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Electric Vehicles Management for carbon neutrality in Europe

Deliverable D3.2
Apps and Tools design principles promoting EVs and V2X adoption

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Disclaimer

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[1] https://ev4eu.eu/

Executive Summary

The deliverable *Apps and Tools design principles promoting EVs and V2X adoption* suggests main features of tools to improve the potential for response diversity to Electric Vehicle (EV) drivers' individual and collective needs, and build redundancy that can minimize and correct errors in governance.

Additionally, regarding the need for higher plug-in rates, to allow Vehicle-to-Everything (V2X) mass deployment, incentives and gamification solutions are proposed, to engage users to always plug-in their vehicles after each use.

Other V2X uptake barriers are addressed, such as cost, inconvenience, distrust, confusion, range anxiety, battery degradation and charging time. Design standards and guidelines will be provided, with specifications for User Experience (UX) and User Interface (UI) implementation that will be developed in T5.7.

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Keywords, Acronym

CCTV	Closed-circuit television
EV	Electric Vehicle
EV4EU	Electric Vehicles Management for Carbon Neutrality in Europe
ICEV	Internal Combustion Engine Vehicle
RES	Renewable Energy Sources
UI	User Interface
UX	User Experience
VPP	Virtual Power Plant
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything

1 Introduction

The Electric Vehicles Management for Carbon Neutrality in Europe (EV4EU) project proposes and implements user-centric Vehicle-to-Everything (V2X) management strategies that set the stage for mass deployment of electric vehicles (EVs).

Effective V2X management requires reaching agreements between many parties with conflicts of interest. Based on the results of task 3.1: EV Users' Needs and Concerns, this deliverable intends to propose the main features of tools to improve the potential for response diversity to EV drivers' individual and collective needs, and build redundancy that can minimize and correct errors in governance.

A critical barrier for the mass deployment of V2X is the plug-in rate, i.e., the time percentage the vehicle is plugged into a charging station. Task 3.1: EV Users' Needs and Concerns provided some insight into this topic, and the current task (task 3.2) used that to propose incentives and gamification solutions to engage users to always plug-in their vehicles after each use. This and other perceived barriers for V2X uptake, such as cost, inconvenience, distrust, confusion, range anxiety, battery degradation, and charging time, will also be addressed in this deliverable, by proposing a set of guidelines and design standards, as well as specifications for the correct User Interface (UI) and User Experience (UX) implementation that will be developed in task 5.7: Integration Between User Interfaces and Open V2X Management Platform.

Finally, a specific function will be proposed regarding queueing methods for EVs charging (based on users' feedback).

1.1 Scope and Objectives

In this document, the results obtained by following the methodology presented in Chapter 2 are analyzed, and features deriving from that analysis are described in Chapter 4, along with a set of design guidelines (Chapter 5) that assure a better user experience. Features proposed and design guidelines mentioned have the goal to inform work being developed to create a V2X management platform, during task 5.7.

1.2 Structure

The document starts by describing the methodology used (Chapter 2) and doing an initial analysis of current V2X tools and software available (Chapter 3). Afterwards, a set of features is proposed (Chapter 4), based on the results of the research conducted (results for each step described in appendixes A, B, C and D), and finally design guidelines are provided (Chapter 5).

1.3 Relationship with other deliverables

This deliverable will provide valuable information to the work being developed in task 5.7: Integration Between User Interfaces and Open V2X Management Platform.

2 Methodology

The methodology applied in this task assumed that work would start based on insights gathered from Deliverable D3.1 EV User´s Needs and Concerns – Preliminary Report [1]. Also, it was crucial to cross-reference partners needs for a V2X app and service, with the EV users wishes and daily experiences. The following methodology was applied:

- **Current market tools** were researched, focusing on apps and services that provide Vehicle-to-Grid (V2G) and V2X capabilities. These were presented in the workshop with partners (next step of the methodology), to help understand what already exists in the market, as well as inspire the generation of new ideas. Tools selected are presented in Chapter 3.
- **Workshop with project partners** assigned to task 3.2, to remind partners of main insights deriving from D3.1 [1] (Chapter 4.1), align needs and expectations of partners regarding the V2X app to be developed in the project, and generate a pool of initial ideas to include in it, which then allowed the SEL team to prepare the next steps in task 3.2. The summary of this workshop is available in APPENDIX A: Workshop with project partners - summary.
- **Idea generation exercise**, taking the ideas gathered from the workshop as starting point, with the goal of creating a set of features the V2X app could have, and these were then tested with users, in the following steps of this task. A summary of what this exercise consisted of, and the results it produced, is available in APPENDIX B: Idea generation exercise.
- **Remote exercises with EV users**, so that the features explored in the previous step could be validated by users, thus assuring the app answers to their needs and concerns. An analysis of the exercises' results is available in APPENDIX C: Remote exercises with EV users.
- **Follow-up interviews with EV users**, in order to clarify exercises' results, and deepen some of the gathered insights. An analysis of the interviews conducted is available in APPENDIX D: Follow-up interviews with EV users.

By cross-referencing results from all these steps, a set of specifications, standards and guidelines was created, and these are described in Chapters 4.3 and 5. They will provide input into task 5.7: Integration Between User Interfaces and Open V2X Management Platform.

2.1 Recruitment and sampling process

For this task, the recruitment process was based on contacts gathered during task 3.1. The team used contacts from the interviewed users who gave consent to be reached for further research activities related to the EV4EU project.

All users who replied to the request to participate in task 3.2 received the online exercise. After analysing all exercise submissions, the team opted to interview all participants, tailoring the interview script to each one, based on their country and on the answers they had given in different exercises.

3 Current market tools (V2X & V2G Portals and Services)

In this chapter, a list of existing V2G and V2X apps and software will be presented, where each one will be analysed regarding their features, and how that can be interesting for the EV4EU project.

These apps and software were found by searching for specific e-mobility capabilities such as V2G and V2X, and others that could be interesting for the project.

The list analysed was extensive, but only some were selected as being a source of inspiration for the current task, so only those will be presented in this document. The apps and software analysed are the following: Gridio, Jedlix, Enel X Way, Soft V2X, V2X Track Lite, Harman Savari Mecwave, and Virta.

Gridio

Gridio[2] (Figure 1) is an EV charging app, and its system automatically charges the car when electricity is the cheapest (and usually also the "cleanest", i.e., from renewable energy sources). This system tracks the energy market in real time and reads hourly price fluctuations, and its algorithm selects the best combination of hours to charge to maximize savings.

Shifting consumption enables charging a vehicle using less carbon-intensive electricity, as well as higher rate of exploitation of Renewable Energy Sources (RES) in the power grid.

As an interesting feature to highlight, the **on-screen indicator of the best times to charge** can be a valuable concept to apply in this project, as well as the **countdown feature to the next "electricity happy hour"**.

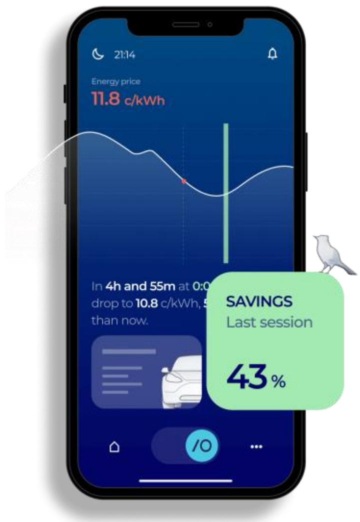

Figure 1: Gridio app screen
(source: https://www.gridio.io/)

[2] https://www.gridio.io/

Jedlix

Jedlix[3] (Figure 2) is an app that allows the transfer of energy leftovers from the vehicle's battery to the power grid, allowing vehicle owners to spend less on car maintenance and charge at the lowest possible price. They also provide a white label app for car manufacturers and other retailers which can be used for managing EV consumption.

Their services include a Virtual Power Plant (VPP) to aggregate a wide range of electric cars into one asset pool and monetize their charging flexibility on energy and balancing markets.

As interesting features to highlight, the **charts providing grid energy injection statistics** can be a valuable concept to apply in this project, as well as the **reward system for injecting power back into the grid with every kWh "smart charged"**.

Figure 2: Jedlix app screen (source: https://www.jedlix.com/whitelabel)

Enel X Way

Enel X Way[4] (Figure 3) is a V2G mobile app for individuals and businesses to monitor and manage public, private, and domestic charging.

It allows for viewing of the status of charging points and to always locate the nearest station.

As interesting features to highlight, the **map system with available chargers in the city** can be a valuable concept to apply in this project, including functionalities such as **markers with V2G discharge capability indicators** and **filters to look for those V2G capable chargers**.

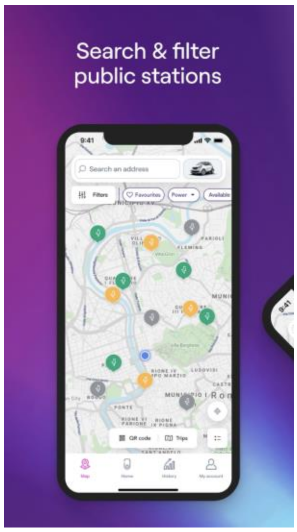

Figure 3: Enel X Way app screen (source: promotional image at Apple's App Store)

[3] https://www.jedlix.com/
[4] https://www.company.enelxway.com/en

Soft V2X

Soft V2X[5] (Figure 4) is an app that can warn users of collision risks between pedestrians and vehicles, as well as possible car crashes to prevent road accidents.

It uses smart closed-circuit televisions (CCTVs) to warn of possible collisions with people or vehicles that do not have the Soft V2X app installed.

As interesting features to highlight, the app allows the user to **switch between different types of commercially available maps**, and it also includes **several points of interest besides charging stations, such as pedestrians, bicycles, and other vehicles** (all flagged with different colours).

Figure 4: Soft V2X app screen (source: http://www.soft-v2x.com/app/introduction)

V2X Track Lite

V2X Track Lite[6] is a device that can be installed in the car, and together with the app (Figure 5), it provides connected services like vehicle location, driving data, health diagnostics, surveillance, security reminders and driving reports.

One interesting feature this service provides is the **geofencing capability for vehicle location reference**.

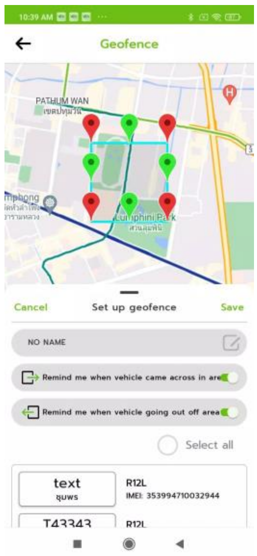

Figure 5: V2X Track Lite app screen (source: https://apkpure.com/v2x-track- lite/th.co.v2x.app.track.lite)

[5] http://www.soft-v2x.com/

[6] https://v2x.co.th/track-lite/

Harman Savari Mecwave

HARMAN Savari MECWAVE [7] (Figure 6) is a software application platform that leverages cellular networks to enable a variety of real-time shared services and applications.

The applications can be deployed on several connected devices such as telematics control units, automotive aftermarket devices, smartphones, and wearables.

As an interesting feature to highlight, this software can **indicate availability or malfunction of charging spots and surrounding infrastructure**, which can be a valuable concept to apply in this project.

Figure 6: Harman Savari Mecwave dashboard that can be installed in vehicles (source: https://car.harman.com/solutions/connectivity/harman-savari-mecwave)

Virta

Virta[8] is a service that, among other features, has Virtual Power Plant capabilities. It aggregates and manages the energy resources of multiple EVs, ensuring that the grid benefits from their combined capacity.

For individual users, this is an interesting app to highlight (Figure 7), as it allows for **private charger integration**, as well as **access to public chargers (with roaming features included)**.

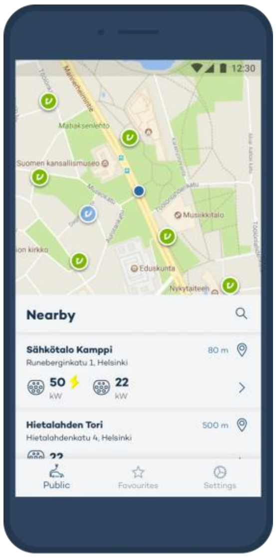

Figure 7: Virta app screen (source: https://www.virta.global/blog/charge-without-a-wallet-virtas-mobile-app)

[7] https://car.harman.com/solutions/connectivity/harman-savari-mecwave
[8] https://www.virta.global/ev-drivers

4 Specifications and features proposed

In this section, a summary of the main insights from D3.1 [1] will be presented, since it provided initial context to the work done in task 3.2. Afterwards, priorities and viability will be discussed, based on results from research activities conducted (see Chapter 2 for a description of the research activities done), and finally suggestions will be proposed for features that could integrate a V2X app.

4.1 Relevant insights from D3.1

As seen in D3.1 [1], there are several contextual characteristics in each country that have an impact in the EV driving experience. There are also some common needs and concerns. In this chapter, a quick summary will be presented, including a brief description of each country studied, as well as the main insights gathered in the key topics related with the EV experience and V2X expectations.

