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Electric Vehicles Management for carbon neutrality in Europe

Deliverable D3.6
Decision support tool for high-level coordination of V2X management strategies

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[1] https://ev4eu.eu/

Executive Summary

The Deliverable D3.6 – *Decision support tool for high-level coordination of V2X management strategies* presents the work carried out under T3.6, which initially aimed to propose and develop a high-level decision support tool to coordinate Vehicle-to-Everything (V2X) management strategies. The task was designed to address key planning questions such as:

- Where should fast-charging stations be installed?
- What power capacity is needed at these stations?
- Is fast charging the optimal solution?
- Where will residents without private parking charge their vehicles?
- Where should on-street charging stations be placed?

However, as the project progressed, it became clear that the city-level co-simulation platform already developed in T3.4 and T3.5 [1], [2] within the project effectively addressed these technical and strategic questions. Consequently, the focus of T3.6 shifted toward enhancing the city-level co-simulation platform by integrating a user adoption dimension into its existing decision-support capabilities, ensuring that the platform reflects real-world behaviour and preferences. This included the development of an interface that answers to the end-user needs (e.g., local authorities) and facilitates the use of the platform for its purpose.

Having this in mind, the goals of this deliverable are:

- Report on the methodology that was defined to achieve a city-level co-simulation platform user-centric interface.
- Present the main outcome of said methodology, which is the interface developed, along with key user profiles assumed by the team as the main future users of the platform.

The methodology mentioned was divided in five parts:

1. Surveys for users and non-users of Electric Vehicles (EVs) about the points of interest that the co-simulation platform gives as result[2];
2. Validation of end-users of the platform and gathering of information and contacts of those end-users to interview and perform surveys;
3. Definition of the User Experience/User Interface (UX/UI) requirements of the platform interface;
4. Development of the platform interface;
5. Workshop with all the partners of the project to discuss results.

[2] It is important to understand if EV users would utilise the public charger if installed in certain points of interest, as per the simulation results of the platform.

As mentioned above, the core contribution of this deliverable is the creation of a user-centric interface for the city-level co-simulation platform, tailored to different user profiles, which are decision-makers such as municipalities, Distribution System Operators (DSOs), and private investors. The efforts made through the defined methodology aimed to ensure the platform is both technically robust and practically usable.

Key findings of the methodology applied highlight the importance of grid capacity data, user behaviour insights, and intuitive design in supporting effective Electric Vehicle Supply Equipment (EVSE) planning. The heuristic analysis revealed moderate to poor usability compliance, guiding significant interface improvements. Additionally, to assure the right user profiles were considered for the platform development, six user profiles were defined – grouped into planning entities, macro investors, and micro investors – each with distinct needs and barriers.

Despite challenges in stakeholder engagement, the deliverable outlines actionable next steps, including real-world validation, enhanced data integration, and role-based platform customisation. This work positions the EV4EU city-level co-simulation platform as a strategic tool for accelerating the deployment of smart, user-informed EV infrastructure across the European Union.

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Acronyms

B2B	Business to Business
CPO	Charging Point Operator
DSO	Distribution System Operator
EV	Electric Vehicle
EVCI	Electric Vehicle Charging Infrastructure
EVCS	Electric Vehicle Charging Station
EVSE	Electric Vehicle Supply Equipment
GPS	Global Positioning System
ICEV	Internal Combustion Engine Vehicle
ISO	International Organization for Standardization
LEC	Local Energy Community
POI	Point of Interest
PHEV	Plug-In Hybrid Electric Vehicle
RES	Renewable Energy Sources
ROI	Return on Investment
TSO	Transmission System Operator
UI	User Interface
UMM	Usability Maturity Model
UX	User Experience
V2X	Vehicle-to-Everything
SS	Secondary Substation
SUMP	Sustainable Urban Mobility Plan
WP	Work Package

1 Introduction

Facilitating a smooth and swift transition to Electric Vehicles (EVs) requires the development of adequate Electric Vehicle Charging Infrastructure (EVCI) tailored to the needs and characteristics of the population. Public Electric Vehicle Charging Stations (EVCS) include accessible infrastructures in various locations (residential buildings, offices, hotels, commercial buildings, schools, etc.) with commercial power trading operations among investors, operators, and EV owners based on total charged energy and peak power. Instead of only charging EVs at home during night-time at private stations, public EVCSs can enable longer cruises with additional EVCS accessibility [3].

The optimal planning and distribution of public EVCSs within the city (including the location, power level, quantity of charging stations, etc.) are essential in improving EV market adoption. For instance, a driver's motivation to use an EV for a long-distance journey, such as an inter-city trip, would depend on the availability of EVCS along the major roadways. However, for short-distance trips, the driver would require a charging-enabled parking space at the journey's end. Accordingly, a charging infrastructure is needed to cater to different types of charging demand, including residential, workplace, en route, and destination charging. This means that a poor location of EVCS can lead to a waste of resources due to low adoption and negatively impact decarbonisation efforts [4], [5].

This is particularly pertinent in cities, where many drivers lack access to private parking, especially in the city centres. Municipal authorities are therefore expected to play a pivotal role in the strategic and orderly development of EVCI, tailored to local geographical characteristics, residential needs, and the required capacity of the EVCS [6].

Adequate planning, not just in the short term but also considering the orderly location of the EVCS as they are installed, will provide a better service to citizens and a more efficient use of the EVCI.

A city-level co-simulation platform such as the one developed in the EV4EU project [1], [2] is crucial for the optimal planning and distribution of public EV charging stations. Such a platform can integrate various simulation tools to model the interactions between distribution networks, and EVCI. By simulating different scenarios, a platform like this can help identify the most effective locations for charging stations, considering factors like traffic patterns, energy demand, and grid hosting capacity. This approach ensures that resources are used efficiently and that charging stations are placed where they are most needed, thereby supporting the widespread adoption of EVs and contributing to decarbonization efforts [8].

Incorporating a user adoption layer into the city-level co-simulation platform is essential for the entities that will use the platform, which could be from municipal authorities to grid operators. This layer can simulate the behaviour and preferences of these stakeholders, providing insights into how they might use the platform to plan and deploy public charging infrastructure. Understanding the needs and priorities of these entities helps in designing a platform that meets their requirements, such as identifying optimal locations for charging stations and ensuring efficient use of resources [9].

An interface that considers the end-user is also vital for the success of the city-level co-simulation platform. A user-friendly interface can make it easier for stakeholders to interact with the platform and make informed decisions. The interface should provide clear visualisations of simulation results, allowing users to understand the impact of different planning scenarios. Additionally, it should offer tools for customising simulations based on specific needs and preferences, ensuring that the platform is adaptable to various contexts and requirements.

1.1 Scope and Objectives

This document presents the work developed for the high-level design of the coordination of Vehicle to Everything (V2X) management strategies, considering the city-level co-simulation platform for V2X developed in EV4EU in T3.4 and T3.5 [1], [2]. Based on this work, this document presents the need and development of a user adoption layer for the platform developed in the project and its characteristics.

The objectives of this work can be folded into two parts. First, it provides an overview of the city-level co-simulation platform for V2X and what aspects are missing in the view of user adoption and experience. Mostly, the development of an interface for the possible end-user on the usability level and the understanding of the utility of the platform in a real-life context. Second, it describes the methodology used in this deliverable, which includes surveys, User Experience/User Interface (UX/UI) development, end-user interviews, heuristic analysis, a workshop, and also the results that were obtained in each. Finally, it presents the conclusions and next steps obtained based on the results.

1.2 Structure

This document is structured as follows: Chapter 2 presents the city-level co-simulation platform for V2X developed in the project and the need for a user adoption layer. Chapter 3 explains the methodology used in this deliverable and the results obtained in each step that comprises it. Chapter 4 then presents the conclusions, including the main findings, challenges, and next steps of the work performed.

1.3 Relationship with other deliverables

The present deliverable takes the number and characteristics of the EVs based on the electric road mobility evolution scenarios proposed in deliverable D1.1 [10], the business models centred on the V2X value chain of deliverable D1.4 [11], and the optimal management of V2X in parking lots defined in deliverable D2.3 [12]. From Work Package 3 – *V2X Integration in Smart Cities and Societal Adoption*, the EV users' needs and concerns from deliverable D3.1 [13] were used. The EVs use clustering results from deliverable D3.3 [14], and the city-level co-simulation platform for V2X from deliverables D3.4 [1] and D3.5 [2].

2 City-Level Co-simulation Platform for V2X

In the rapidly evolving landscape of urban mobility, V2X stands out as a transformative technology. This chapter delves into the characteristics of the city-level co-simulation platform developed in the EV4EU project in T3.4 and T3.5 [1], [2] and the critical aspect of incorporating user needs and behaviours into the platform's development.

2.1 Context

The city-level co-simulation platform for V2X developed in T3.4 and T3.5 [1], [2] simulates the impact of V2X in the cities and the distribution system, considering the V2X users' behaviour. The platform enables the integrated simulation of city traffic, distribution networks, and V2X management strategies. It was designed to assist in optimising the placement of Electric Vehicle Supply Equipment (EVSEs) at the city level. On the other hand, the platform identifies the weak points in the distribution grids supporting the increase of hosting capacity of the grid, as well as the planning of the infrastructure.

It comprises four main stages: Stage 1 is primarily responsible for the traffic simulation of the EVs by getting the profiles to help define the simulated behaviour and the most trafficked roads. Stage 2 processes the energy requirements from the simulated vehicles and defines the typical recharging sites. Stage 3 is responsible for integrating the grid network with two possible options: Option 1 processes Secondary Substation (SS) data to find SSs near recharging sites with available capacity; Option 2 simulates the local power system, considering power grid constraints (e.g., capacity of the secondary substations, cables, variable loads, lines, and voltage/current limits). Then, Stage 4 processes the results of the previous stages and estimates the number of EVSE, their optimal locations, and the rated power of each equipment.

The platform needs the following inputs to function correctly:

- Polygon (with coordinates) of the city area to be simulated;
- Secondary substation data with coordinates (in latitude and longitude format), installed power (in kVA or kW), and available capacity (in percentage, kVA or kW) – if this data is not available, then Stage 3 is not considered.

The platform uses Points of Interest (POI) representing anything normally present on the Global Positioning System (GPS) system, such as parking lots, charging stations, schools, hospitals, apartments, stores, etc. The simulation includes more than 200 different categories of POI. Having found the POIs, the traffic simulator requires user profiles specific to each simulated region.

When the simulation is finished, it gives a list of the characteristics of the final EVSE locations, including the category of the POI, the corresponding selected combination of EVSEs and power, and the cost of installation. Besides this list, it also gives a map of all the EVSE locations with an indication of the category that each point of interest falls into.

In T3.4 [1], the co-simulation was tested for the city of Lisbon as an example, and then in T3.5 [2], the co-simulation was tested for four use cases: Rønne City in Bornholm, Denmark; Mesogia Area in Greece; Ponta Delgada City in Azores, Portugal; and Krško City in Slovenia.

Figure 1 presents the co-simulation performed for the city of Rønne to show what the user would see.

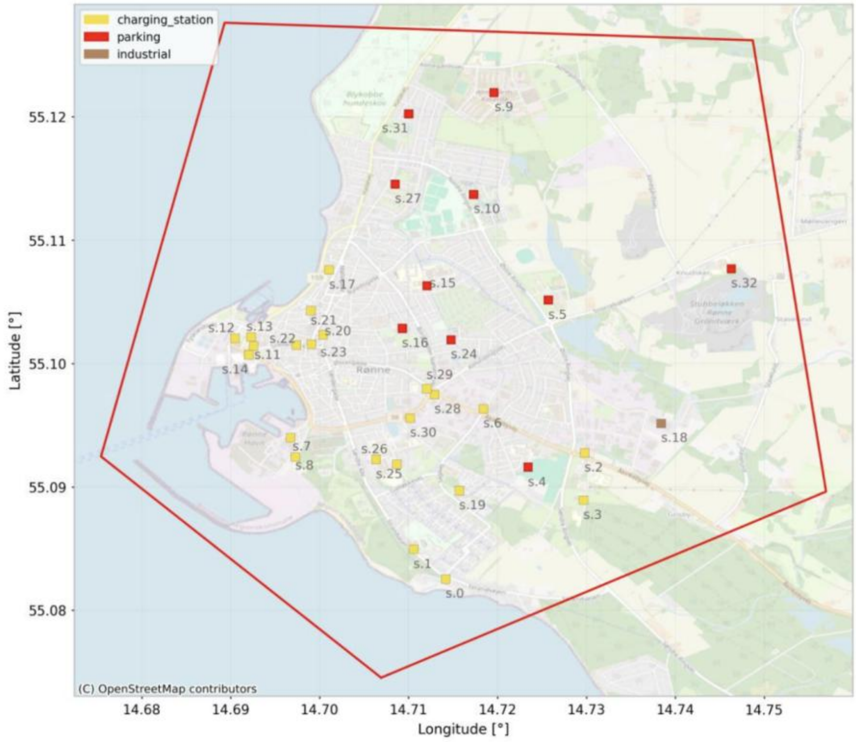

Figure 1: Co-simulation EVSE locations for Rønne [2].

2.2 User Adoption

The developed city-level co-simulation platform's main goal for V2X was to simulate the impact of V2X in cities and the distribution system, considering the V2X users' behaviour/profile and city traffic information. The focus was on the technical level of simulation to then be able to test the mass deployment of EVs in cities with different characteristics, mainly cities of the project, as Ponta Delgada (PT), Krško (SI), Mesogia (GR), and Rønne (DK). While this was done, the work of this deliverable is focused on including the user adoption layer that the platform developed in T3.5 and T3.4 [1], [2] did not have.

Including a user adoption layer in the city-level co-simulation platform for V2X is crucial for several reasons. This layer addresses the needs and behaviours of both EV users and decision-makers, ensuring the platform's effectiveness and relevance.

For EV users, the user adoption layer provides valuable behavioural insights. By understanding user preferences, such as preferred charging locations, the platform can simulate realistic scenarios based on actual EV user data. This helps in accurately predicting the demand for EVSEs at various POIs. Additionally, optimising the placement of EVSEs near popular POIs like shopping centres, workplaces, and residential areas enhances the overall user experience, making EV adoption more attractive.

Safety and efficiency for the EV users are also improved through the user adoption layer. By considering the impact of V2X on city traffic, the platform can identify potential congestion points and optimise traffic flow. This is particularly important for EV users who rely on efficient routes to reach EVSEs. Furthermore, understanding the energy requirements of EV users helps in planning the distribution network more effectively, ensuring that charging stations are placed where they are most needed and reducing the risk of overloading the grid.

For decision-makers, the user adoption layer is essential for strategic urban planning. Accurate data on EV user behaviour and preferences help identify high-demand areas, ensuring that investments in infrastructure are made strategically and maximising their impact. Additionally, by identifying points without additional hosting capacity for EVSEs in the distribution grid, the platform helps decision-makers plan necessary upgrades and expansions, supporting the increase in hosting capacity and ensuring the grid can handle the growing number of EVs.

Cost efficiency is another significant benefit for decision-makers. The user adoption layer presents the estimation of the number and type of EVSEs required at different locations, allowing for efficient resource allocation and avoiding unnecessary expenditures on underutilised charging stations. By optimising the placement of EVSEs, the platform can reduce operational costs and improve the economic viability of the charging infrastructure, which is crucial for gaining support from stakeholders and ensuring long-term sustainability.

An interface is essential for this platform because it facilitates user interaction and system interaction. A well-designed interface allows decision-makers to easily input data, visualise simulation results, and make informed decisions based on the insights provided by the platform. It ensures that the platform is user-friendly and accessible, enabling decision-makers to efficiently navigate through various functionalities and obtain the information they need.

This interface should be based on the decision-makers' needs because they are the ones responsible for planning and implementing the EV public infrastructure. By tailoring the interface to their requirements, the platform can provide relevant data and tools that support their decision-making process [15]. This includes features such as customizable reports, detailed visualisations, and intuitive navigation, which help decision-makers analyse the simulation results and make strategic choices regarding the placement and capacity of EVSEs.

Incorporating a user adoption layer and a decision-maker-focused interface into the city-level co-simulation platform is essential for both EV users and decision-makers. It ensures that the platform accurately reflects real-world scenarios, enhances user experience, and supports strategic planning. By addressing the needs and behaviours of both groups, the platform can effectively contribute to the successful deployment and adoption of EVCI.

3 Methodology and Results

This chapter delves into the methodology employed and presents the results obtained. The methodology sections outline the systematic approach taken to address the research questions shown in APPENDIX A: Research Questions, including the process definition of the data collection and analysis techniques.

Chapter 3 is structured into several key sections, where each section presents the following:

- Process Definition: This section describes the initial steps taken to define the research process, including the identification of objectives and the formulation of hypotheses, as well as mitigation techniques for the lack of collected research data.
- Surveys for users and non-users of EVs: The methodology for the conducted surveys is detailed, including the design of questionnaires, sampling techniques, and data collection methods. The results obtained from the surveys are analysed and presented.
- UX/UI Development: This section outlines the approach to developing the user experience and user interface design for the platform's interface, including prototyping and iterative testing. The results of the development process are discussed.
- End-User Interviews and Surveys: The methodology for conducting interviews with end-users is explained, including interview protocols, data analysis techniques, and surveys tailored for the end-users. The insights gained from both the interviews and surveys are presented.
- Heuristic Analysis: This section describes the heuristic evaluation process of the developed UX/UI, including the frameworks used for analysis and the findings obtained.
- Workshop: The methodology for the conducted workshop is detailed, including the planning, execution, and analysis of the workshop activities. The outcomes of the workshop are presented.

