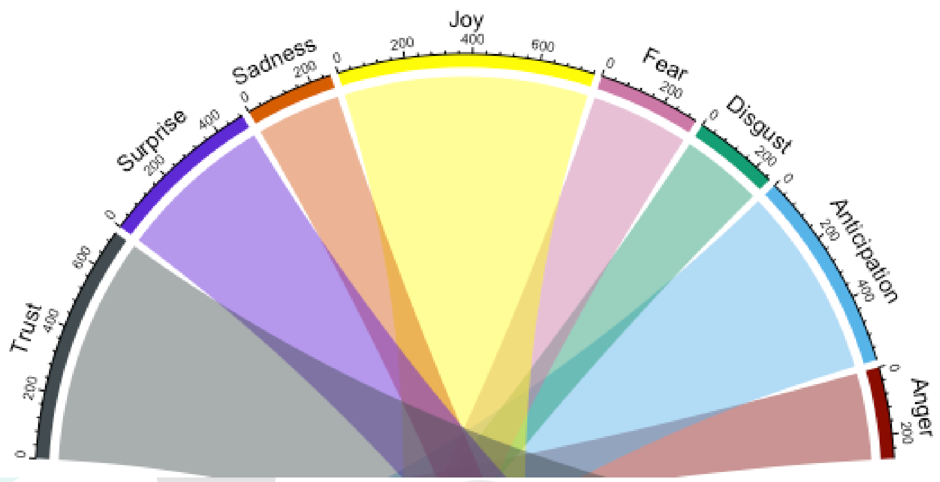


Figure 424. . Emotion distribution for tweets of Environment Topic - English

Government and policy

The following diagram shows the top 20 most frequent terms for the government and policy topic.

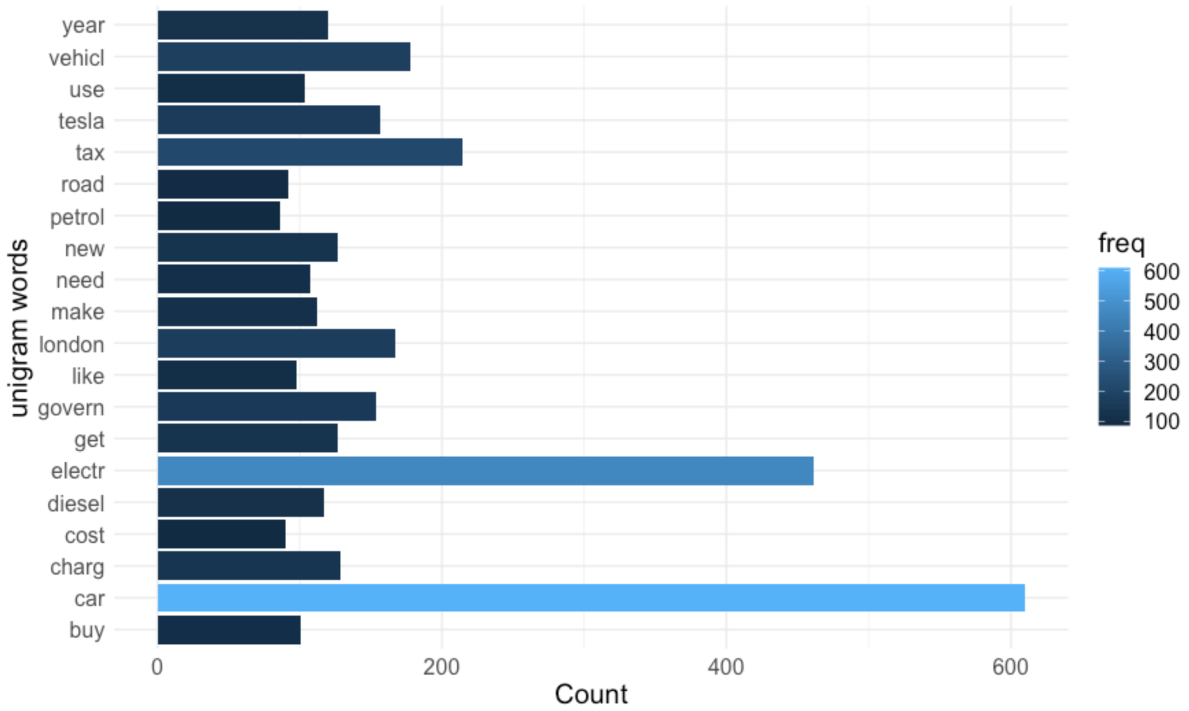


Figure 425. Term frequencies - top 20 plot - Government Policy – English

The following Figure presents the network of words.

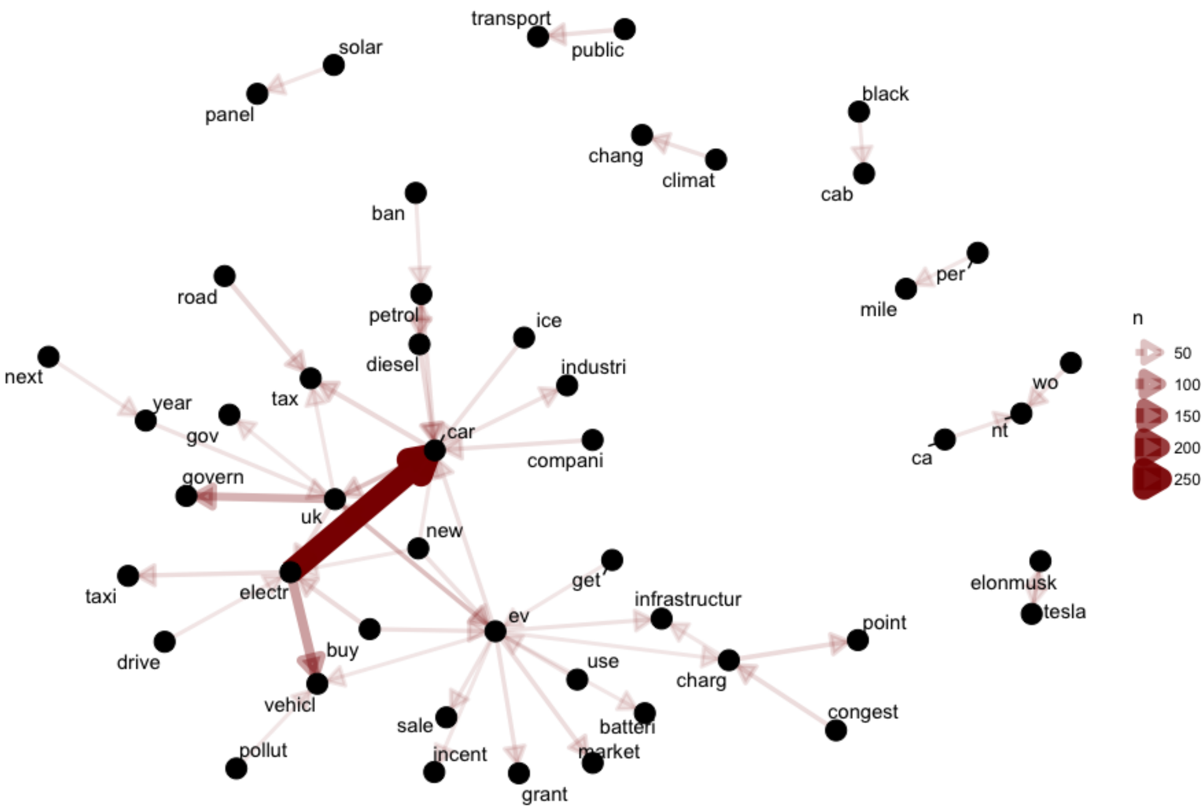


Figure 426. Network of words - bigram - Government Policy – English

Then, the most frequent bigrams have been analysed and plotted in the following figure

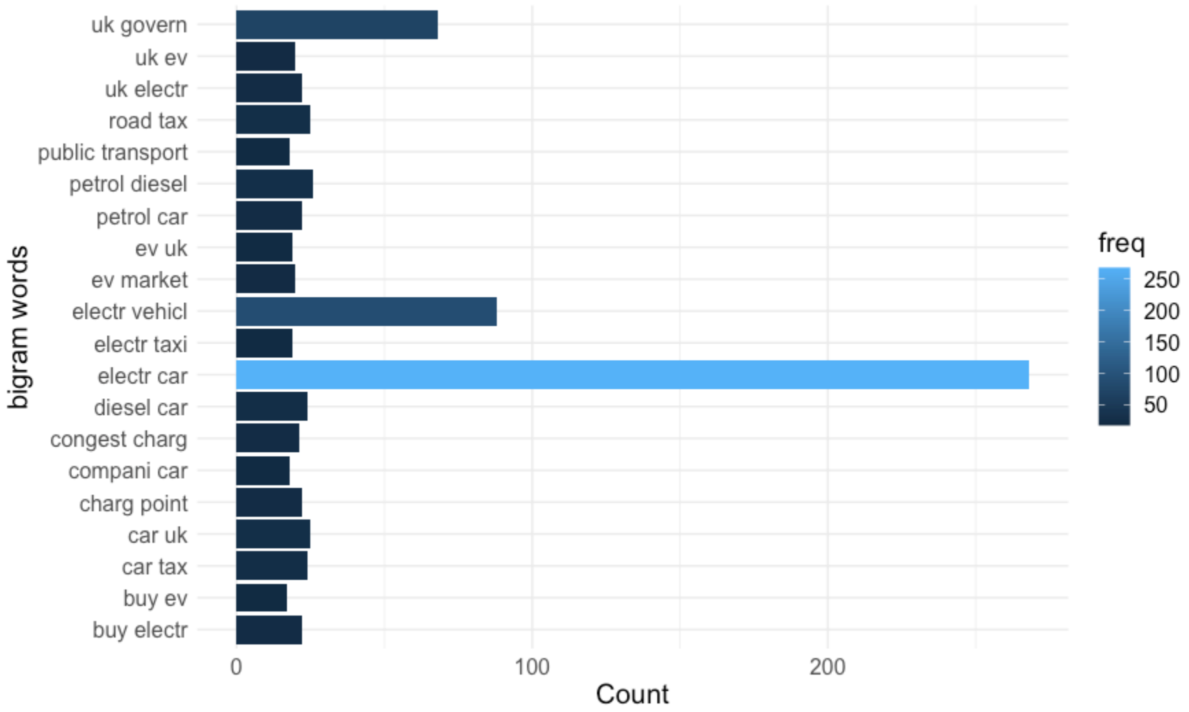


Figure 427. Bigram Term frequencies - top 20 plot – Government Policy English

63% of the tweets from this topic are classified as positive and 37% as negative. Then, the following figure presents the emotion distribution for the charging infrastructure topic.

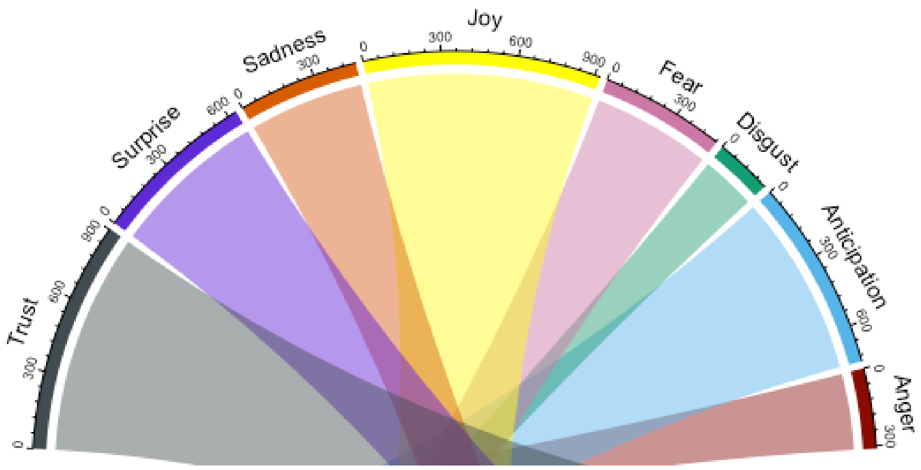


Figure 428. . Emotion distribution for tweets of Government and policy Topic - English

Production

The following diagram shows the top 20 most frequent terms for the production topic.

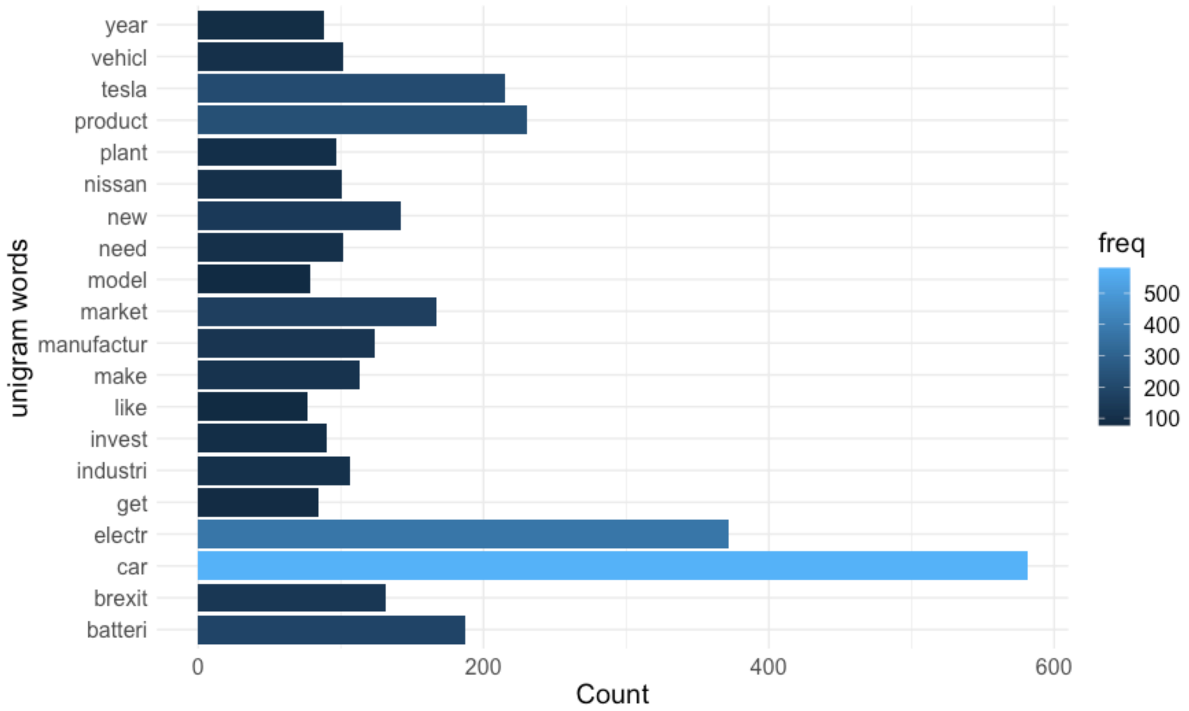


Figure 429. Term frequencies - top 20 plot – Production – English

The following Figure presents the network of words.

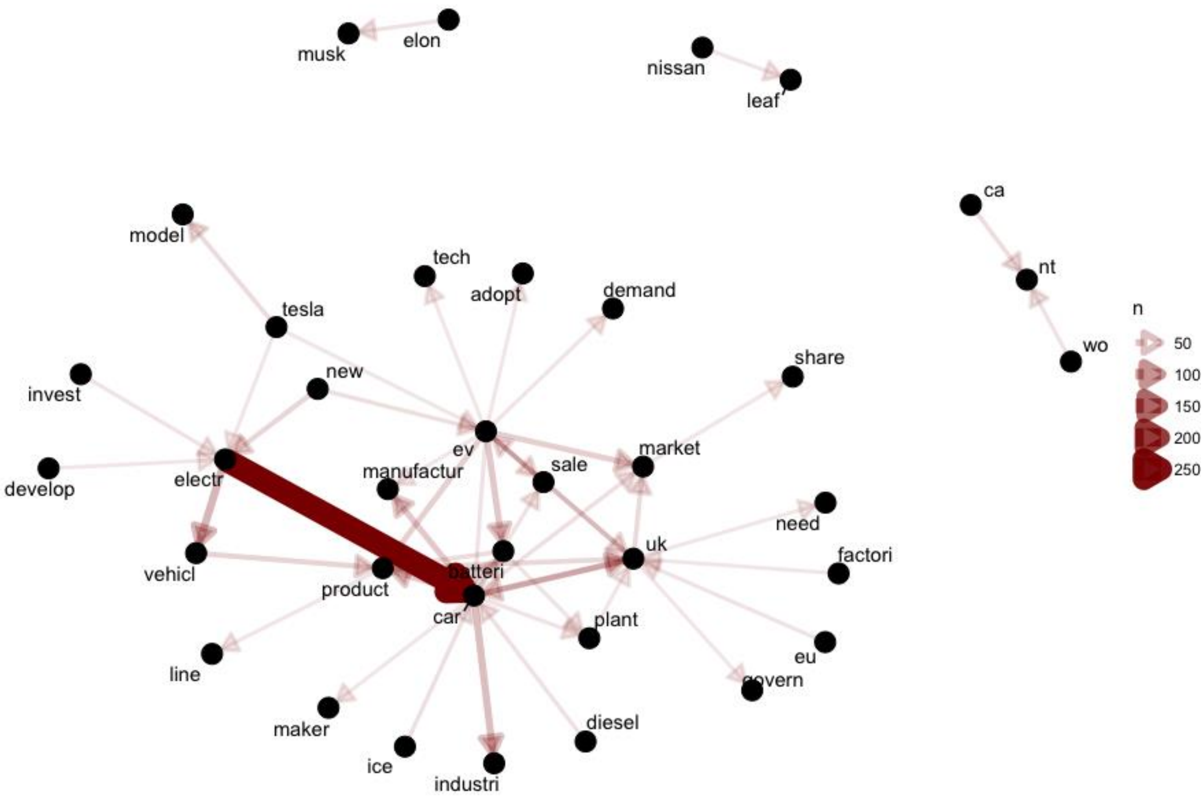


Figure 430. Network of words - bigram – Production – English

Then, the most frequent bigrams have been analysed and plotted in the following figure.