Starting with an overview of each country, Table 1 summarizes the key factors to have in mind regarding EV users:

Table 1: Key insights from each country, described in D3.1

Country	Energy literacy[9]	Incentives[10]	Main motivators for EVs[11]	Main barriers for EVs[12]	Perceived plug-in rates[13]
Slovenia	2.23 of 3	State incentives have been decreasing	Low CO2 footprint (77%), cheaper “fuel” (68%), less noise (41%) and state incentives (41%)	Electricity prices are rising rapidly, difficulties with charging network	“Always charging” preference, linked with range anxiety
Greece	2.30 of 3	Not high enough, and not applicable to second-hand vehicles	Low CO2 footprint (76%), cheaper “fuel” (55%) and technology associated with EVs (45%)	Batteries are very expensive, sense of “blackmail” for maintenance to keep battery warranty	Economic savings dictate charging times (at home), and charge only when needed (in public network)
Denmark	2.42 of 3	Automatic tax reduction (in a country where registration taxes can go up to 180%)	Low CO2 footprint (82%), technology associated with EVs (50%) and less noise (41%)	High purchase costs	“Always plugged-in” when at home or office, but settings dictate charging times
Portugal	2.07 of 3	Azores provides additional funds, cumulative with Portuguese ones	Cheaper “fuel” (86%), low CO2 footprint (69%) and state incentives (43%)	Insufficient charging infrastructure, with a lot of uncertainty involved	“Always plugged-in” when at home or office, but settings dictate charging times

To describe the perceived EV experience and V2X expectations that were analysed in D3.1 [1], eight key topics were identified as follows, including the respective main insights:

[9] Average of energy literacy scores for each country, given in research study done in D3.1 [1]. Each participant was scored by doing an average of 11 topics, where each one was evaluated by participants according to their level of understanding of the topic (being 0 the lowest score, and 3 the highest).
[10] Analysis of expert and user interviews done in D3.1 [1].
[11] Options more often chosen by participants in quantitative studies done in D3.1 [1].
[12] Options more often chosen by participants in quantitative studies done in D3.1 [1].
[13] Analysis of expert and user interviews done in D3.1 [1].

- Topic 1: **Energy literacy** _ How much do users know about energy consumption and other related topics? And does it impact the adoption and use of an EV?
    - In a general sense, energy literacy does not seem to be as low as initially expected, and it seems to be increasing, due to the current energy crisis;
    - Energy literacy seems to have some correlation with EV adoption. Denmark, the country with the highest EV adoption percentage, is also the one displaying higher energy literacy;
    - A higher energy literacy appears to also be linked to a greater dedication in lowering energy consumption costs.
- Topic 2: **EV adoption** _ What are the main motivations driving people to adopt electric vehicles? And how can we leverage on that, to further promote EVs?
    - Economic and ecologic reasons are at the core of people's main motivators to adopt EVs;
    - Even though almost everyone mentions ecological concerns, the perceived savings related to using electricity as fuel appear to be the main driver for EV adoption. This could be concerning, since electricity prices have been rising recently;
    - State incentives play an important role, but they are seen as "not enough", and different types of support are expected.
- Topic 3: **EV current experience** _ Is there a "life before and after EV" kind of feeling? What has changed, and how did people adapt their needs and routines? Are there concerning barriers in daily EV use?
    - Increased planning is the main routine change that comes with driving an EV;
    - EV owners see the public charging network as insufficient, especially when travelling outside of big cities. Emergency scenarios are the most concerning, when considering the lack of available alternatives;
    - People seem to prefer having a way to charge at home, either by using simple plugs or by installing a home EV charger, due to increased convenience and lower prices.
- Topic 4: **All about batteries** _ Is battery degradation really the main issue? What kind of concerns do people have related to this part of their vehicles?
    - Battery degradation concerns appear to be highly linked to the perceived cost of a new battery, and an uncertainty of how long a battery will really last (lack of confidence and understanding of warranties);
    - Plug-in rates seem to be more dependent on whether people can charge at home or at work, or if they rely solely on public infrastructure. Some mentioned that, if they feel secure that always plugging the car in will not degrade the battery faster, they might even prefer to do it, as it is more convenient;
    - Many mentioned having a setting in their car that defined how much, or at what time to charge, and this is both related with battery degradation concerns and lower energy prices at certain times.
- Topic 5: **Charging network** _ What are users' main needs and concerns regarding the current charging network available, and what do they expect for its future?
    - Charging network "dramatically"[14] insufficient availability seems to be closely related to 2 issues: range anxiety and disregard for rules. Better planning and occupation detection systems might solve these two, but users still seem to expect an increased network;

[14] Expression used by EV users interviewed, as mentioned in [1].

- Just as it was done for telecoms, roaming features are expected in public chargers across Europe, to facilitate travelling between countries with an EV.
- Topic 6: **Parking concerns** _ Contextual constrains shape needs and habits regarding parking issues, so what can be done in each setting?
  - Even though this was not on our minds in the beginning, we realised parking issues are a big concern, especially when physical characteristics of each location limit availability;
  - Fairness for all seems to be the main message, as people still expect internal combustion engine vehicles (ICEVs) to have a big presence in coming years, and prioritising EVs should not make life harder for the rest.
- Topic 7: **V2X benefits** _ When V2X becomes a reality, what do users expect to benefit from this system?
  - EVs are seen (by some) as "batteries on wheels", and increasing this perception might be a steppingstone to V2X adoption;
  - Depending on the financial model of EV acquisition, costs associated with battery exchange dictate maintenance concerns, and that can affect V2X compensation expectations;
  - Lower EV maturity seems to be related with expected monetary benefits from V2X participation;
  - Community-driven scenarios might be an interesting way to push V2X adoption, creating smaller "energy ecosystems" with intelligent grids and renewable sources.
- Topic 8: **V2X barriers** _ What concerns and constraints might prevent V2X from being possible, and what might we do to address these issues?
  - Besides economic factors, assuring control seems to be the main requirement for people to be comfortable with the grid "taking energy away" from their batteries. This means being able to set limits of how much energy can be taken away, and when. Also, enabling "opt-in" or "opt-out" features to allow for variations in daily routines (like holidays or other specific mobility needs);
  - Regulations and protocols need to be created, ensuring benefits for everyone involved in the system, and working details need to be proven and widely communicated, otherwise people will not trust this technology.

4.2 Priorities and viability

As a result of the aforementioned methodology (Chapter 2), a set of features were considered most relevant for partners, and potentially answering users' main needs and concerns. Therefore, after validating them with exercises and interviews, it seems the app's priorities should lie with two main functions:

- Mapping the public charging network (regardless of brand), simplifying its use, and including V2G incentives in this dimension.
- V2G scheduling capabilities, focusing on user control and information transparency, including energy price fluctuations and forecasts, in order to better educate users and facilitate their decision- making processes.

The app can and should include more functionalities, but research seems to support that these two will be the main focus for users.

Regarding viability, these features might pose some barriers with their implementation, namely:

- Will it be possible to include all chargers in one app, regardless of their brand?
- Will it be possible to assure a seamless payment method, that accommodates mentioned pain points such as needing different apps for different chargers, and lack of network signal in underground facilities?
- Will it be possible to communicate energy prices being practiced in real-time, and will it be clear for users?
- Will it be possible to predict energy sources used in following days, and therefore predict main times when the grid will benefit from users discharging their batteries into it?

In the following section, the previously mentioned features, along with other suggestions for features to include in a V2X app will be described, with notes supporting why users might need them, including some feedback obtained from them during interviews.

4.3 Suggestions for V2X specifications and features

Based on the methods applied in this task, it is possible to list some suggestions of features and specifications regarding V2G and V2X, that could be included in the app to be developed in task 5.7: Integration Between User Interfaces and Open V2X Management Platform. The list is the following:

- Charger mapping and unlocking feature, that allows users to use all chargers, regardless of brand and country, and thus replace apps from other brands.
- Include charging point status information, allowing for both automatic feedback and user created warnings.
- Energy price forecast tool, that distinguishes buying and selling prices (for charging or discharging). Include possibility to set up alerts for specific price intervals, to suggest charging or discharging when prices are better for users. Also include possibility to automatically start charging or discharging, if the user allows that automation.
- Community section, including gamification and incentivizing more sustainable behaviours.
- User account, including EV details, to personalize app contents to EV characteristics.
- EV charging priorities and queueing methods, to better communicate with users the actions the system is performing, creating a more transparent process, and increasing trust in the service.

4.3.1 Charger mapping and unlocking feature

As discovered in D3.1 [1], one of users' main pain points is related to finding and using public chargers. These difficulties are usually related with the need to have a lot of different apps to use chargers from different brands, and not knowing if the charger is being used by someone else, or if it is working properly. Additionally, connection issues might also be a barrier in using public chargers (without cell phone network, many chargers are difficult to use, since users need an app and an internet connection to unlock them).

During the exercises and interviews conducted in task 3.2 (see APPENDIX C: Remote exercises with EV users and APPENDIX D: Follow-up interviews with EV users), the map feature was considered the most important one, since it seemed to solve the majority of the pain points listed before. Therefore, it was seen as a must-have in a V2X app, even if apparently it is not its main goal.

As the first feature proposed to be included in the V2X app, a map with all chargers should be developed, in order to allow users to easily solve the issue of finding chargers and using them, regardless of brand or country.

Figure 8 shows a proposal of a new set of wireframes for this feature, including functionalities like:

- Use colours to differentiate charger status (available, occupied, and not working);
- Include an indication of user's location;
- Have filters available, that might include filtering options by price range, unlocking fees, charger brand, charger type, V2G compatibility, distance, favourites, and rating;
- Include additional information and actions in the charging station detail, such has charger power, distance from user and how to get there, additional details in pricing information, and buttons to start charging (when the user is next to the station) and to give feedback;
- If the app connects to the user's EV, it can also provide more detailed information like expected battery when user reaches charger, and how long it will take to fully charge the car;
- Possibility to reserve a charger.

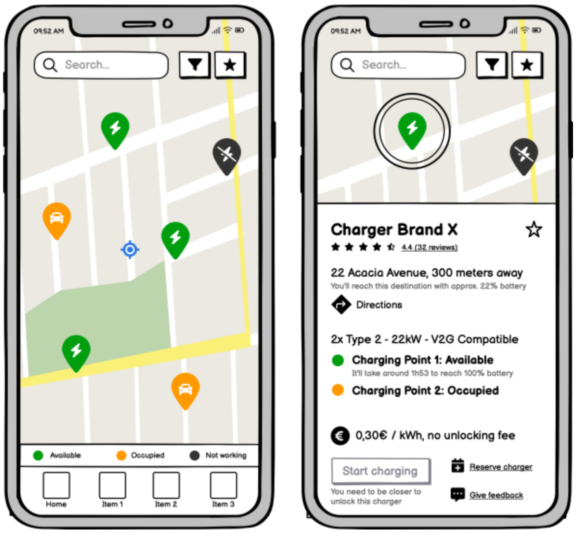

Figure 8: Screens for charger mapping and unlocking feature, produced by the SEL team.

About this last point, the possibility of reserving a charger was overall considered to be a very helpful feature. However, certain users expressed frustration for the fact that some people might not appear at their allotted reservation time and subsequent charger unavailability leads to frustration. The issuing of fines was proposed in case of people not appearing on their reserved slot or in the case they stay for a longer period after their charging session has ended.

4.3.2 Include charging point status information

As an addition to the previously mentioned feature, the charging station detail should also allow for charger status communication (functionality already mentioned above, stating the use of different colours for different charger status).

Moreover, it is also possible to see in Figure 8 a "review" indication, that should allow users to see in more detail the feedbacks already given to that charging station, as well as allow users to provide feedback themselves. This feedback might include fields such as rating, text review, selection of predefined feedback ("not working", "difficult to park", "poor internet connection", etc), and include photos.

4.3.3 Energy price forecast tool

It was initially assumed that a feature to schedule V2G discharge should be accompanied by energy price and source forecasting functionalities. This led to the creation of one of the exercises tested with users (see APPENDIX C: Remote exercises with EV users, Figure 17). After feedback received from participants, the main issue seemed to be the difficulty in understanding the purpose of the graphs. They were deemed very important but were not understood at a first glance. Therefore, it is proposed that they are included as a part of a V2G activation and planning feature, as an additional tool.

These charts should also be divided by energy prices depending on buying (i.e., charging EV battery) or on selling (i.e., discharging EV battery to the grid). Also, participants saw this as a very interesting tool to keep them informed and make decisions regarding whether they would charge or discharge at certain times, but felt that it would need an alert system, to let them know when energy is below a certain value (to charge), or above (to discharge). Finally, some suggested that, if the car is always connected, then these alerts could become settings, and allow an algorithm to automatically decide when to charge or discharge, based on energy prices (and always assuring a minimum battery percentage in the car). This seemed to be mostly suggested for nighttime use, for users that can charge at home, or for users that can leave their EVs charging all day at their workplaces. Figure 9 shows a suggestion of how this tool could be shown.

Figure 9: Screens for energy price forecast tool, produced by the SEL team.

4.3.4 Community section

During the exercises (APPENDIX C: Remote exercises with EV users) and interviews (APPENDIX D: Follow-up interviews with EV users), it was possible to understand that the "green score" [15] functionality proposed was not very interesting to users, or at least not a vital one, even though it could be seen as an interesting gamification technique, which could end up promoting more adoption and engagement.