Together, these sections form the backbone of the present study, offering a comprehensive understanding of the research process and its outcomes. This chapter aims to provide a clear and concise presentation of the methods used and the significant findings that emerged, setting the stage for further discussion and interpretation in the following chapter.

3.1 Process Definition

The defined research protocol assumed the following methodology process:

1. **Quantitative surveys**, targeting both EV and non-EV users, to collect information about the types of locations the user would like to have EV chargers nearby, considering their routines and needs, and which ones would be used regularly.
2. **Development of UX/UI,** with the intent of developing an interface to the platform that was only developed at the backend level in T3.4 and T3.5 [1], [2].
3. **Interviews with possible end-users of the platform**[3] (stakeholders' contacts collected through previous research performed in T3.1 [13]and project partners) to understand if the city-level

[3] People that have roles in certain entities that we considered could be the end-user of the platform (decision-makers who decide or influence the decision of where the public charging stations equipment can be installed).

co-simulation platform would be useful for them, and perform usability tests on the developed interface, and also address V2X-related concerns.

4. **Workshop with partners** to present, discuss, and validate collected insights, as well as ideate about the characteristics, needs, and priorities of the decision-makers who were considered to be the end-users of the platform.

To apply such methodology, the following efforts were made:

1. The survey developed for D3.7[4] included questions to address issues related to preferences in the placement of public EV charging points – Section 3.2.
2. An interface was prepared, with a low-fidelity prototype[5] done in Figma[6], that included features based on the platform developed and submitted in T3.4 and T3.5 [1], [2] – Section 3.3.
3. Interview and survey scripts were done to explore needs and barriers for platform end-users. Additionally, all project partners were involved in collecting potential contacts for interviews and surveys with these platform end-users – Section 3.4.
    a. As a mitigation effort, after difficulties in collecting contacts were mentioned, new research tasks were planned and performed by all task partners – Section 3.5.
4. Finally, a Workshop was organised for all Work Package partners (mandatory for task partners, optional for all others) to process all information gathered and collaboratively create platform user profiles – Section 3.6.

3.2 Surveys for users and non-users of EVs

The deployment of chargers for EVs at various POIs is a critical component of developing sustainable transportation infrastructure and is, thus, a critical component of the co-simulation platform. To ensure the effective placement and utilisation of these chargers, it is essential to conduct societal context surveys. These surveys provide valuable insights into user preferences, local needs, and the relevance of different POIs in various contexts and countries. By understanding where and when people are most likely to use public chargers, planners can identify the most convenient and appealing locations. This ensures higher location rates and user satisfaction.

The relevance of different POIs for public charger placement can vary significantly across countries and contexts. For instance, urban areas may benefit from chargers near shopping centres and public transport hubs, while rural areas might find chargers at community centres or local stores more useful. Surveys help identify these nuances, ensuring that charger deployment can be tailored to the specific needs of each region.

[4] This deliverable is still being prepared and will be submitted later on in the project.
[5] A prototype is "a hypothesis — a candidate design solution that you consider for a specific design problem" [16]. This means that a prototype for a digital interface is a copy of it, with higher or lower fidelity (more or less like the final result), but done in a less time-consuming manner, like sketching screens on paper, or using a digital screen design tool to represent screens and interactions between them.
[6] https://www.figma.com/

Placing public chargers in locations identified through surveys can enhance accessibility for EV users. This reduces range anxiety and encourages the adoption of sustainable transportation options. Ensuring that chargers are conveniently located is key to supporting the mass deployment of EVs.

Data collected from surveys can inform decision-makers and investors about the most effective locations for charger deployment. This leads to more strategic investment and policies that support the expansion of EV infrastructure. Informed decisions are crucial for the efficient use of resources.

In T3.1, a Societal Context Survey was prepared, based on the survey launched previously for D3.1 [13], and now improved for D3.7. This new version of the survey focuses more on analysing experience and expectations and includes questions that were added for T3.6. Here, the goal was to optimise resources and ensure easier distribution of the survey (to collect more interesting data), by only having one survey to map more information.

In this survey for D3.7, the questions (listed in APPENDIX A: Research Questions) were included to provide deeper insights for T3.6, from the society perspective. Note that respondents included people owning an EV, Plug-In Hybrid Electric Vehicle (PHEV) and/or Internal Combustion Engine Vehicle (ICEV), and even people who don't own any vehicle. The goal was to understand an overall perspective and then analyse different preferences by profile type (for example, people owning an EV might prefer chargers in supermarkets, and people owning ICEVs could believe chargers should only be in gas stations).

The questions allowed participants to provide their quick and quantitative input regarding public charger placement, while also allowing for some qualitative data input to complement insights.

The collected sample counted 463 answers, characterised as follows:

- 73% male, and 24% female (3% other, or preferred not to say).
- 33% below 35 years old, 56% between 35 and 64 years old, and 11% over 65 years old.
- Participants are mainly from Slovenia (32%), Denmark (31%), Portugal (21%) and Greece (11%), with 5% from other countries around the world.
- 78% have a bachelor's degree or higher level of education.
- 39% in city outskirts, 38% live in urban areas, and 22% in rural areas (1% in other types of areas).
- 61% have a private parking space at home, where they have (or could have) an EV charger, 10% need permission from condominiums to have an EV charger, and 26% do not have a private parking space (they either have a shared parking area, or park in the street).
- 82% own either an EV or a PHEV, but only 22% of those (18% of the total sample) use it as their primary means of transportation.

For Question 1, included in the Societal Context survey, only 26 answers were submitted, meaning only 26 people both have EVs/PHEVs and do not or can't use public chargers inside their city. These results are as seen in Table 1.

Table 1: Results from Question 1, included in the Societal Context Survey, from T3.1.

Option selected	Number of answers	Percentage of answers (total of 26)
Yes, since near me (either home or place of work) there are only a few public chargers, and it's difficult to find one available	2	7.69%
Yes, since near me (either home or place of work) there are no public chargers	2	7.69%
No. There are public chargers available near me, but I prefer not to use them, because:	15	57.70%
No. There are no public chargers available near me, but even if there were, I would prefer not to use them, because:	7	26.92%

From these results, we can see that only 15% of people who do not use public charging would use it if it were available. They either do not have it, or there are so few that it is difficult to find availability.

The majority of people who do not use public charging actually have them available, and they choose not to use them. And some that do not have, would still not use them. The main reasons are that all of them can charge at home, and some also mention price as being an important factor, since public charging is considered to be more expensive than charging at home.

From other insights collected from the survey, we could see that less than 10% of EV/PHEV owners prefer or regularly use public chargers. Half of them report not having a charger at home or the office available, so this could be a reason for this preference. However, additional data is lacking to draw more concrete conclusions.

Regarding the second question included in the survey, Figure 2 shows a graph with the number of answers for each area mentioned in the list. All participants answered this question, so this is related to a sample of 463 respondents.

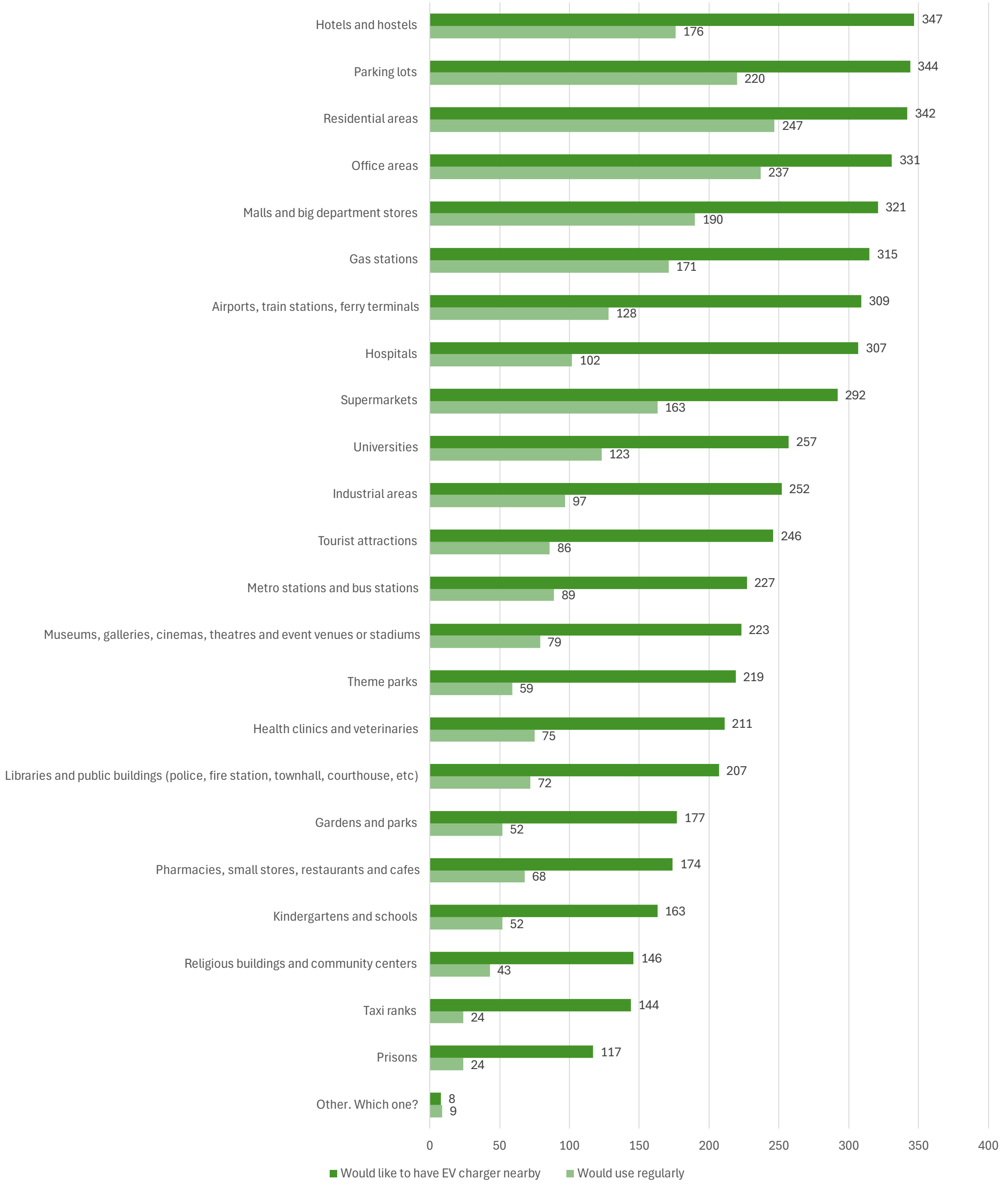

Figure 2: Question 2 results, from the Societal Context Survey in T3.1.

From this graph, it is possible to see that the majority of people would like to have EV chargers in "hotels and hostels" (74.9%), in "parking lots" (74.2%), and in "residential areas" (73.8%). In all of these, we see a big gap between places where people would like to have EV chargers and places where they would use them regularly.

To better access this preference, the sample was filtered to people with either EV or PHEV, which resulted in a total of 87 participants. From this sample, the majority of people would like to have EV chargers in "parking lots" (82.7%), in "hotels and hostels" (81.6%), and in "hospitals" (75.8%). The gap between places people would like to have EV chargers and places where they would use them regularly is still big in this sample. The results are displayed in Figure 3.

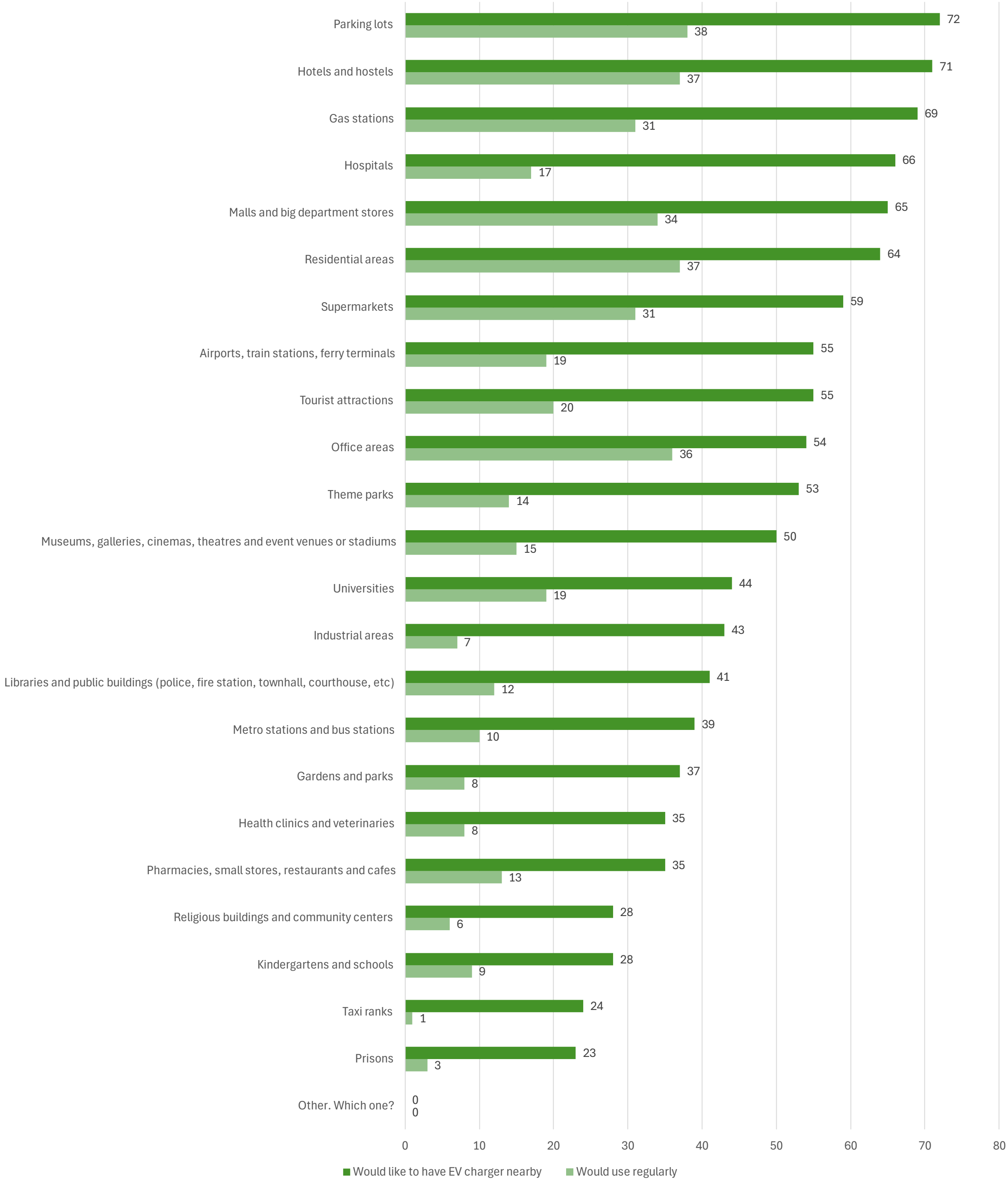

Figure 3: Question 2 results, from the Societal Context Survey in T3.1, filtered for EV/PHEV owners.

Finally, to try and understand this gap, the sample was further reduced, accounting only for people who have a private parking space, and who can have a way of charging their EV/PHEV there (even if an authorisation is required). The sample was reduced to 77 people. The top two preferred places to have EV chargers are “parking lots” and “hotels and hostels” (both with 83.1%), and “gas stations” (80.5%). The results are displayed in Figure 4.

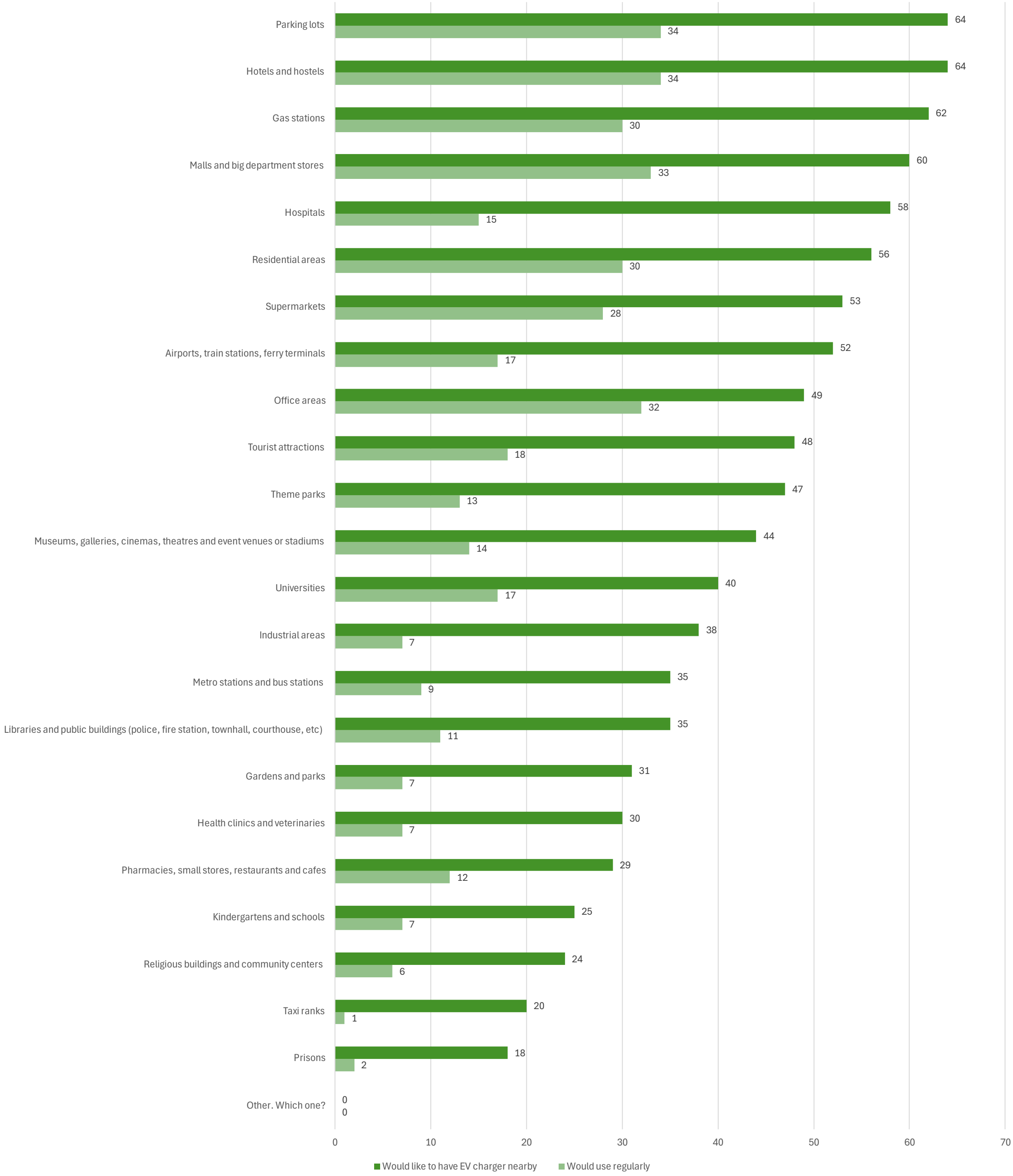

Figure 4: Question 2 results, from the Societal Context Survey in T3.1, filtered for EV/PHEV owners with private parking.