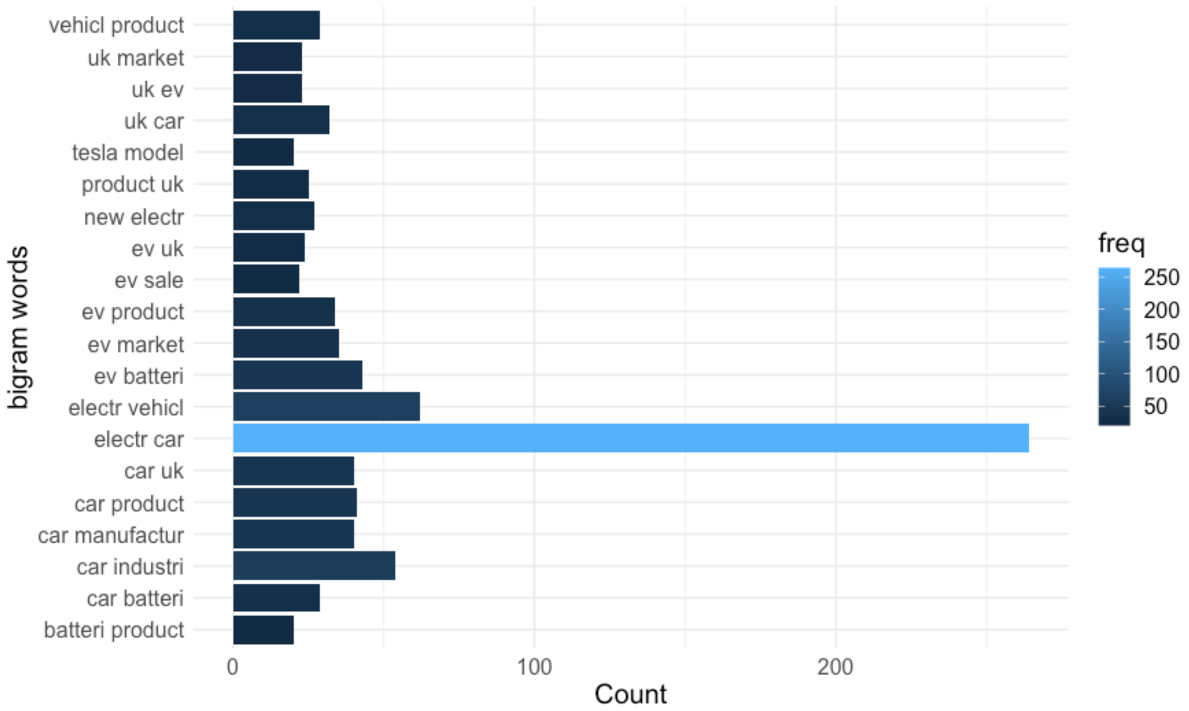


Figure 431. Bigram Term frequencies - top 20 plot – Production – English

Finally, the sentiment and emotion of the tweets is analysed. 72% of the tweets from this topic are classified as positive and 28% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

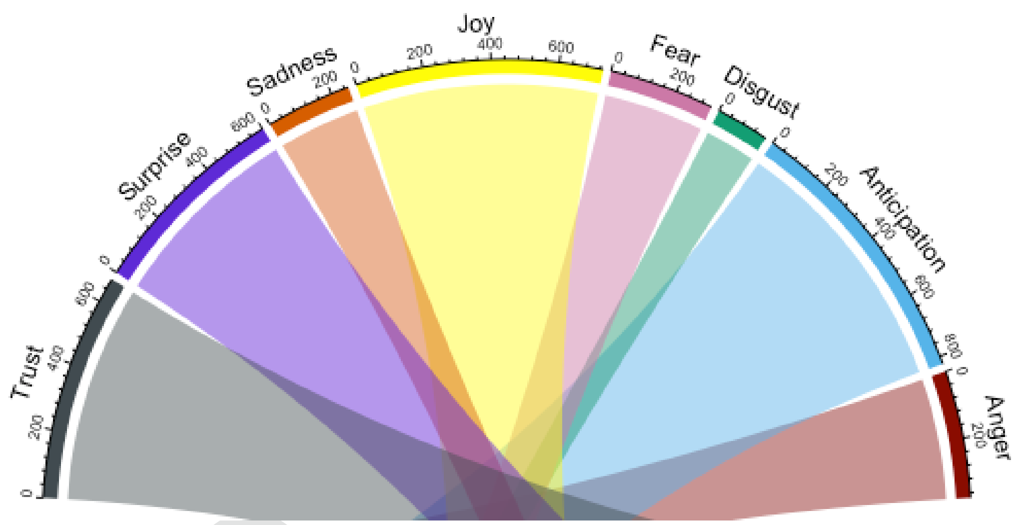


Figure 432. Emotion distribution for tweets of production Topic - English

Technology

The following diagram shows the top 20 most frequent terms for the technology topic.

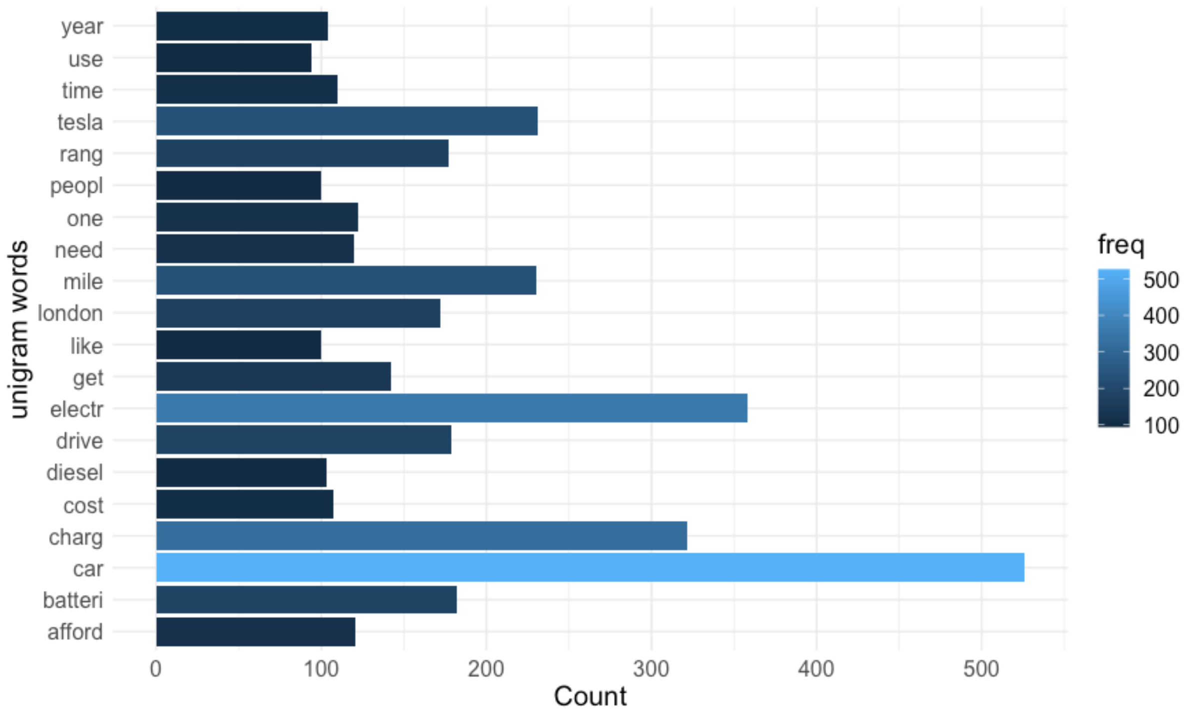


Figure 433. Term frequencies - top 20 plot – Technology - English

The following Figure presents the network of words.

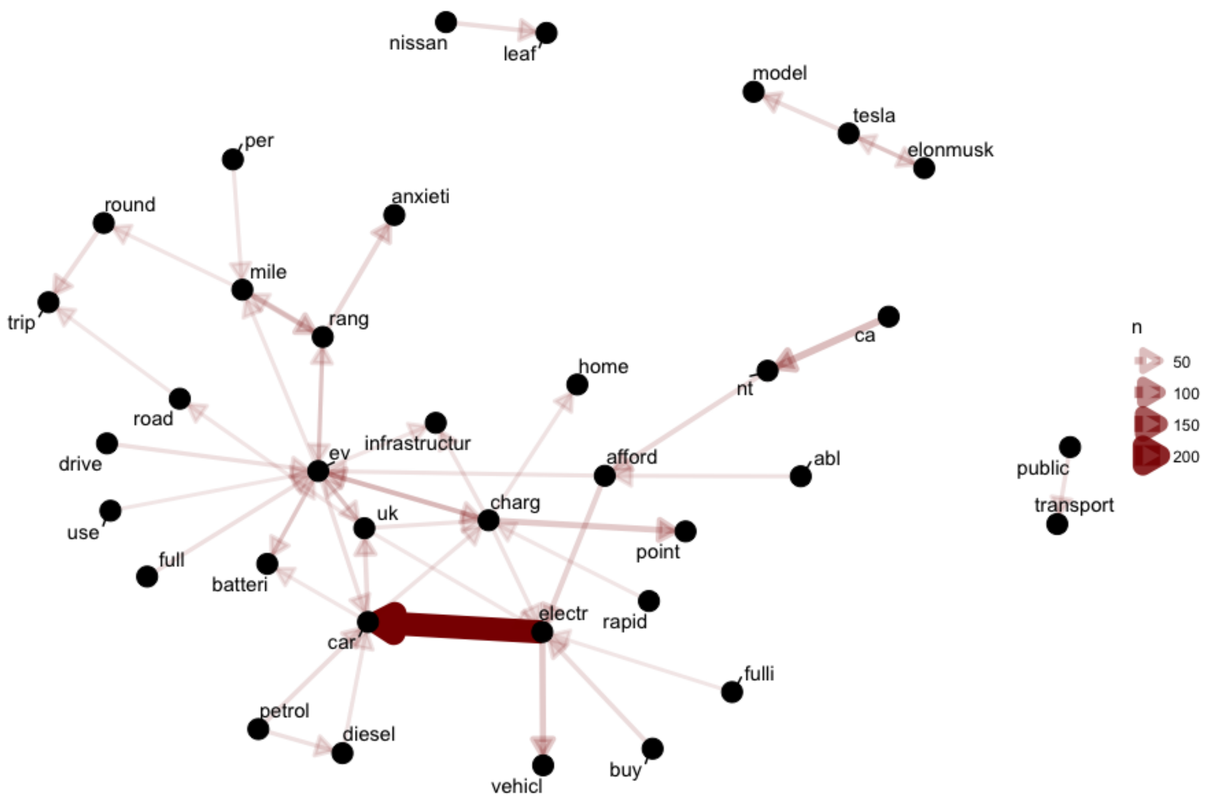


Figure 434. Network of words - bigram – Technology – English

Then, the most frequent bigrams have been analysed and plotted in the following figure.

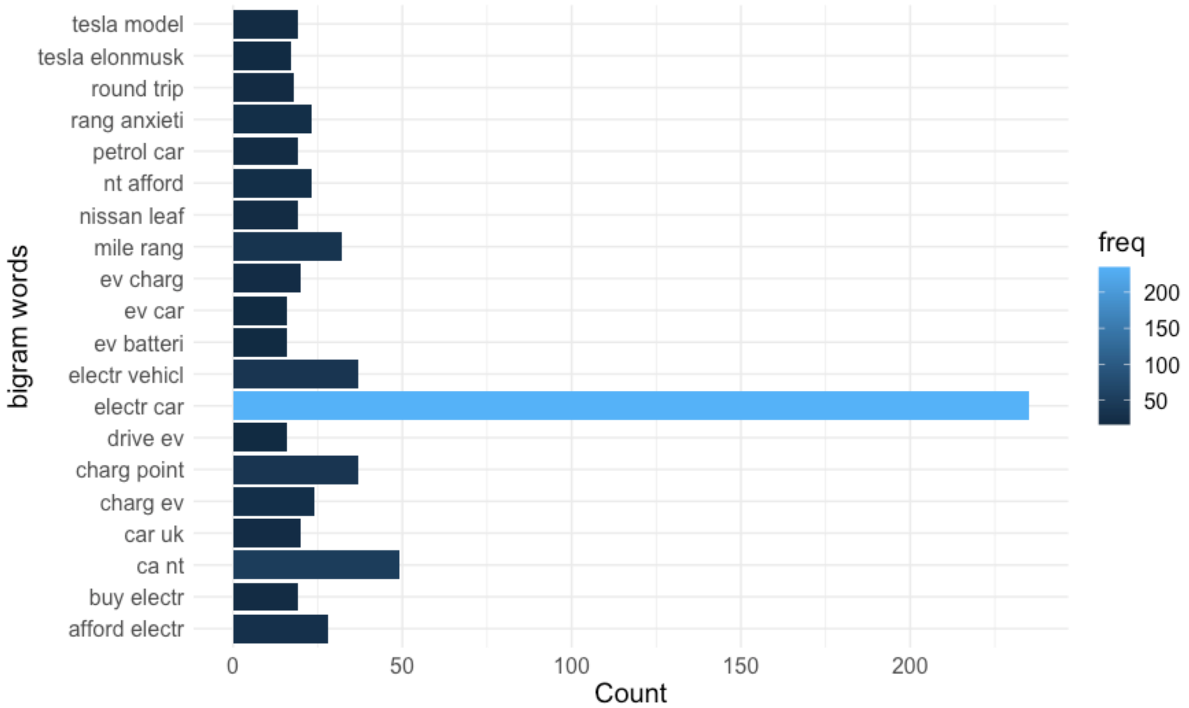


Figure 435. Bigram Term frequencies - top 20 plot – Technology – English

Finally, the sentiment and emotion of the tweets is analysed. 68% of the tweets from this topic are classified as positive and 32% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

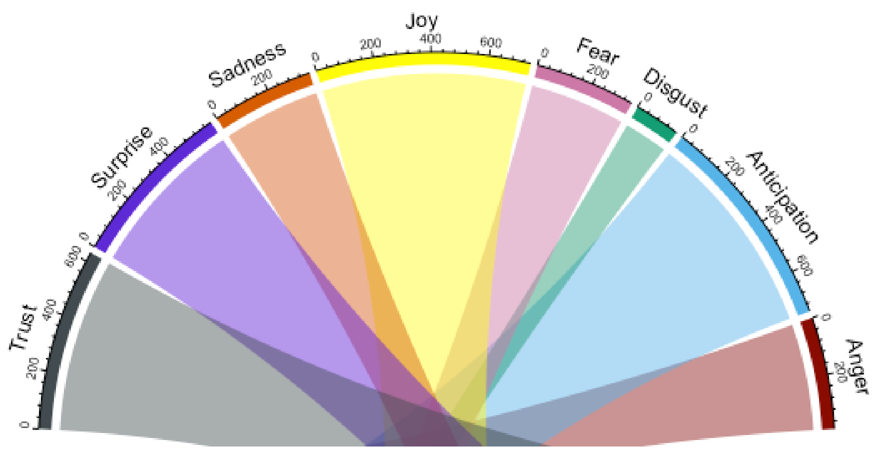


Figure 436. Emotion distribution for tweets of technology Topic – English

GERMAN

The following section presents the results for the social media analysis of the German tweets.

Charging Infrastructure

The following diagram shows the top 20 most frequent terms for the charging infrastructure topic.

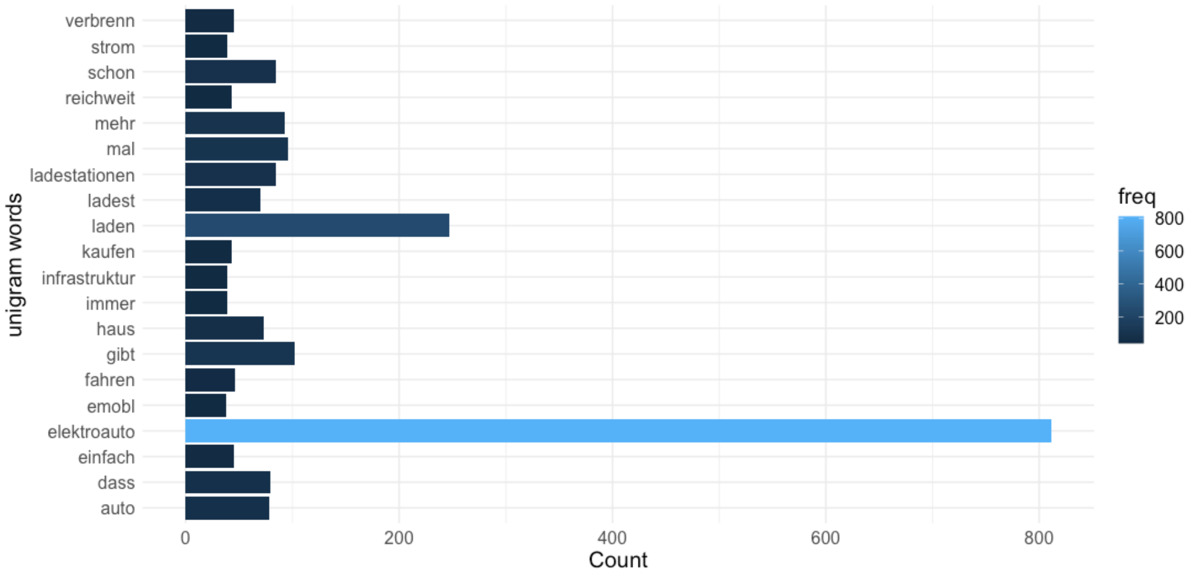


Figure 437. Unigram Term frequencies - top 20 plot - Charging Infrastructure - German

The following Figure presents the network of words.

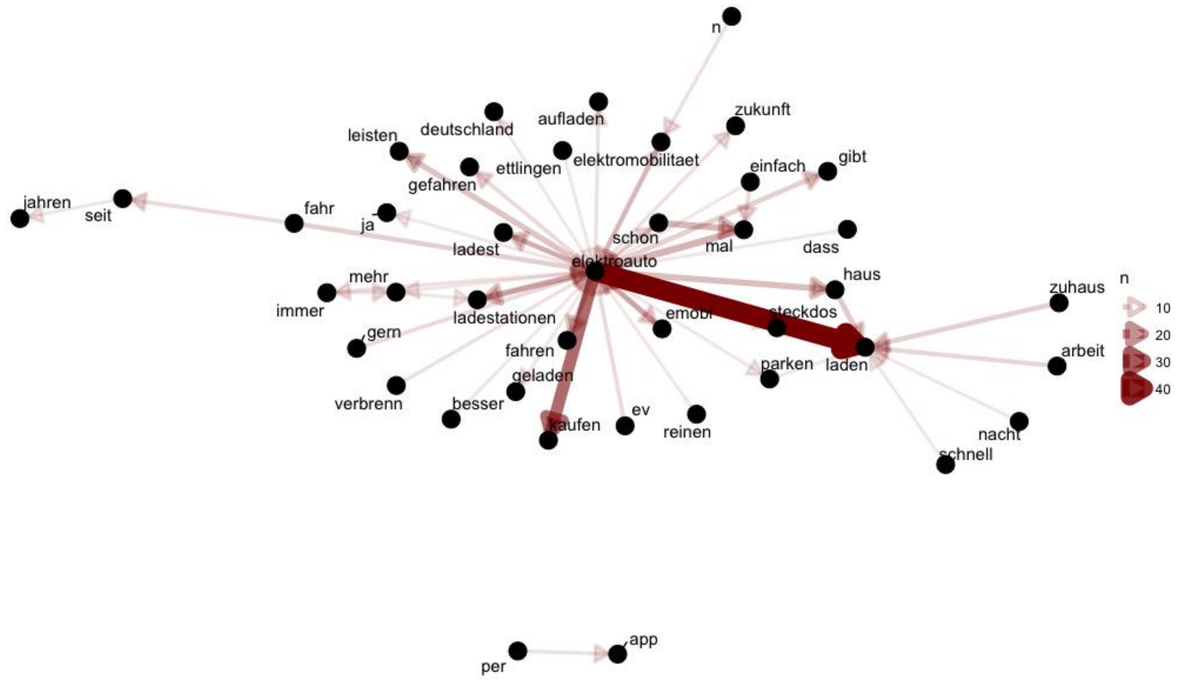


Figure 438. Network of words - bigram - Charging infrastructure – German

Then, the most frequent bigrams have been analysed and plotted in the following figure.