Nevertheless, some mentioned in the interviews that it could be an interesting way to have gamification by competing amongst neighbours and friends, and in a sense build a community. That way, it was suggested to create a competition between users of the app, to see who got the greatest green score amongst members of a community, in order to make this idea more valuable.

Another way to promote engagement with this app would be to provide detailed statistics related to users' consumptions and discharges, also creating a sense of individualised gamification, where each user tries to have better results over time. Having information stating how much CO2 was saved by their contribution, how many kWh were already given, and the amount of money earned can trigger a will to do more, contribute more, and earn more as well. These statistics, although they are more individual ones, they can also be used as a comparison between members of a community, further creating a sense of sustainable competition.

Thus, it is suggested that this section could be included, where users can add their friends or create a local community and compete through more sustainable behaviours.

4.3.5 User account

Some participants seemed to expect that the app should be connected to their own EV, to easily provide information like battery percentage, range available, and battery's degradation status, among other details.

Although this might not always be possible, it is advisable that users can set up their own account, stating EV characteristics and their charging preferences (for example, if their car has a CHAdeMO type plug, it should have that as a predefined setting, and always filter chargers in the map which have that connection), as well as having a section dedicated to their favourite chargers, saved routes, notification preferences, among other personalisation functionalities.

4.3.6 EV charging priorities and queueing methods

One concern related to EV charging is managing energy distribution priorities and queueing methods, and building redundancy via intelligent charge and discharge scheduling. At a first glance, expectations from EV drivers seem to indicate they are not concerned with how energy is distributed, they are solely focused on meeting their own charging needs.

Also, interviews conducted in task 3.1 [1] showed that users seem to expect an efficient, smart, and fair charging system that can meet the needs of EV owners while balancing the grid and ensuring that everyone benefits. It was even mentioned by some participants that, if it were up to each individual

[15] The "green score" is a concept introduced in the exercises done with users (APPENDIX C: Remote exercises with EV users, Figure 18), that considers user behaviours regarding EV use and charge, like using renewable energy, as well as V2X contributions, and gives each user an overall score (the more RESs used and the more users participate in V2X, the higher that score will be).

driver to define the rules, a "selfish" approach would be chosen, whereas if the good of the group is prioritized, all involved would probably agree with the fairness of the system.

Having this in mind, it might be interesting to assume a model that takes each individual charging need as input, cross-references all needs, and distributes energy in the most efficient way possible. For this to be accepted by users, the method needs to be communicated very clearly. This means that, when a user plugs their EV into a charging point that has this system implemented, they should be able to immediately know that there is an algorithm deciding how much energy their EV will receive at each moment, what are the criteria the system considers, and what are the main goals it wants to achieve.

For example, assuming a scenario of an EV driver who connects their car to a charging point with an algorithm deciding how to distribute energy, he should be clearly informed of the following types of information:

- during the time their EV is connected, the system will take into account how much energy they need, and at what time they need it by, as well as for all other EVs connected;
- charging power might vary during the session;
- discharging capabilities might be activated, to make a more efficient use of energy;
- criteria based on how much renewable energy is available might be in play and affect how much energy each EV will receive;
- the system intends to make a more efficient energy distribution, while trying to meet all energy needs communicated;
- by the end of the session, it might be possible that the EV does not have as much energy as it was requested.

This last item is crucial. More than not meeting required needs, frustration in users seems to come from lack of information and warning about what might happen, what scenarios are in play. If a user is aware that they might not receive as much energy as they requested from the beginning, then the experience will not be as frustration, since they were given the information necessary to adjust expectations. This way, users seem to mainly need transparency of information. If all is communicated in a clear and straightforward way, then users are aware of what they can expect, and their experience will become a more positive one.

This topic is also explored in Deliverable D2.2 Control Strategies for V2X Integration in Buildings [2], regarding users' perceptions about V2X technology and how it might impact their daily energy needs. The principles afore mentioned apply to both cases, since the two require the same: for users to be informed of what is happening.

This way, as a suggestion of what can be implemented regarding EV charging priorities and queueing

The system should consider individual needs but prioritize energy efficiency and the good of the whole.

- Information needs to be available to users, in a clear and straightforward way, so that expectations can be adjusted, and frustration is avoided.

5 Design guidelines and standards

Design principles are essential guidelines that designers follow to ensure their designs are functional, intuitive, and effective. These principles are based on a wide range of disciplines, such as behavioural science, sociology, physics, and ergonomics, each providing valuable insights and experience to help designers make informed decisions [3].

By applying design principles, designers can ensure that their work meets the needs of their clients and users while staying true to their vision. These principles can help designers address important considerations such as usability, accessibility, and user experience, as well as the aesthetics of their designs. Moreover, design principles are not static, they evolve over time as new technologies and trends emerge. By continuing to learn and adapt, designers can continue to create innovative and impactful designs that meet the needs of their clients and users.

Jakob Nielsen, a usability expert, identified ten usability heuristics that he believes should apply to any interface. These "commandments" all work with the user at the center, as the most important actor in the system, and they are called heuristics because, rather than being rigid guidelines, they work as a suggestion of what is more important in a general sense [4]. The ten heuristics are:

1. **Visibility of system status** - it is considered very important to always keep users informed of system status, with constant and timely feedback. Constant communication with users regarding what is happening in the system creates a sense of transparency and helps build trust. An example of a daily use of this heuristic is a map saying "you are here", letting the user know how they are related to the rest of the system (in this case, the system could be a shopping center, and the map would show the user how to navigate it).
2. **Match between system and the real world** - design should use a familiar language, real-world conventions, and a natural and logical order. Users may not understand internal jargon or concepts, so it is important to follow natural mapping for controls that correspond to desired outcomes, in order to create an intuitive experience, as well as uncover users' familiar terminology and their mental models around important concepts. An example of a daily use of this heuristics could be as simple as a stovetop, since if its layout matches the controls' layout, then users can quickly identify which control corresponds to which heating element.
3. **User control and freedom** - it is important to provide a clear and easily discoverable "emergency exit" for users to leave unwanted actions without frustration, to ensure they remain in control of the system and avoid getting stuck or feeling frustrated. By providing a sense of control and confidence, users are empowered to navigate through the system freely, which ultimately fosters a better overall user experience. In a sense, digital interfaces need an emergency exit as much as physical spaces.
4. **Consistency and standards** - to improve user experience, it is important to maintain both internal and external consistency, follow established industry conventions, and minimize cognitive load by avoiding the need for users to learn something new. Jakob's Law [16] emphasises the importance of consistency in maintaining learnability and meeting user expectations. An example of this heuristics in daily life could be the fact that people usually expect the check-in counter of an hotel to be located at its entrance, and if it was not, clients probably would not find it easily.

[16] Users spend most of their time on other sites. This means that users prefer your site to work the same way as all the other sites they already know. Design for patterns for which users are accustomed [5]

5. **Error prevention** - even though error messages are crucial, the best designs prevent problems from even occurring, by eliminating error-prone conditions and by providing confirmation steps in actions that can potentially be problematic if done by mistake. It is considered that there are two types of errors: slips and mistakes. The first are unconscious, and usually result from lack of attention, while the second are consciously done based on a dealignment between the interface and the user's mental model. It is possible to avoid slips with helpful constraints and good defaults, and prevent mistakes by removing memory burdens, supporting undo, and warning users. In daily life, an example of this could be a guard rail on curvy mountain roads, since they prevent drivers from falling from cliffs.
6. **Recognition rather than recall** - to minimize the user's memory load, it is important to make elements, actions, and options visible. Information required to use the design should be visible or easily retrievable when needed. Interfaces that promote recognition reduce the cognitive effort required from users, allowing them to recognise information instead of having to remember it. It is important to offer help in context and reduce the amount of information that users have to remember.
7. **Flexibility and efficiency of use** - shortcuts and customisation can speed up interaction for expert users, while flexible processes allow people to choose the method that works best for them. It is important to provide accelerators such as keyboard shortcuts and touch gestures, personalisation of content and functionality for individual users, and allow for customisation so that users can make selections about how they want the product to work. For example, a map might show the route to a certain place, but locals might know shortcuts and better alternatives.
8. **Aesthetic and minimalist design** - When designing interfaces, it is essential to prioritise essential content and features, and avoid irrelevant or rarely needed information, since it ends up competing for visibility with what is really important. Letting go of unnecessary elements ensures that the user's primary goals are supported and there are no distractions from important information. As an example, the famous industrial design icon "Juicy Salif", the citrus reamer designed by Phillippe Starck (Figure **10**), might be considered by most as a beautiful object, but its primary function is almost made impossible by the object itself, showing that if aesthetics are considered more important than function, users will eventually end up not being able to use it. In sum, the interface should prioritize function, being user-friendly and intuitive.

Figure 10: Juicy Salif, citrus reamer designed by Phillippe Starck (source: https://www.starck.com/juicy-salif-alessi-p2009)

9. **Help users recognise, diagnose, and recover from errors** - error messages should be written in a simple and direct language (avoiding error codes), indicating the problem in a straightforward way, and if possible suggest solutions, like stating what should be done or providing shortcuts to solve the problem immediately.
10. **Help and documentation** - ideally, systems would not need additional explanations. However, that is not always possible, and in case it is necessary to provide users with support information and extra documentation, it should be easy to find, dedicated to the task being done, and ideally presented in context, exactly when the user will need it.

Besides these 10 heuristics, more recommendations are often provided regarding digital interfaces, to reinforce and expand these principles that have in mind creating a better user experience. Whitney Hess, an empathy expert, added some thoughts to Nielsen's heuristics [3], such as offering clear paths and few options, reducing distractions, grouping related objects and having an easy-to-scan visual hierarchy that reflects users' needs, making things easy to find, provide users context of where they have come from and where they are headed, avoiding technical language, making designs efficient and emotional, using the "less is more" principle, being consistent throughout the interface, as well as being trustworthy and credible.

These guidelines can be fundamental in creating the UX and UI of the V2X tool that task 5.7 will focus on. Below, examples are given on how some of these principles can be applied to a V2X tool, from the user's point of view:

- Heuristic 1 ("Visibility of system status") can be achieved by always having direct messages and texts that clearly indicate what is happening in that moment. For example, if the EV is connected to the grid, it should be easy for the user to identify if, at that specific moment, their vehicle is giving or receiving energy from the grid.
- Heuristic 3 ("User control and freedom") might mean that users have the possibility of choosing whether they allow the grid to take energy from their vehicles, including during the session itself. For example, if the EV is connected and energy is being given to the grid, the user should be able to stop that process at any time, in an easy and direct way.
- Heuristic 5 ("Error prevention") is a principle mostly related with tasks that are more definite, or difficult to reverse. Messages like "Are you sure you want to proceed?" help more inattentive users to prevent possible slips (unconscious errors). Additionally, clearly stating what an action means helps users better understand the consequences their choices will have, and that will assure the number of mistakes (conscious errors made by lack of alignment or understanding) is reduced.

Additionally, in APPENDIX D: Follow-up interviews with EV users, several suggestions of details that could improve the function and user-friendliness of the interface are mentioned. An important example is related to the use of icons in the interface. Recalling heuristics 4 ("Consistency and standards") and 6 ("Recognition rather than recall"), the use of universal icons is essential, since users are most likely already familiar with them (Jakob's Law).

Another example, considering heuristic 2 ("Match between system and the real world"), could be related to the map feature. People are used to using both physical and digital maps, and some elements of these are already expected, like being able to distinguish names of roads, if they're highways or city roads, and specifically in the digital context, knowing where the user is, and how far he is from the destination chosen, as well as how to get there. This means that any map feature designed should include these elements, regardless of what other functions it will have.

More examples can be found in APPENDIX C: Remote exercises with EV users and APPENDIX D: Follow-up interviews with EV users, considering the feedback users gave, and suggestions mentioned.

These are only some of the ways design principles can help guide UX and UI creation, to produce an overall seamless experience for the end-user. A more detailed approach should be taken into consideration when working on the V2X tool.

6 Conclusions

This document analyses the results obtained by following the methodology presented (Chapter 2), and proposes features deriving from that analysis (Chapter 4) along with a set of design guidelines (Chapter 5) that assure a better user experience.

Overall, V2G tech seems to be seen as good due to the benefits it can bring to the users who decide to sell their energy back to the grid, but a mindset change seems to be needed. The establishment of a community in which its members can help each other by sharing energy is seen as valuable by some users, besides using only their car batteries to provide backup energy to their homes.

Some users advocated that, for V2G to work widely, there needs to be a purpose for adoption or an incentive, since most people always hope to win something by using this type of tech. The interest seems to be always the same for anyone who considers using the technology: to charge at the lowest price, sell at the highest and have an income anytime energy is given back to the grid.

A way to stimulate these adoptions could be by potentially providing overall statistics that might help people realize how much they contributed to the grid or how much impact they had on the environment (showing messages that quantify their contribution, like “with this you helped the grid in 3000 kWh”, or messages that translate that contribution into something more tangible for users, like “you saved 100 trees”), besides the financial incentives the users receive for giving energy back to the grid. Additionally, creating communities and using gamification techniques might also help levering up V2G adoption.