From this analysis, it is possible to see that preferences regarding public charging are related to different factors. The one that seems to affect users' habits the most is the possibility of charging their vehicles at home, or similar locations they regularly use in their routines. In general, public charging does not seem to be a preferred way of charging.

Nonetheless, there are some places where users prefer to have chargers available, even if their routine allows them to use other methods instead. With this in mind, one interesting feature to add to the city-level co-simulation platform, to consider users' habits and preferences, would be to highlight these POIs that were seen as preferred, like "parking lots", "hotels and hostels", "hospitals", "residential areas" and "gas stations".

One interesting factor to analyse would be changes of preferences according to different contexts, like people from different countries. However, the sample collected is not representative enough to conduct this kind of analysis, since not only there are not enough answers from each country to do an individual analysis, but also representativeness of each country is very heterogeneous.

It is also important to have in mind that these results were collected from March to June 2025. New studies should be recurrently done, to keep this information up to date. It is also important to distinguish between current users' preferences (people with EVs/PHEVs) for immediate actions, as well as perceived preferences (from people without EVs/PHEVs) for long-term planning and information dissemination.

3.3 UX/UI Development

The absence of a user interface in the co-simulation platform limits user interaction with the developed functionalities. Developing an interface is essential to make the platform accessible to the end-user and user-friendly. A UI provides a visual representation of data and processes, facilitating user understanding and navigation.

The interface serves as a bridge between complex backend processes and end-users, translating technical functionalities into comprehensible actions. It also enables users to provide feedback, which can be utilised for continuous platform improvement.

Initiating development with UX[7] and UI[8] efforts (such as information organization and interactive flow's definition, among other crucial activities) ensures the platform can be designed with the end-user in mind, focusing on their needs and preferences. Early UX/UI development allows for iterative testing and refinement, ensuring the result can be well-tuned to the user's requirements.

3.3.1 Interface Requirements

To ensure the co-simulation platform is intuitive and functional, a set of interface requirements were carefully defined at the beginning of T3.6. These requirements were chosen based on the code functionalities necessary for users to effectively interact with the platform, as well as best practices in user experience design. The goal was to create a seamless and efficient workflow that supports users in planning and evaluation of optimal locations for public charging stations. The requirements focused on three main areas: secure and accessible user authentication, flexible and precise data input capabilities, and comprehensive output management tools. Each of these areas plays a critical role in enabling users to perform simulations, analyse results, and make informed decisions with ease. For this stage, different profile needs were not considered, as that was considered a next step for future developments.

The interface requirements identified were as follows:

[7] User Experience (UX) efforts are the ones focused on defining content for the interface, and how to organize it in a way that answers most common tasks performed in the platform.
[8] User Interface (UI) efforts are more closely related to visual aspects, such as understanding if a link should appear as underlined text or a button, visually presenting the right information in the right way.

- **Login capacity**, where the user must have the option to create an account with the following fields: complete name, entity name, e-mail, and password. To log in, the user needs to input their e-mail and password, and there must be an option to recover the password to the defined e-mail.
- **Input capacity**, where the user must be able to input geographical coordinates to evaluate where to install the charging stations (that constitutes a polygon). Input prioritisation criterion of results with a selection on a list of local topologies, and input charging power preference with a selection on a list of powers.
- **Output management capacity**, where the user must be able to visualise the simulation results in a map and list format, with the option to filter by local topology and the possibility of exporting the results list. It must also be able to perform history management of several simulations, with the option of saving the obtained results.

With those requirements, an interface was developed as wireframes[9] to quickly provide a visual representation of what these requirements should look like and how users should interact with this interface. Wireframes are typically presented in black and white to avoid the distraction of colour, allowing the focus to remain on functionality and the overall structure of information. Accordingly, the images below emphasise usability over visual design.

Figure 5 shows wireframes with the planned search flow, that can be seen by following the numbered steps. From top left, starting with choosing to draw an area (Step 1), selecting different points directly on the map (Steps 2 and 3), closing that area to form a polygon (Step 4), a loading moment for the platform to process results (Step 5), and the results page (Step 6). Figure 6 shows the "My Profile" screen, with the user personal data, the last performed search, and saved searches favourited by the user. Figure 7 shows the "Saved Searches" screen, with both complete searches saved, and lists of points saved directly from the results (without saving the whole search). A complete set of screens can be seen in APPENDIX B: Interface Screens, as well as a fully functioning prototype.

[9] "A wireframe is **a visual representation of content layout in a design**. It helps you **organize and simplify the elements and content** within a space (web or mobile) and is an essential tool in the designing process." Besides wireframes, there are also sketches, mockups and interactive prototypes, among other stages of the interface development [17].

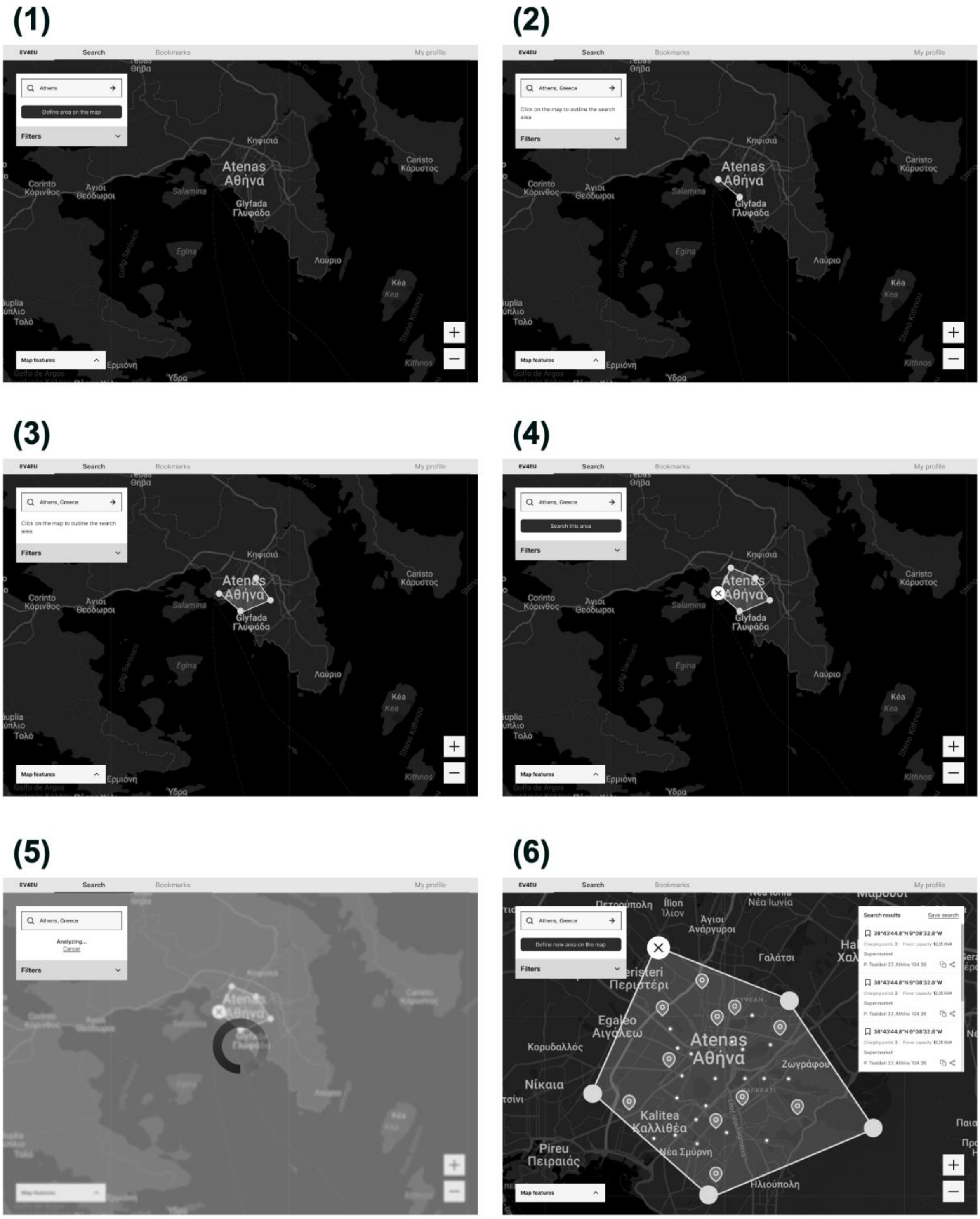

Figure 5: Wireframes indicating search flow in the developed interface.

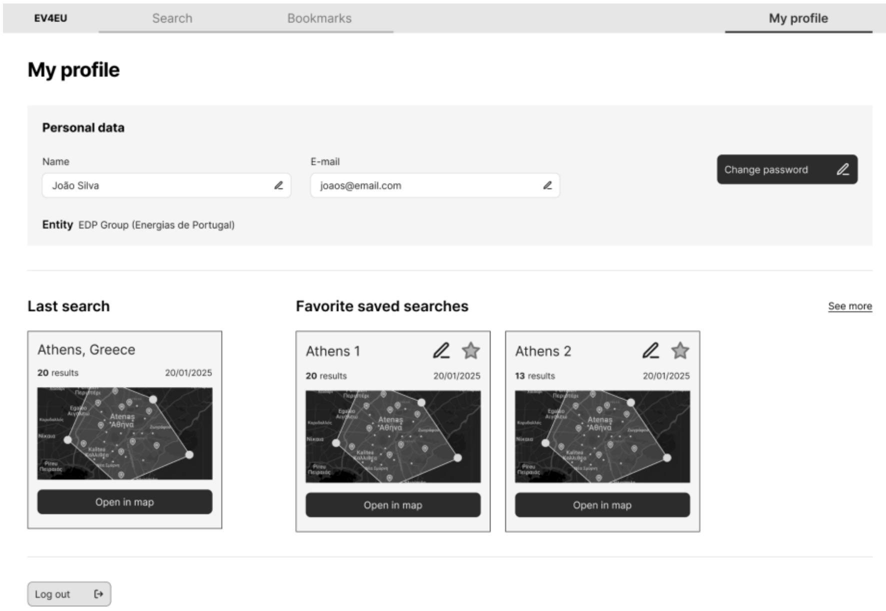

Figure 6: "My Profile" screen.

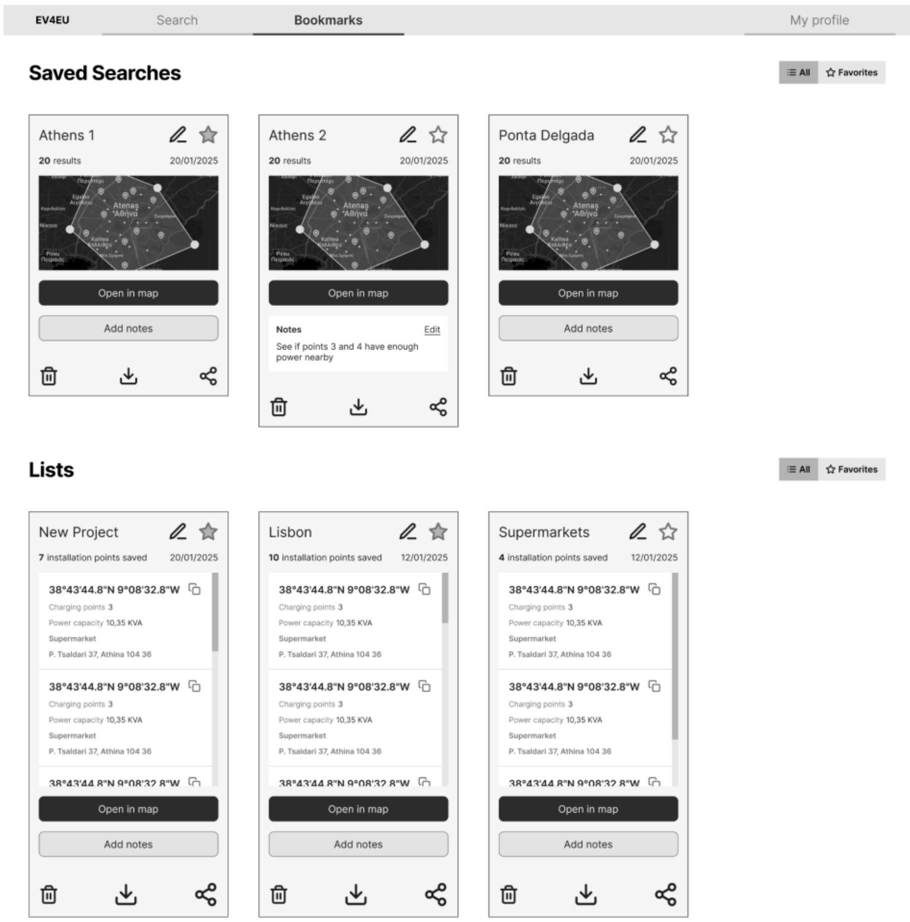

Figure 7: "Saved Searches" screen.

3.4 End-User Interviews and Surveys

According to the defined methodology, it was planned to interact with possible platform's end-users, with the goal of understanding if the city-level co-simulation platform would be useful for them. Furthermore, these interactions would allow the performance of usability tests on the interface developed for the platform. Finally, V2X-related concerns would also be addressed.

Initially, a script for the interviews was drawn generically, including questions that would approach the following topics (this generic script for the interviews is available in APPENDIX C: Generic script for platform's end-user interviews):

- Map and describe experiences with EVs, charging them, and with V2X technologies.
- Perceptions regarding utility and adoption of V2X technologies.
- Needs and concerns regarding the city-level co-simulation platform (generically, focusing mainly on the platform's main goal of planning public charger placement).
- Impacts that V2X technologies might bring to the grid, to EV users, and whether there are perceived risks or benefits.
- Recommendations and future expectations regarding V2X implementation.
- Think-aloud test (usability test with the platform's interface).
- Wrap-up questions to allow further input.

While asking project partners for contacts for these interviews, the initial script was then tailored to each contact profile, so that more unique insights could be obtained.

Unfortunately, no contact came to fruition, despite a lot of effort, and as such, the interviews were not possible. Because of that, a new step in the plan was included, regarding mitigation efforts (Section 3.5), so that some information regarding platform users' needs and concerns could still be obtained.

3.5 Mitigation Efforts

Due to a lack of response from the contacts made by SEL for the end-user interviews to understand if the co-simulation platform would be useful for them and if so, perform usability tests on the developed interface, two mitigation efforts were implemented. Regarding the developed interface, a heuristic analysis by usability experts was performed; and regarding the platform's end-users, a request was made to the task partners (Elektro Celje, HEDNO, INESC-ID and PPC).

The heuristic analysis is presented in Section 3.5.1, and the request made to the partners with the results obtained by each one of them are presented in Section 3.5.2.

3.5.1 Heuristic Analysis

The proposed plan assumed that the interface developed for the city-level co-simulation platform would be subjected to usability tests, by performing interviews with a “think aloud” component. The interviewee would look at the interface, try to use it, and provide feedback regarding its usability.

Because that method was not possible, a heuristic analysis was performed on the developed interface to identify design problems. Additionally, it would be possible to iterate on the developed UX/UI, if needed, to correct those issues.

A heuristic analysis is a systematic evaluation method used to identify usability issues in a user interface design. It involves expert evaluators examining the interface and judging its compliance with recognised usability principles (known as “heuristics”) [18]. This evaluation method was developed by Jakob Nielsen and Rolf Molich [19], [20]. It has become one of the most widely used methods for assessing user interface design due to its efficiency, cost-effectiveness, and ability to identify major usability issues early in the development process [21].

Key characteristics of a heuristic analysis include:

- Expert-based evaluation: Conducted by usability experts rather than actual end users.
- Systematic approach: Uses established usability principles as a framework for evaluation.
- Cost-effective: Requires fewer resources compared to full user testing.
- Early detection: Can identify potential problems before implementing the design.

The typical process involves [21]:

1. Multiple evaluators independently examining the interface (between 3 and 5 is the recommended number of evaluators [21]).
2. Each evaluator inspects the interface multiple times.
3. Comparing findings against established heuristic principles.
4. Recording and rating the severity of identified issues.
5. Aggregating and analysing the results to create improvement recommendations.