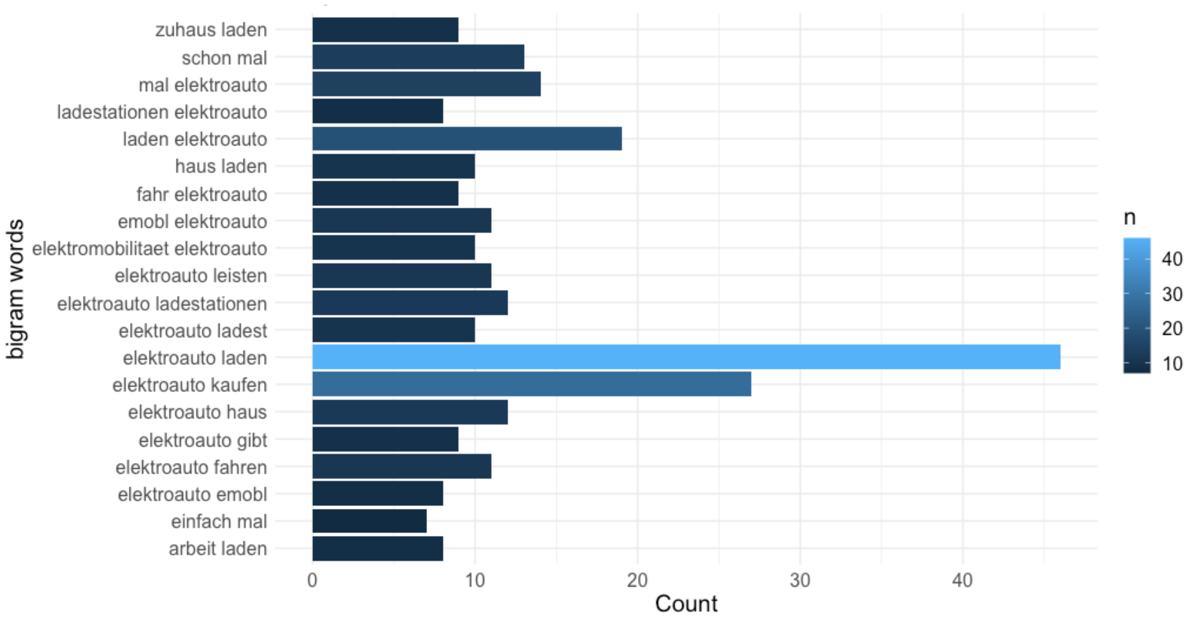


Figure 439. Bigram Term frequencies - top 20 plot - Charging Infrastructure - German

Finally, the sentiment and emotion of the tweets is analysed. 62% of the tweets from this topic are classified as positive and 38% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

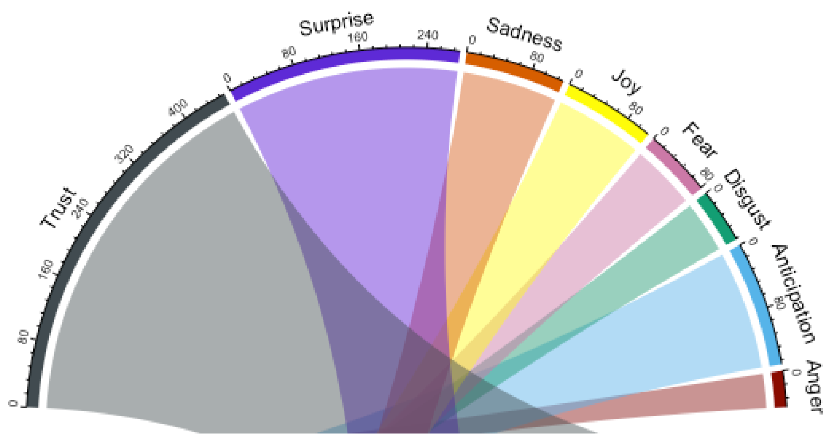


Figure 440. Emotion distribution for tweets of Charging Infrastructure Topic - German

Environment

The following diagram shows the top 20 most frequent terms for the environment topic.

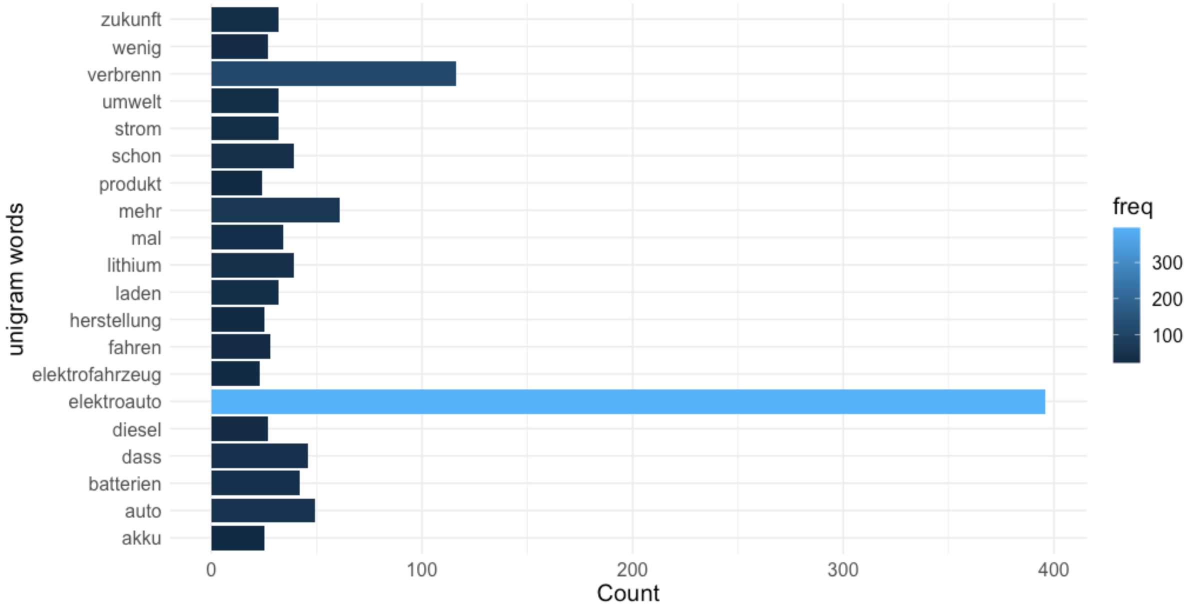


Figure 441. Term frequencies - top 20 plot – Environment – German

The following Figure presents the network of words.

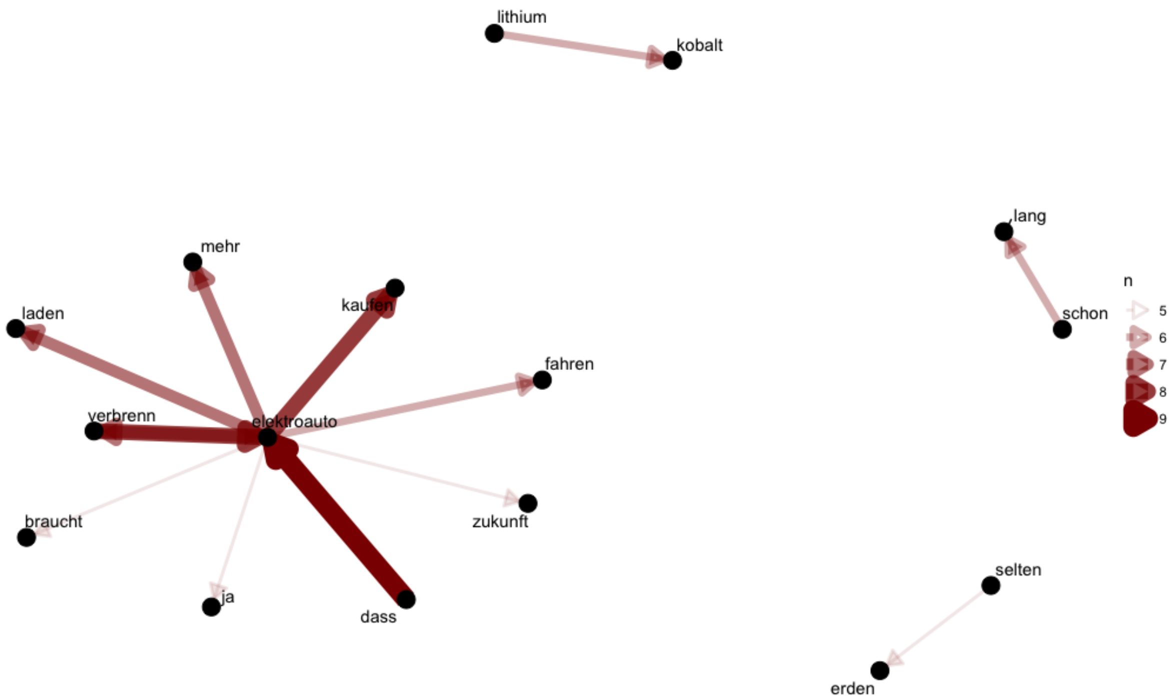


Figure 442. Network of words - bigram – Environment - German

Then, the most frequent bigrams have been analysed and plotted in the following figure.

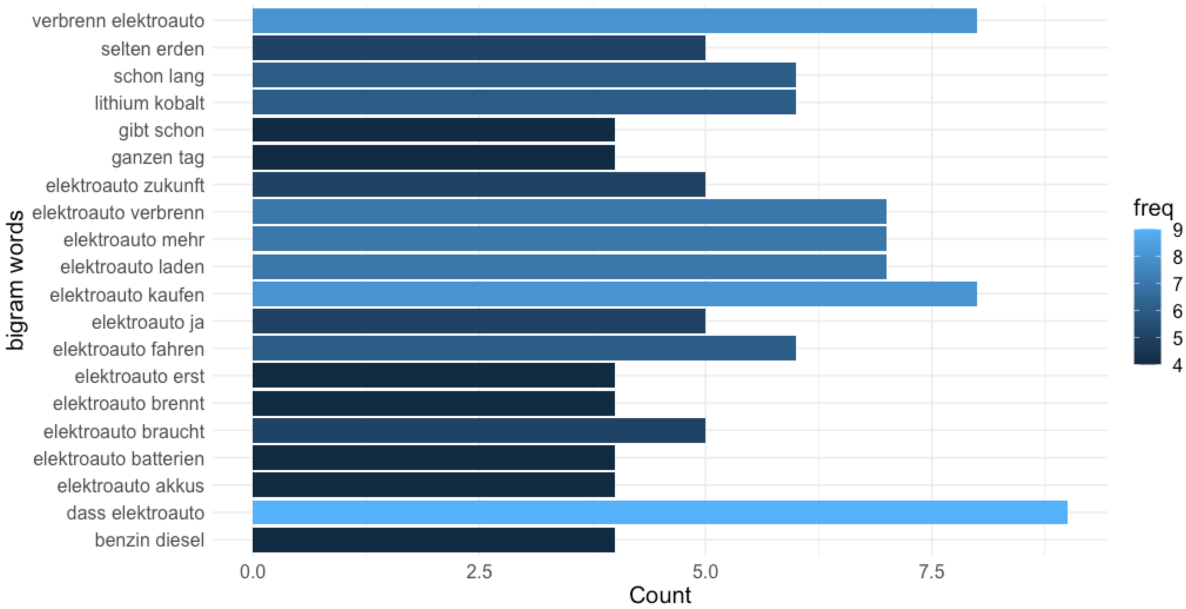


Figure 443. Bigram Term frequencies - top 20 plot – Environment

Finally, the sentiment and emotion of the tweets is analysed. 53% of the tweets from this topic are classified as positive and 47% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

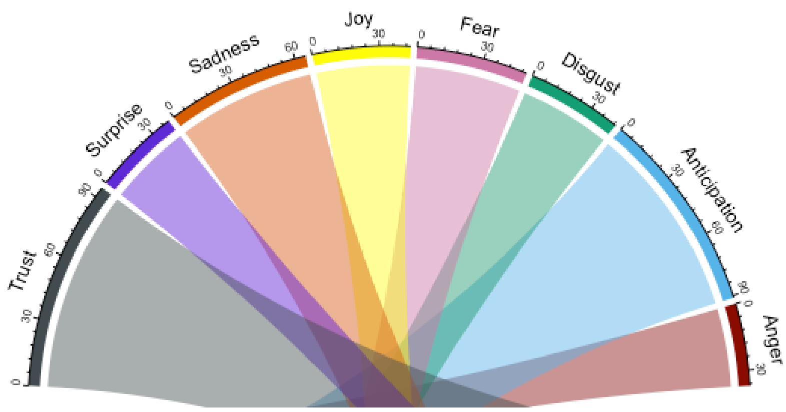


Figure 444. Emotion distribution for tweets of environment Topic - German

Government and policy

The following diagram shows the top 20 most frequent terms for the government and policies topic

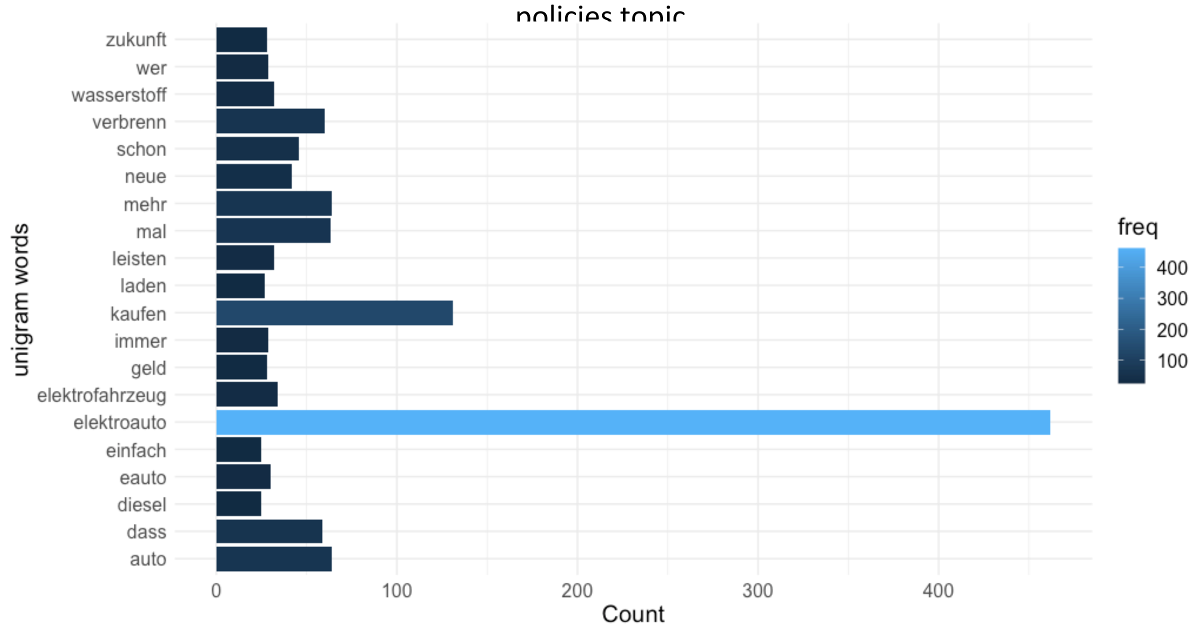


Figure 445. Term frequencies - top 20 plot - Government Policy – German

The following Figure presents the network of words.

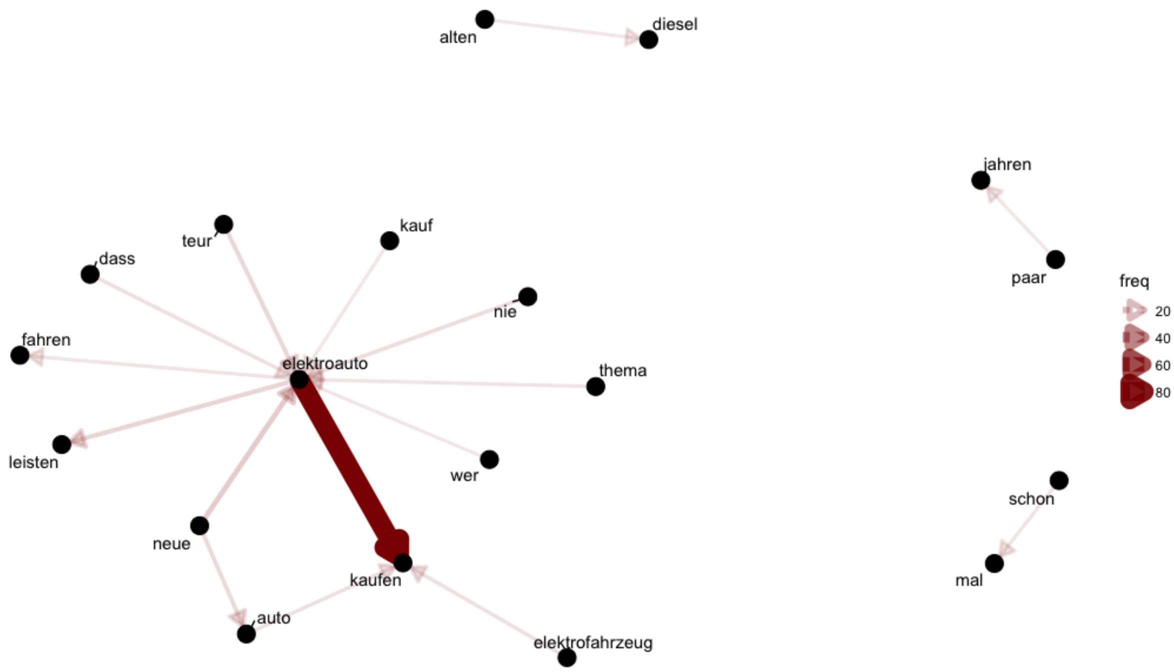


Figure 446. Network of words - bigram - Government Policy – German

Then, the most frequent bigrams have been analysed and plotted in the following figure.

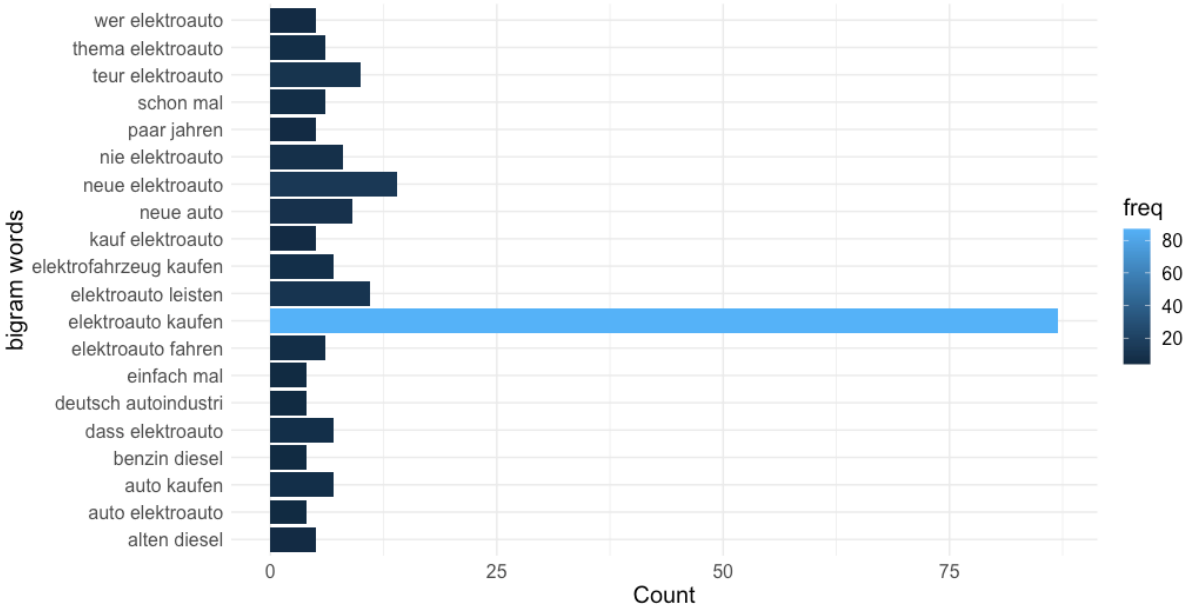


Figure 447. Bigram Term frequencies - top 20 plot – Government Policy

Finally, the sentiment and emotion of the tweets is analysed. 65% of the tweets from this topic are classified as positive and 35% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

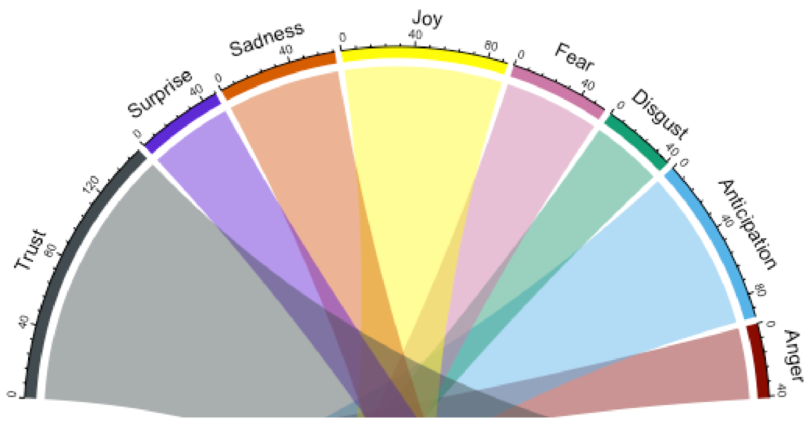


Figure 448. Emotion distribution for tweets of government and policy Topic - German

Production

The following diagram shows the top 20 most frequent terms for the production topic.