7 References

[1] C. Rocha *et. al.*, “Deliverable 3.1: EV Users’ Needs and Concerns - Preliminary Report". Ref. Ares(2023)3047151. Electric Vehicles Management for carbon neutrality in Europe (EV4EU) Horizon Europe funded project, grant agreement 101056765, 2023.

[2] C. Ziras *et. al*., “Deliverable 2.2: Control Strategies for V2X Integration in Buildings, Electric Vehicles Management for carbon neutrality in Europe (EV4EU) Horizon Europe funded project", grant agreement 101056765, submitted.

[3] “Design Principles - Interaction Design Foundation,” [Online]. Available: https://www.interaction-design.org/literature/topics/design-principles. [Accessed 7 August 2023].

[4] “Ten Usability Heuristics - Nielsen Norman Group,” [Online]. Available: https://www.nngroup.com/articles/ten-usability-heuristics/. [Accessed 7 August 2023].

[5] “Jakob's Law - Nielsen Norman Group,” [Online]. Available: https://www.nngroup.com/videos/jakobs-law-internet-ux/. [Accessed 7 August 2023].

APPENDIX A: Workshop with project partners - summary

The workshop held in this task was called "Critical Features for V2X". The main goals of this session were the following:

- Bring partners up to date with insights collected in task 3.1;
- Understand and prioritize needs that partners have for the V2X platform to be developed in the EV4EU project;
- Ideate on possible solutions to answer the identified needs and classify them on their level of importance for partners, as well as their perception on the importance those solutions could have for end users.

The session started with a creation of a "wishlist", so that all partners had the opportunity to identify their main requirements for the V2X platform to be developed in the EV4EU project. Each person had to share their needs, and what they believed were the requirements for the platform.

After sharing all their needs and requirements, participants had to classify them in a priority scale, where each colour represented a different level of importance of that requirement. In this case:

- The colour orange symbolised a "Critical to have" requirement;
- The colour green meant an "Important, but not critical" requirement;
- The colour blue represented a "Nice to have" requirement.

When all participants were done with their own requisites, participants worked together to create a formal Needs and Requirements Wishlist, classified by importance of each one. The result can be seen in Figure 11.

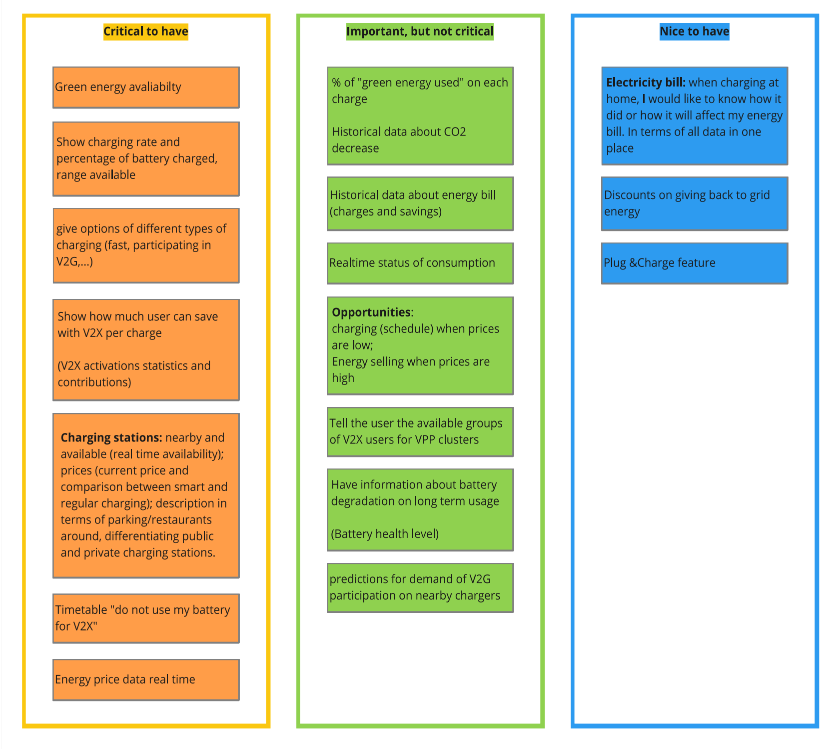

Figure 11: Needs and Requirements Wishlist, created during the workshop with partners.

With the requirements defined, the session moved on to sharing ideas and possible solutions on how to include all the listed requirements in the V2X platform to be developed.

Each person contributed with their own suggestions, and then the group worked together to cluster all ideas into the following topics (predefined by session moderators):

- Data visualisation;
- Charging points management;
- Energy consumption management;
- Grid management;
- Trip planning;
- Incentives for discharging.

During the clustering exercise, participants felt the need to create three more clusters, namely:

- Financial;
- Useful information;
- Interaction with users.

All participants worked together to formulate refined ideas for each cluster, either by completing and merging ideas already shared, or by creating new ones. The result gave the SEL team a good set of ideas and suggestions to include in the V2X platform, as seen in Figure 12.

With a plethora of ideas shared, each participant had to choose the ideas they thought best served project partners and other stakeholders, and then choose the ideas that they believed would be better for end users. This was done through a voting exercise, and the voting resulted in the construction of a Desirability Matrix.

After each participant had the opportunity to analyse the resulting matrix and share with the group their thoughts and comments about the result, the session had a final exercise to allow each participant to identify the ideas they believed were most feasible (3 blue dots per person), and the least feasible one (one red dot per person). This resulted in a final matrix, called Desirability and Feasibility Matrix, seen in Figure 13.

This was considered a very productive workshop, where every partner had the opportunity to share their concerns and ideas, as well as have an important role in defining what the team should consider a priority moving forward.

With the results of this session, the SEL team analysed all ideas shared (giving more importance to the most valued ones) and created a set of exercises to send to EV users, so that the ideas could be validated regarding their usefulness to EV drivers.

Figure 12: Initial and refined ideas, clustered by topics, created during the workshop with partners.

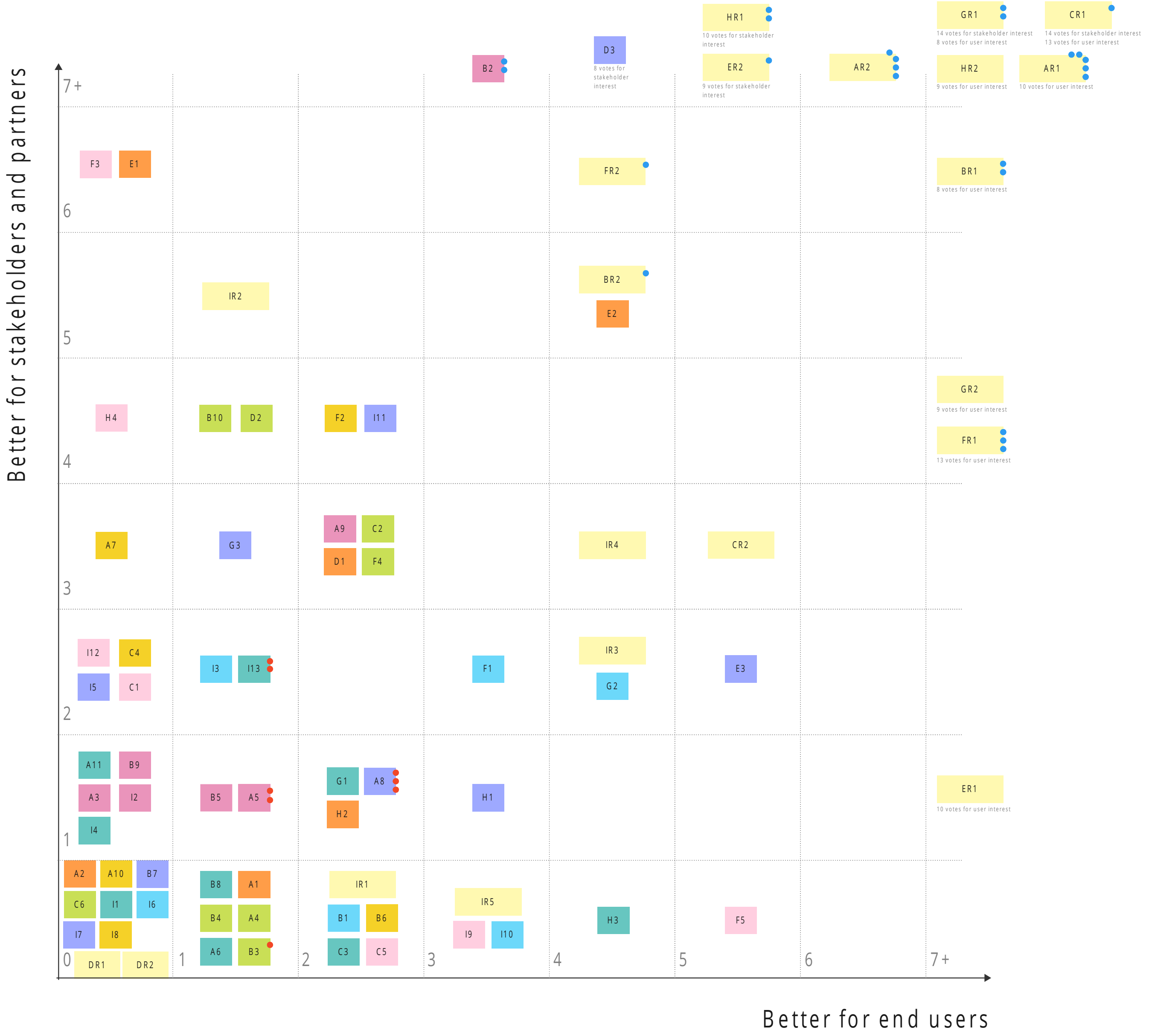

Figure 13: Desirability and feasibility matrix, created during the workshop with partners.

APPENDIX B: Idea generation exercise

This method was planned with the purpose of creating a set of possible features for a V2X app, to then validate with EV drivers regarding their usefulness and usability.

The starting point was based on the outcomes from the workshop with project partners (see APPENDIX A: Workshop with project partners - summary). The SEL team started by reviewing all the needs shared by partners, so that these could be mapped according to different topics. Afterwards, all ideas were mapped as well, in those same categories. This process allowed the team to better grasp if the ideas answered all requirements, if there was something missing, if there were still doubts or questions that needed clarifying, as well as a chance to discuss new ideas and possibilities. The result was mapped, as seen in Figure 14.

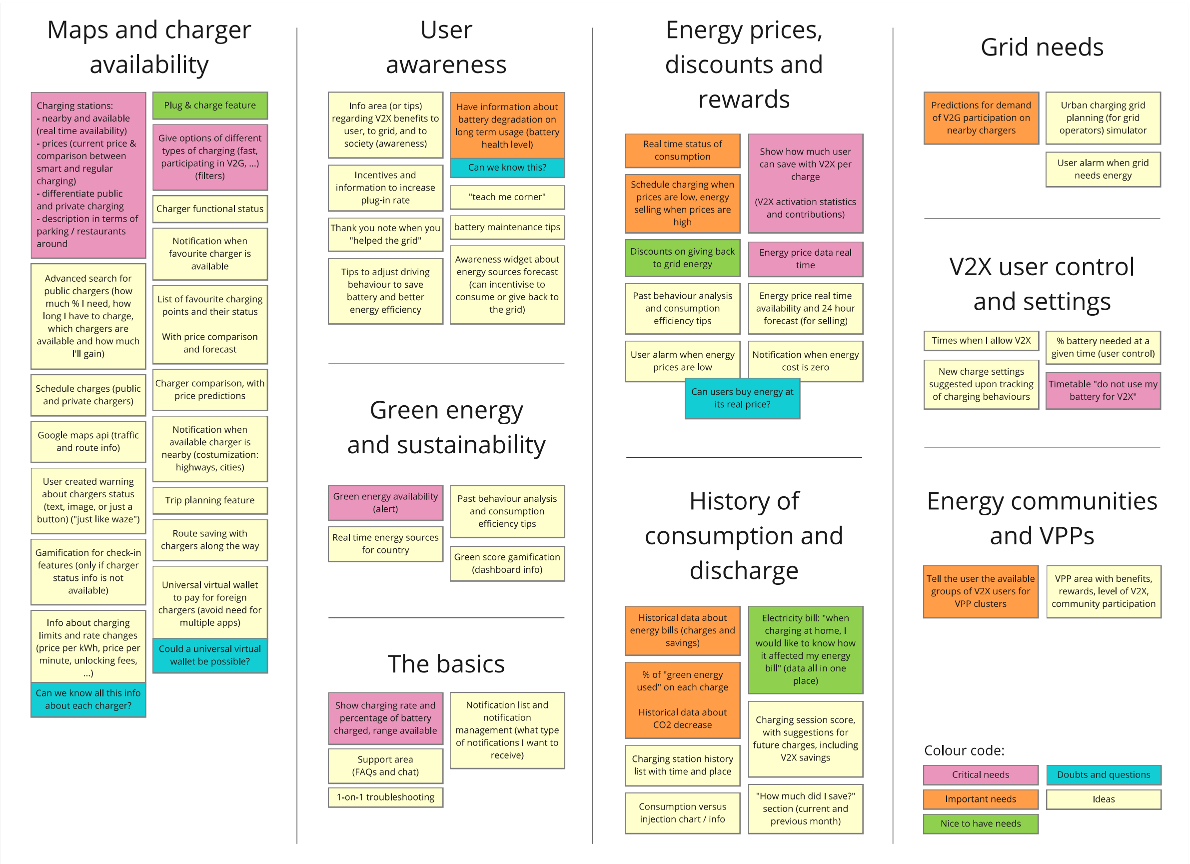

Figure 14: Needs and ideas resulting from the workshop, mapped by the SEL team.