This method is particularly valuable because it can uncover a wide range of potential usability issues before investing in more expensive user testing or full implementation. However, while a heuristic analysis is a powerful tool, it should be noted that it works best as part of a comprehensive evaluation strategy that includes other methods such as user testing, analytics analysis, and user feedback collection. It may not catch all user-specific issues that could emerge in real-world usage.

A heuristic analysis is typically performed at various stages of the design and development process, but it is particularly valuable in the following situations:

- **Early Design Phase:** To evaluate preliminary designs and prototypes before significant resources are invested in development.
- **Before User Testing:** To identify and fix obvious usability issues before conducting more expensive user testing sessions.
- **During Iterative Development:** To assess new features or modifications before they are implemented.
- **Pre-Launch Evaluation:** As a final quality check before releasing a product or major update.

A heuristic analysis can be performed for several compelling reasons:

- **Cost-Effectiveness:** It requires fewer resources than full usability testing while still providing valuable insights.
- **Time Efficiency:** Can be completed relatively quickly compared to other evaluation methods.
- **Risk Reduction:** Helps identify potential usability problems early, reducing the risk of costly fixes later.

- **Systematic Approach:** Provides a structured method for evaluating interfaces against established usability principles.
- **Complementary Method:** Works well in combination with other evaluation techniques to provide comprehensive insights.

A heuristic analysis was performed on the interface developed in this task, which was presented in Section 3.3, for the city-level co-simulation platform developed in T3.4 and T3.5 [1], [2]. For this process, a model for the analysis was chosen (Section 3.5.1.1), experts ran the analysis on the interface (Section 3.5.1.2), and conclusions were drawn on possible issues and recommendations (Section 3.5.1.3).

3.5.1.1 Choosing a Model for the Heuristic Analysis

Two models were chosen for the heuristic analysis, from a set of Usability Heuristics Frameworks [22]. These frameworks are listed in Table 2, along with a small overview of each one.

Table 2: Models and Frameworks for Heuristic Analysis.

Model / Framework	Description	Best used for	Usability Components [23]
Nielsen's 10 Usability Heuristics [19]	Created by Jakob Nielsen, these are the **most widely used heuristic principles** focusing on feedback, errors, consistency, and efficiency	General UX evaluations and audits, identifying interface issues.	- Learnability[10] - Efficiency[11] - Errors[12] - Memorability[13]
Shneiderman's 8 Golden Rules of Interface Design [24]	Core design rules emphasizing **consistency, control, and cognitive ease**	UI/UX design, improving interface consistency and efficiency	- Learnability - Efficiency - Errors - Memorability
System Usability Scale (SUS) [25]	A standardized **10 questions** survey developed by John Brooke to measure the usability of a system	Quick usability assessments, system comparisons and benchmarking	- Learnability - Efficiency - Satisfaction[14]

[10] This component analyses how easy is it for users to accomplish basic tasks the first time they encounter the design, and even more easily on future visits, giving a nearly effortless understanding of the architecture and navigation of the site.
[11] This component analyses how quickly can users perform tasks, once they have learned the design.
[12] This component analyses how many errors users make, how severe are these errors, and how easily can they recover from them. It measures error frequency and severity, and explores error tolerance.
[13] This component analyses, when users return to the design after a period of not using it, how easily can they reestablish proficiency.
[14] This component analyses how pleasant is it to use the design. It's about subjective satisfaction, if the user likes using the system, if they find it pleasant and engaging to use and appropriate for its industry/topic.

Amélie Boucher's Ergonomic Criteria [26]	A framework focusing on **interface ergonomics** and user comfort	Evaluate ergonomic and usability aspects of digital interfaces, improving navigation and clarity	- Learnability - Efficiency - Satisfaction - Errors
The Ten User Experience Heuristics of Arhippainen [27]	UX-focused heuristics including **emotional and aesthetic** aspects	Design emotionally engaging and satisfying user experiences, by evaluating both usability and user delight	- Learnability - Efficiency - Satisfaction - Utility[15]
Bastien & Scapin Ergonomic Criteria for Human-Computer Interfaces [28]	**Ergonomic criteria** for software usability, focusing on **guidance and error handling**	Deep software audits, reducing workload and improving control in complex applications	- Learnability - Efficiency - Satisfaction - Errors - Memorability
Colombo & Pasch's 10 Heuristics for an Optimal User Experience [29]	Heuristics for multimedia UX, balancing **usability** and **engagement**	Gamified and entertainment platforms	- Learnability - Efficiency - Satisfaction - Utility
Dieter Rams' 10 Principles of Good Design [30], [31]	A **design philosophy** that emphasizes simplicity, functionality, longevity, and sustainability in product design (both physical and digital)	Product and minimalist UI design	- Learnability - Satisfaction - Utility
ISO 9241-110: Interaction Principles [32]	**International standard** for ergonomic interaction principles	Enterprise systems, ensuring usability and error tolerance	- Learnability - Efficiency - Satisfaction - Errors - Utility
Kaniasty's CARMEL Guidelines [33]	Usability framework focusing on **clarity, consistency, and accessibility**	Web/mobile apps prioritizing usability and inclusivity, designing systems for users with varying technical expertise	- Learnability - Efficiency - Errors - Memorability

From Table 2, a choice was made to perform the Heuristic Analysis using two models:

- Nielsen's 10 Usability Heuristics;
- International Organization for Standardization (ISO) 9241-110: Interaction Principles.

[15] This component analyses if the interface provides the features users need it to perform.

This choice was made based on the following factors:

- Both frameworks are widely recognised and established in the field of usability evaluation, providing comprehensive coverage of essential interface aspects.
- While Nielsen's heuristics offer a practical and proven approach for general usability assessment, ISO 9241-110 provides a more standardised and formal evaluation framework, particularly valuable for professional software development.
- Together, these frameworks complement each other by combining intuitive usability principles with structured interaction guidelines, ensuring a thorough evaluation of the interface.
- Other frameworks, while valid and proven in the field of usability evaluation, was not as applicable or as appropriate for the type of interface being evaluated.

With the models chosen, a team of three experts performed independent heuristic analyses, using the same two models mentioned above. Each of the experts was given a set of topics in a checklist to confirm compliance with each heuristic of both models. The detailed process is described in Section 3.5.1.2.

3.5.1.2 Running the Heuristic Analysis

As outlined in Section 3.5.1.1, once both models were selected, each usability expert performed an independent heuristic evaluation using a predefined checklist. Each item on the checklist was a question designed to assess compliance with usability standards. If the interface met the criteria, a severity rating of 0 was assigned. If not, a rating between 0 and 4 was given, depending on the impact of the issue on the overall user experience (even when not complying, an issue can have a 0 severity rating, because it can have no impact on the experience). The severity rate is as follows:

- **0 – I don’t agree that this is a problem at all:** either it complies with the usability standard, or not complying is not a problem at all.
- **1 – Cosmetic problem only:** need not be fixed unless extra time is available on the project.
- **2 – Minor usability problem:** fixing this should be given low priority.
- **3 – Major usability problem:** important to fix, should be given high priority.
- **4 – Usability catastrophe:** imperative to fix this before the product can be released.

The checklist used was based on a curated list of items, validated by experts in the team beforehand, based on their experience in the field.

Each expert reviewer received a list with the same structure of Table 3 (filled with a few lines as examples).

Table 3: Example of a list received by experts to perform Heuristic Analysis.

Checklist	Compliance[16] (YES, NO, N/A)	Severity[17] (0 - 4)	Recommendations	Model / Framework & Heuristic
Does every display begin with a title or header that describes screen contents?	NO	3	Missing in the Search tab. This can be confusing for first-time users, so it's recommended to add a contextual title (optionally adding a description)	Nielsen's 10 Usability Heuristics #01 - Visibility of System Status
Are menu titles either centred or left-justified?	YES	0	-	Nielsen's 10 Usability Heuristics #04 - Consistency and Standards
Are icons, labels, and tooltips descriptive and easy to understand?	NO	3	The wording for each action seems obvious, but the iconography is not, due to the lack of labels	ISO 9241-110: Interaction Principles #02 - Self-Descriptiveness
Are animations and transitions used appropriately to enhance engagement?	N/A	-	-	ISO 9241-110: Interaction Principles #07 - User Engagement

After the three analyses were done, they were matched in a single final analysis. This merge was done by a usability expert who considered the following list as rules:

- If there is at least one expert who believes an item is applicable (either compliant or not), even if the others do not consider it applicable, the item should count in the final analysis.

[16] Does the interface evaluated comply with this item of the checklist? If "not applicable", leave N/A, and don't input any value in the Severity field.
[17] If it complies, write 0 here. If "not applicable", don't input any value, leave it blank.

- When experts disagree about an item being compliant or not compliant, the item's final analysis shows non-compliance, with a severity score averaged across values given by three reviewers, rounded to the upper unit.
- When experts disagree on the severity rate given, the final severity score is an average of all three, rounded to the upper unit.

From all the checklist items provided, Table 4 indicates how many items in each heuristic were applicable (i.e. items that were considered as either compliant or not compliant, leaving the "not applicable" out). It also shows the average severity score of each heuristic.

Table 4: Heuristics per model with checklist count and average severity score.

Model	Heuristic	No. of applicable items in the checklist	Average severity score
Nielsen's 10 Usability Heuristics	#01 - Visibility of System Status	18	0.83
	#02 - Match Between System and the Real World	14	0.79
	#03 - User Control and Freedom	8	1.63
	#04 - Consistency and Standards	27	0.41
	#05 - Error Prevention	7	1.14
	#06 - Recognition Rather than Recall	22	0.36
	#07 - Flexibility and Efficiency of Use	1	2.00
	#08 - Aesthetic and Minimalist Design	10	0.40
	#09 - Recognise, Diagnose, and Recover from Errors	3	0.33
	#10 - Help and Documentation	8	1.25
ISO 9241-110: Interaction Principles	#01 - Suitability for the User's Tasks	9	2.33
	#02 - Self-Descriptiveness	7	3.00
	#03 - Conformity with User Expectations	8	2.00
	#04 - Learnability	9	2.56
	#05 - Controllability	7	2.00

	#06 - Use Error Robustness	4	2.50
	#07 - User Engagement	5	0.20

After merging all the analyses into one, a calculation was then performed to ascertain, in percentage, the compliance score of each heuristic. A score of 100% means perfect compliance with that heuristic.

The formula used to calculate that score was the following:

$$Compliance\ score\ (\%) = \left(1 - \frac{S}{4}\right) \times 100, \qquad (1)$$

where S is the average severity of all the items in each heuristic (scale of 0 to 4).

In Table 5, the compliance score is shown for each heuristic.

Table 5: Heuristics per model, with compliance score added.

Model	Heuristic	No. of applicable items in the checklist	Average severity score	Heuristic Compliance Score [%]
Nielsen's 10 Usability Heuristics	#01 - Visibility of System Status	18	0.83	79.25
	#02 - Match Between System and the Real World	14	0.79	80.25
	#03 - User Control and Freedom	8	1.63	59.25
	#04 - Consistency and Standards	27	0.41	89.75
	#05 - Error Prevention	7	1.14	71.50
	#06 - Recognition Rather than Recall	22	0.36	91.00
	#07 - Flexibility and Efficiency of Use	1	2.00	50.00
	#08 - Aesthetic and Minimalist Design	10	0.40	90.00
	#09 - Recognise, Diagnose, and Recover from Errors	3	0.33	91.75
	#10 - Help and Documentation	8	1.25	68.75
ISO 9241-110:	#01 - Suitability for the User's Tasks	9	2.33	41.75
	#02 - Self-Descriptiveness	7	3.00	25.00

Interaction Principles	#03 - Conformity with User Expectations	8	2.00	50.00
	#04 - Learnability	9	2.56	36.00
	#05 - Controllability	7	2.00	50.00
	#06 - Use Error Robustness	4	2.50	37.50
	#07 - User Engagement	5	0.20	95.00

Finally, a weight is attributed to each heuristic. Depending on the interface being analysed, as well as the detail level of it, some heuristics might be less relevant than others. For that reason, a weight variable (*W*) is added to the formula, as seen in the equation below. The weight value is manually given by the expert, that analyses all other expert inputs and merges all the analyses, to produce a final result.

$$Weighted\ Compliance\ Score = W \times Compliance\ Score =$$
$$= W \times \left[\left(1 - \frac{S}{4}\right) \times 100\right], \quad (2)$$

where *S* is the average severity of all the items in each heuristic (scale of 0 to 4) and *W* is the weight given to that heuristic by a usability expert.

Table 6 shows each heuristic's weight, as well as its final weighted compliance score.

Table 6: Heuristics per model, with weights attributed and weighted compliance scores calculated.

Model	Heuristic	No. of applicable items in the checklist	Average severity score	Heuristic Compliance Score [%]	Heuristic Weight	Weighted Compliance Score [%]
Nielsen's 10 Usability Heuristics	#01 - Visibility of System Status	18	0.83	79.25	1.00	79.25
	#02 - Match Between System and the Real World	14	0.79	80.25	1.00	80.25
	#03 - User Control and Freedom	8	1.63	59.25	1.00	59.25
	#04 - Consistency and Standards	27	0.41	89.75	0.25	22.44
	#05 - Error Prevention	7	1.14	71.50	1.00	71.50

	#06 - Recognition Rather than Recall	22	0.36	91.00	0.50	45.50
	#07 - Flexibility and Efficiency of Use	1	2.00	50.00	1.00	50.00
	#08 - Aesthetic and Minimalist Design	10	0.40	90.00	0.25	22.50
	#09 - Recognise, Diagnose, and Recover from Errors	3	0.33	91.75	1.00	91.75
	#10 - Help and Documentation	8	1.25	68.75	1.00	68.75
ISO 9241-110: Interaction Principles	#01 - Suitability for the User's Tasks	9	2.33	41.75	1.00	41.75
	#02 - Self-Descriptiveness	7	3.00	25.00	1.00	25.00
	#03 - Conformity with User Expectations	8	2.00	50.00	0.80	40.00
	#04 - Learnability	9	2.56	36.00	0.90	32.40
	#05 - Controllability	7	2.00	50.00	1.00	50.00
	#06 - Use Error Robustness	4	2.50	37.50	1.00	37.50
	#07 - User Engagement	5	0.20	95.00	0.20	19.00

After scoring each heuristic for both models, it is now possible to calculate the final compliance score of the analysed interface, considering each model used. Table 7 presents those scores.

The score is calculated as follows:

$$Model\ Compliance\ Score\ = \frac{\sum_{i=1}^{n} W_i \times S_i}{\sum_{i=1}^{n} W_i}, \quad (3)$$

where S is the average severity of all the items in each heuristic (scale of 0 to 4), W is the weight given to that heuristic by a usability expert, and n is the total number of heuristics in the model.

Table 7: Final Compliance Scores for both models used in the Heuristic Analysis performed.

Model	Model Compliance Score[18]
Nielsen's 10 Usability Heuristics	73.89%
ISO 9241-110: Interaction Principles	41.64%

Defining percentage intervals for compliance with a heuristic model like Nielsen's or ISO 9241-110 depends on the context of evaluation, the purpose of the model, and often expert-defined thresholds. These models do not have strict numeric cutoffs, but here is a grounded approach with literature-based reasoning, available in Table 8.

Table 8: Compliance intervals and corresponding interpretation.

Compliance Score (%)	Interpretation	Reasoning
90–100%	Excellent **– Fully compliant**	Few to no usability problems. Commonly interpreted in expert reviews and benchmarks
75–89%	Good **– Minor improvements needed**	Usability still solid, but room for optimization. See usability benchmarks Sauro & Lewis (2016)[19] [34] and Usability Maturity Models (UMMs)[20]
60–74%	Moderate **– Noticeable usability issues**	Indicates some non-trivial problems; users may experience friction
40–59%	Poor **– Significant usability concerns**	Many heuristics not well met; intervention recommended. Refer to severity scales[21]
<40%	Critical **– Non-compliant or unacceptable**	Usability is likely to impair task success. Similar thresholds are used in heuristic evaluation reports

[18] This score is calculated by averaging the Weighted Compliance Scores (%) of each heuristic of that model, according to equation 3.

[19] This study suggests benchmarking usability metrics using percentile rankings, implies that 70–80% indicates acceptable usability depending on context, and emphasizes interpreting scores in relative terms (compared to peers or industry).

[20] General principles emphasize *fit for purpose*, but don't provide numeric scoring. However, compliance scoring is common in ISO-based audits and UMMs, where thresholds such as ≥75% compliance are often considered "pass" in audits.

[21] While the Nielsen Norman Group doesn't specify numeric thresholds, they advocate heuristic evaluation severity ratings (0-4 scale), where a severity 3-4 usually requires attention. If many heuristics have high-severity issues, usability is compromised.

For this analysis, and considering the compliance score ranges above, the interface does not comply with either of the models presented, as both are below the first two score ranges. We can consider *Nielsen's* score as in the *Moderate* range, and ISO 9241-110 in the *Poor* range.

In the next section, a detailed analysis of the results obtained in each model is presented. After a list of recommendations is suggested, consider the major issues identified with the analysis.

3.5.1.3 Results Analysis

Nielsen's 10 Usability Heuristics

Regarding the framework, *Nielsen's 10 Usability Heuristics*, the interface scored an overall of 73.89% compliance. We can consider *Nielsen's* score as in the *Moderate* range.

To better understand compliance with the model, it is important to recall that weighting the heuristics is crucial, so that the most relevant ones will have a higher impact in the final model score than others that might not be as relevant at this step of the interface development. For example, heuristic #08 - Aesthetic and Minimalist Design weighs 0.25 (from 0 to 1), because it mostly analyses the use of colour, iconography, and micro-animations. For an interface still in a wireframing stage, most of these concepts are not even applicable, and this is not the development phase for these concepts to be determining for interface analysis.