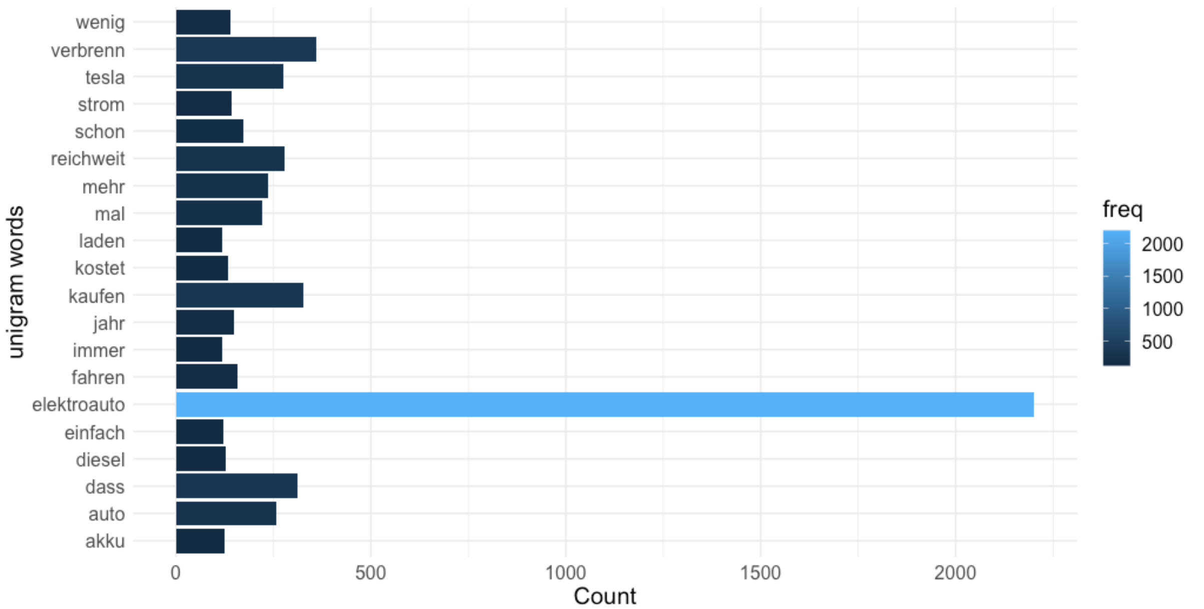


Figure 449. Term frequencies - top 20 plot– Production - German

The following Figure presents the network of words.

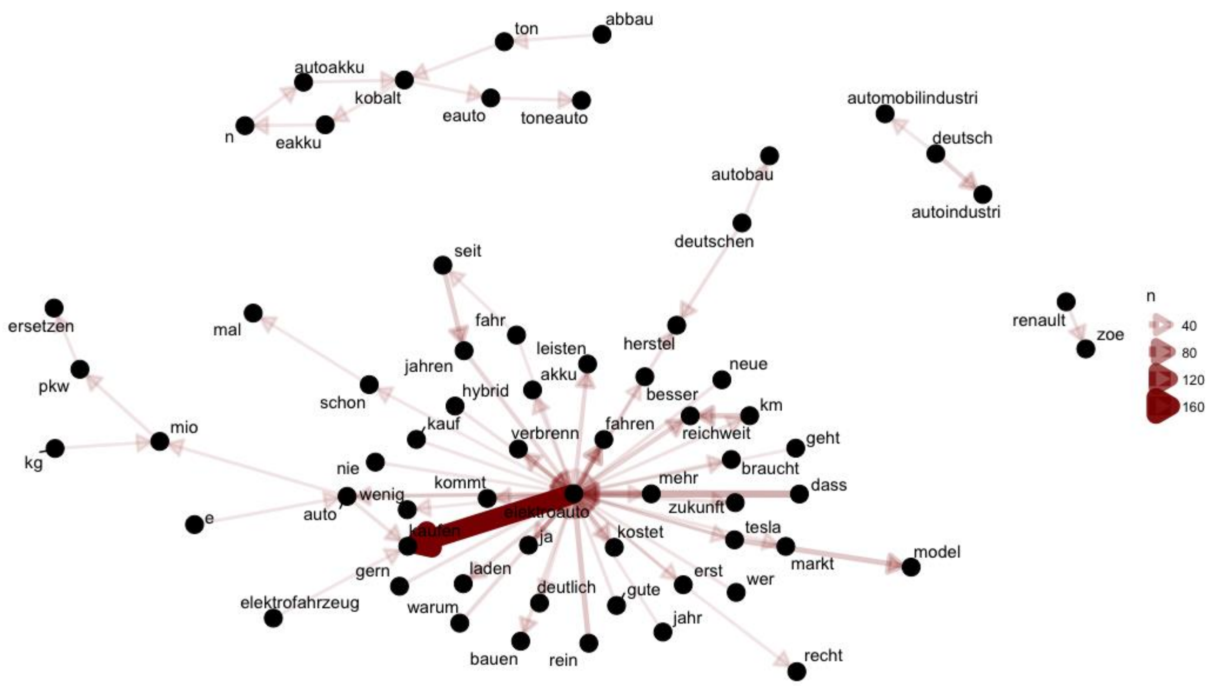


Figure 450. Network of words - bigram – Production - German

Then, the most frequent bigrams have been analysed and plotted in the following figure

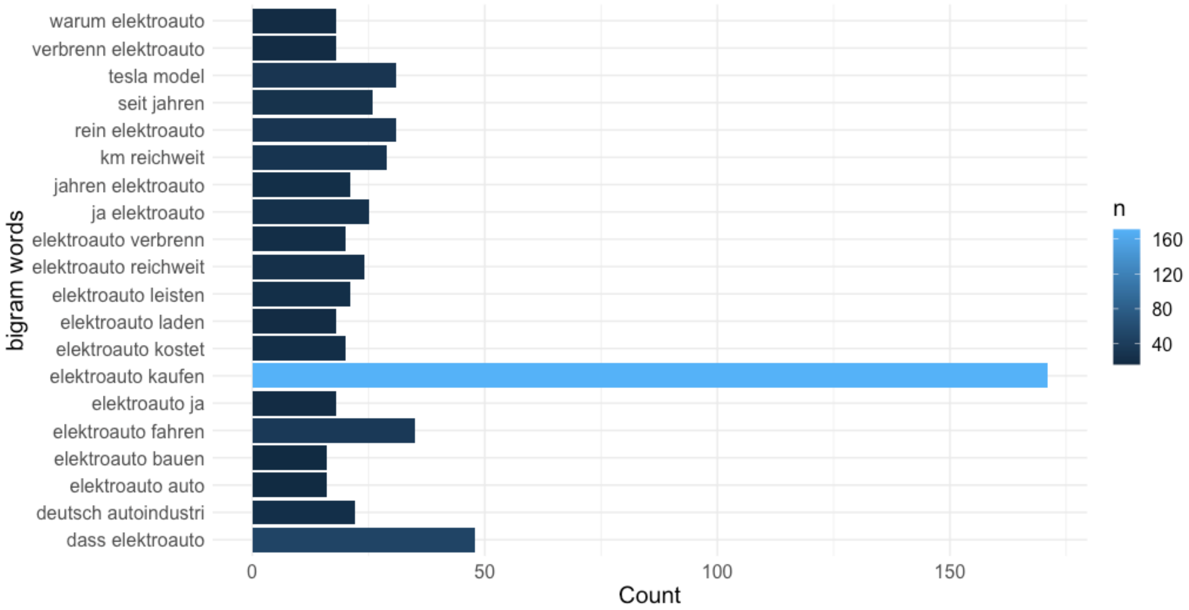


Figure 451. Bigram Term frequencies - top 20 plot – Production – German

Finally, the sentiment and emotion of the tweets is analysed. 58% of the tweets from this topic are classified as positive and 42% as negative. Moreover, the following figure presents the emotion distribution for the production topic.

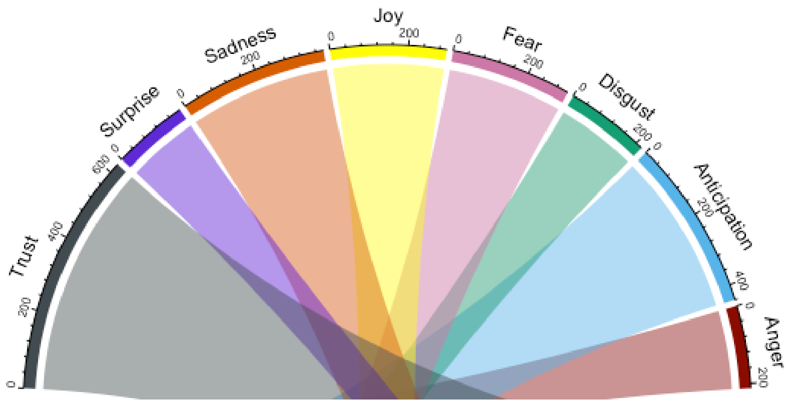


Figure 452. Emotion distribution for tweets of production Topic - German

Technology

The following bar plot shows the top 20 most frequent terms for the technology topic.

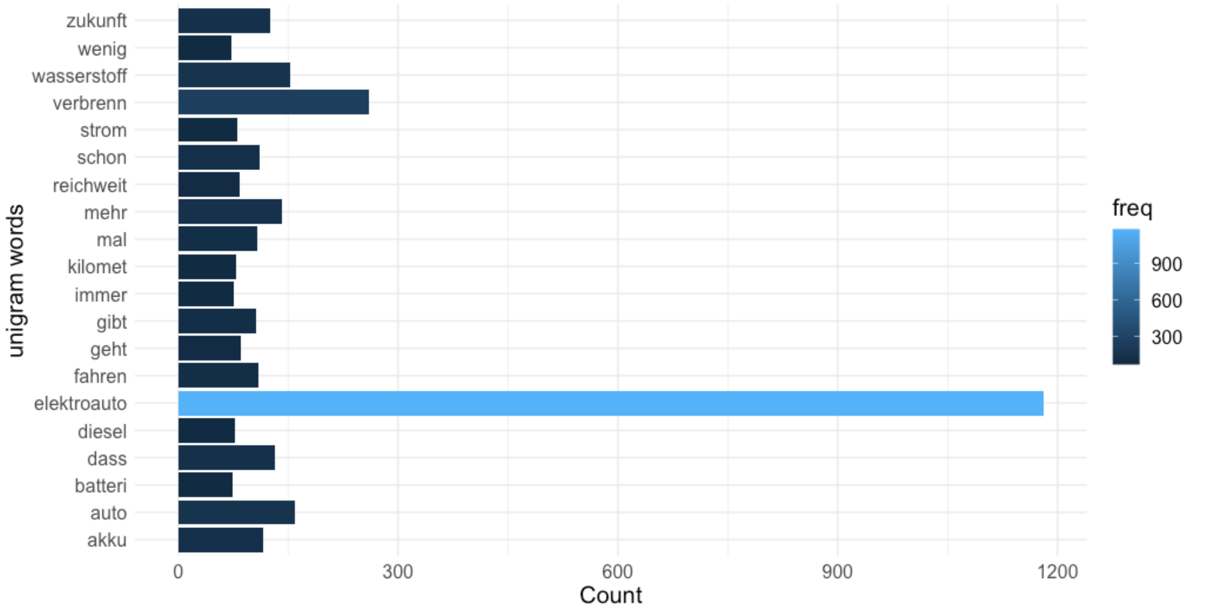


Figure 453. Term frequencies - top 20 plot – Technology - German

The following Figure presents the network of words.

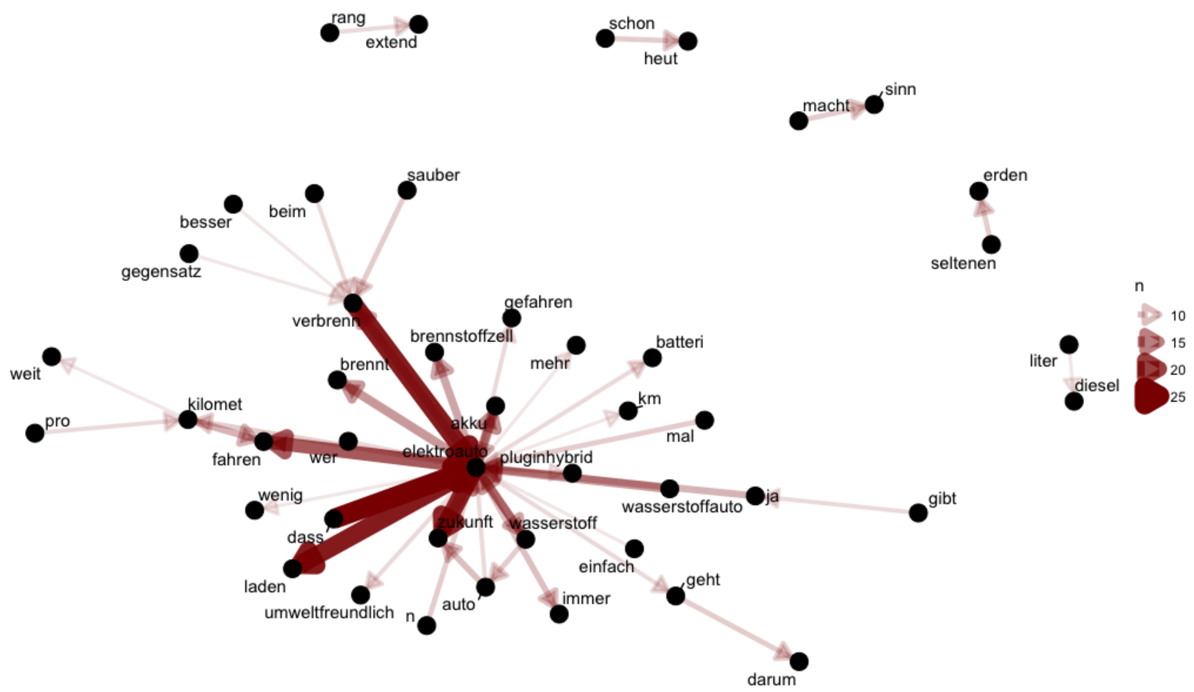


Figure 454. Network of words - bigram – Technology - German

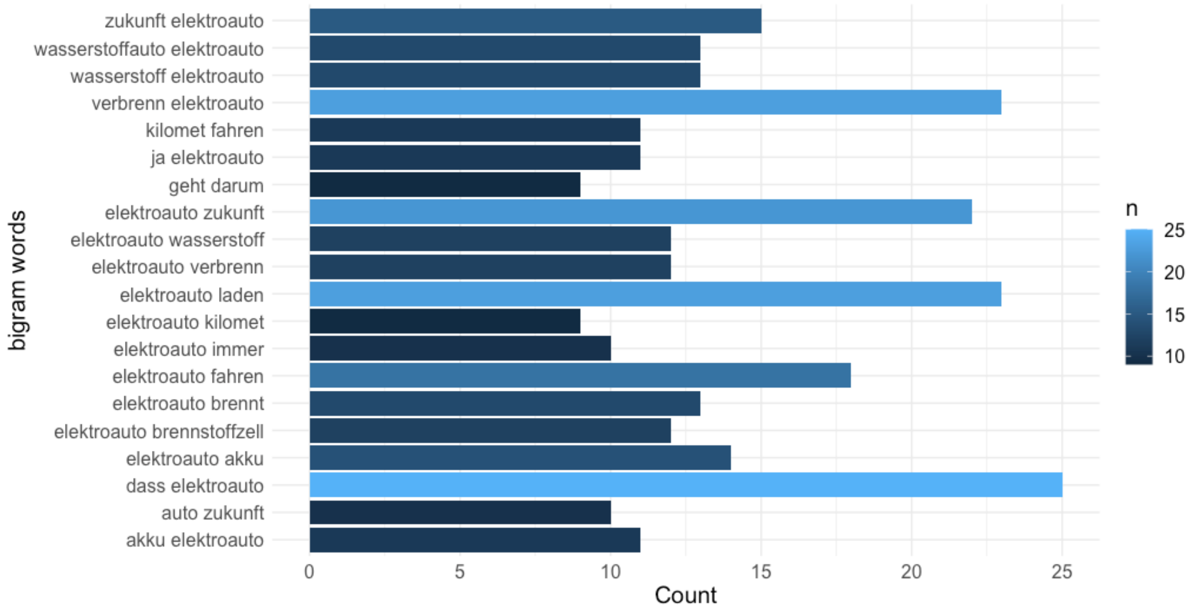


Figure 455. Bigram Term frequencies - top 20 plot – Technology - German

Finally, the sentiment and emotion of the tweets is analysed. 55% of the tweets from this topic are classified as positive and 45% as negative. Moreover, the following figure presents the emotion distribution for the technology topic.

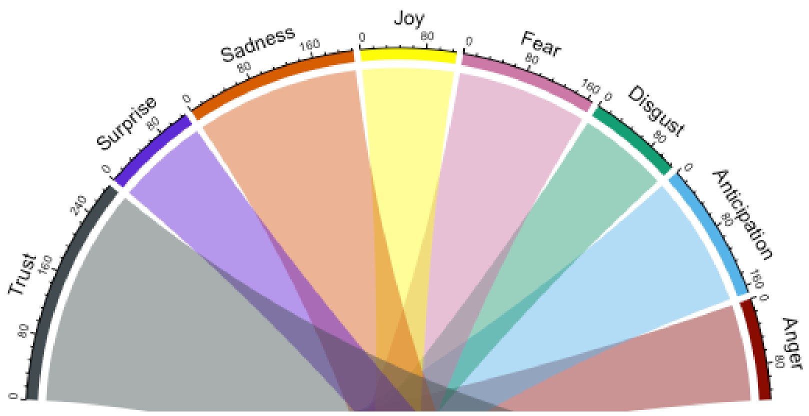


Figure 456. Emotion distribution for tweets of production Topic - English

SPANISH

The following section presents the results for the social media analysis of the Spanish tweets.

Charging Infrastructure

The following bar plot shows the top 20 most frequent terms for the charging infrastructure topic.