The team started to list features that could be included in an V2X app, which involved the ideas shared, focusing on the ones most voted by partners during the workshop. These features comprised all requirements and tried to predict users' main needs. The features listed were the following:

- Mapping charging stations, including information like location, availability and functional status, filters, advanced search, favourites, notifications, schedule, comparison and forecast, prices, trip planning and route saving, check-in, and user created warnings.
- Historical data, including charges, V2X participation, costs and gains (€), percentage of green energy used, time, place, charging session score (with V2X savings and suggestions). "How much did I save?" (monthly comparison).

- Plug and Charge feature. Important to understand which payment method users would prefer (such as a universal wallet on your cell phone (like Apple pay) for all chargers used, a debit card using contactless, a system similar to Tesla (when car is connected, the billing is done automatically), or other systems).
- Home charging schedules based on energy prices (charge when prices are low and give to grid when prices are high). Include forecasts and alerts.
- V2X availability calendar, with battery percentage available (user control about V2X participation).
- Information corner, with different types of information needed (use ideas listed in the user awareness cluster). Use different ways of communicating information (text, video, walkthroughs, etc).
- Gamification (create a green score, win points by reporting chargers' status, use green energy, participate in V2X and with community competition). What type of reward would be alluring for users?
- Check interest in participating in VPP clusters and receive alerts about grid needs. In which contexts would users be interested?
- Community creation and management (with neighbourhood; based on individual green score).
- Green energy availability (have an alert, with real time energy sources for their country). Include green score gamification, with tips based on past behaviours and other good habits.

Finally, the team had to decide which of these features would be tested with users. Some of them were more crucial to test than others, and to ensure good results, the exercises should not be too lengthy, otherwise participants might become tired, and insights collected would lose their reliability.

To choose the features that would be tested, the team analysed the priorities that resulted from the workshop, and ordered them by importance, as seen in Figure 15.

This prioritization resulted on the decision of testing 3 features, namely:

- **Map feature**, that allows users to find chargers from any brand. The chargers would have detailed information regarding location, prices, type of charger, as well as indications of V2G capabilities.
- **V2X participation schedule with energy forecast**, which would have as its main goal to facilitate users in understanding how energy prices fluctuate during the day, and according to the different energy sources available. This would then allow for users to schedule their own availability to give energy to the grid, in moments when the energy prices would probably be higher, and therefore they would have more to gain.
- **Historical data feature**, which would list all charges and discharges made, and provide users with some general statistics, to understand their overall costs and gains, how much they have saved, and other statistics regarding their environmental footprint (charging with renewable energy sources, discharging to avoid using non-renewable energy sources).

The exercises were then prepared and sent to users recruited. Results of these exercises can be seen in APPENDIX C: Remote exercises with EV users.

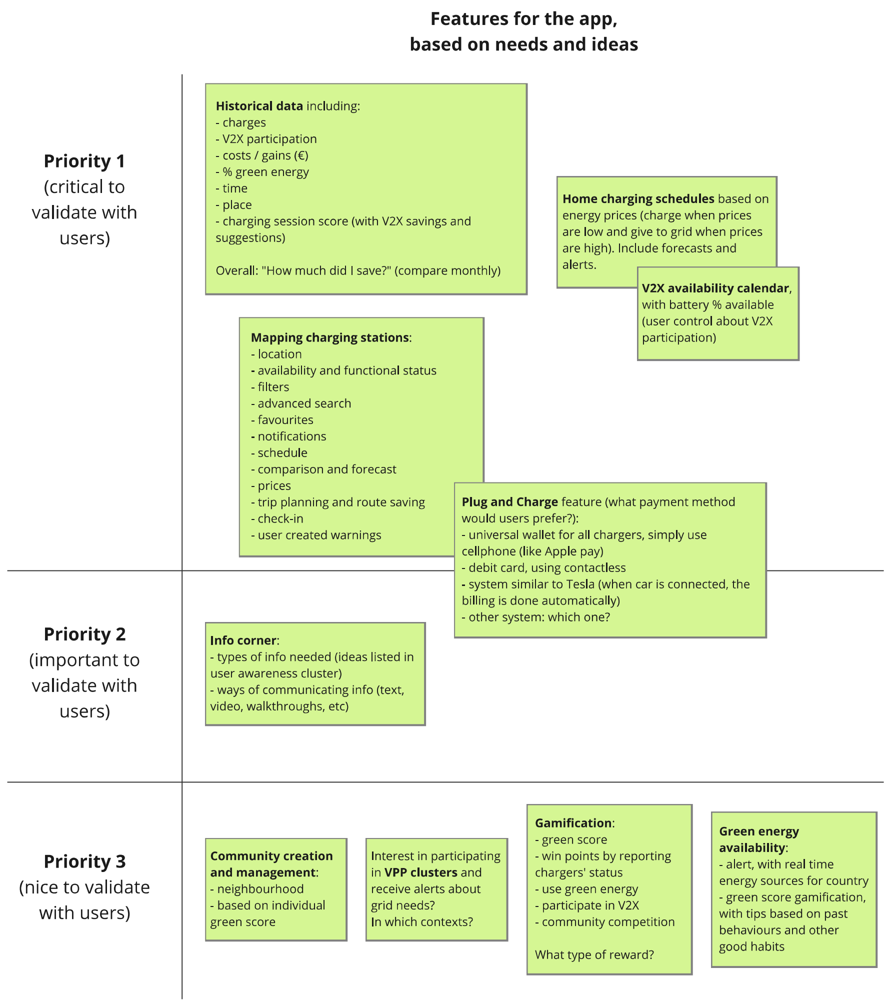

Figure 15: Prioritization exercise done by the SEL team, to decide which feature to validate with users.

APPENDIX C: Remote exercises with EV users

To validate the ideas generated in task 3.2, EV drivers interviewed in task 3.1 were contacted, with the purpose of doing a set of exercises following-up the topics discussed in the prior interviews. From the EV drivers contacted, nine agreed to participate in task 3.2. Table 2 shows their demographics.

Table 2: Participants' demographic characterization

ID	Country	Gender	Age group
ID 1	Slovenia	Female	31 – 49 years old
ID 2	Greece	Male	50 – 65 years old
ID 3	Denmark	Male	50 – 65 years old
ID 4	Greece	Male	50 – 65 years old
ID 5	Slovenia	Male	31 – 49 years old
ID 6	Denmark	Male	50 – 65 years old
ID 7	Greece	Male	31 – 49 years old
ID 8	Slovenia	Female	31 – 49 years old
ID 9	Portugal	Male	50 – 65 years old

The exercises sent to these participants consisted of a survey with 4 exercises, each one answering some questions regarding a specific feature for a V2X app. Below are the exercises sent to the participants, with the corresponding results.

Exercise 1 – Map feature

Initial description:

Starting with the first thing we want to ask you, we are wondering about a map functionality for the V2X management app. Below, you can see a few drawings that show you how we are imagining this map could be. Please, carefully look at these images (Figure 16), and then answer the questions below.

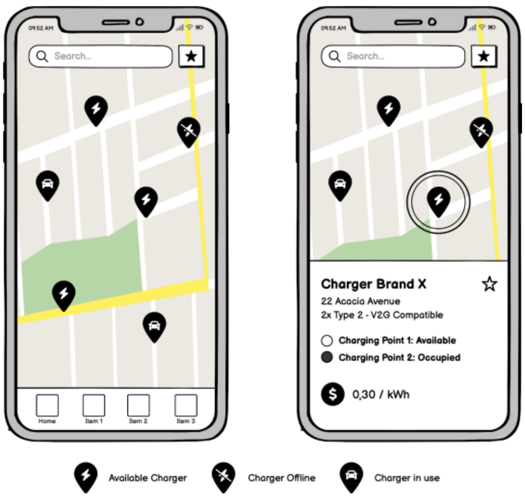

Figure 16: Screens shown in exercise 1, produced by the SEL team.

Question 1 (Q1): On a scale of 1 to 5, how much do you believe this type of functionality would be important to you? (1 = "not important at all", 5 = "maximum importance")

The average value of answers to Q1 is approximately 4.67, with a mode of 5 (detailed results in Chart 1). This shows a high importance given to this type of feature.

Chart 1: Answers to Q1

Question 2 (Q2): In a MAP context, what kind of functionalities would you like to have? Select all that you like.

From the options given (see Chart 2), the most frequently chosen were "Charger availability (is it being used by someone else? or can I use it?)" and "Charger functional status (is it working? or is it broken?)", with all participants selecting these. This seems to be in line with what was seen previously in D3.1 [1], since one of the pain points identified was the uncertainty associated with using public chargers.

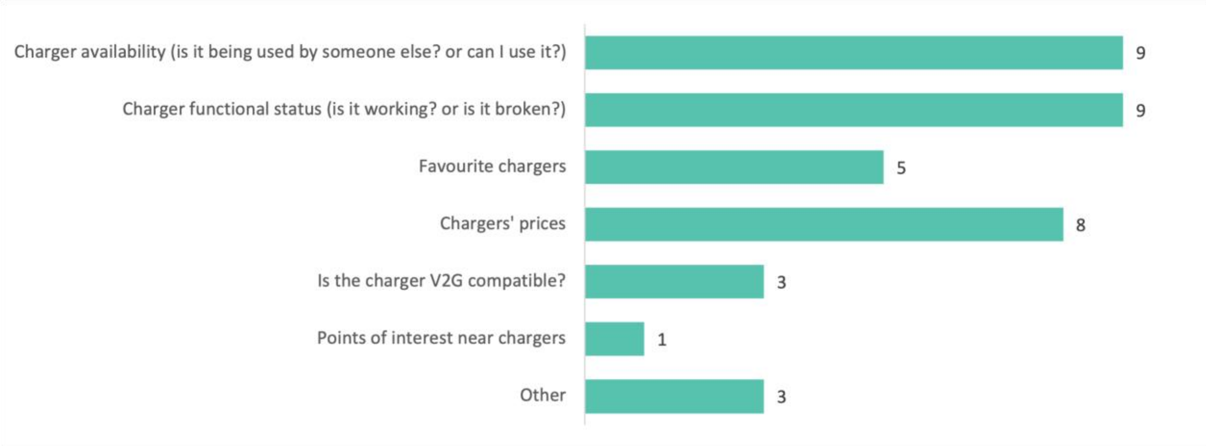

Chart 2: Answers to Q2

Participants that chose the option "other" mentioned the following:

- "If the energy is 100% green, produced from RES locally or not."
- "What provider or charging network belongs the charger. Also the icon on the map for unavailable or under construction charges should look like the ones from similar apps (plugshare)."
- "Charger type."

Question 3 (Q3): In a CHARGING STATION DETAIL[17] context, what kind of functionalities would you like to have? Select all that you like.

[17] "Charging station detail" is when you click in a specific charging station in the map, and some information about that charger appears in the screen, as you can see on the right screen in the image shown above.

From the options given (see Chart 3), the most frequently chosen were "Number of charging points (how many cars can charge at the same time in that charger)" and "Type of charger", with all participants selecting these.

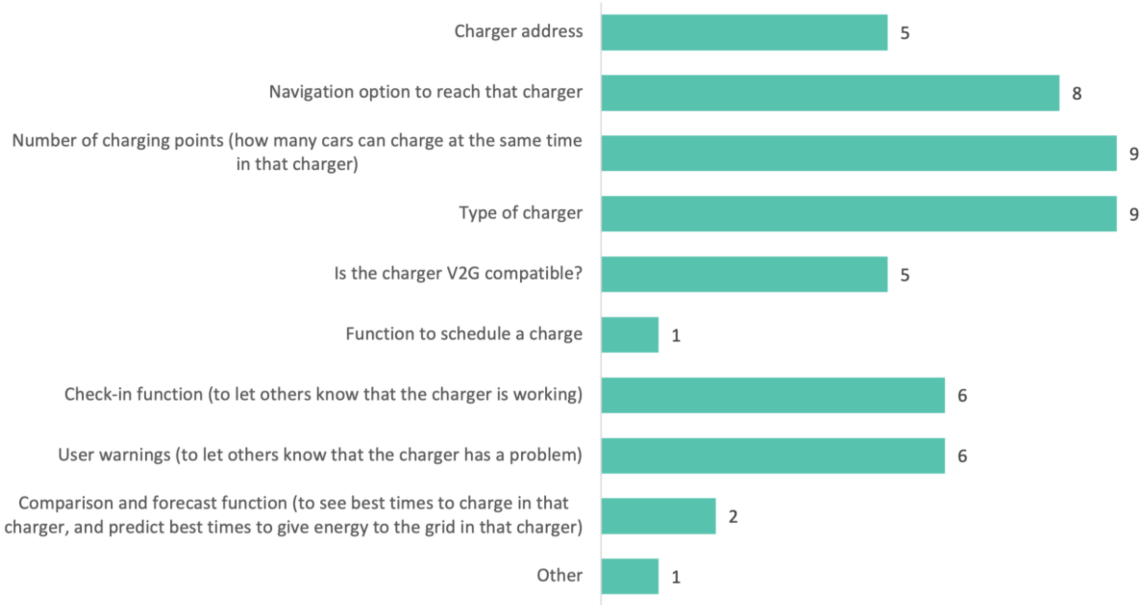

Chart 3: Answers to Q3

Besides these characteristics of the charging station, navigation options to reach it, as well as check-in and feedback features seem to be the most valued ones, when seeing the details of a specific charging station. The participant that chose the "other" option mentioned "Feedback from the users about the services and availability in general".