Recalling Table 6, we can see the compliance scores for all heuristics of this model, both before and after weighting them.

We can also apply the score ranges mentioned above in Table 8. Below, in Table 9, we can see those ranges applied to each heuristic.

Table 9: Applying compliance intervals to each heuristic of Nielsen's model.

Heuristic	Compliance Score (before weighting) [%]	Compliance Score range
#01 - Visibility of System Status	79.25	***Good*** *– Minor improvements needed*
#02 - Match Between System and the Real World	80.25	***Good*** *– Minor improvements needed*
#03 - User Control and Freedom	59.25	In the threshold between: ***Poor*** *– Significant usability concerns* and ***Moderate*** *– Noticeable usability issues*
#04 - Consistency and Standards	89.75	In the threshold between: ***Good*** *– Minor improvements needed* and ***Excellent*** *– Fully compliant*
#05 - Error Prevention	71.50	***Moderate*** *– Noticeable usability issues*

#06 - Recognition Rather than Recall	91.00	***Excellent** – Fully compliant*
#07 - Flexibility and Efficiency of Use	50.00	***Poor** – Significant usability concerns*
#08 - Aesthetic and Minimalist Design	90.00	***Excellent** – Fully compliant*
#09 - Recognise, Diagnose, and Recover from Errors	91.75	***Excellent** – Fully compliant*
#10 - Help and Documentation	68.75	***Moderate** – Noticeable usability issues*

With the compliance scores, prior to the application of weights, we can understand the most critical heuristics, as well as the ones that are performing well.

In this interface, considering *Nielsen's* model, the focus of improvements should be on the four heuristics with the worst scores (which were also considered as having weight 1, i.e., with a maximum level of importance in this analysis):

- #07 - Flexibility and Efficiency of Use: 50.00%, **Poor** (significant usability concerns)
- #03 - User Control and Freedom: 59.25%, in the threshold between **Poor** (significant usability concerns) and **Moderate** (noticeable usability issues)
- #10 - Help and Documentation: 68.75%, **Moderate** (noticeable usability issues)
- #05 - Error Prevention: 71.50%, **Moderate** (noticeable usability issues)

The main issues identified in each of these heuristics can be found in Table 10. These are not the only issues found, but they were considered the most critical ones.

Table 10: Main issues identified using Neilsen's model

Heuristic	Main issues identified
#03 - User Control and Freedom	No undo/redo function on the map while interacting with the location selection flow. Lack of confirmation when deleting saved searches/lists.
#05 - Error Prevention	The delete option is placed alongside harmless actions, without a proper warning or action confirmation.
#07 - Flexibility and Efficiency of Use	No distinction between novice and expert users, particularly in the location selection and the filtering functionalities, which can compromise the ability to use the platform. Manual coordinate entry is not supported - users must select locations on the map, which is imprecise due to zoom limitations and can cause errors.

#10 - Help and Documentation	No clear help available or inline help options. Lack of instructions/context for the search page, making it difficult for new users.

Other smaller issues were found, which are listed in APPENDIX D: Heuristic Analysis – overview of results. In the Recommendations part of this section, some of the changes and improvements that were made are related to those issues.

ISO 9241-110: Interaction Principles

Regarding the framework *ISO 9241-110: Interaction Principles*, the interface scored an overall of 41.64% compliance. We can consider the *ISO 9241-110: Interaction Principles* score as *Poor*.

Recalling Table 5, we can see the compliance scores for all heuristics of this model, both before and after weighting them.

We can also apply the score ranges mentioned above in Table 9. Below, in Table 11, we can see those ranges applied to each heuristic.

Table 11: Applying compliance intervals to each heuristic of the ISO 9241-110 model.

Heuristic	Compliance Score (before weighting) [%]	Compliance Score range	Heuristic Weight
#01 - Suitability for the User's Tasks	41.75	***Poor*** *– Significant usability concerns*	1.0
#02 - Self-Descriptiveness	25.00	***Critical*** *– Non-compliant or unacceptable*	1.0
#03 - Conformity with User Expectations	50.00	***Poor*** *– Significant usability concerns*	0.8
#04 - Learnability	36.00	***Critical*** *– Non-compliant or unacceptable*	0.9
#05 - Controllability	50.00	***Poor*** *– Significant usability concerns*	1.0
#06 - Use Error Robustness	37.50	***Critical*** *– Non-compliant or unacceptable*	1.0
#07 - User Engagement	95.00	***Excellent*** *– Fully compliant*	0.2

As seen above, most heuristics are either performing poorly or critically, with only one heuristic performing well. In this case, the weight column is also present, to recall the ones considered most important by experts.

In this interface, considering *ISO 9241-110: Interaction Principles* model, the focus of improvements should be on the four heuristics that have higher weights in the analysis (#02, #06, #01 and #05), followed by the other two with slight less importance (#04 and #03):

- #02 - Self-Descriptiveness: 25%, **Critical** – Non-compliant or unacceptable
- #06 - Use Error Robustness: 37.5%, **Critical** – Non-compliant or unacceptable
- #01 - Suitability for the User's Tasks: 41.75%, **Poor** – Significant usability concerns
- #05 - Controllability: 50%, **Poor** – Significant usability concerns
- #04 - Learnability: 36%, **Critical** – Non-compliant or unacceptable
- #03 - Conformity with User Expectations: 50%, **Poor** – Significant usability concerns

The main issues identified in each of these heuristics can be found in Table 12. These are not the only issues found, but they were considered the most critical ones.

Table 12: Main issues identified using ISO 9241-110 model

Heuristic	Main issues identified
#01 - Suitability for the User's Tasks	Manual coordinate entry is not supported, leading to potential errors. System limitations affecting user workflow.
#02 - Self-Descriptiveness	No instructions for first-time users. Unclear distinction between Saved Searches and Lists.
#03 - Conformity with User Expectations	Inconsistent button behaviour. Non-standard map controls placement.
#04 - Learnability	Missing labels and tooltips for icons. No clear instructions for search area functionality.
#05 - Controllability	Single workflow only. No undo/redo functions.
#06 - Use Error Robustness	No prompts before irreversible actions. No confirmations for critical operations.

Other smaller issues were found, which are listed in APPENDIX D: Heuristic Analysis – overview of results. In the Recommendations part of this section, some of the changes and improvements are related to those issues.

Recommendations

With the Heuristic Analysis results, the interface was iterated, illustrating ways of improving screens and features, keeping in mind the issues discovered. The screens shown in this section are quick iterations of the original ones, and no new prototype was created. With these screens, the goal is to explore alternatives for the interface that answer problems detected in the Heuristic Analysis, and not to create an improved version of the interface. For that, more time would be needed, as well as further testing and analysis.

Each screen shown below is accompanied by a description of improvements done to it, contextualising changes with specific feedback from the Heuristic Analysis.

In Figure 8, a "Register" button was added. With this, new users can quickly create an account, which was an action that was not visible on the original wireframes.

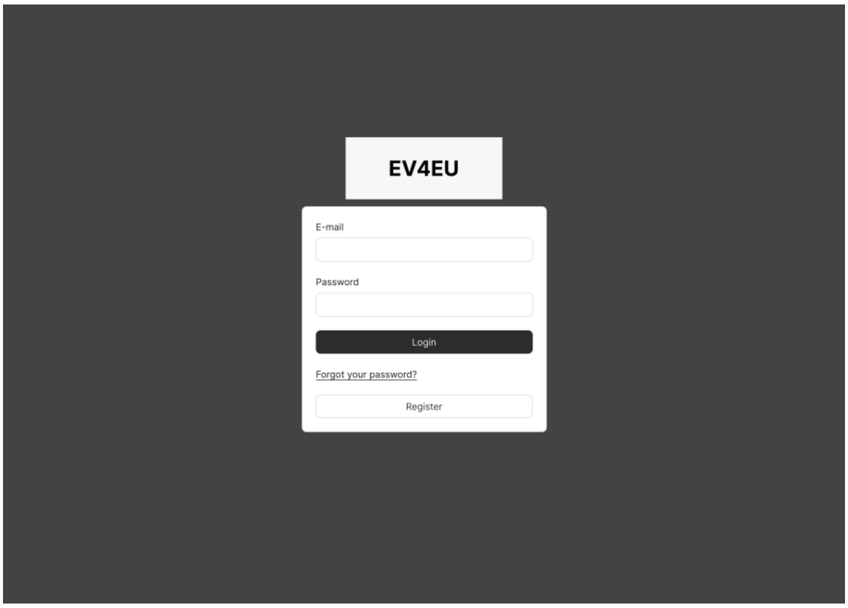

Figure 8: Login screen – Alternative version proposed.

Having the button visible allows for a quicker understanding of actions possible, as well as increased confidence in how different task flows answer user needs.

Figure 9 shows the alternative version of the Search screen.

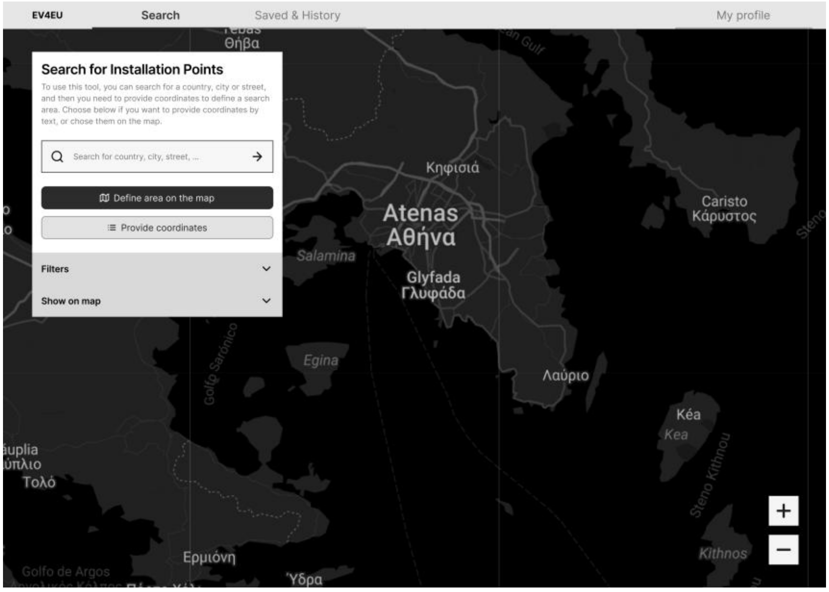

Figure 9: Search screen – Alternative version proposed.

In this version of the Search screen, several details were changed, considering the feedback obtained regarding the search flow and the map view:

- Menus in the tab above were updated to copy[22], which is clearer on the contents of each tab.
- A context was included (title and description, included in the search feature rectangle).
- Instructions for the search flow are now available in the description provided, as well as instructions that accompany the whole flow (see Figure 10 and Figure 11).
- New input functionalities were added, namely coordinate entry, to allow the user to choose the search method most convenient to them.
- Map features were relocated and renamed to "Show on map" to increase clarity and findability for the user.
- Filters were updated to increase the findability of different filtering options, as well as promote a quicker deselection of all filters applied.

To see in more detail what changed in the search flow, Figure 10 and Figure 11 include different steps available in the search flow, along with a diagram to explain how users go from one step to another.

Figure 10 shows the starting point (1), then the beginning of the "define area on the map" flow (2), afterwards it shows the "define area on the map" flow with 4 points selected on the map (3). With (4) it shows the beginning of the "provide coordinates" flow, and (5) shows the "provide coordinates"

[22] "Copy" is a term used frequently when designing and planning interfaces. It refers to the written text in interfaces, like text in labels or buttons, as well as other "action-oriented" elements of the interface, which is carefully studied to be tailored to users' needs and expectations and has in mind specific interface users, rather than being generic for any person [35].

option with 3 points written. When choosing to perform the search, by clicking on "search this area", a loading message is shown (6), regardless of flow used. Figure 11 shows the same images (1 to 6), ordered in the two possible flows (either choosing coordinates directly on the map, or adding them manually).

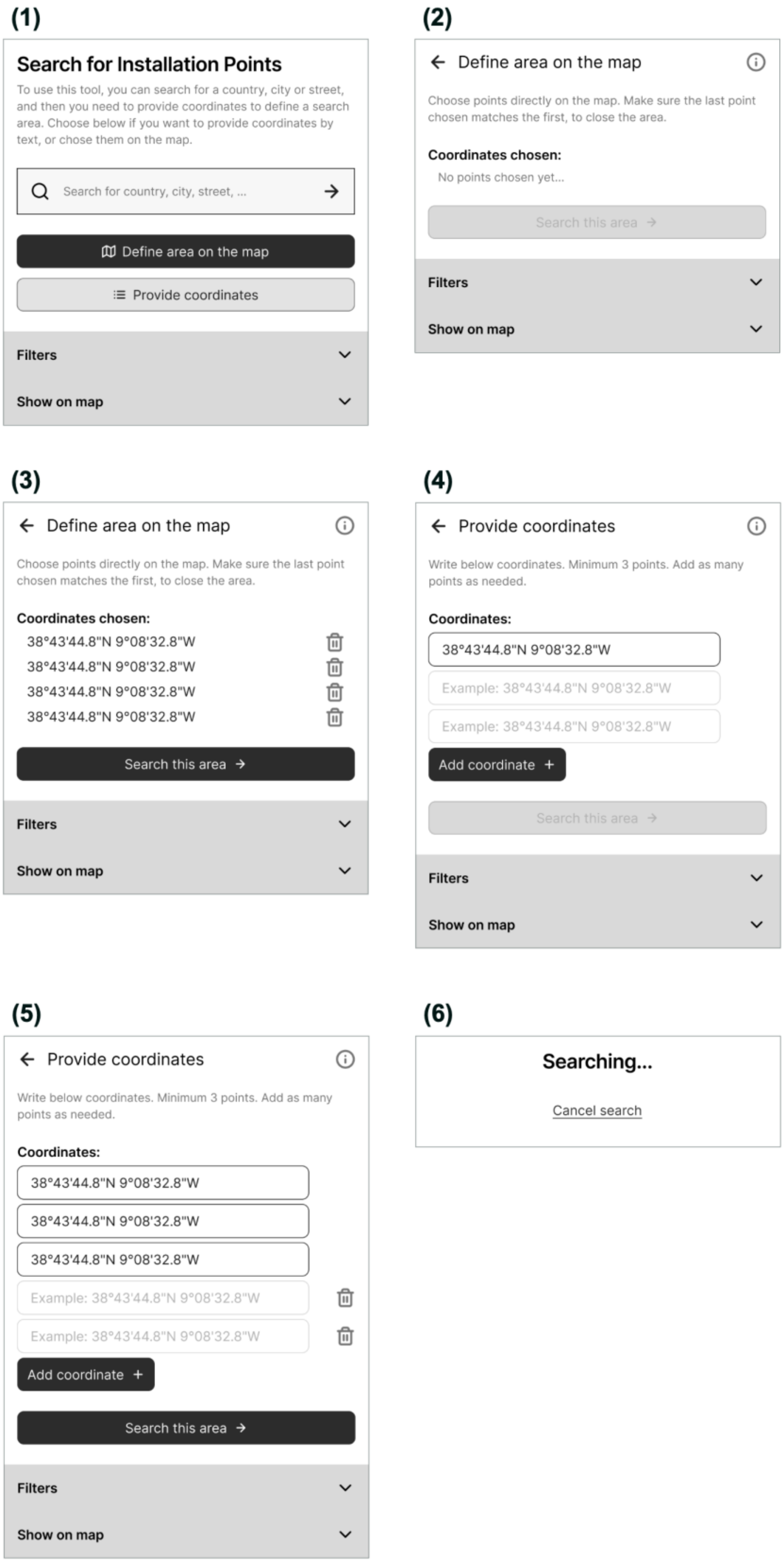

Figure 10: Search flow images – Alternative version proposed.

Figure 11: Search flow diagram – Alternative version proposed.

Updates on filters are available on Figure 12, where several steps of the filtering flow are mapped. Alphabetic order and a search feature were added, as well as a "clear all" button. The numbered images show: (1) the "Filters" menu closed; (2) the menu open, with 4 types of filters available; (3) "Points of interest" filter type open; (4) filters being applied; (5) the filter type closed, now with filters selected; (6) the "Filters" menu closed, now with filters selected.