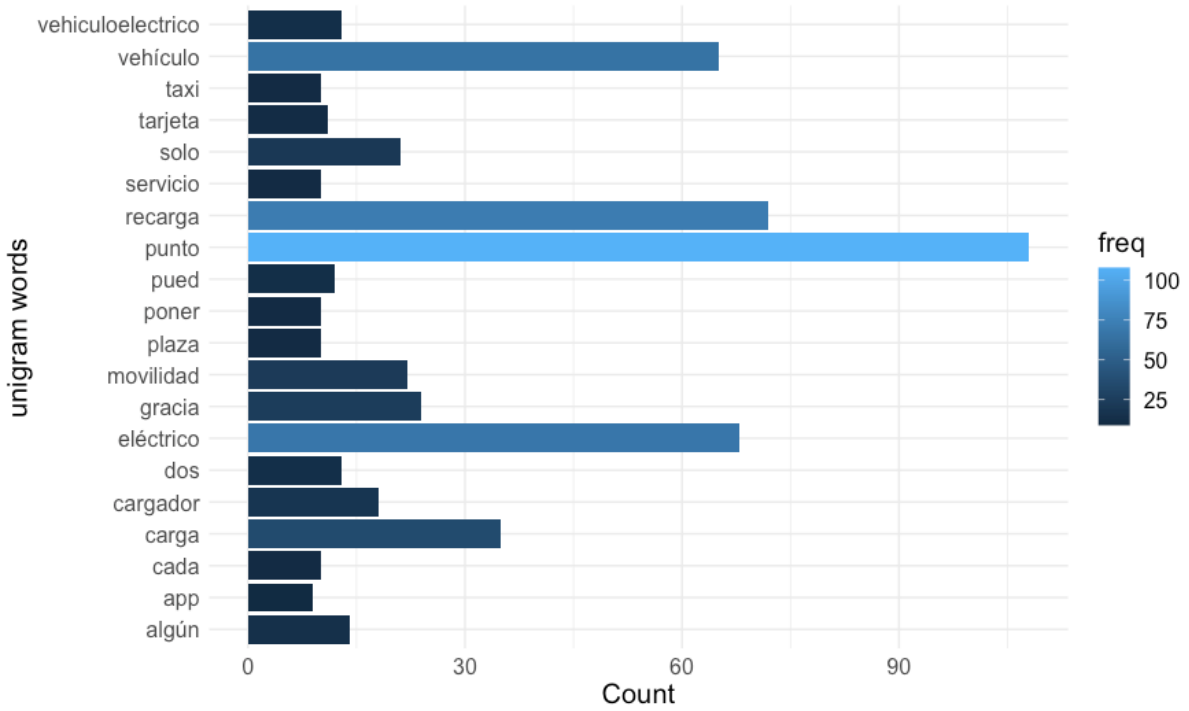


Figure 457. Unigram Term frequencies - top 20 plot - Charging Infrastructure – Spanish

The following Figure presents the network of words.

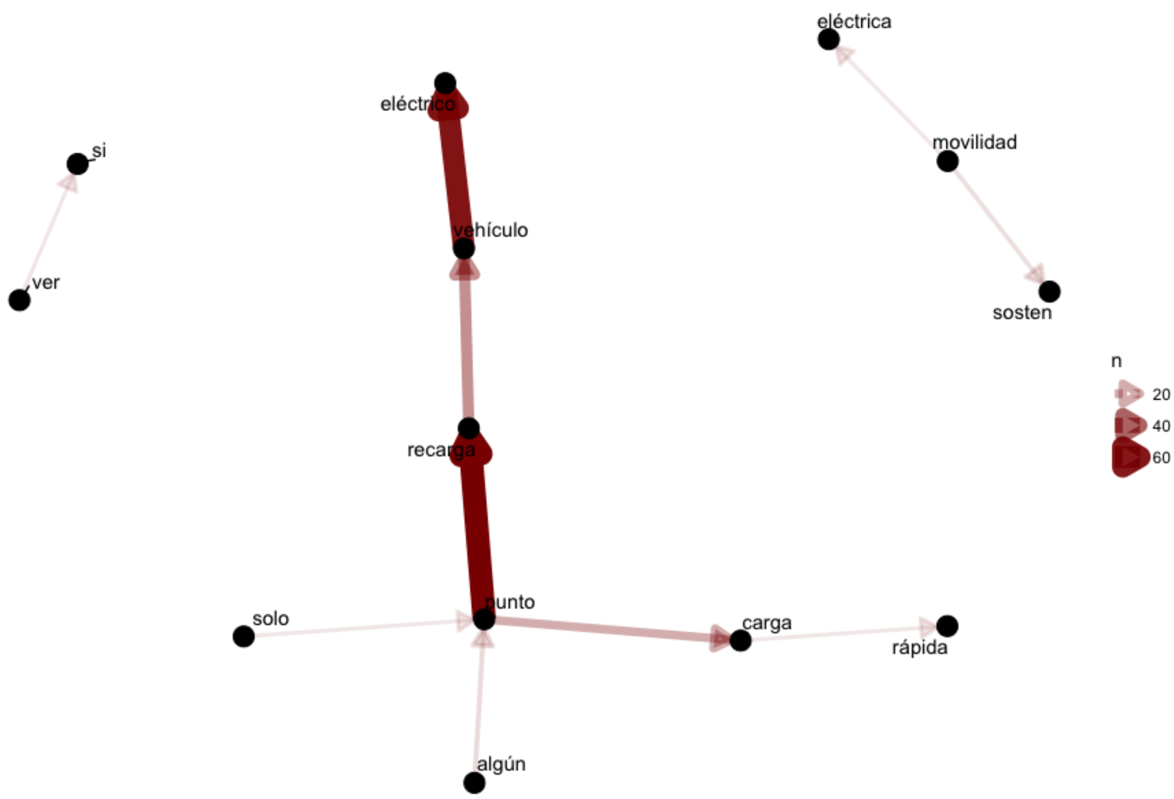


Figure 458. Network of words - bigram - Charging infrastructure - Spanish

Then, the most frequent bigrams have been analysed and plotted in the following figure.

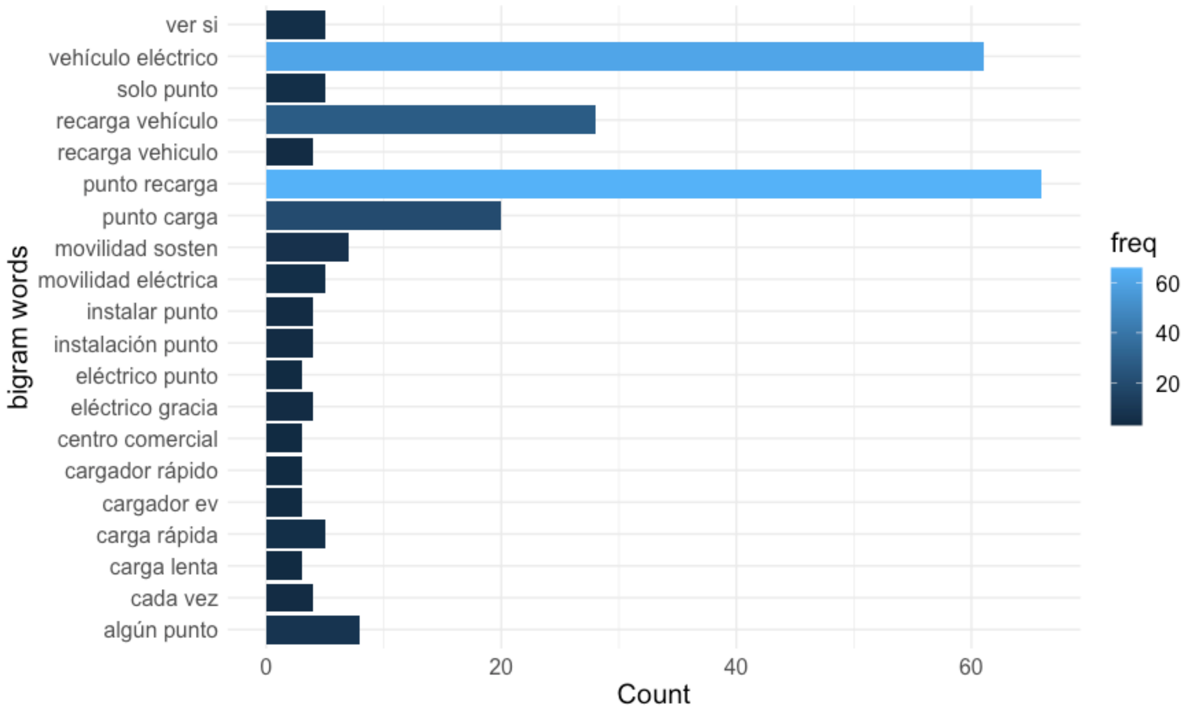


Figure 459. Bigram Term frequencies - top 20 plot - Charging Infrastructure - Spanish

Finally, the sentiment and emotion of the tweets is analysed. 46% of the tweets from this topic are classified as positive and 54% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

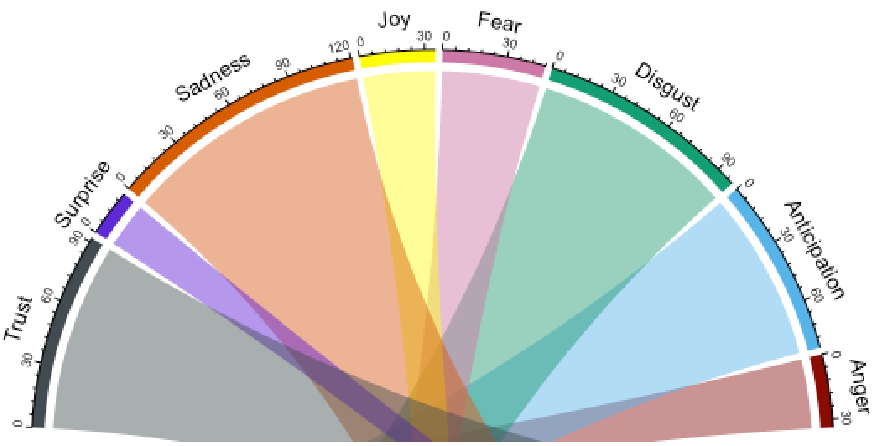


Figure 460. Emotion distribution for tweets of Charging Infrastructure Topic - Spanish

Environment

The following bar plot shows the top 20 most frequent terms for the environment topic.

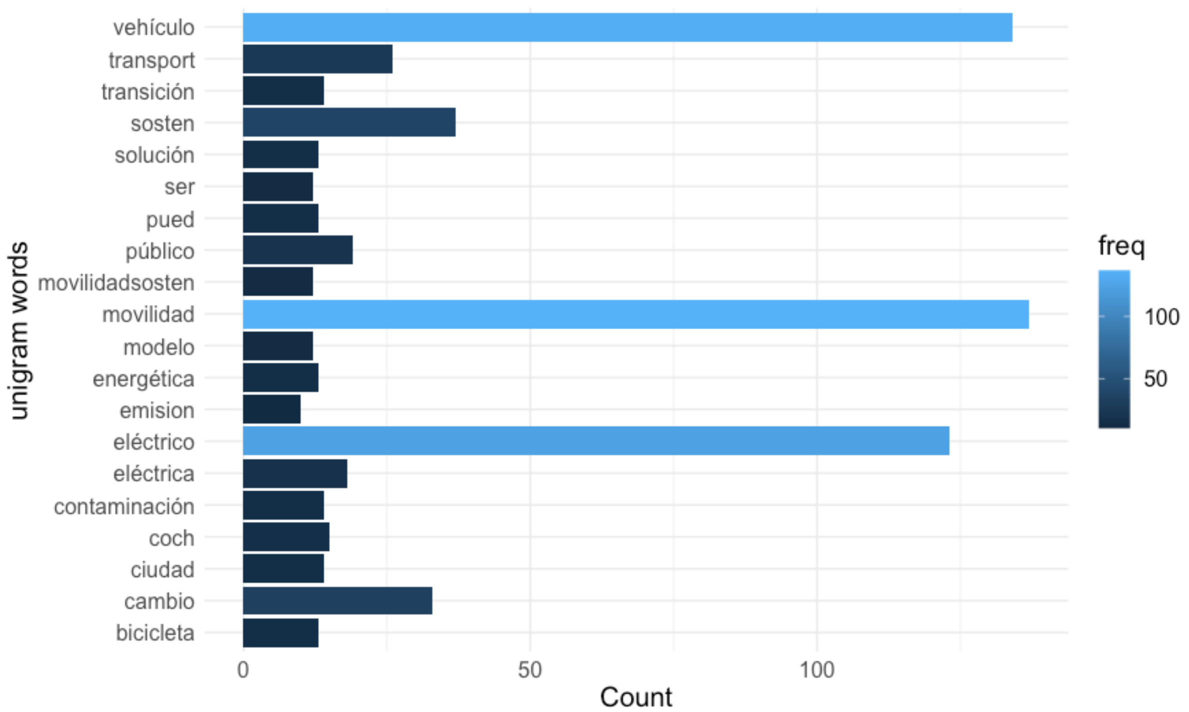


Figure 461. Term frequencies - top 20 plot– Environment - Spanish

The following Figure presents the network of words.

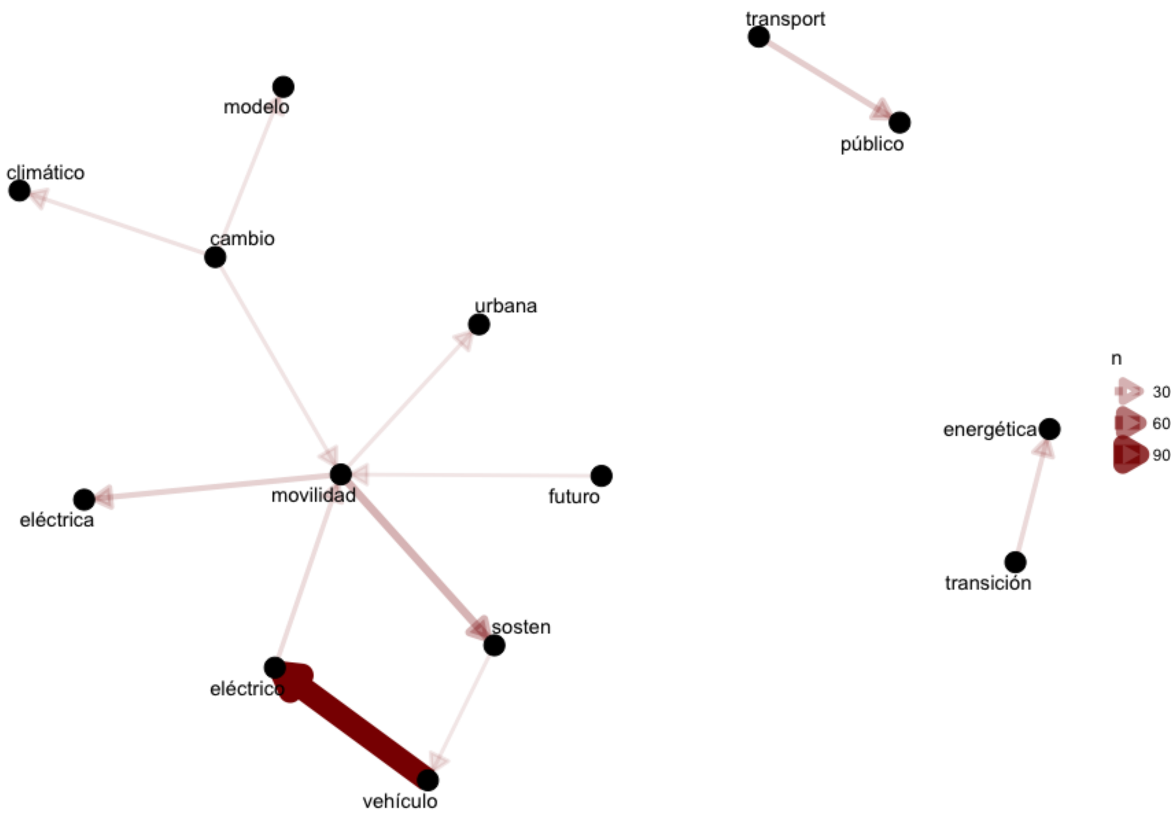


Figure 462. Network of words - bigram – Environment - Spanish

Then, the most frequent bigrams have been analysed and plotted in the following figure.

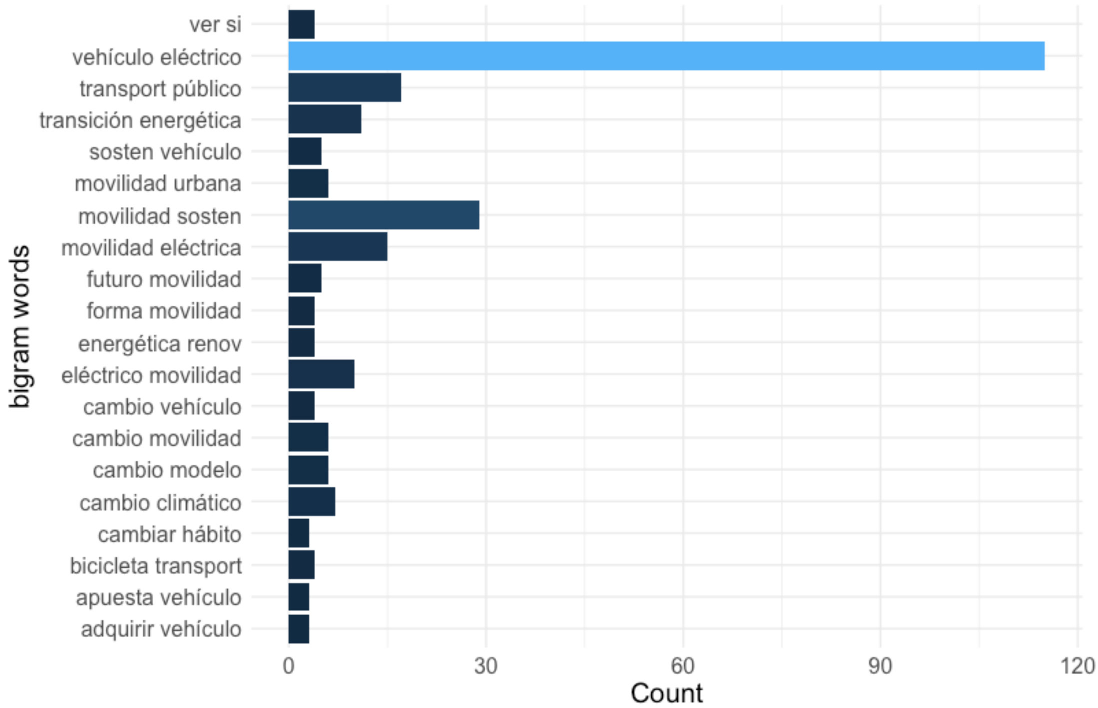


Figure 463. Bigram Term frequencies - top 20 plot – Environment - Spanish

Finally, the sentiment and emotion of the tweets is analysed. 38% of the tweets from this topic are classified as positive and 62% as negative. Moreover, the following figure presents the emotion distribution for the environment topic.

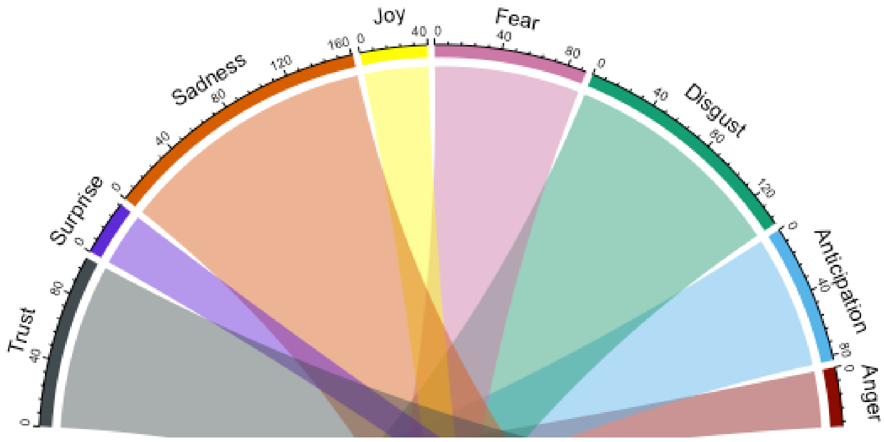


Figure 464. Emotion distribution for tweets of environment Topic - Spanish

Government and policy

The following bar plot shows the top 20 most frequent terms for the government and policy topic.