Question 4 (Q4): What type of FILTERS would be important for you to have in this map? Select all that you like.

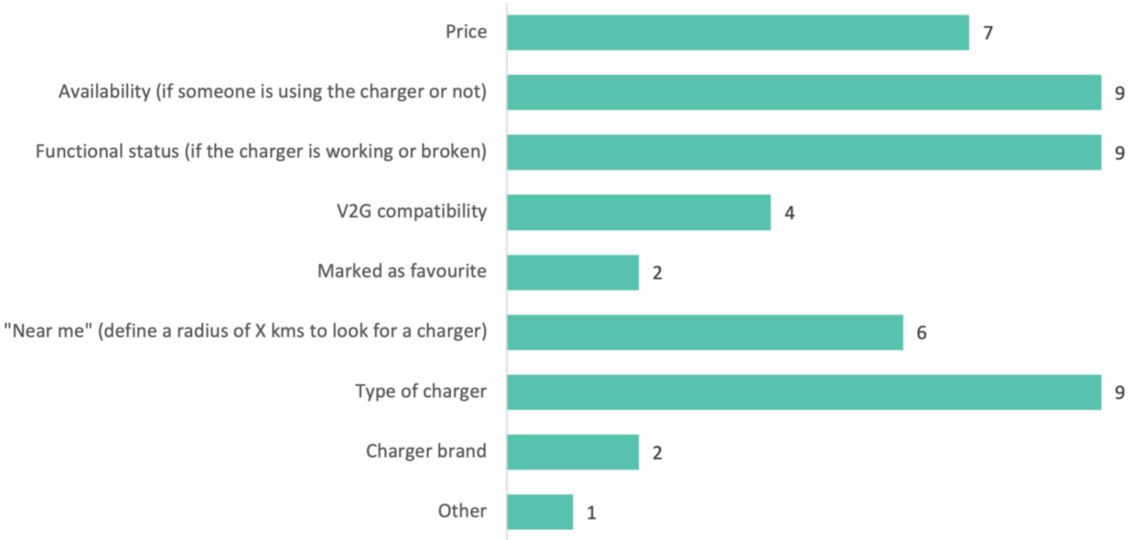

Chart 4: Answers to Q4

From the options given (see Chart 4), availability, functional status and type of charger are apparently the key characteristics to assure when filtering for charging stations. This seems to reinforce the concern seen before, regarding the uncertainty around the use of public charging stations, specially where their availability and functional status are concerned.

The participant that chose the option "other" mentioned "'Green' energy produced from RES", which brings the environmental concern as a possible aspect to have in mind also in this context.

Question 5 (Q5): Now, please read carefully the following descriptions of more complex functionalities that could be included in the map of this V2X app. Please classify the following functionalities on a scale of 1 to 3, where 1 is a "nice to have functionality", 2 is an "important, but not critical functionality", and 3 is a "critical[18] to have functionality".

The functionalities are the following:

- **Advanced search** - With this advanced search, you could ask the app to automatically suggest a charger, based on criteria like the range you need at that time, how long you have available to stop and charge your car, which chargers are available to use (or which ones are occupied and broken), and also how much you can save on energy or even gain (if you have possibility of doing V2G while charging). This would be a functionality that would ask you a few questions and collect information about your past behaviours using the app and would suggest the best place and time of charge, so that you could maximize what you save/gain and the battery you have for your trip.
- **Trip planning** - When you want to go on a trip, you can use this app to say where you want to go, and when you want to arrive, and it will recommend the best places to charge, taking into account the possibility of doing V2G along the way.
- **Route saving** - If you do the same trip often, you can save it as a favourite route, and it will include ideal chargers, but also alternative ones, in case there is something wrong with the one you usually use.
- **User created warnings** - Sometimes chargers have no way of communicating if they have a problem, and so we suggest a way for the users to be able to let the app know that a certain charger is not working. This way, not only will other users know there is a problem with that charger, but the ones responsible for that charger will also be notified, which will help speeding up the repairing process.
- **Check-in** - There are some chargers that do not have the ability to communicate their status, either if they are working, or not. For these cases, we propose a way of manually letting others know if the charger is working. If the chargers can communicate their status, they will show a log of recent charges (when and how long the most recent charges lasted). For the chargers that cannot communicate with the app, we suggest that users input the charger's status manually, by checking-in on that charger and indicating when and for how long they charged (no other information would be shared).
- **Schedule charges** - Even though this might not be possible for all chargers, we propose a functionality that would let people reserve a charger in advance, so that they know they will have it available when they need it. This functionality would also need to communicate when a charger is going to be used by other people who already have a reservation for a specific time, so that other users might know that for that specific time, that charger will not be available for use. Besides this, the app would also enforce a penalty or consequence for an EV driver who would use the charger during someone else's reservation period.

[18] When we say "critical", we mean that this would be the type of functionality you believe is essential, and without it the map would not be useful for you.

- **Plug & Charge** - This functionality would allow you to charge on literally any charger, regardless of brand or country. This could work in one of three ways:
    - You could have a "digital wallet" charged with your money in the V2X app, and it could be used on any charger, regardless of charger brand (no need to have all the different apps). You would just need to put your smartphone next to the charger to pay for it.
    - You could have a debit or credit card associated with the V2X app, and it automatically charges that debit or credit card. You would only need to put your smartphone next to the charger to pay for it.
    - By connecting your car to the charger with the charging cable, the charger would recognize your car, and would charge you directly, without the need to use your phone. For this you would need to have a debit or credit card already associated with your car.

The answers to Q5 (see Chart 5) show that a simplified method of payment appears to be a big concern among participants, being considered the most important feature, followed by user created warnings, trip planning (both consistent with what was seen above), and advanced search (this one shows participants interest in having more personalized recommendations).

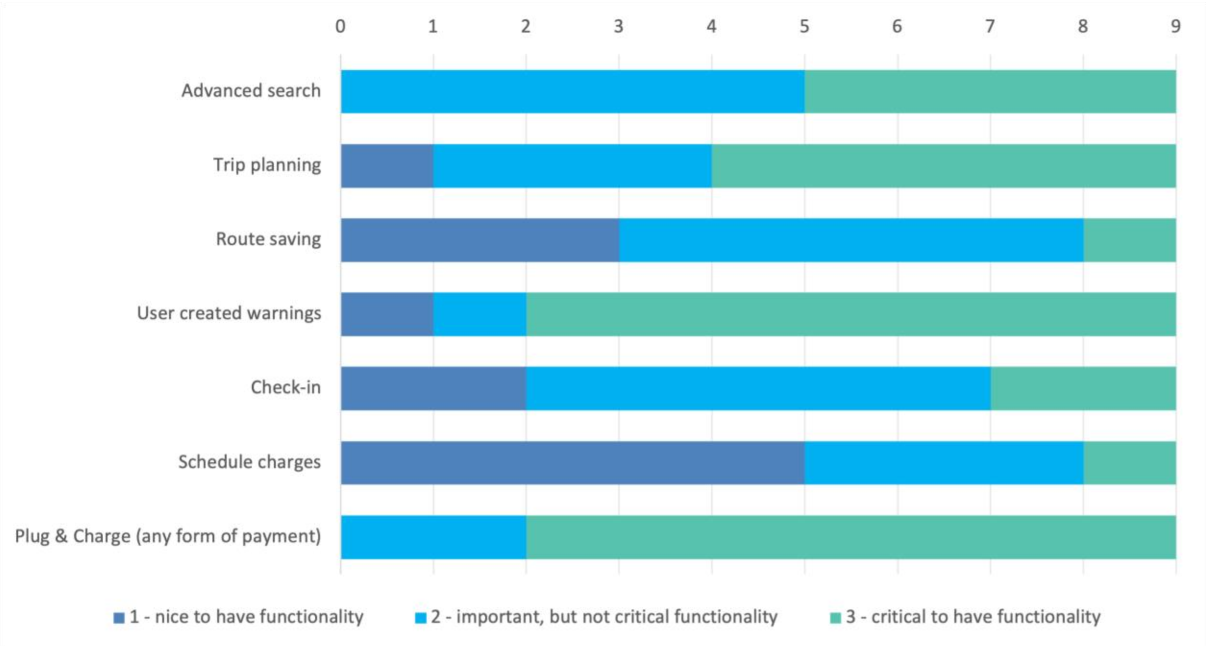

Chart 5: Answers to Q5

Question 6 (Q6): Regarding the last functionality, Plug & Charge, what method would you prefer to have, in terms of payment options?

The options given were:

- You could have a "digital wallet" charged with your money in the V2X app, and it could be used on any charger, regardless of charger brand (no need to have all the different apps). You would just need to put your smartphone next to the charger to pay for it.
- You could have a debit or credit card associated with the V2X app, and it automatically charges that debit or credit card. You would only need to put your smartphone next to the charger to pay for it.
- By connecting your car to the charger with the charging cable, the charger would recognize your car, and would charge you directly, without the need to use your phone. For this you would need to have a debit or credit card already associated with your car.
- Any of these would work for me.
- Other.

In Chart 6 it is possible to see that there is a majority of participants preferring the charger to connect directly to the car (with the cable), and with that connection do every step necessary, without the need to have any other app or card involved. The participant that chose the “other” option, suggested using and “RFID card or keyring”.

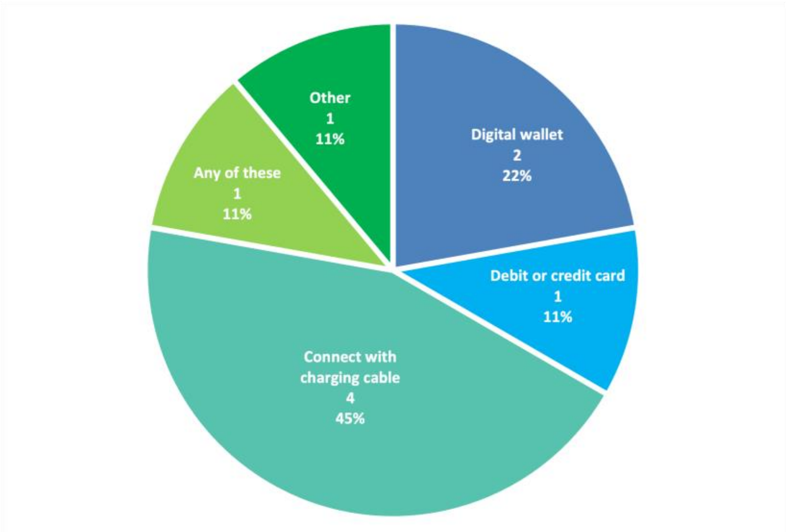

Chart 6: Answers to Q6

Question 7 (Q7): Do you want to leave any comment regarding this MAP functionality, or the other functionalities related to it?

Participants that left their comments said:

- “To my opinion it is crucial for the app usage, that all of the supporting charging stations are included. There are multiple apps on the market, that promote/are able to use only specific chargers (for instance in Slovenia - petrol, gen-i, mega M, moon). Only one generic app for all chargers is essential for user practicality.”
- “It's essential to have also information about the traffic and weather conditions.”
- “By connecting your car to the charger - this means that if I lend my charger to someone, I give also my money. There needs to be some kind of authentication and not 100% automatisation.”

These comments reinforce some concerns seen earlier, regarding the need for multiple apps to use public chargers. Also, these show a lack of understanding of what might mean automating the payment process. Users will probably only trust an automatic system if they fully understand how it works.

Exercise 2 – V2X participation schedule with energy forecast

Initial description:

Now in this exercise, we want to know your opinion about a functionality to manage V2X participation. This means it would be a place where you can dictate when you want energy going in your car, and when you allow it to go out of your car, either to go to the grid (V2G) or to go to your house, or the building where you work, etc. This functionality would let you define specific settings and limits, like when you allow or not allow energy to be taken from your car, battery you need at specific times, and even create routines (for example, you could define that you need to have 70% battery every morning at 8AM, so that you can go to work). You would also be able to override these routines, in case you want to go on vacations and choose a different percentage or time of day to assure full battery. Having this in mind, please answer the questions below.

Question 8 (Q8): On a scale of 1 to 5, how much do you believe this type of functionality would be important to you? (1 = "not important at all", 5 = "maximum importance")

The average value of answers to Q8 is approximately 3.67, with a mode of 5 (detailed results in Chart 7). This shows a slightly lower importance given to this type of feature, comparing with the map one.