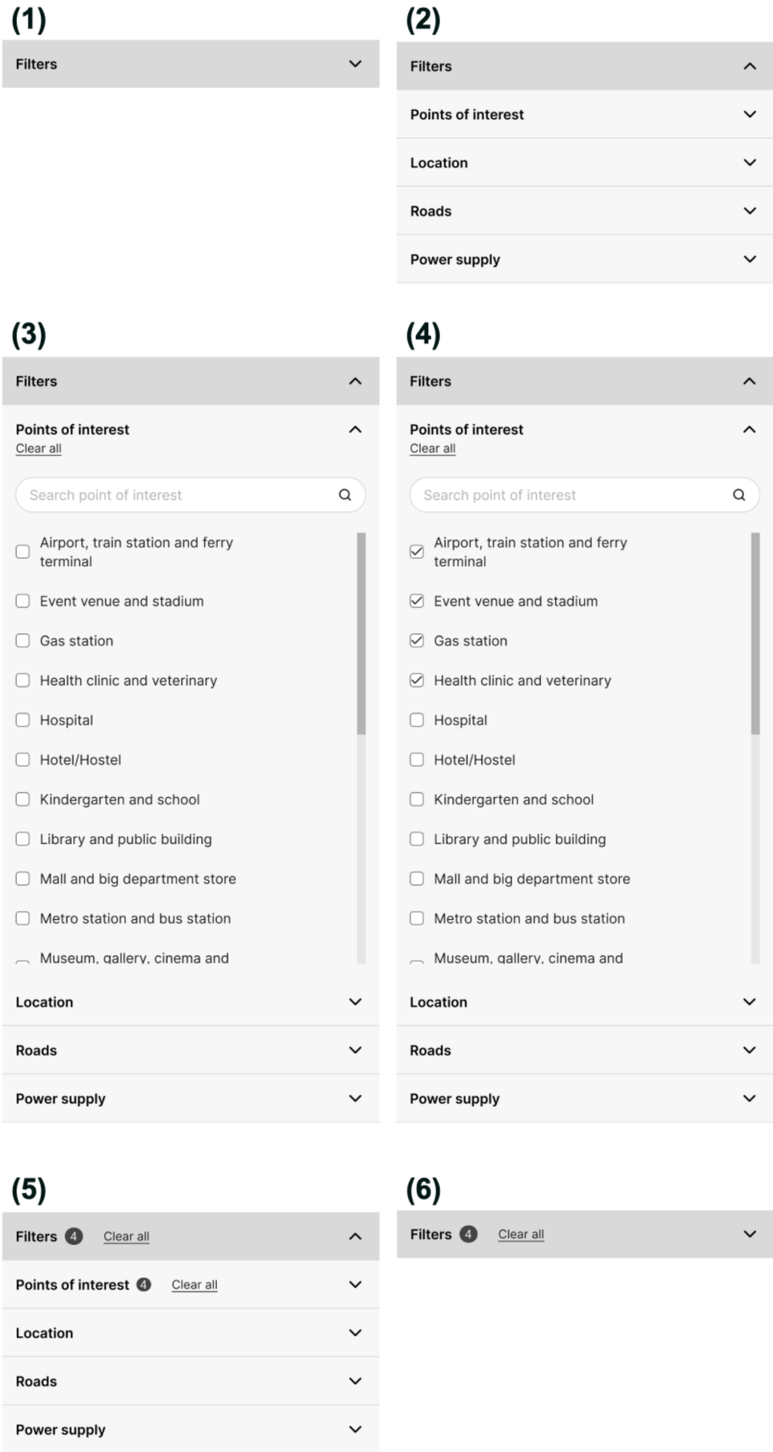

Figure 12: Filters – Alternative version proposed.

The results page also had some margin for improvement, and a new suggestion is presented in Figure 13 and Figure 14, with a new way of indicating points of interest in the map (with icons), as well as a rework of how the whole search can be saved, and how each point can be added to a saved list. Figure 13 presents the entire screen, where search results will appear listed on the right side of the screen, as well as pins in the map (map pins for installation points, and icons for points of interest visible nearby). Figure 14 zooms in on the search results' list (image on the left) and shows how the user can save the whole search, as well as each installation point suggested ("add point to list" button). Additionally, each point has a detail view (image on the right), and it can be shared and saved in a list.

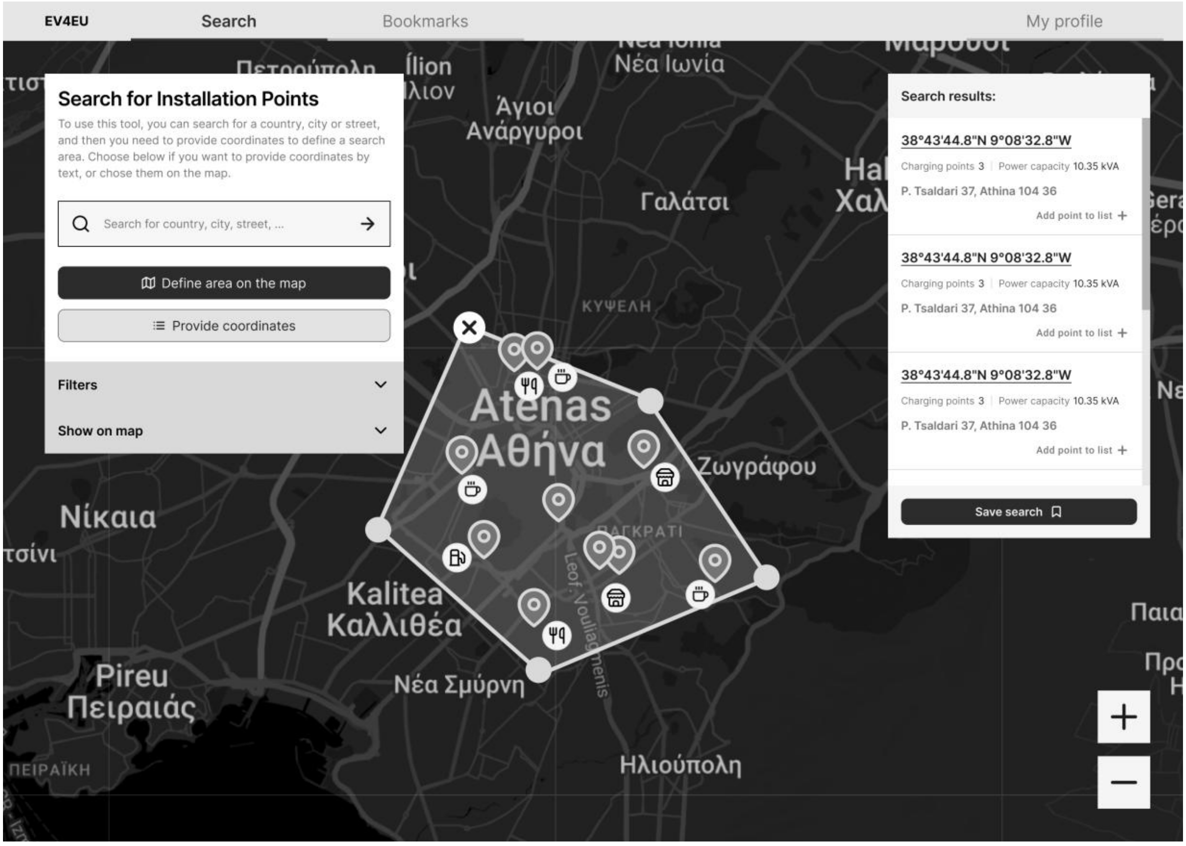

Figure 13: Search results screen – Alternative version proposed.

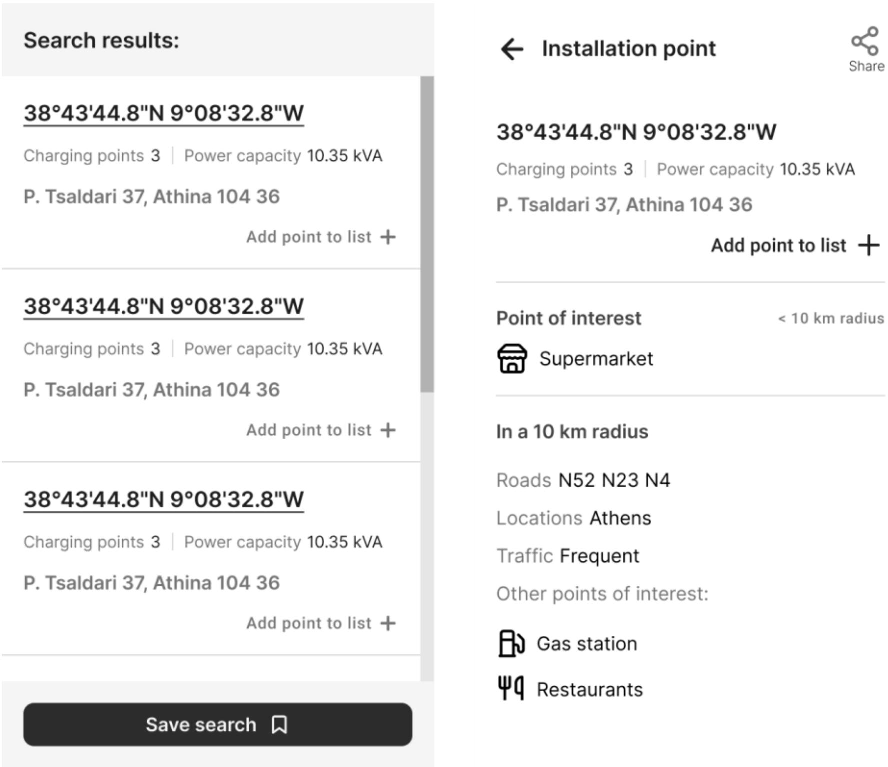

Figure 14: Search results list – Alternative version proposed.

For the “Saved & History” page (previously the “Bookmarks” page), a new version was also developed, focusing on two main issues: clarifying the differences between types of lists and providing confirmation before critical actions, such as deleting a list or saved search. For that, a description of each list type was added and is presented in Figure 15, where it’s possible to see 3 types of lists, and the corresponding description explaining to new users what each list is, as well as actions they can perform with them.

For critical actions (like deleting a list), a dialogue box was designed as shown in Figure 16, so the user can confirm any critical action before making irreversible damage. Some other details were also updated, like adding labels to icons and placing the “delete” button further away from other actions.

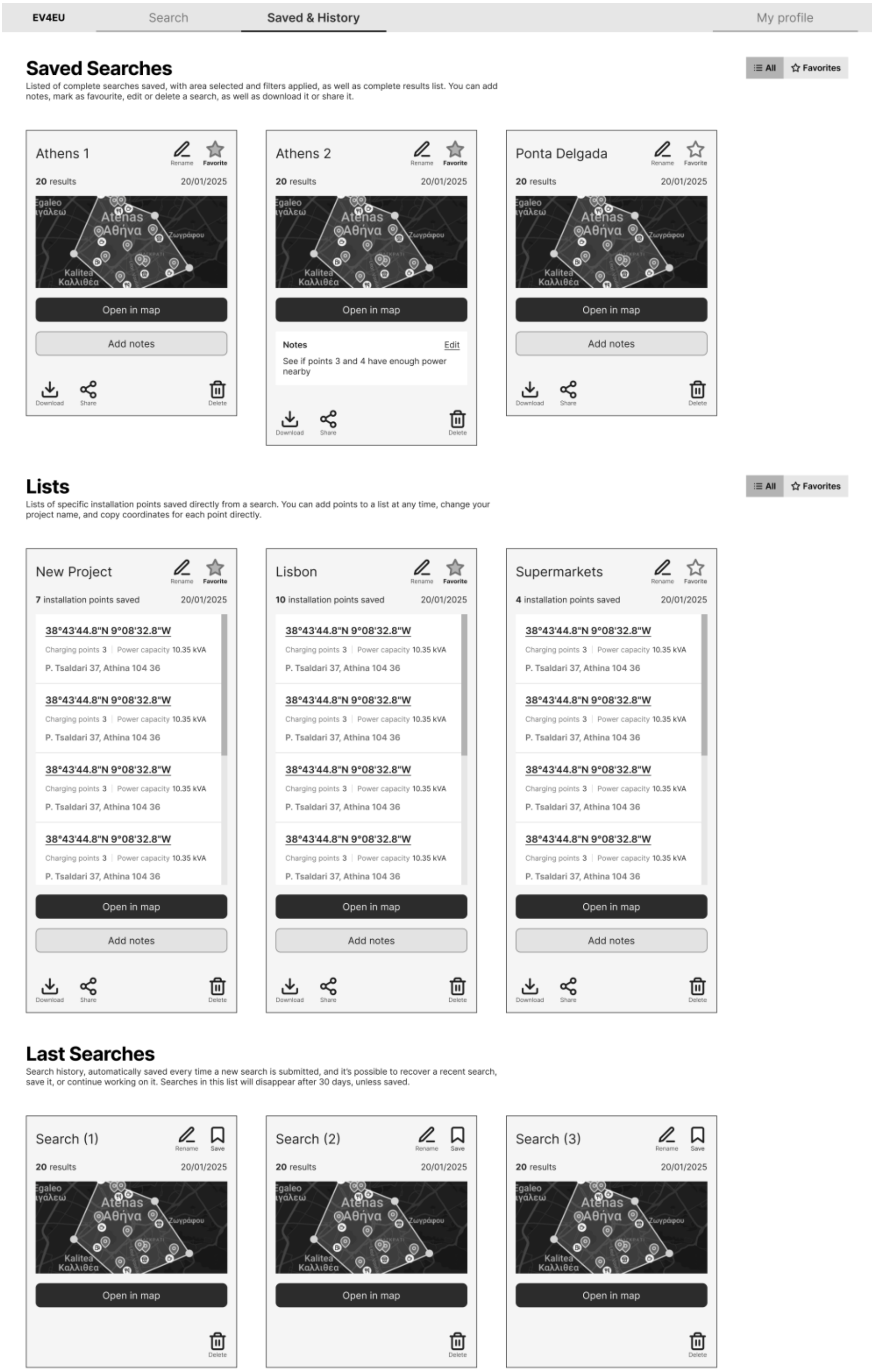

Figure 15: Saved & History screen – Alternative version proposed.

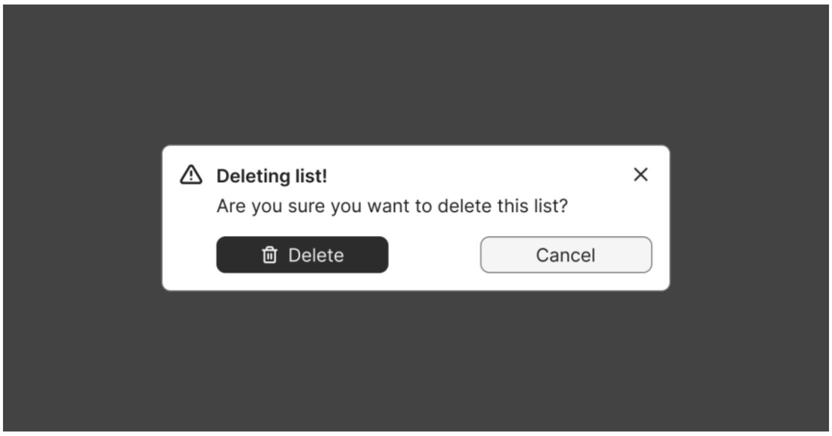

Figure 16: Delete confirmation – Alternative version proposed.

Finally, the "My profile" screen was adjusted to consider other updates done in other screens. As last searches are now a list in the "Saved & History" screen, they were taken out of the "My profile" screen. The password change feature was also modified to mimic a more common approach. These changes are visible in Figure 17, a screen that includes account information, the log out function, and favourite saved searches.

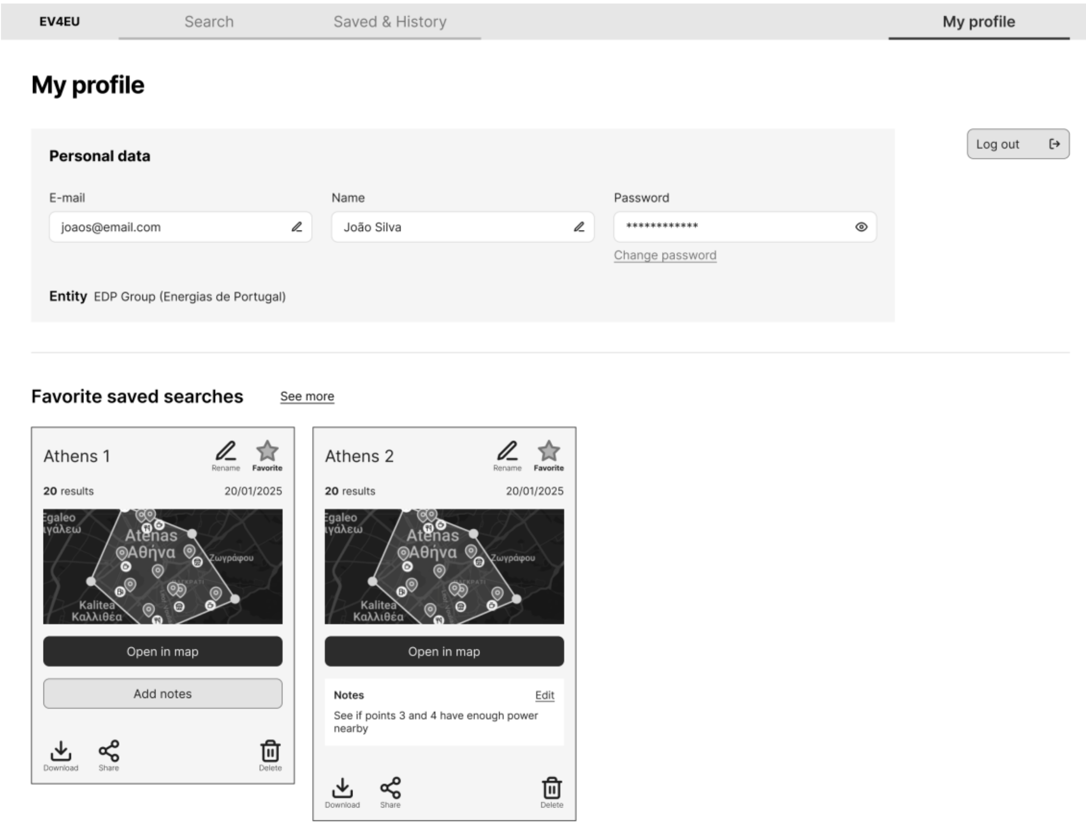

Figure 17: My profile screen – Alternative version proposed.

With all these updates, better usability is expected, considering the Heuristic Analysis results. This analysis should not fully replace Usability testing with platform users, but it can provide a good baseline of problems that may arise based on field experts' experience.