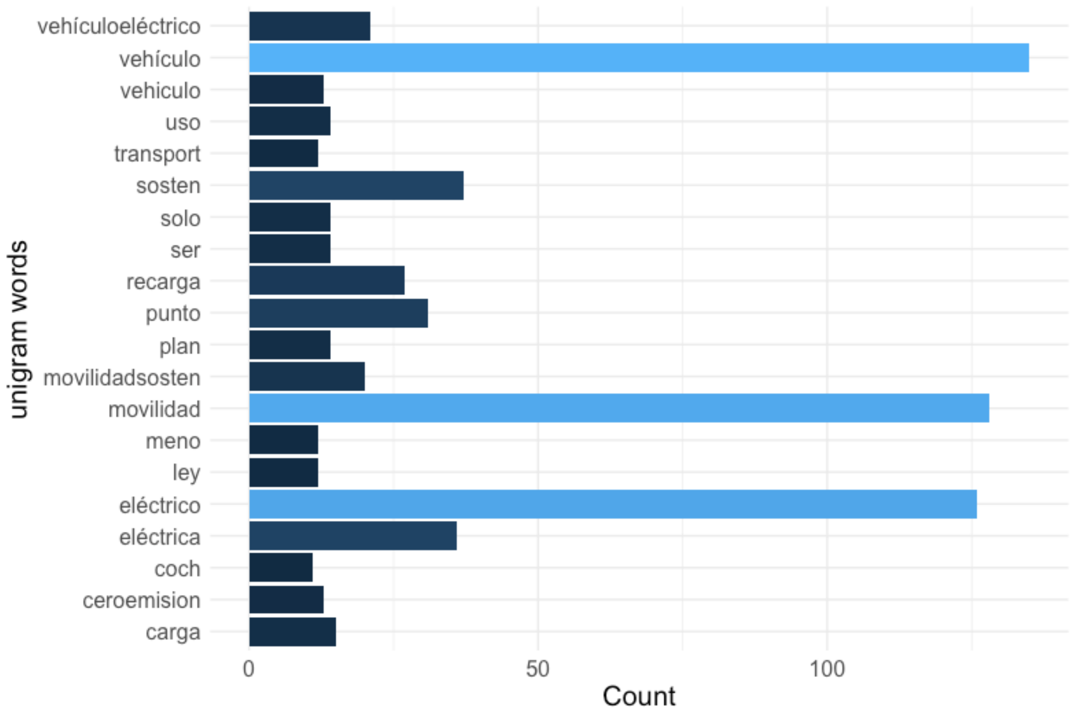


Figure 465. Term frequencies - top 20 plot - Government Policy - Spanish

The following Figure presents the network of words.

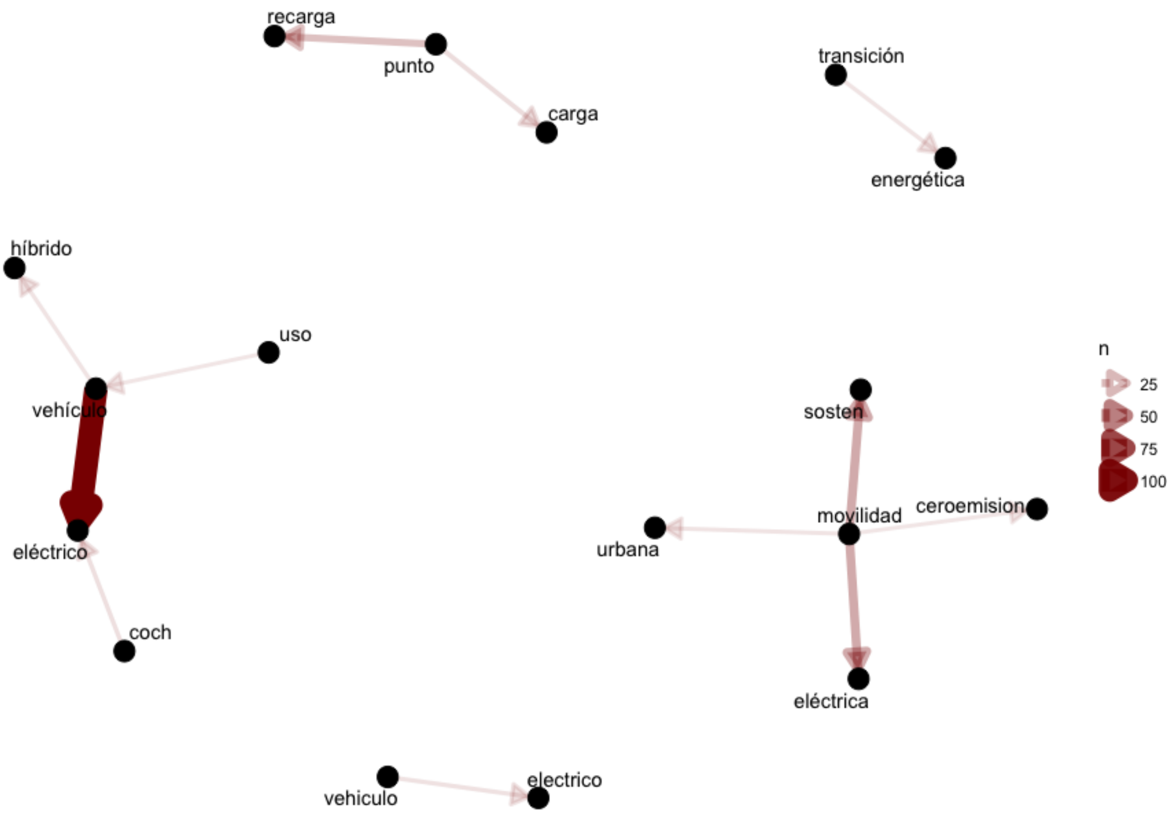


Figure 466. Network of words - bigram - Government Policy - Spanish

Then, the most frequent bigrams have been analysed and plotted in the following figure.

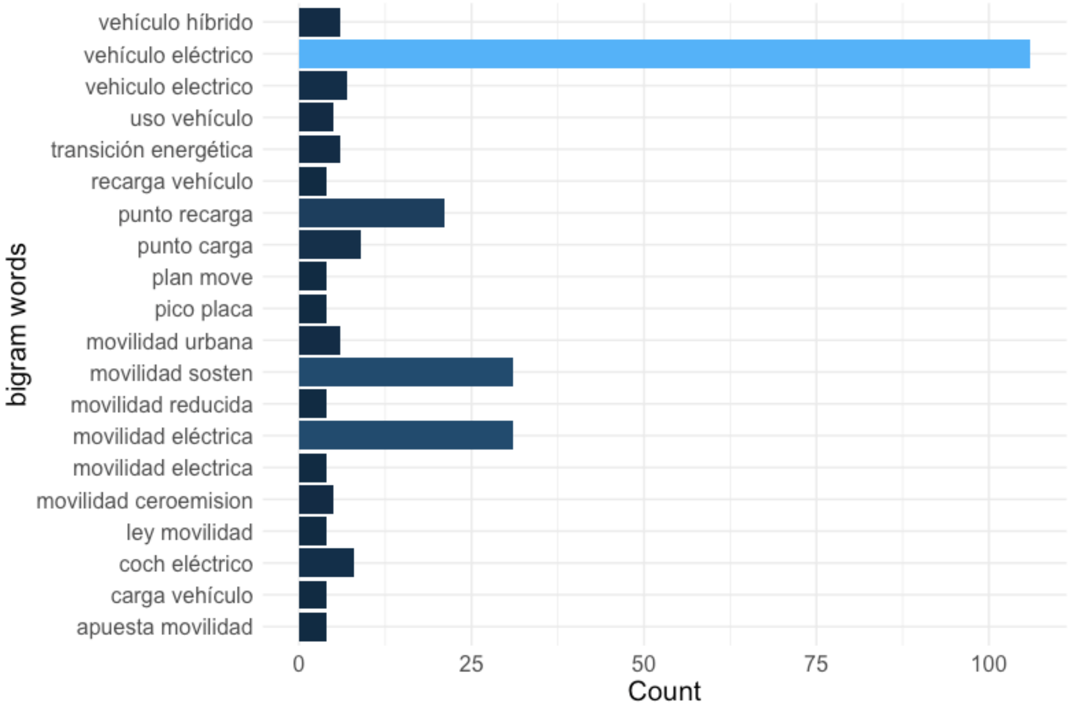


Figure 467. Bigram Term frequencies - top 20 plot– Government Policy - Spanish

Finally, the sentiment and emotion of the tweets is analysed. 42% of the tweets from this topic are classified as positive and 58% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

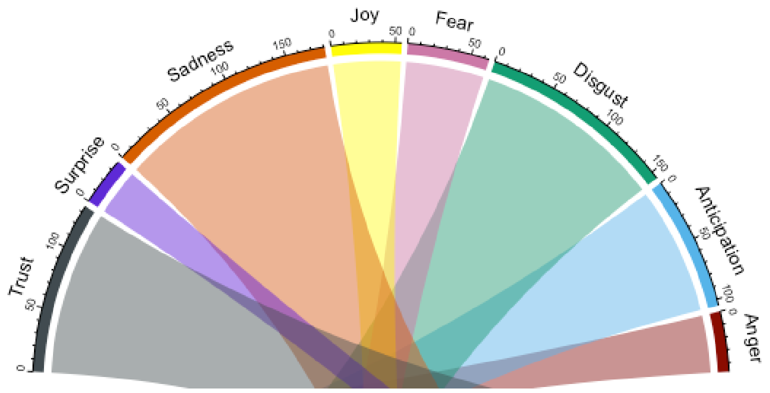


Figure 468. Emotion distribution for tweets of production Topic - Spanish

Production

The following bar plot shows the top 20 most frequent terms for the production topic.

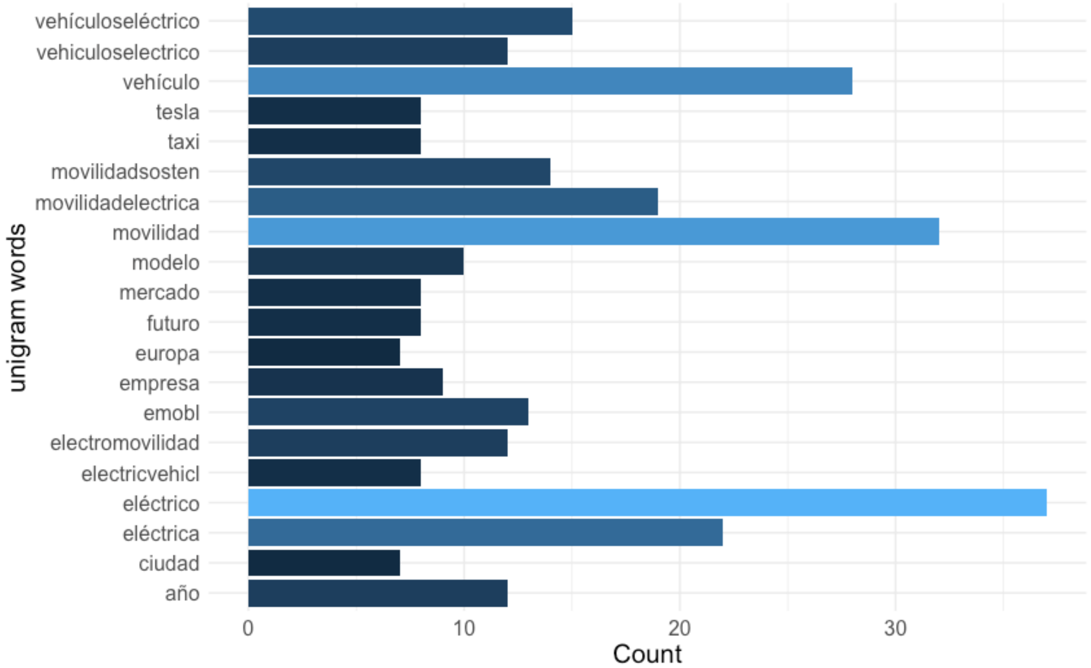


Figure 469. Term frequencies - top 20 plot– Production - Spanish

The following Figure presents the network of words.

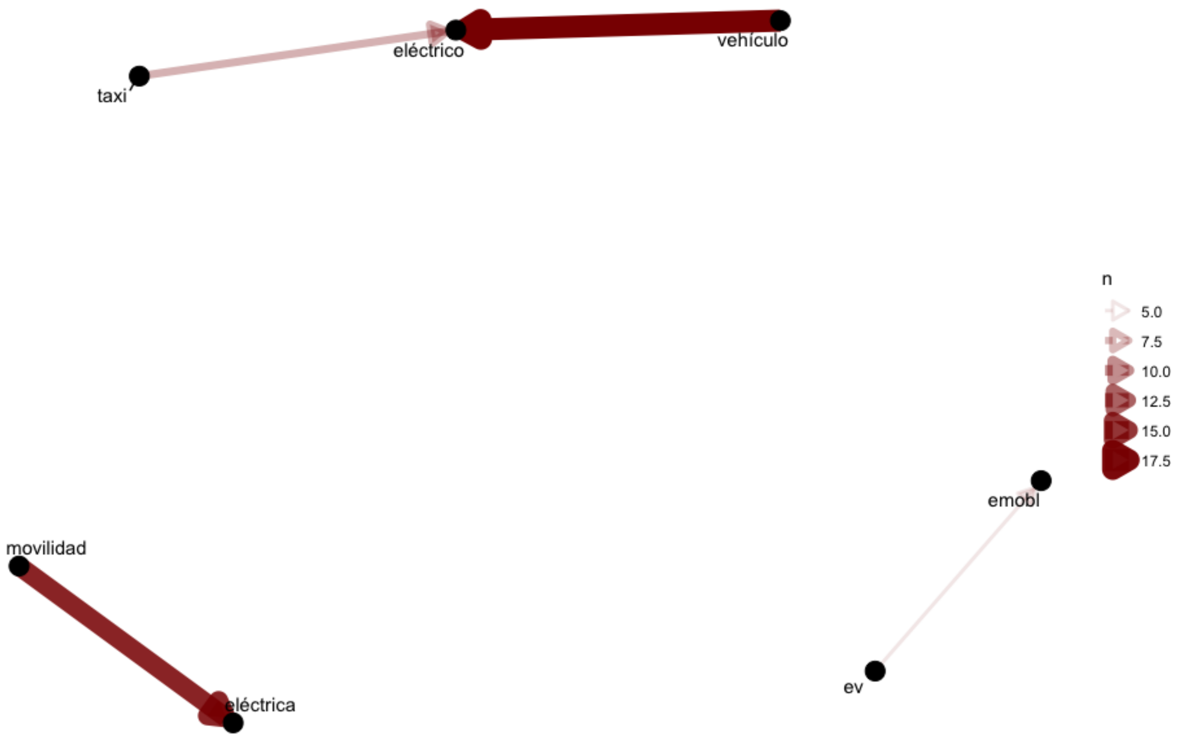


Figure 470. Network of words - bigram – Production - Spanish

Then, the most frequent bigrams have been analysed and plotted in the following figure.

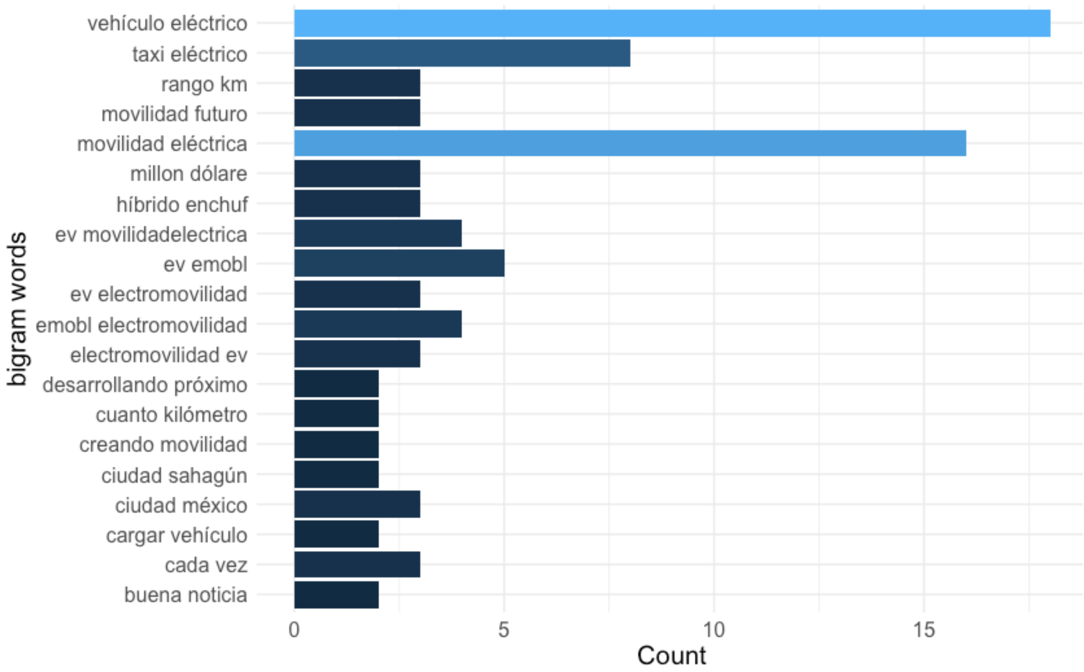


Figure 471. Bigram Term frequencies - top 20 plot – Production – Spanish

Finally, the sentiment and emotion of the tweets is analysed. 56% of the tweets from this topic are classified as positive and 44% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

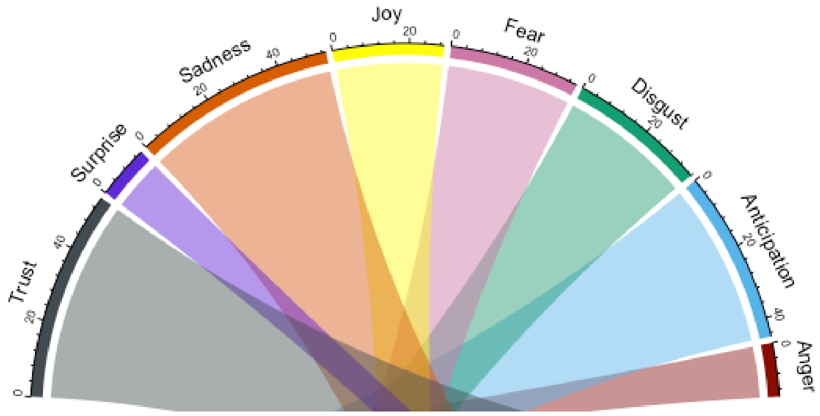


Figure 472. Emotion distribution for tweets of production Topic - Spanish

Technology

The following bar plot shows the top 20 most frequent terms for the technology topic.

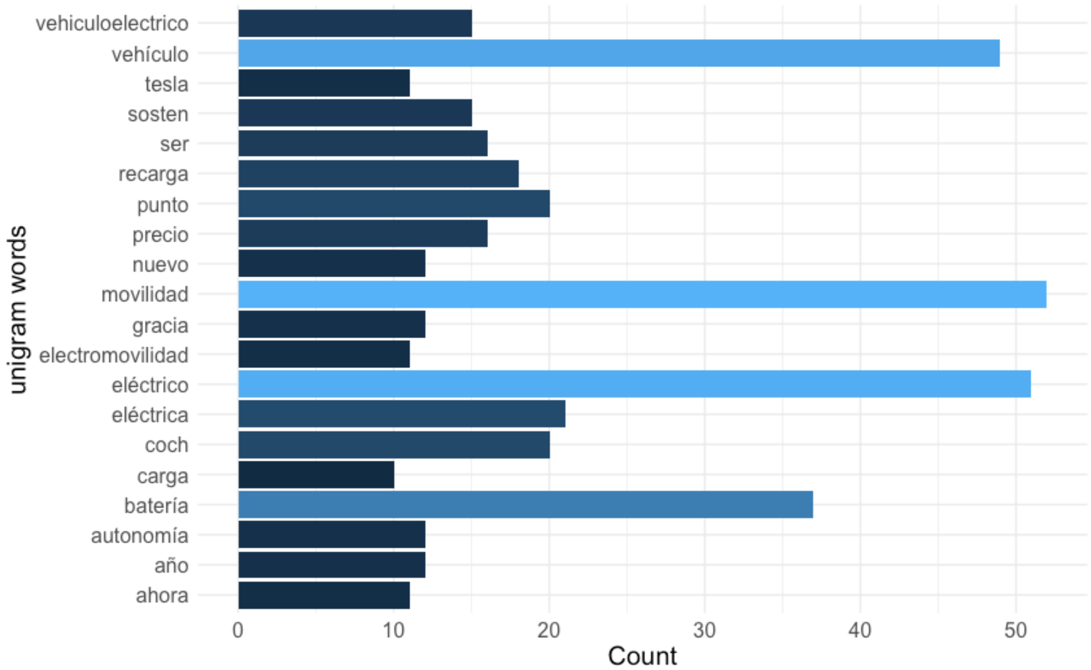


Figure 473. Term frequencies - top 20 plot– Technology – Spanish

The following Figure presents the network of words.