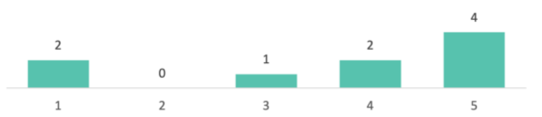

Chart 7: Answers to Q8

Question 9 (Q9): What kind of system would work better for you?

a. An "opt-in" system where you have to state when you are available for V2G exchanges.
b. An "opt-out" system, where you are always available, except for the moments you state you are not.
c. Other.

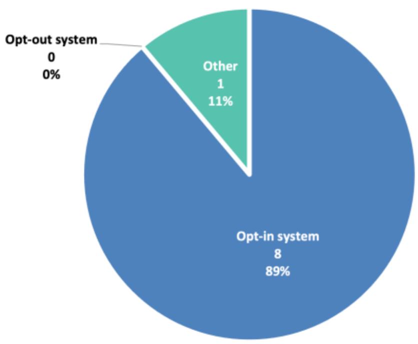

Chart 8: Answers to Q9

As seen in Chart 8, most participants prefer option A, with only one choosing the "other" option, and stating that they would prefer "both ways, according to grid needs, receiving warnings / notifications / offers".

This preference seems to indicate that users are more likely to adhere to V2X technologies if they feel they can control it and choose when to participate, rather than choosing when to opt-out of it.

Question 10 (Q10): Would you like to define some kind of limit to V2G exchanges? And if so, how would you like to do it?

a. I would not need to define a limit. The electricity grid can use as much of my battery as needed.

b. I would need to define a limit, and I would like to do it stating the battery interval that I allow the grid to use (for example, I only allow the grid to use 10% of my battery).

c. I would need to define a limit, and I would like to do it stating the amount of battery I need at a certain time, so that the grid calculates how much it can use, as long as it assures I have the battery I need at the time I stated (for example, I need my car to have 80% battery at 9AM every morning).

d. Other.

As shown is Chart 9, around 67% would prefer to state how much battery they would need in their EV at a given time, and with that information the grid would be able to balance between charging and discharging according to arising needs, as long as the settings defined by the user were assured.

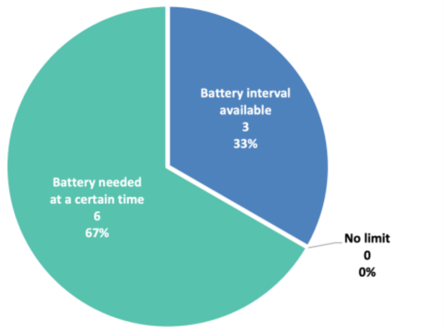

Chart 9: Answers to Q10

Exercise 2 continues with two screens, explaining two different functionalities included in this V2X participation feature.

Description provided:

Besides allowing to define V2X participation limits, this functionality we are talking about would also allow you to see a forecast of predicted energy prices in the upcoming hours / days. This would allow you to choose the best times to allow V2G, since you would be selling energy back to the grid, and that way you would be able to define periods of time when you would probably gain more money from allowing V2G.

One way of seeing this forecast would be with a **"previous and next 24-hour view"**. You would be able to know the electricity price in the past 24 hours, and also the predicted price for the next 24 hours. Check the images (Figure 17, first two screens) to see how this could work.

Another way of viewing this information would be based on a **"weekly forecast view"**, where you could see the predictions for the next week. This forecast would not give you information about exact prices, but rather a suggestion based on energy sources available in your country for that week. Based on weather predictions, the app would be able to show you the percentage of energy that could be produced from different sources (if the weather shows clear skies, more solar energy would be available; if the weather predicts a windy week, more energy would be available from wind turbines). For example, energy from solar panels might be less expensive than energy produced with coal. That means that, in days where more energy was being produced with coal, you would probably gain more money if you sold energy to the grid, because you would be avoiding coal-based energy production. Check the image (Figure 17, last screen) to see how this could work.

Figure 17: Screens shown in exercise 2, produced by the SEL team, the first two regarding the "previous and next 24-hour view" and the last one regarding the "weekly forecast view".

Questions 11 and 12 were regarding the **"previous and next 24-hour view"**, and questions 13 and 14 were regarding the **"weekly forecast view"**.

Regarding the **"previous and next 24-hour view"**:

Question 11 (Q11): Would you consider this to be useful for you?

Majority of participants considered this view to be useful, as seen in Chart 10.

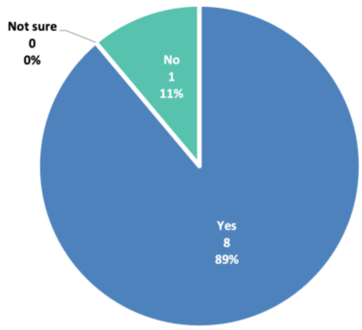

Chart 10: Answers to Q11

Question 12 (Q12): Why?

According to participants, the "previous and next 24-hour view" is useful for optimizing discharging prices and time scheduling, allowing for price optimization and control over when to give energy back to the grid. Users can schedule V2G function and set alerts for discharge scheduling, making it easier to find the cheapest charging prices.

Additionally, it was possible to notice by these answers that some participants did not fully understand the purpose of these screens, mixing charging and discharging functions and assuming the graph would be applicable to both. This might mean additional explanations are required. This issue will be further explored during the interviews.

Regarding the **"weekly forecast view"**:

Question 13 (Q13): Would you consider this to be useful for you?

Majority of participants considered this view to be useful, as seen in Chart 11, although more doubts arose regarding this view.

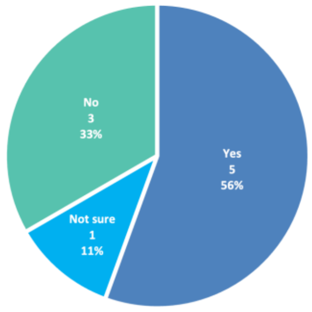

Chart 11: Answers to Q13

Question 14 (Q14): Why?

The weekly view seems to be interesting from an ecological point of view, where some participants mention the importance of charging when energy is mostly produced by renewable energy sources (optimizing them), and discharging during coal production, thus scheduling giving energy back to the grid in a weekly basis when electricity production is from expensive or polluting methods. Nevertheless, many mentioned the importance of the economical aspect (not obvious in this screen), and some assume they would prefer to define their schedule daily rather than weekly and would like to schedule based on prices rather than source.

In these answers it was also possible to notice some confusion regarding the screen presented, mixing the charging and discharging functions. This issue will also be further explored during the interviews.

Question 15 (Q15): Do you want to leave any comment regarding this V2X Participation Schedule with Energy Forecast functionality?

Participants that left their comments said:

- It would be nice to have a prediction of RES production in the local area where I am.
- It needs cooperation with energy companies to give us detailed feedback.
- Also a factor could be the electricity imports from other countries. If its high I would like to give back energy to the grid.

These comments reinforce not only ecological concerns, but also a sense of community, preferring locally produced energy from renewable sources.

Exercise 3 – Historical data feature

Initial description:

Another functionality we would like to show you is the historical data part. This would be like a log of all your exchanges between your car's battery and the grid, or other equipment. You would be able to see, all in one place, the charges and discharges (take energy out of battery) you made, and the money transactions related to them, as well as other types of information. Please, carefully look at these images (Figure 18), and then answer the questions below.

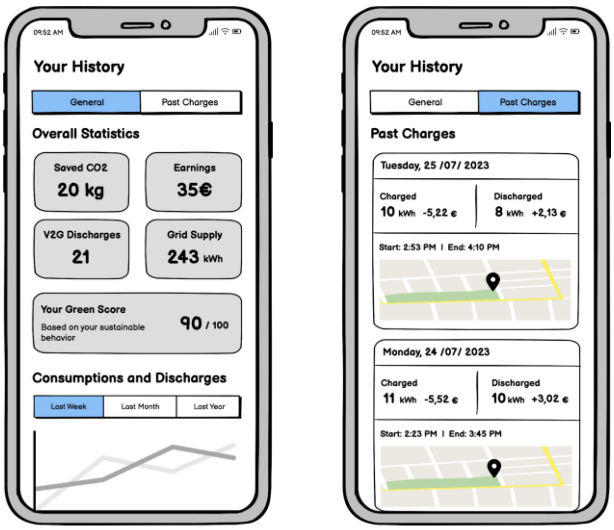

Figure 18: Screens shown in exercise 3, produced by the SEL team.

Question 16 (Q16): On a scale of 1 to 5, how much do you believe this type of functionality would be important to you? (1 = "not important at all", 5 = "maximum importance")

The average value of answers to Q16 is approximately 3.77, with a mode of 4 (detailed results in Chart 12). This shows an apparently lower importance given to this type of feature.

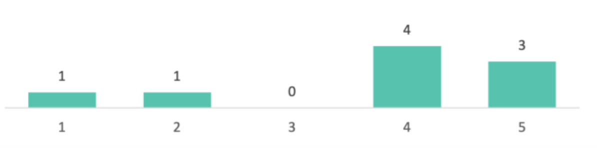

Chart 12: Answers to Q16

Question 17 (Q17): Now, please read carefully the following descriptions of more complex functionalities that could be included in the historical data of this V2X app. Please classify the following functionalities on a scale of 1 to 3, where 1 is a "nice to have functionality", 2 is an "important, but not critical functionality", and 3 is a "critical[19] to have functionality".

The functionalities are the following:

- **Detailed list with charges made** - This list would show you comprehensive details about where and when you charged your car in the past (with options to see by month, week, day, etc), identifying the charger used, money spent, kWhs charged, and other related details.
- **Detailed list with discharges made** - This list would show you comprehensive details about where and when you discharged your car in the past (with options to see by month, week, day, etc), identifying the charger used, money gained, kWhs discharged, and other related details.
- **General statistics about balance of charges and discharges** - This would be a comparison between charges and discharges, showing you an overview of energy exchanges.
- **Percentage of "green energy" used in each charge** - In the detail of each charge session, you would be able to know how much of that energy came from renewable sources, and which ones.
- **Amount of CO2 saved by doing V2G/V2X** - In the detail of each discharging session, you would be able to know how much CO2 you prevented by helping the energy grid, since if you did not help, the grid operators might have needed to produce energy with coal, or other non-renewable sources.
- **Charging score for each charge session** - In the detail of each charging session, you would have a score, evaluating things like energy source used, if it was at an optimal time, if you participated in V2G during that session, etc.

[19] When we say "critical", we mean that this would be the type of functionality you believe is essential, and without it the historical data would not be useful for you.

The answers to Q17 (see Chart 13) show that detailed lists with charges and discharges made are the most critical functionalities to have in this feature, with the percentage of “green energy” used coming in third, which reinforces the concern seen before regarding the source of the energy being used.

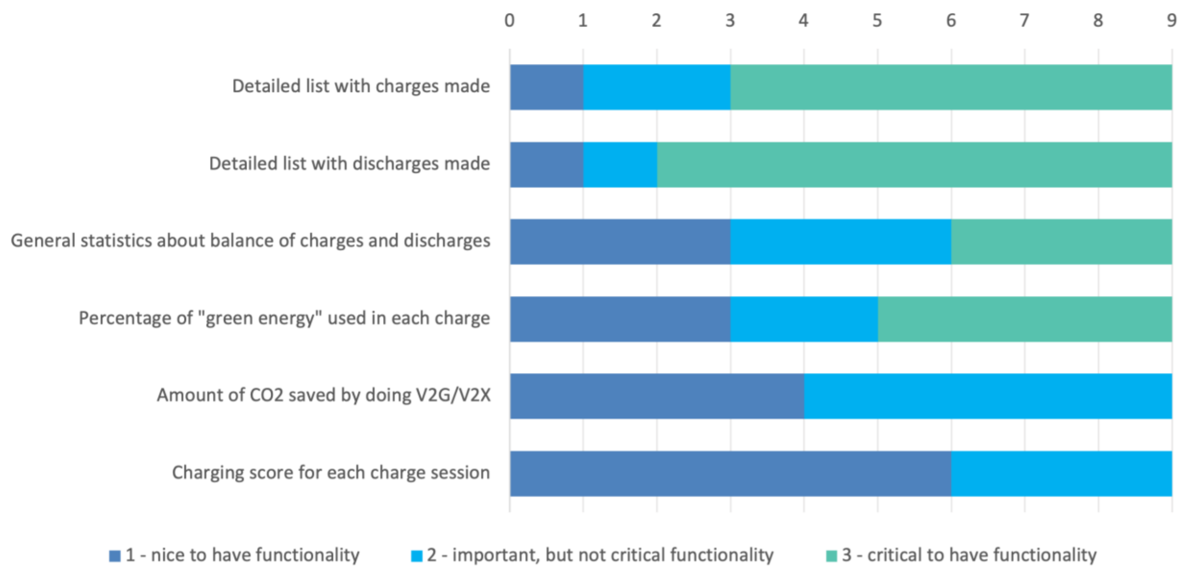

Chart 13: Answers to Q17

Question 18 (Q18): Do you want to leave any comment regarding this HISTORICAL DATA functionality?

Participants that left their comments said:

- The possibility to export data (.xls, .txt) would be useful.
- A comparison list with other users of the app would be useful (although nice to have).
- It helps us for statistics reasons.

These comments provide two very interesting suggestions, namely data exporting capabilities, as well as fostering some level of competition amongst other EV drivers to incentive V2X participation.