3.5.2 Partners Contributions based on request made

The request made to the task partners (Elektro Celje, HEDNO, INESC-ID and PPC) consisted of:

- Each partner had to **make a methodology proposal to find answers** to several questions that are listed below.
- This **methodology was presented in a meeting with all the partners**, with the respective justification (SEL provided advice on the chosen methodology and recommendations on how to apply it).
- The partners had to apply their proposed methodology and gather results.
- The **results had to be presented in a meeting the week before the workshop** to serve as a basis for the workshop.
- If there were **no results, a justification for not collecting data should be given**, providing evidence of an attempt to apply the methodology, an explanation of why it failed, and what the partner would do alternatively if the opportunity arose.

The questions that were given to the partners regarding the city-level co-simulation platform are the research questions present in APPENDIX A: Research Questions.

3.5.2.1 Elektro Celje Methodology

As part of Elektro Celje's methodology, a series of interviews was conducted with various Charge Point Operators (CPOs) and the Motorway Company in the Republic of Slovenia (DARS). The objective of these interviews was to gain insight into the current state and challenges related to the deployment of EVCI in Slovenia. The interviews were focused on the criteria that they regularly use when deciding on the location of public charging points, the types of information they consider crucial before making such decisions, and the main challenges and barriers they face during the planning and implementation phases. Additionally, they were asked which types of information would be useful to them if a centralised planning platform for charging infrastructure were to exist.

In addition to the above, an informal discussion was held with representatives from two departments of Elektro Celje, specifically the Development Department and the Investment Department, both of which are directly and indirectly involved in the processing of applications for the connection of EV charging infrastructure to the electricity distribution network. This conversation focused primarily on the challenges they encounter in handling these applications and in planning appropriate network solutions.

The complete results obtained from each of the interviews are in APPENDIX E: Partners methodology – scripts and results.

Table 13 presents a summary of the methodology and results obtained by Elektro Celje.

Table 13: Elektro Celje methodology and results obtained.

Partner	Elektro Celje
Planned methodology	**Methodology planned:** - Identify simulation tool's potential users. - Conducting interviews and informal conversations with simulation tool's potential users.

Methodology application	**Interviews and informal conversations with simulation tool's potential users:** - CPO's and Energy supplier with EV infrastructure services (various) - Motorway Operator (DARS, d.d.) - The department within our company that issues project conditions and approvals for connections to the electricity distribution network, and the department responsible for managing investments in the distribution network (Elektro Celje, d.d.)
With results	
Data collected	A series of interviews were held individually with CPOs, DARS and Elektro Celje departments.

Conclusions obtained	**Summary of Interviews with CPOs**
	
	- **Current Market Situation**
	    - Slovenia is still in the early adopter phase of electromobility (less than 10% EV penetration).
	    - Projects must be both economically viable and commercially attractive.
	- **Business Model of CPOs**
	    - Focus on Business to Business (B2B) partnerships with companies, municipalities, and shopping centres.
	    - Rural areas are generally not of interest due to widespread access to private home charging.
	- **Preferred Locations for Deployment**
	    - Parking lots of shopping centres located near high-density residential areas (apartment complexes).
	- **Key Challenges in Deployment**
	    - Insufficient grid connection capacity and local network limitations.
	    - Uncoordinated and lengthy administrative procedures with DSOs; in some cases, no response is received.
	    - Investment in secondary transformer substations is financially unjustified for CPOs.
	    - ICEVs often occupy charging spots designated for EVs.
	    - Charging stations in garages or closed parking lots of shopping centres are often inaccessible during non-business hours (e.g. nights, Sundays, holidays).
	- **Future Opportunities**
	    - Public funding calls that also include supporting infrastructure are viewed positively.
	    - Legislation requiring a minimum number of EV charging spots in newly built parking areas supports further development.
	- **Information Needs from a Planning Platform**
	    - Availability of grid connection capacity at specific locations.
	    - Access to information on urban development and construction plans to enable better investment planning.
	
	Summary of the Interview with DARS – Motorway Company in the Republic of Slovenia
	
	- **Key Decision Criteria**
	    - The primary factor for selecting charging infrastructure locations is traffic frequency.
	    - Transit traffic is considered the only relevant user group on the motorway network.
	- **Strategic Planning**
	    - DARS develops five-year strategic plans for motorway development.
	    - In 2025, the new strategy for 2026-2030 will be adopted.
	    - The upcoming focus will be on charging infrastructure for electric trucks and high-power fast chargers.
	- **Current Infrastructure Status**
	    - A few fast chargers have been installed by the Transmission System Operator (TSO).
	    - Existing infrastructure is insufficient to meet future demand.
	- **Challenges and Barriers**
	    - Lack of grid connection capacity in the distribution network is a major issue.

	- DARS is now engaging exclusively with the TSO due to inadequate DSO capacity.
	- Additional transformer substations will be needed along the motorway corridors.
	- Infrastructure for electric truck charging must include sanitary facilities, showers, restaurants, and require land acquisition.
	- High land prices and the need for multiple permits (e.g., building permits) further complicated implementation.
	- Vandalism remains a recurring problem for existing infrastructure.
	- **Views on a Centralized Planning Platform**
	  - DARS expressed no clear need for such a platform at this time.
	  - They are unsure what type of information or functionality it could offer that would be of practical value to them.
	
	Summary of the Interview with Elektro Celje – Development and Investment Departments
	
	- **Increase in Connection Requests**
	  - Significant rise in applications for connection approvals for EV charging stations.
	  - Many applications are denied or approved for lower capacity due to insufficient grid capacity.
	- **Causes of Capacity Shortages**
	  - Widespread connection of self-supply solar power plants in previous years.
	  - Network investments have not kept pace with growing demand and still lag behind.
	  - Elektro Celje considers both realized and already issued (but unused) approvals when assessing capacity.
	- **Impact on Competition**
	  - Issued approvals can be held for up to four years without realization.
	  - This practice allows investors to block capacity, preventing others from accessing the network.
	- **High-Capacity Requests**
	  - For requests above 600 kW, Elektro Celje requires the investor to build their own secondary transformer substation.
	  - The company only invests in areas where it has strategic interest.
	- **Administrative and Investment Challenges**
	  - All applications are processed within the three-month legal deadline.
	  - When Elektro Celje plans reinforcements or new substations, it faces long procedures for obtaining permits and approvals.
	  - Material costs have increased significantly post-COVID, limiting investment capacity.
	  - The "Not in my backyard" phenomenon is growing, with landowners opposing energy infrastructure on their property due to perceived land value loss.
	- **Needs for a Centralized Planning Platform**
	  - Elektro Celje would benefit from access to data on planned EV charging infrastructure investments.
	  - This information is vital for long-term network investment planning.

Without results	
Reasons for no data	N/A
Alternative methods you would apply	N/A

3.5.2.2 HEDNO Methodology

HEDNO's methodology consisted of a survey of potential users of the co-simulation tool. This survey was divided into two sections that can be found in APPENDIX E: Partners methodology – scripts and results.

The survey was structured in a way that is common for every stakeholder it will be shared with. From HEDNO's perspective, the survey is intended to be shared among stakeholders who have a crucial role during the installation and electrification of public charging points. Thus, the survey was shared with a local Municipality, a CPO, HEDNO's e-mobility department and an Energy Agency. Due to the heavy workload of these companies and the hierarchical processes during the sharing of the survey, few surveys were filled out.

The organisations that answered the survey were the E-Mobility Department of HEDNO and the CPO Department of PPC. Their responses are depicted in APPENDIX E: Partners methodology – scripts and results.

Table 14 presents a summary of HEDNO's methodology and results obtained.

Table 14: HEDNO methodology and results obtained.

Partner	HEDNO

Planned methodology	**Surveys:**
	- Identify potential users for the city level co-simulation tool:
	  - Municipality's planning departments.
	  - CPOs.
	
	- Identify people having knowledge regarding the "After deciding on the installation location, what needs to be done?":
	  - HEDNO colleagues who know the processes regarding the installation and electrification of chargers.

Methodology application	**Potential users for the city level co-simulation tool:** - Municipality of Saronida (Attica Greece, adjacent Municipality to Greek Demonstrator's Municipality). **Steps in the application of the methodology:** - Reaching a contact to identify who should be asked to answer the survey. - Reaching colleagues inside HEDNO department to check availability. - Reaching colleagues in local HEDNO departments who are responsible for the installation processes.
With results	
Data collected	Eleven questions were replied from two out of the four stakeholders that the survey reached.
Conclusions obtained	Lengthy procedures exist now with the involvement of many departments from different stakeholders (CPO, DSO, Municipality, Ministries, Official Services, etc.) Each stakeholder has also many internally involved departments with a lot of bureaucracy. In addition, the planning tools and decision location tools are different for each included party making the procedures even more time consuming.
Without results	
Reasons for no data	Due to the heavy working load of these companies (local Municipality, a CPO, HEDNO's e-mobility department and an Energy Agency) and the hierarchical processes during sharing of the survey, few surveys are expected to be delayed

Alternative methods you would apply	Since the questions of the survey are very indicative and to-the-point on the public charger installation procedure, the survey could be performed as interview directly to the stakeholders not responded.

3.5.2.3 INESC-ID Methodology

INESC-ID's methodology consisted of informal conversations and a survey with two Municipalities and a DSO that are partners from two Horizon Europe projects in which INESC-ID participates in. The script with the questions is present in APPENDIX E: Partners methodology – scripts and results.

Table 15 presents a summary of INESC-ID's methodology and results obtained.

Table 15: INESC-ID methodology and results obtained.

Partner	**INESC-ID**
Planned methodology	INESC-ID is part of several research projects, of which two are directly linked with EV4EU - **AHEAD**[23] and **U2DEMO**[24]. **Informal conversations + Surveys** with partners of these two projects: - From AHEAD, there were Municipality of Funchal, in the Madeira Island, and Electricidade da Madeira, the DSO of the Autonomous Region of Madeira, in Portugal. - From U2DEMO, there was Den Haag, the capital of South Holland, in the Netherlands.
Methodology application	- Talk directly to the contacts in each of these municipalities/companies. - Request a first informal meeting (by email) to learn what they thought about the co-simulation tool and whether they were a good match to answer the more meaningful surveys.
With results	
Data collected	- No data was collected.
Conclusions obtained	N/A
Without results	
Reasons for no data	- Municipality of Funchal: The people directly contacted at the end of the meetings were not the most suitable. They were asked to make the appropriate contact with the relevant people in the municipality, which did not happen. - Electricidade da Madeira: They showed interest in collaborating, but they could not find the time to meet. - Den Haag: No response from this partner.
Alternative methods you would apply	Take advantage of conferences, projects' General Assemblies, and international meetings with partners to ask these questions in person.

[23] https://he-ahead-project.eu
[24] https://u2demo.eu

3.5.2.4 PPC Methodology

PPC's methodology consisted of interviews with PPC E-Mobility Department (DEI BLUE), DSO charging point managers from HEDNO and Municipalities. However, HEDNO was the only entity that answered the corresponding survey. The responses obtained and the surveys' scripts are depicted in APPENDIX E: Partners methodology – scripts and results.

Table 16 presents a summary of PPC's methodology and results obtained.

Table 16: PPC methodology and results obtained.

Partner	PPC
Planned methodology	1. **Internal Interviews:** 1.1. Conduct 30-minute sessions with PPC E-Mobility Department (DEI BLUE). 2. **External Interviews:** 2.1. Target 2 to 3 municipalities in the Mesogia area (Markopoulo, Koropi, Spata-Artemida) through 15-minute in-person (with their technical departments) or online sessions to understand their involvement and decision criteria in charger deployment. 2.2. Contact 15-minute sessions with local public transport departments if applicable. 2.3. Conduct 30-minute sessions with DSO charging point managers from HEDNO. 3. **Document Analysis:** 3.1. Review current policies, procedures, planning documents, and approval processes. 3.2. Extract formal decision criteria. 3.3. Analyse existing workflows and time requirements.
Methodology application	- Develop an interview guide for key stakeholders and a survey via email or Outlook Forms to DEI BLUE, DSO charging point managers from HEDNO and public infrastructure actors (Municipalities' technical departments). Schedule and conduct interviews, record responses with permission, and create a thematic analysis. - Coordinate structured interviews with DEI BLUE engineers and DSO charging point managers from HEDNO. Additionally, contact and schedule interviews with selected municipalities from the Mesogia region (Koropi, Spata, Artemida). - Analysis of collected responses to identify relevant answers, critical points, data gaps, extract insights from workflow procedures. - Demonstration of end-user workflow that reflects the Greek demo and include diagrams describing public charger installation procedures in Greece.
With results	
Data collected	- One interview was conducted with HEDNO where they answered the survey
Conclusions obtained	- Clear technical expectations from DSOs - Recognition of platform's value for streamlining approvals - Importance of structured data exchange with Municipalities/DSOs - Relevance of real-time and pre-validation data for feasibility checks - Supports platform design focus: o Grid-aware visual interface o Siting simulation and constraints mapping o Role-based access (Municipality, DSO, CPO)
Without results	
Reasons for no data	- Response rates per recruitment approaches and participation challenges - Scheduling conflicts or resource limitations - Organizational barriers encountered

Alternative methods you would apply	- Leveraging existing meetings to gather input (piggybacking on scheduled department meetings) - Short-term interviews (5-10 minutes) conducted via phone if full interviews not possible - Expanded document analysis if direct stakeholder input limited or discard - Benchmarking against similar municipalities with public information available

3.6 User Profile Co-creation Workshop with T3.6 partners

According to the proposed plan, the task would conclude with a workshop involving all T3.6 partners. This workshop was a critical step to consolidate and align the main findings related to the city-level co-simulation platform. Holding it as the final activity ensured that all relevant findings, insights, and outputs were available for collective review and discussion. By this point, all research methods had been applied, allowing for a comprehensive alignment of results and a shared understanding of the co-simulation platform's development. This timing also supported the collaborative creation of preliminary platform user profiles based on actual data and outcomes, even though there were still some assumptions due to lack of results in parts of the work performed, mainly regarding the end-user of the platform.

These profiles would serve as a starting point for possible platform improvements and feature developments, but would need further validation with final users.

The workshop was conducted remotely, with Microsoft Teams, and used an online collaboration tool called Miro[25]. The participant partners were EDA, EDP NEW, HEDNO, INESC-ID, PPC and SRTTE, with one person from each entity. The workshop was divided into two parts:

1. Reviewing and clustering learnings from the research done by all task partners (results shown in Sections 3.2 and 3.5).
2. Collaborative creation of possible platform user profiles, based on research and previous experiences.

Regarding the first part, dedicated to reviewing and clustering research learnings and insights, the main conclusions drawn were the following:

- Platform users need an easy and user-friendly interface that includes detailed information on grid capacity, as well as information about planned EV charging infrastructure (and not only the one already installed).
- Planning EV charger placement is a procedure burdened by (excessive) bureaucracy, leading to user resistance to change an already difficult to learn and navigate environment. Besides that, frequent applications may be rejected due to limited grid capacity.
- Platform users should consider what people who drive EVs think and prefer, and that could be translated into having a "Frequently Asked Questions" section and an easy-to-read report, before using the planning feature of the platform.

The second part of the workshop, dedicated to collaboratively creating possible user profiles, provided a basis for these profiles. However, due to low workshop participation, the outcomes were not directly

[25] https://miro.com/index/

usable as a final result for end-user profiles. After the workshop, a deeper analysis of the profiles was needed and performed by SEL's team.

This deeper analysis concluded that it is possible to identify three types of user profiles. Within each type, two user profiles were identified and described, according to their tasks, assumed needs and concerns, barriers they might find, and finally, in what way the platform can support them.

The types of profiles identified were as follows:

- Planning entities: Profiles that have direct responsibility in creating and adjusting regulatory frameworks for urban and e-mobility planning, and to whom the platform can provide support in that regulation creation; usually, these are public entities.
- Macro investors: Profiles of entities that have the possibility and interest of investing in electric mobility at wider scales (either at the city or country level); usually utilities or big companies with greater investment possibilities.
- Micro investors: Profiles of entities that have the possibility and interest of investing in electric mobility at a small scale, within their available physical area of actuation; usually owners of a private space with public access.

The team opted to use the investment dimension criteria as the differentiating characteristic to divide these types. This way, there is a profile for regulators, who have no direct investment in the public EVCI, there is a profile for big investors, who will plan higher volumes of investment made in public EVCI, and finally, a profile for lower dimensions of investments in this type of infrastructure.

Table 17 presents the layout for the detailed profiles of the assumed users of the platform.

Table 17: Assumed city-level co-simulation platform users – Layout table.

User Profile		**Profile type**	
Profile that is assumed to have interest in using the platform		*Identify which of the 3 types of users this profile fits into: regulator, macro investor, or micro investor*	
Description	*This field describes what this user does in their job, their responsibilities and tasks*	**Concerns**	*Concerns are issues this user thinks about and that have impact when making decisions*
Main needs	*A need is some information or automation that a user needs to perform their tasks*	**Barriers**	*Barriers are things that might happen to this user, that prevents them from doing their job*
Platform	*Specific features and capabilities that the platform already has (or could have), that directly answer to this user's needs, concerns and barriers*		

The six user profiles are mapped below, in Table 18, Table 19, Table 20, Table 21, Table 22 and Table 23, where each profile was divided by the three profile types defined above.

Table 18: Assumed city-level co-simulation platform users – Public entity that makes urban planning policies related to e-mobility.

User Profile		Profile type	
Public entity that makes urban planning policies related to e-mobility		Planning entity	
Description	- Promote pilots to explore innovative solutions regarding public EVCI/E-mobility - Mobility policies and regulatory frameworks (define and approve) - Define guidelines for public EV charging infrastructure placement - Prevision of public EVCI upcoming needs (medium to long-term) - Provide support to regional/local entities	**Concerns**	- Know EV-users' needs for public EVCI
Main needs	- Know the current public EVCI, as well as near future plans	**Barriers**	- Bureaucracy to propose and approve policies and regulatory frameworks
Platform	- Provides current public EVCI (not future plans) - Includes EV-users' needs (select POIs and traffic flow)		

Table 19: Assumed city-level co-simulation platform users – Local public entity (municipality) that decides/approves urban developments (namely public EVCI).