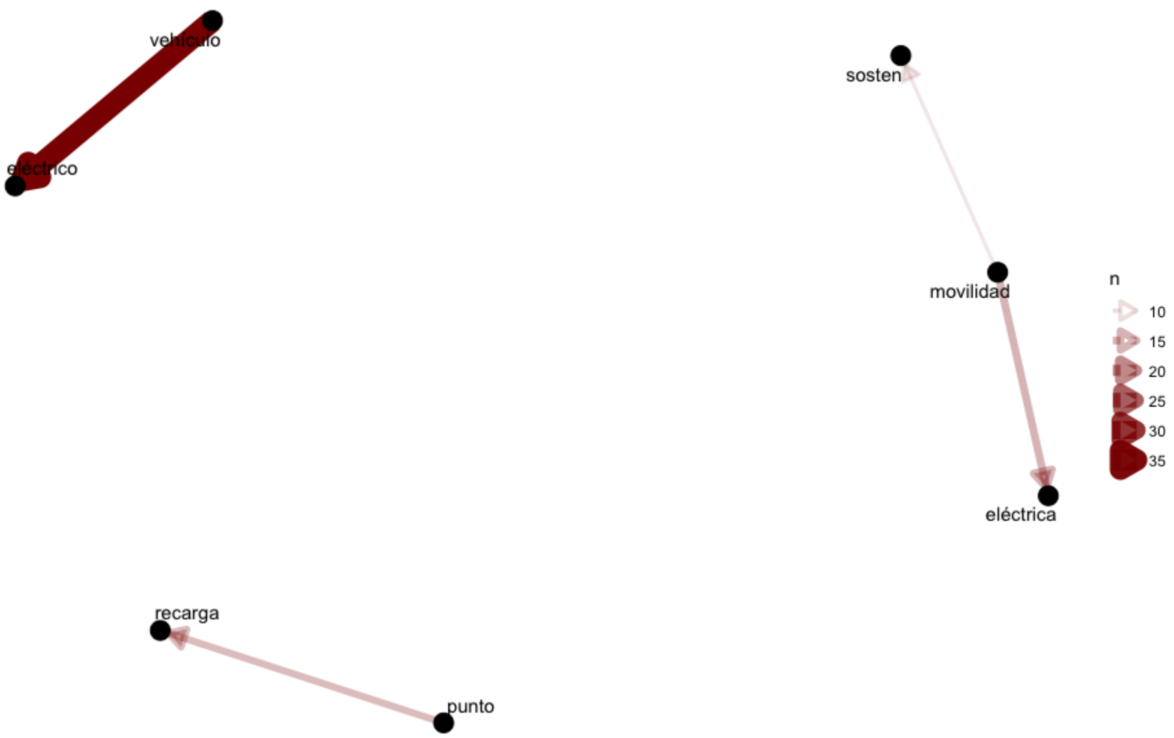


Figure 474. Network of words - bigram – Technology – Spanish

Then, the most frequent bigrams have been analysed and plotted in the following figure.

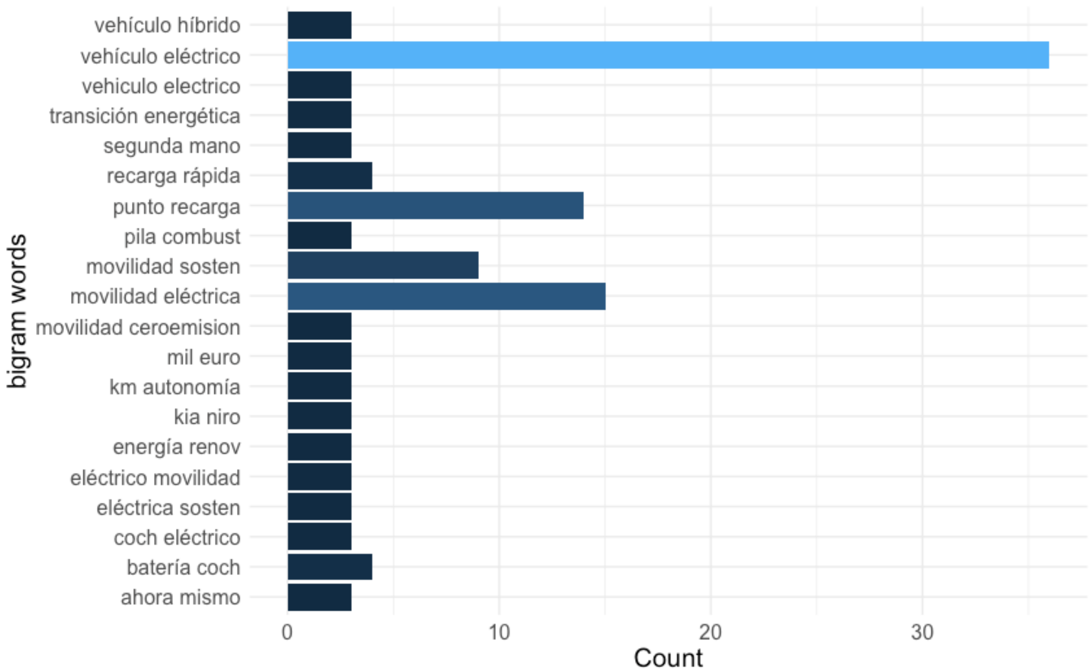


Figure 475. Bigram Term frequencies - top 20 plot– Technology - Spanish

Finally, the sentiment and emotion of the tweets is analysed. 51% of the tweets from this topic are classified as positive and 49% as negative. Moreover, the following figure presents the emotion distribution for the charging infrastructure topic.

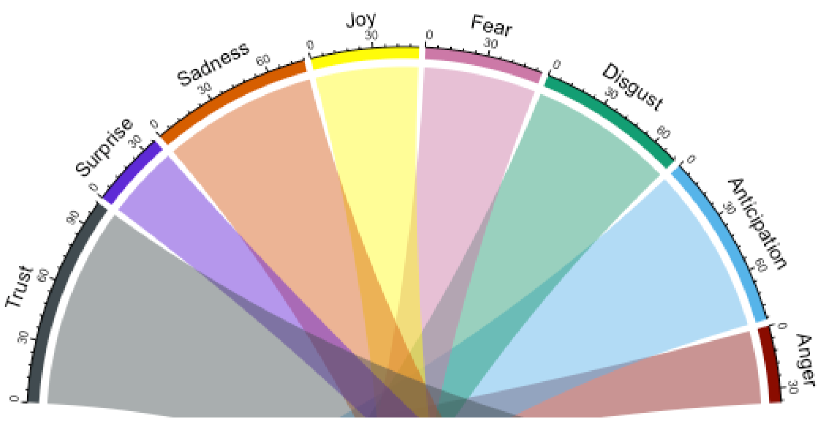


Figure 476. Emotion distribution for tweets of technology Topic - Spanish

ANNEXE A.3. ADDITIONAL FIELD DATA ANALYTICS CHARTS AND TABLES

AUSTRIA

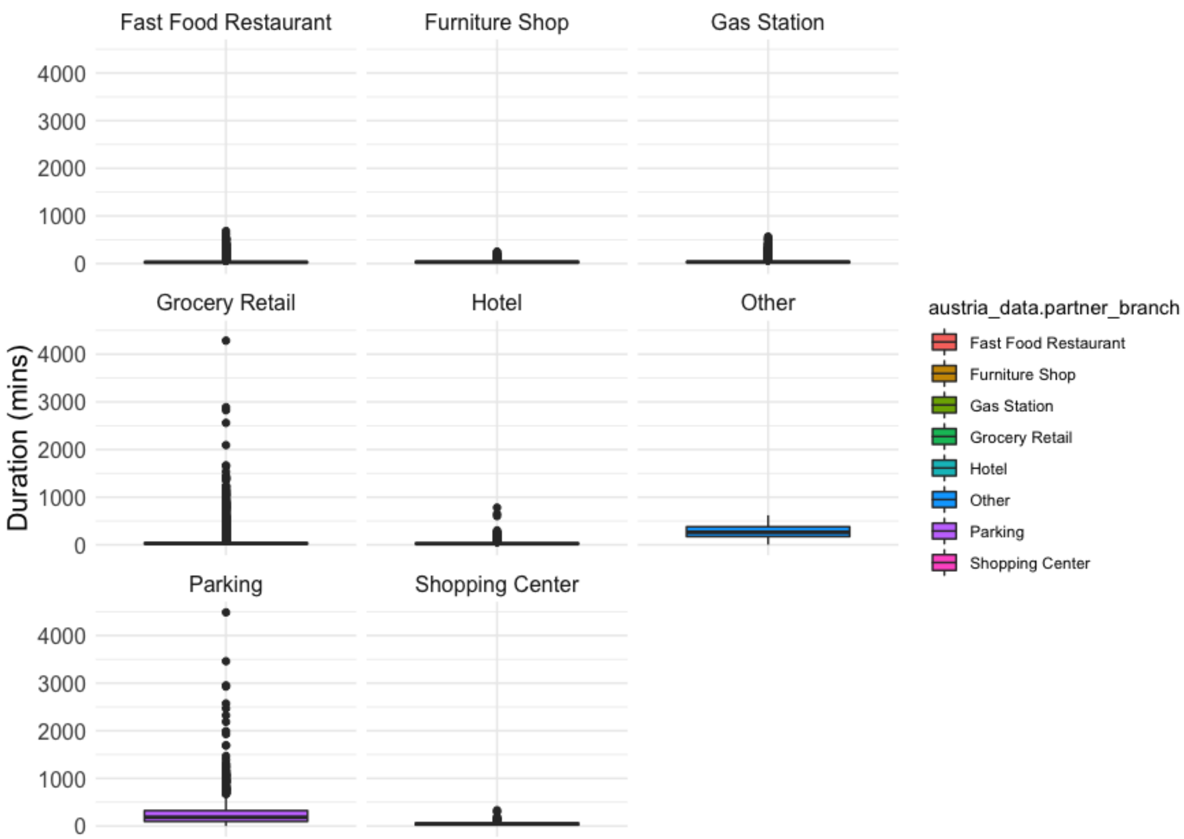


Figure 477 Box plots concerning session duration per type of location -Austria demonstration area

Table 86 Statistics concerning session duration per type of location -Austria demonstration area

Fast Food Restaurant					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1 min	19.42 min	19.42 min	27.87 min	32.46 min	683.82 min
Furniture Shop					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.02 min	18.58 min	29.67 min	35.81 min	46.08 min	250.07 min
Gas Station					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.03 min	21.1 min	32.2 min	39.13 min	42.55 min	566.13 min
Grocery Retail					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**

1 min	18.32 min	28.2 min	45.19 min	41.17 min	4285.98 min
Hotel					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.18 min	16.80 min	23.63 min	32.87 min	36.05 min	780.90 min
Parking					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
1.20 min	95.76 min	184.63 min	250.36 min	324.23 min	4485 min
Shopping Centre					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
3.05 min	23.23 min	44.28 min	57.93 min	64.72 min	331.12 min
Other					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
4.33 min	173.05 min	263.38 min	275.12 min	379.60 min	619.88 min

- **Energy consumed per session**

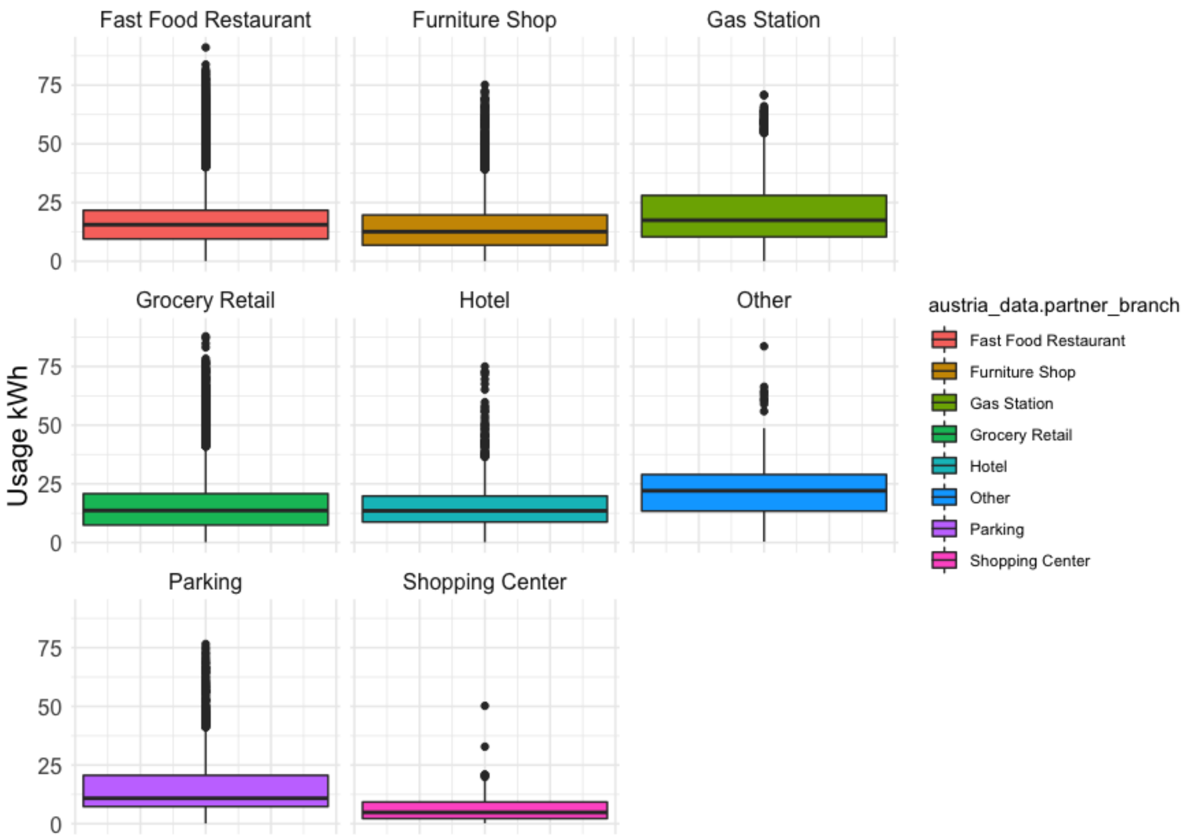


Figure 478 Box plots concerning energy consumed per session per type of location -Austria demonstration area

Table 87 Statistics concerning energy consumed per session per type of location -Austria demonstration area

Fast Food Restaurant					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.10 kWh	9.52 kWh	15.58 kWh	16.78 kWh	21.74 kWh	91.10 kWh
Furniture Shop					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.10 kWh	6.84 kWh	12.61 kWh	14.68 kWh	19.73 kWh	75.18 kWh

Gas Station					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.11 kWh	10.39 kWh	17.48 kWh	19.46 kWh	28.06 kWh	70.95 kWh
Grocery Retail					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.1 kWh	7.42 kWh	13.63 kWh	15.47 kWh	20.80 kWh	87.84 kWh
Hotel					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.12 kWh	8.72 kWh	13.51 kWh	15.52 kWh	19.81 kWh	74.98 kWh
Parking					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.1 kWh	7.31 kWh	10.85 kWh	15.30 kWh	20.63 kWh	76.57 kWh
Shopping Centre					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.22 kWh	2.20 kWh	4.82 kWh	6.87 kWh	9.27 kWh	50.23 kWh
Other					
Minimum	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Maximum**
0.34 kWh	13.38 kWh	22.04 kWh	23.10 kWh	28.97 kWh	83.58 kWh

Most significant connections and number of trips for each connection – Austria demonstration area

Table 88 Most significant trips and their number – Austria demonstration area

Graz → Wien (162 trips)	Wien → Graz (72 trips)	Salzburg → Wien (47 trips)
Innsbruck → Wien (22 trips)	Graz → Innsbruck (17 trips)	Graz → Salzburg (13 trips)
Wien → Innsbruck (12 trips)	Innsbruck → Salzburg (10 trips)	Wien → Salzburg (10 trips)
Salzburg → Innsbruck (8 trips)	Innsbruck → Graz (5 trips)	Salzburg → Graz (5 trips)

BARCELONA

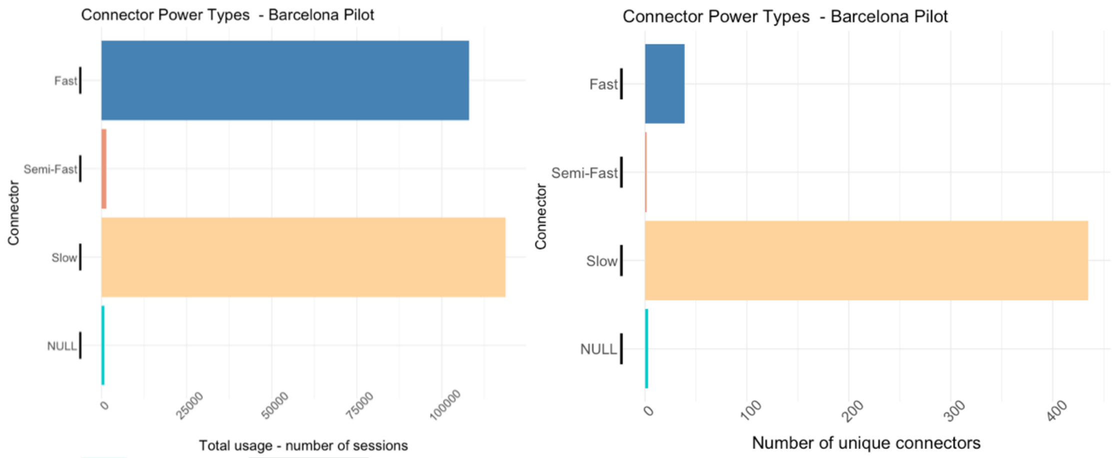
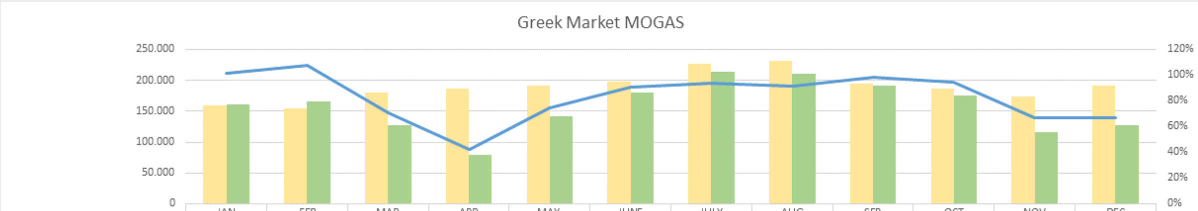


Figure 479 Total sessions happened with each connector power type (left) and total number of each connector power type (right)