Exercise 4 – Comparing functionalities

Initial description:

Now that you have seen 3 of the main functionalities we want to include in our V2X app, we would like you to do a comparison exercise with them.

Question 19 (Q19): If you had to order these 3 functionalities by importance, how would you order them?

As can be seen in Chart 14, there is a clear preference for the map feature, considering it the most relevant of the app. Based on previous findings [1], it might be safe to assume that this is due to the fact that, nowadays, a lot of EV drivers struggle with having "too many apps" to use public chargers, since each brand forces the user to install a specific app. Having a single app that combines all chargers would answer this pain. Nevertheless, this issue will be further explored in the interviews, to confirm if this assumption is valid.

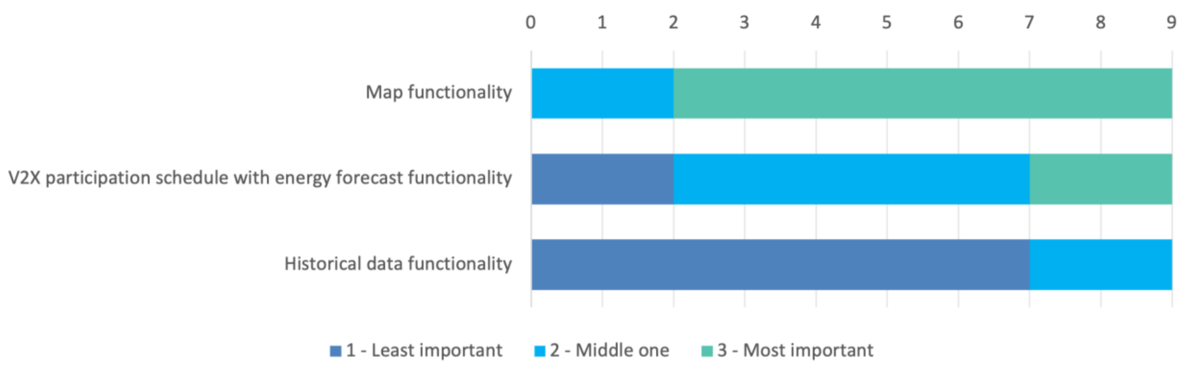

Chart 14: Answers to Q19

Question 20 (Q20): Why did you order these functionalities this way?

According to participants, functionality and price are what matter the most. Since it is a V2X app, some participants mention the V2X participation feature and energy forecast should be prioritized. Nevertheless, the majority reinforce that the map feature is the most important one for finding chargers, organizing trips, and checking costs. Finally, most seem to agree that the historical data is a nice-to-have feature, with a participant even stating that it could be omitted if necessary.

Question 21 (Q21): Do you want to leave any comment regarding this comparison between functionalities, or add anything regarding each one of them?

Only one participant left some final remarks:

- It would be nice if some things would be more specific. For example, how will you define source of electricity (solar, wind, coal)? How would you calculate points (90/100) and what can I do with points? Is it just some kind of KPI or do I have some benefits from it? Also 'schedule discharge' will be made based on forecast... What if realisation of price will be much higher/lower? Will there be some kind of alert system, or this is it and consumer needs to check by himself/herself if something is changing?

Being a set of exercises based only on an initial concept, a lot of these questions were left unanswered when explaining features. This participant rises very pertinent questions, that should be addressed when developing features for a V2X app, in task 5.7: Integration Between User Interfaces and Open V2X Management Platform.

APPENDIX D: Follow-up interviews with EV users

Following up the exercises sent to participants, all 9 of them were interviewed, with the purpose of clarifying and deepening the insights gathered with the exercises sent. All interviews had a baseline script, to assure they went through all the exercises and relevant topics, but each one was tailored specifically to the participant being interviewed, since the questions were very dependent on the answers given during the exercises. This meant each interview had its own script, and no two interviews followed the exact same questions.

During the interviews conducted, participants expressed their satisfaction with the V2G system, highlighting various benefits. Saving money on their electricity bills was one of the most common reasons cited, followed by the desire to contribute to a more sustainable planet. Additionally, many participants expressed their desire to support their local community through their participation in the V2G system, stating that building a sense of community is more important than financial gain, also mentioning the assistance they could provide to the electrical grid during peak demand hours.

Generally speaking, V2G tech is seen as good on the account of the benefits that it can bring to the users who decide to sell their energy back to the grid. However, a mindset change is needed, according to some participants. Some users advocate that for V2G to work widely, there needs to be a purpose for adoption or an incentive, because most people always hope to win something by using this type of tech. A way to stimulate these adoptions could be by potentially providing overall statistics that might help people realize how much they contributed to the grid or how much impact they had on the environment (“you saved 100 trees” or “with this you helped the grid in 3000 kwh”), but the financial incentives they receive for giving energy back to the grid appear to be the main request.

In this sense, to ensure its long-term viability, a financial support seems to be necessary to encourage participation and avoid problems that may arise from a lack of engagement. By providing financial incentives, the V2G system can continue to grow and flourish, helping to build a more sustainable and resilient energy system for future generations. According to these interviews, the success of V2G / V2X technology seems to depend on overcoming the "me first" mentality and building a sense of community around energy sharing. It is important to ensure the long-term viability of this technology by providing financial incentives and optimizing the charging process. With the right incentives and community support, V2G / V2X technology has the potential to revolutionize the energy system and promote a more sustainable future.

The app discussed with the interviewees was considered useful for optimizing consumption and finding available chargers. It was described as a must-have for some users, with the potential to change the way people interact with V2G technology. However, some users may not have frequent use for it, and mentioned only using in while on vacations, away from home.

One of the main reasons for the use of the app is controlling and seeing how much money a user gets by injecting energy back to the grid, across several time periods such as day, week, and month. Nevertheless, the consensus between participants seems to be more focused on questions like “how cheap can I charge, where can I locate the cheapest chargers and in which times of the day is it cheaper to charge?”. There is a lot of emphasis on receiving alerts (push notifications) for this. It was also mentioned that the real-time information presented in the app could positively influence its usage.

Some people expressed the desire to know where the energy they are consuming comes from and where it is going to, in case of V2G discharge. There is also a preference to know if the energy being used to charge their vehicles is based on renewables.

Overall, the interest for most interviewees seems to be to charge always at the lowest price, sell at the highest, and have income anytime energy is given back to the grid. The app was considered to be generally good for people who want to optimize their consumptions and contribute to having a positive environmental impact.

Map feature

As seen in APPENDIX C: Remote exercises with EV users (exercise 1), one of the exercises was focused on a possible Map functionality (see screens in Figure 16).

In each interview, participants discussed their opinions and suggestions regarding this functionality, and the following notes should be highlighted:

- Users want to know, just by looking at the icons in the map, if chargers are working (or if they are broken or undergoing repair), and if they are available or occupied. They also want to see other characteristics for each charger, like prices (both fixed fees and price per kWh or per minute), type and speed of chargers, and if they are V2G compatible. Participants also mentioned the importance of showing where they are in the map and the route they need to take to get to each charger, how far it is (in kms), and how long it will take to get there (considering traffic). Finally, some users mentioned it could be useful to include information like supermarkets or other facilities available near chargers.
- One user reinforced the importance of using icons that are commonly used in other apps, so that the cognitive load on the user can be decreased.
- Users have mixed opinions about reserving chargers. Some find it useful to ensure a free charger, while others think it may cause frustration if people reserve and do not show up. Some suggest penalties for no-shows and the possibility of extension of the charging period if there are no reservations after the reservation time.
- Users have mixed opinions on V2G compatibility for charging stations. It is not a priority for most, but having the icon visible on the map is important. V2G availability and compatibility information should be easily accessible, but some users assume they might use V2G more at home.
- When choosing a charger, price seems to be the most important factor, along with ease of payment method and charging speed. This could be facilitated by implementing filters in the map view, related to prices and payment methods, to avoid the need to examine details of each charging station. Other filters also suggested were for favourite charging stations and for specific charger brands.
- A keyring for payment was suggested, especially to predict locations where lack of network signal might prevent users from activating the charging point.
- Participants reinforced the usefulness of feedback from past charging point users, as well as the possibility of users reporting when something is broken.
- One important factor mentioned by most participants is the indication of their own location, and the relation between that and the chargers, i.e., how distant they are. Participants mentioned wanting the app to give suggestions based not only on distance, but also considering the range they had in their EV, and including route suggestions to reach the charging station, possibly also including traffic information and estimated time of arrival.
- A route planning feature would be valued, giving charging station suggestions based on the type of EV the user has, and optimizing the journey to a specific destination. Here, a few participants mentioned the possibility of having favourite charging stations, as well as favourite destinations (and therefore, favourite routes).

V2X participation schedule with energy forecast feature

Another exercise was regarding V2X scheduling and energy forecasts, as can be seen in APPENDIX C: Remote exercises with EV users (exercise 2). The screens for this feature are available in Figure 17.

In each interview, participants discussed their opinions and suggestions regarding this functionality, and the following notes should be highlighted:

- Several participants had difficulties understanding the charts and screens, with some suggesting the need for tutorials or video explanations. Confusion arose from unclear graphics and difficulty in understanding the price points and energy forecasts. Suggestions were made to divide the charts into two and provide separate information for current cost and grid needs.
- A recurring theme among users seems to be the desire to save money while also contributing to environmental conservation and helping the grid. They are interested in optimizing their charging and discharging cycles to ensure they take advantage of the cheapest charging rates while also providing energy to the grid when needed.
- Participants seem to value predictability and the ability to program their charging and discharging cycles in advance, which seems to be in line with what has been observed before [1]. They want to be able to schedule their vehicle's charging times to coincide with the cheapest energy rates, and they also want to be able to schedule the discharging of excess energy back to the grid, especially during peak demand periods. These comments might lead to a rethinking of this feature, making it useful for both charging and discharging needs, instead of making it solely to predict discharging scheduling.
- Many reinforced the desire to assure flexibility and the ability to cancel agreements if necessary. Participants mentioned they want to ensure they are not left without energy when they need it. Some showed concern regarding the reliability of the system, and steps should be taken in increasing their trust in it, which might be achieved with a more transparent process, letting the user know what is happening at all times.
- In addition to ensuring reliability and flexibility, some participants suggested incentives to encourage participation, as well as customization of data visualization options. They want to be able to see the cheapest and most expensive charging rates, as well as the percentage of renewable energy being used. Some also suggested a feature that would allow them to customize energy source preferences to ensure they are supporting the most environmentally friendly options.

Historical data feature

The third exercise was concerning an historical data feature, as can be seen in APPENDIX C: Remote exercises with EV users (exercise 3). The screens for this feature are available in Figure 18.

In each interview, participants discussed their opinions and suggestions regarding this functionality, and the following notes should be highlighted:

- Participants displayed mixed reactions to the importance of historical and earnings information. While some found it interesting to look at their spending and earnings, others did not consider it relevant and did not want to constantly check the numbers. However, most seemed to agree that having all the information in one screen and displayed clearly is important.

- A few participants seemed to be confused about the screens shown, mentioning the information displayed could be less complex.
- One of the features displayed in these screens was the “green score”. Its purpose seemed to be unclear for some participants, and they mentioned the need to better understand how it is calculated, so that they could try to achieve a higher score. Some mentioned they suspected the “green score” was related to the energy source being used when charging, CO2 emissions prevented from charging and discharging, and even a comparison with other app users.
- Some users left a few recommendations as to what they believed these screens could have:
    - Adding statistics for day, week, and month, which would allow the user to filter the page using a specific timeframe, providing them with a more comprehensive view of their charging and discharging cycles.
    - Related to the charges and discharges list, some mentioned allowing users to submit information and photos about the chargers, including ratings, surroundings, and functional status.
    - Possibility to customize the general statistics screen to suit individual preferences.
    - Having in the charge or discharge detail a mention to the type of charger used, and how it might have impacted battery life (this suggestion came from a participant that mentioned they believed using a “faster” charger more often would decrease their battery’s lifespan).

Participants’ final remarks

Participants seemed interested in the app, and some even mentioned that it could help EV drivers better understand and trust V2X technologies.

Many reinforced the importance of assuring user control over charging and discharging processes. Additionally, some suggested the map should be the first screen, being the most important feature in the app, but simultaneously they feel the app should give more emphasis on V2X technology, since that is its purpose.

Some participants gave suggestions for additional functionalities for the app, such as the ability to view real-time battery levels, real-time statistics on the battery's remaining lifespan, possibility to add their own notes on chargers, and price alerts to help users find the most affordable charging options.

Finally, to help users better understand how the app works, video animations could be incorporated to explain the app's functionality and demonstrate the various features in a visually engaging way.

Interviews’ conclusions

The V2X app was generally well-received by participants, who cited saving money on electricity bills and contributing to a more sustainable planet as key benefits. Financial incentives were seen as necessary for widespread adoption, and the app was considered useful for optimizing consumption and finding available chargers. Participants were very interested in the map feature that shows charger availability, prices, and V2G compatibility, as well as the V2X participation schedule with energy forecast feature that allows users to program charging and discharging cycles in advance. Historical data was also discussed, with some participants finding it interesting to view spendings and earnings, while others did not consider it relevant. Overall, participants were interested in the app and suggested additional functionalities, such as real-time battery level and price alerts, among other suggestions.