Table 89 OD trips from/to Barcelona

Barcelona – Teruel (2 trips)	Badajoz – Barcelona (1 trip)	Barcelona – Girona (12 trips)
Alicante – Barcelona (4 trips)	Barcelona – Huesca (2 trips)	Barcelona – Cantabria (1 trip)

GREECE



	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
2019	158.636	153.784	180.015	186.880	190.636	198.093	226.668	230.820	193.987	186.016	174.448	192.007
2020	161.452	165.160	127.009	79.116	141.570	179.974	213.118	210.418	191.121	175.887	116.770	127.692
Performance 2020 vs 2019	102%	107%	71%	42%	74%	91%	94%	91%	99%	95%	67%	67%

Figure 480 COVID-19 effect – Greece demonstration area

GRENOBLE

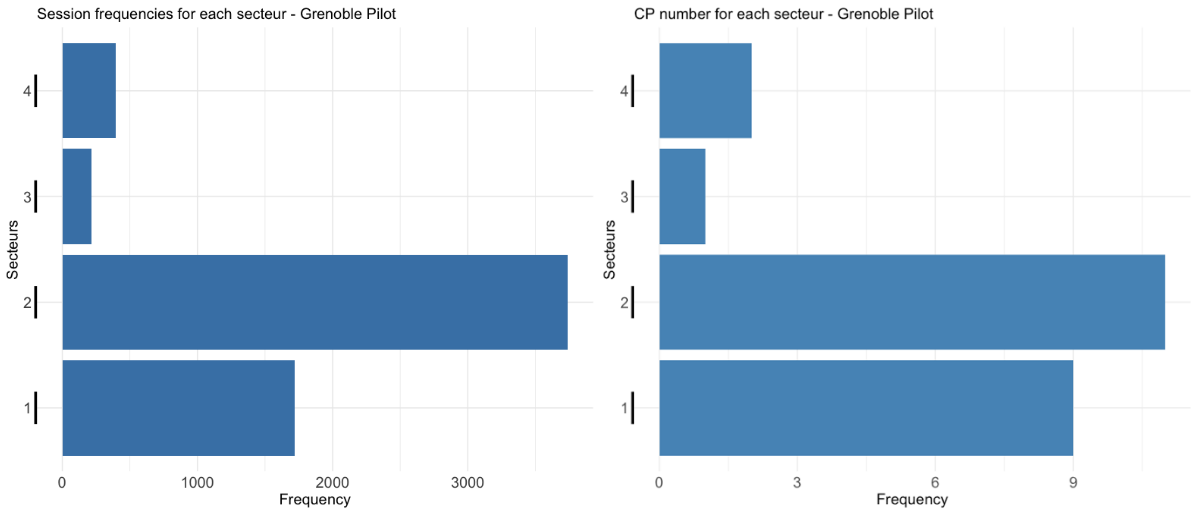


Figure 481 Usage distribution per sector – Grenoble demonstration area

LUXEMBOURG

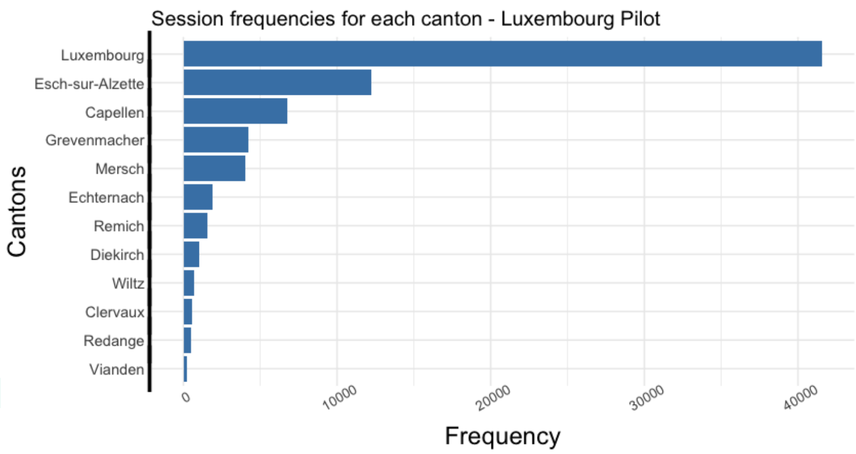


Figure 482 Usage distribution per canton - Luxembourg demonstration area

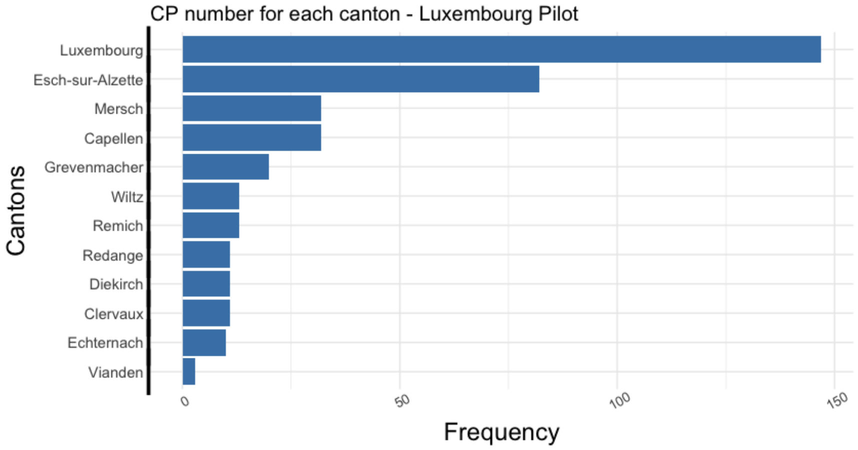


Figure 483 Session distribution per canton - Luxembourg demonstration area

Table 90 shows the most significant inter-canton trips, being Luxembourg, Capellen and Grevenmacher the cantons present in more trips.

Table 90 Most significant trips and their number - Luxembourg demonstration area

Luxembourg-Capellen (309 trips)	Luxembourg-Echternach (110 trips)	Luxembourg-Mersch (88 trips)
Luxembourg-Grevenmacher (80 trips)	Capellen-Luxembourg (71 trips)	Mersch-Luxembourg (63 trips)
Echternach-Grevenmacher (62 trips)	Luxembourg-Remich (60 trips)	Luxembourg-Diekirch (44 trips)
Remich-Luxembourg (44 trips)	Capellen-Grevenmacher (35 trips)	Capellen-Echternach (31 trips)
Grevenmacher-Luxembourg (31 trips)	Grevenmacher-Remich (27 trips)	Luxembourg-Wiltz (27 trips)

Table 91: Number of cantons visited by users – Luxembourg demonstration area

	1	2	3	4	5	6	7	8	9	10	11	12
Total	2528	953	385	143	57	30	6	4	6	1	1	1
%	61.43	23.16	9.36	3.48	1.39	0.73	0.15	0.1	0.15	0.024	0.024	0.024

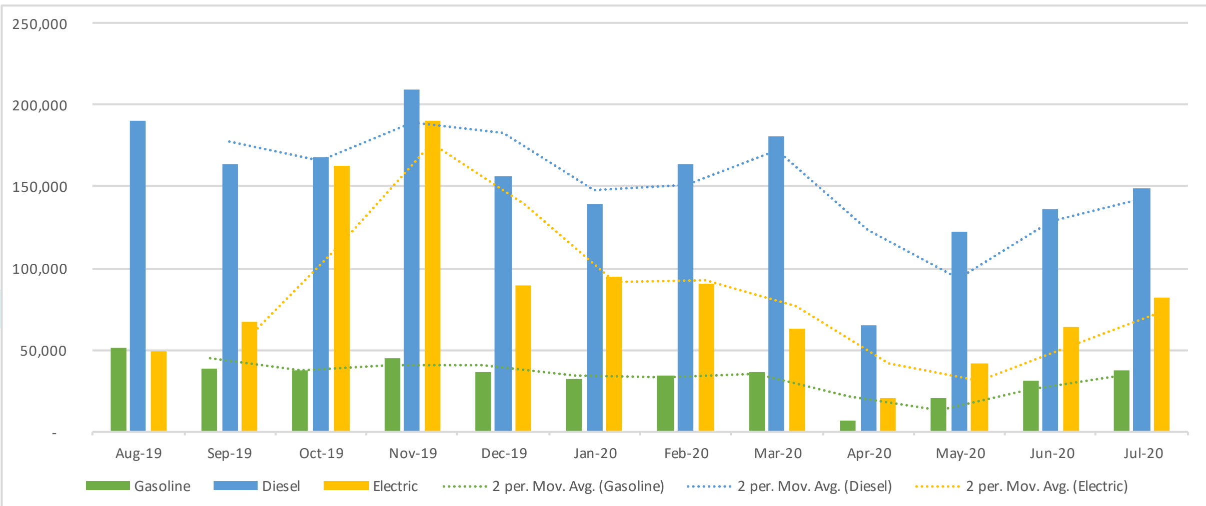


Figure 484: COVID-19 effect – Luxembourg demonstration area

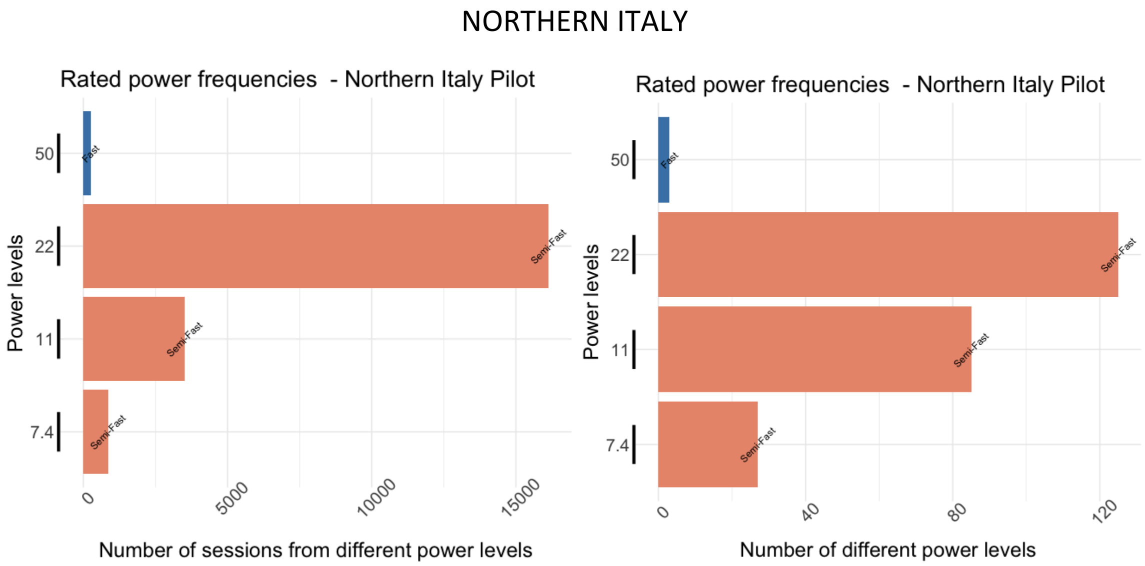


Figure 485 Charging power analysis – Northern Italy demonstration area

Total sessions happened with each connector power type (left) and total number of each connector power type (right) – Northern Italy demonstration area

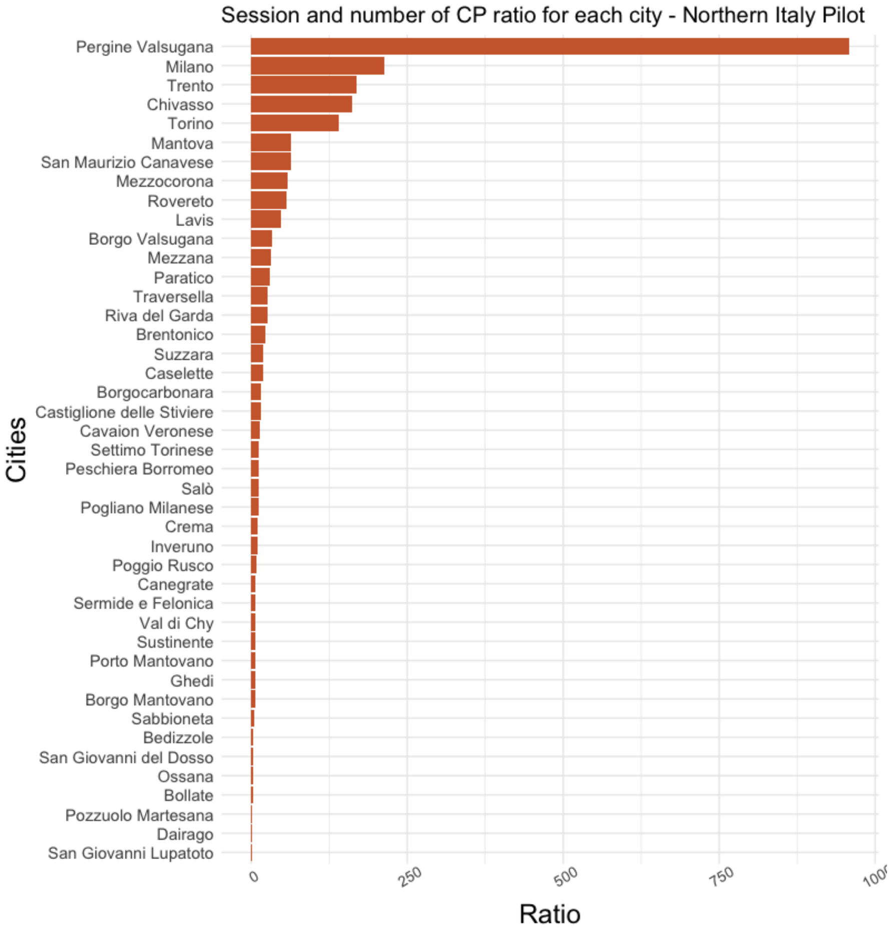


Figure 486 Ratio of sessions per CP in the Northern Italy demonstration area

Table 92 Number of cities visited by users - Northern Italy shows the number of cities visited by the users of the Northern Italy demonstration area. It can be noted that most of the users (79%) charge their vehicles in one city. 13% of the users charge in 2 cities and the rest of them (8%) in 3 or more cities.

Table 92 Number of cities visited by users - Northern Italy demonstration area

	Number of cities visited								
	1	2	3	4	5	6	7	8	10	More than 10
Total	905	152	40	13	10	7	2	4	1	11
%	79	13	3	1	1	0.52	0.17	0.35	0.09	1

Table 93 Most significant trips and their number - Northern Italy demonstration area

Borgo Mantovano - Borgo Valsugana (6 trips)	Paratico - Pergine Valsugana (8 trips)	Chivasso-Crema (11 trips)
Castiglione delle Stiviere - Chivasso (6 trips)	Torino - Traversella (8 trips)	Pergine Valsugana-Riva del Garda (11 trips)
Crema - Mantova (6 trips)	Pergine Valsugana - Torino (8 trips)	Borgo Valsugana-Pergine Valsugana (11 trips)
Mezzocorona - Pergine Valsugana (6 trips)	Mezzana - Milano (8 trips)	Lavis-Mantova (14 trips)
Milano - Pergine Valsugana (6 trips)	Pergine Valsugana - Trento (8 trips)	Mantova-Mezzana (14 trips)

Salò - San Maurizio Canavese (7 trips)	Borgo Valsugana - Trento (8 trips)	Settimo Torinese-Torino (14 trips)
San Maurizio Canavese - Torino (7 trips)	Chivasso - San Maurizio Canavese (8 trips)	Torino-Trento (17 trips)
Chivasso - Settimo Torinese (7 trips)	San Maurizio Canavese-Settimo Torinese (9 trips)	Chivasso-Torino (26 trips)

TURKEY

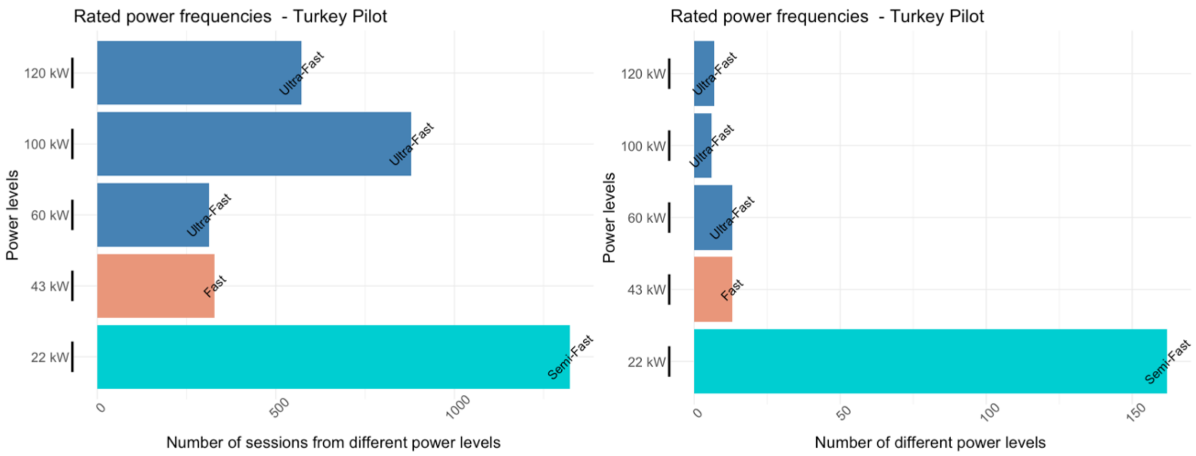


Figure 487 Charging power analysis – Turkey demonstration area

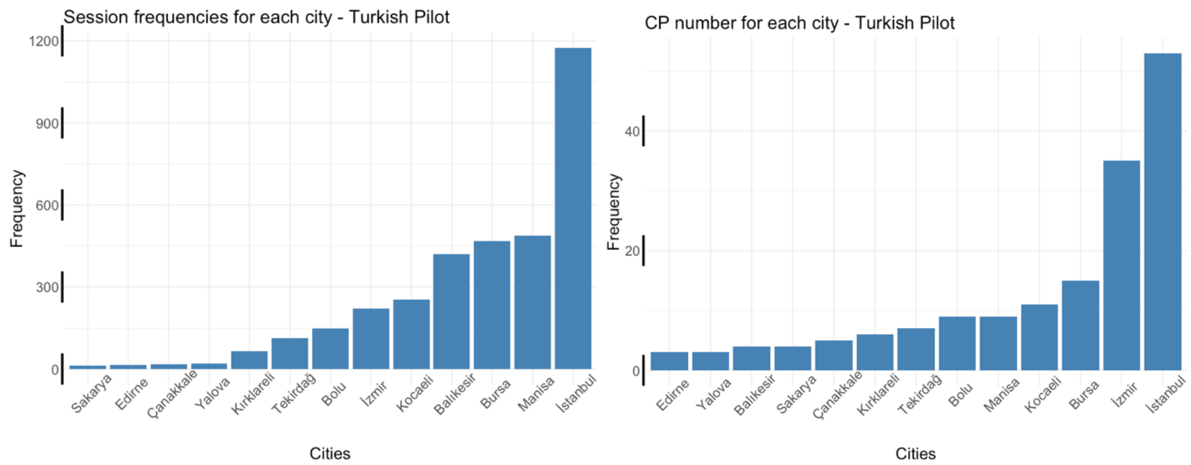


Figure 488 Usage distribution and number of charging points - Turkey demonstration area

It can be inferred from Table 94 that most of the users charge their vehicle in one (58.3%) or two cities (19.9%). The users with more than one location for charging sessions will be also taken into account for a corridor analysis.

Table 94 Number of cities visited by users – Turkey demonstration area

	Number of cities visited						
	1	2	3	4	5	6	7
Total (785)	458	156	84	50	23	11	3
Percentage	58.3%	19.9%	10.7%	6.4%	2.9%	1.4%	0.4%