User Profile		Profile type	
Local public entity (municipality) that decides / approves urban developments (namely public EVCI)		Planning entity	
Description	- Plans local transport network - Identifies key strategic public EVCI placement - Approves "construction permits"	**Concerns**	- Know EV-users' needs for public EVCI
Main needs	- Know the current public EVCI, as well as near future	**Barriers**	- Respect policies (local and country-wide)
Platform	- Provides current public EVCI (not future plans) - Includes EV-users' needs (select POIs and traffic flow)		

Table 20: Assumed city-level co-simulation platform users – Entities looking to invest in a specific city or location in e-mobility.

User Profile		Profile type	
Entities looking to invest in a specific city or location in e-mobility		Macro investor	
Description	- Can be CPOs or energy utilities wanting to invest in public charging - Plan public EVCI investments - They either coordinate installation & operation, or subcontract/sell	**Concerns**	- Know EV-users' needs for public EVCI - Manage investment funds
Main needs	- Know the current public EVCI, as well as near future	**Barriers**	- Know grid capacity (current and near future) - Permissions and bureaucracy to get permits from urban planning entity - Archaeological sites, protected areas, or zonal definition
Platform	- Provides current public EVCI (not future plans) - Includes EV-users' needs (select POIs and traffic flow) - Provides generic costs for each EVSE - Informs on current grid capacity		

Table 21: Assumed city-level co-simulation platform users – DSO's e-mobility planning department.

User Profile		Profile type	
DSO's e-mobility planning department		Macro investor	
Description	- Market facilitator (providing grid capacity) - Consumption data manager	**Concerns**	- Want smart grids and smart charging technologies to better manage grid distributions
Main needs	- Know where grid capacity is lacking	**Barriers**	- Need investment approval from public regulatory entities
Platform	- Suggestions might provide help in investment plan definition		

Table 22: Assumed city-level co-simulation platform users – Owners of private areas where EV drivers expect to be able to charge.

User Profile		Profile type	
Owners of private areas where EV drivers expect to be able to charge		Micro investor	
Description	- Can be parking lots or gas station's owners/managers (when they own more than one) - Owners of a private space (small and finite) of public access - This space matches EV-users' mental model of "where to charge an EV"	**Concerns**	- The private area is on EV-users' minds - Investment vs. ROI - Peak usage vs. average usage (calculate how much to invest)
Main needs	- Know if the grid has enough capacity for installation	**Barriers**	- Grid capacity cap - Regulations that might limit or hinder investment - Permit approval by public entities
Platform	- Informs on current grid capacity - Provides generic cost of each EVSE		

Table 23: Assumed city-level co-simulation platform users – Energy community managers.

User Profile		Profile type	
Energy community managers		Micro investor	
Description	- Manages RES production and consumption in LECs - Manages community individual and collective interests in energy including e-mobility	**Concerns**	- Maximize benefits from RES LEC - Community endorsement for EV charging stations
Main needs	- Know if grid has enough capacity for EVSE installation	**Barriers**	- Grid capacity cap - Regulations that might limit or hinder investment - Permit approval by public entities
Platform	- Informs on current grid capacity - Provides generic cost of each EVSE - Find ideal placement of EVSEs		

All these profiles have in common the requirement of grid capacity knowledge, as well as current and future public EVCI. Also, they all need to understand EV users' needs and preferences. Finally, bureaucratic challenges seem to apply to all profiles.

The main differences are especially related to investments. Public entities focus on strategic planning, while private space owners and energy community managers are more concerned with investment returns and community interests. Bigger investment entities and DSOs are more involved in macro-level decisions and grid management.

Understanding all these profiles, it is possible to highlight the diverse roles and needs of stakeholders in the e-mobility sector, emphasising the importance of tailored platform features to address their specific challenges and requirements. These key features are:

- Mapping of the current grid capacity, with visibility of the current public EVCI. Adding future grid expansion plans to this map can make it even more powerful in informing decision-makers.
- Finding ideal EVSE placement, considering, among other factors, EV users' habits and preferences.
- Providing approximate costs for new EVSEs, supporting investment decisions (both small and large scale).

4 Conclusions

This deliverable presents the work developed on the EV4EU city-level co-simulation platform for V2X management. The work focused on enhancing the platform's usability and relevance for end-users, particularly decision-makers involved in the planning and deployment of EVCI. For this, the performed work was based on the development of a user adoption layer that was not included in the early development of the city-level co-simulation platform.

The integration of a user adoption layer, by performing EV and non-EV users' surveys to understand their preferences regarding the points of interest that can have EVSE installed, developing an interface with UX/UI design and heuristic evaluations, and stakeholder engagement, was essential to ensure the city-level co-simulation platform meets real-world needs. The results demonstrate that while the technical foundation of the platform is robust, its usability and accessibility must be continuously refined to support diverse user profiles and planning contexts.

4.1 Main Findings

During this work, some key findings should be highlighted, namely:

- **User-Centric Design is essential**: The development of a user interface tailored to decision-makers significantly enhances the platform's accessibility and practical utility. Wireframes and prototypes revealed key interaction flows and usability gaps, which, after being addressed, can make the platform more useful and seamless to use.

- **Stakeholder diversity requires flexibility**: The platform must accommodate a wide range of users, from municipal planners to private investors and DSOs, each with distinct goals, constraints, and technical expertise.

- **Grid capacity and POIs data are critical**: Across all platform user profiles, access to up-to-date information on grid capacity and public EVCI was identified as a top priority for effective planning.

- **Heuristic evaluation provided actionable insights**: The heuristic analysis using Nielsen's and ISO 9241-110 models revealed moderate to poor compliance in several usability areas, particularly around self-descriptiveness, error robustness, and learnability. These insights guided concrete interface improvements, mainly a search flow refinement and improvement in saved searches method.

- **Surveys validated societal relevance**: Public input confirmed that EV users prioritise charger availability near daily-use EV users' POIs, like parking lots and residential areas, as well as areas of bigger need on sporadic occasions, like hospitals, hotels and hostels. They also maintain the current mental model of "filling up the tank" at gas stations, reinforcing the need for the simulation outputs to reflect these types of user behaviours and preferences.

- **Workshop enabled user profile definition**: A collaborative workshop helped define six key user profiles, grouped into three categories: planning entities, macro investors, and micro investors. These profiles will guide future platform iterations.

4.2 Main Challenges

While performing this work, some main challenges were found, namely:

- **Limited Stakeholder engagement**: Despite outreach efforts, interviews with potential end-users were not successful, limiting direct validation of the platform's utility. Mitigation was achieved through heuristic analysis of the developed UX/UI and partner-led research.

- **Balancing simplicity and technical depth**: Designing an interface that is both intuitive for non-technical users and powerful enough for expert planners is a persistent design challenge, made worse by the difficulty of testing this interface with real platform users.

- **Validation of simulation outputs**: Ensuring that the simulation results align with real-world behaviour and infrastructure constraints requires ongoing validation and refinement, particularly as user preferences and grid conditions evolve.

Furthermore, some challenges regarding the topic discussed in this work were also found, namely:

- **Bureaucratic complexity**: Stakeholders consistently cited administrative hurdles, fragmented responsibilities, and lengthy permitting processes as major barriers to EVSE deployment. The platform must help streamline these processes through better data integration and reporting.

- **Data availability and standardisation**: Access to consistent, high-quality data on grid capacity, urban planning, and EV usage remains a challenge. The platform's effectiveness depends on integrating such data from multiple sources.

4.3 Next Steps

Following the challenges faced, some key topics should be addressed in the future. A list of those key topics is provided below, along with a suggestion of a specific action plan:

- **Validate platform utility with platform end-users** to confirm the platform's relevance, usability, and decision-making support capabilities. Conducting targeted interviews and usability testing with municipal planners, DSOs, and CPOs can be a good way to collect direct feedback that will help refine features and ensure alignment with real-world workflows.

- **Integrate survey results into the simulation weighting** of the platform to reflect user preferences more accurately in EVSE placement recommendations. Usage of the societal survey data from D3.7[4] (e.g., preferred POIs) can provide insights to adjust the simulation engine's prioritisation logic, since it enhances the realism and societal acceptance of simulation outputs.

- **Enhance the interface based on heuristic analysis feedback** to improve usability, especially around error prevention, user control, and learnability. Implementing the recommended UX/UI improvements from the heuristic analysis can steer the interface to a more intuitive one, which will increase adoption among non-technical users.

- **Expand data integration** to improve the accuracy and foresight of the simulation platform. This can be achieved through incorporating additional data layers, such as future grid expansion plans, urban development forecasts, real-time traffic and energy usage. All of these can enable more strategic, long-term planning.

- **Develop role-based access and custom views** for the platform, thus providing relevant insights and tools based on user needs and technical expertise. This can be achieved by tailoring the interface and outputs for different user profiles (e.g., planners vs. investors), thus increasing platform relevance and reducing cognitive load.

- **Pilot the platform in a real-world planning scenario**, i.e., testing the platform's performance, usability, and impact in a live context. A collaboration with a municipality or utility can be done to use the platform in an actual EVSE planning process, and with that, provide critical validation and showcase the platform's value.

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APPENDIX A: Research Questions

For this deliverable, a set of research questions were defined, that helped provide guidance and structure to methodologies applied to gather information.

Some questions were more directed to EV users, and society in general. Others were tailored to the city-level co-simulation platform users. Below, both are listed.

The research questions regarding **EV users and society in general** are the following:

- Do people prefer to use EV public chargers (when they're available), or do they prefer other options?
- Where do people prefer and use EV public chargers?

To answer these issues, two questions were included in a Societal Context Survey from T3.1 [13]. The questions included are the following:

1. If you had public chargers available to you, both closer to you and in greater numbers, would you use them? *[This question is only displayed to participants who have EV/PHEV, and mention they don't use charging points in public space, inside the city.]*
    a. Yes, since near me (either home or place of work) there are no public chargers.
    b. Yes, since there are only a few public chargers near me (either home or place of work) there are only a few public chargers, it's difficult to find one available.
    c. No. There are public chargers available near me, but I prefer not to use them, because: *[Text input]*
    d. No. There are no public chargers available near me, but even if there were, I would prefer not to use them, because: *[Text input]*
2. Select from the list below the types of places you would like to have EV chargers nearby, considering your routines and needs. In the second column, select the ones that you expect you would probably use regularly. Even if you don't have an electric vehicle, assume you would have one in this scenario.
    a. Residential areas
    b. Office areas
    c. Gardens and parks
    d. Tourist attractions
    e. Theme parks
    f. Hotels and hostels
    g. Industrial areas
    h. Airports, train stations, ferry terminals
    i. Metro stations and bus stations
    j. Gas stations
    k. Taxi ranks
    l. Parking lots
    m. Supermarkets
    n. Malls and big department stores
    o. Museums, galleries, cinemas, theatres and event venues or stadiums
    p. Libraries and public buildings (police, fire station, town hall, courthouse, etc.)
    q. Religious buildings and community centres
    r. Prisons
    s. Health clinics and veterinarians
    t. Pharmacies, small stores, restaurants and cafes

u. Hospitals

v. Kindergartens and schools

w. Universities

x. Other. Which one? *[text input]*

The research questions regarding the **city-level co-simulation platform users** are the following:

- What are the roles of people who will use this platform? Validate the assumption that they are (1) urban planning and/or transport departments of municipal councils or other public entities, (2) charging point managers from DSOs and energy retailers, and (3) energy agencies.
- What challenges and barriers exist today regarding the decision to install public charging points?
- Would the existence of a planning platform for public charging point installation be beneficial? If so, in what aspects? What concrete benefits would the platform bring?
- Considering the platform's user profile, what needs do they have?
    - Simple systems, usable by many different profiles (requiring less technical knowledge)? Or complex systems, usable by planning experts (requiring more technical knowledge)?
    - What types of criteria are regularly used in deciding on public charging point installation?
- After deciding on the installation location, what needs to be done?
    - What information is critical to move the process forward?
    - How many people/departments does the process go through?
    - Is it agile, or does it involve a lot of bureaucracy?
    - Is there potential to streamline? Or are the processes very "closed" and "immutable"?

APPENDIX B: Interface Screens

In this Appendix, all interface screens developed in the first iteration of the city-level co-simulation platform are presented. The working prototype can be consulted through this link: https://github.com/EV4EU/wireframes_cosimulation_platform.git. When opening it, it's possible to see the first screen (Figure 18), and by clicking it, the flow will proceed, in a similar way it would if the platform was already implemented.

Figure 18: Login screen.

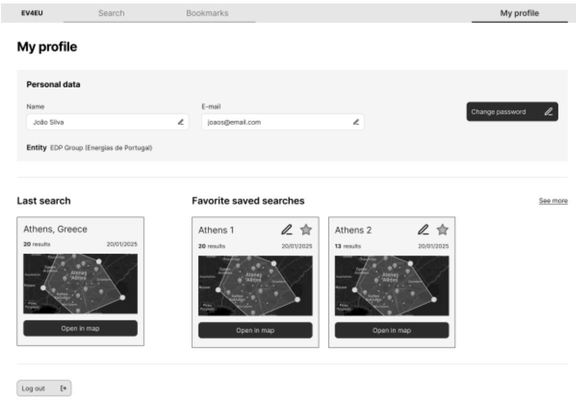

Figure 19: "My Profile" screen.

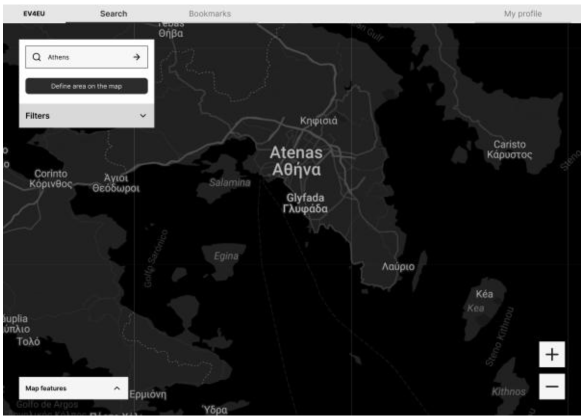

Figure 20: Search screen – Landing.

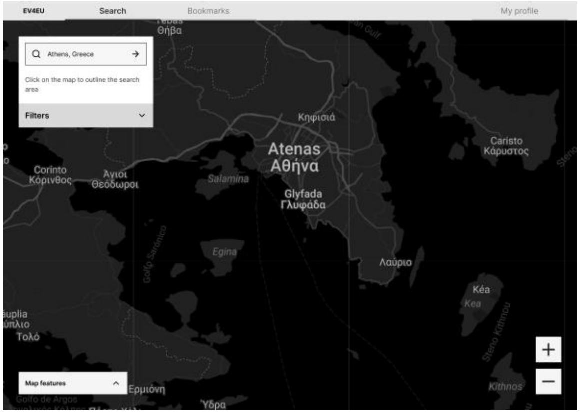

Figure 21: Search screen – Step 1.

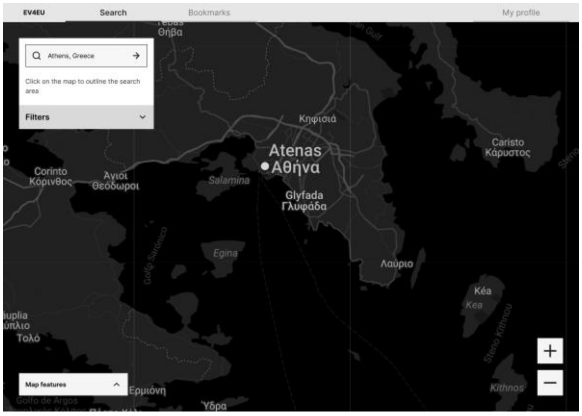

Figure 22: Search screen – Step 2.

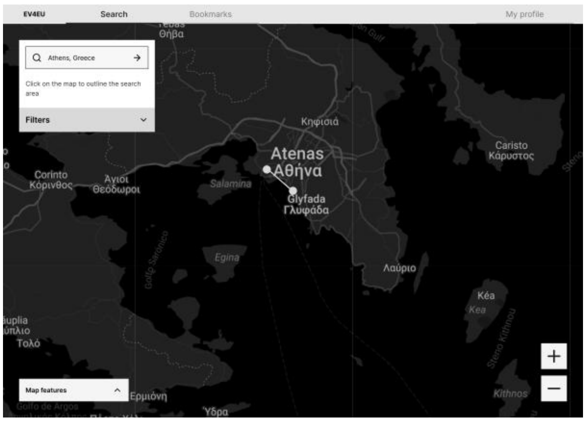

Figure 23: Search screen – Step 3.

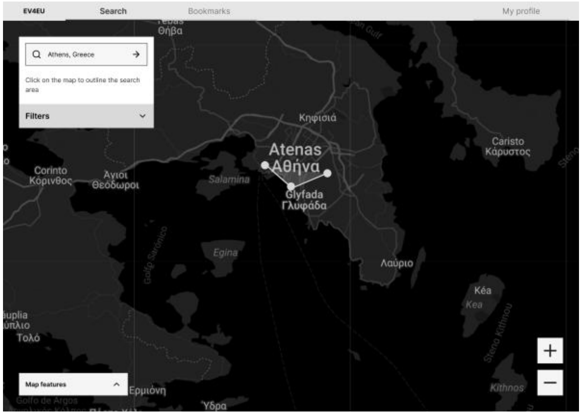

Figure 24: Search screen – Step 4.

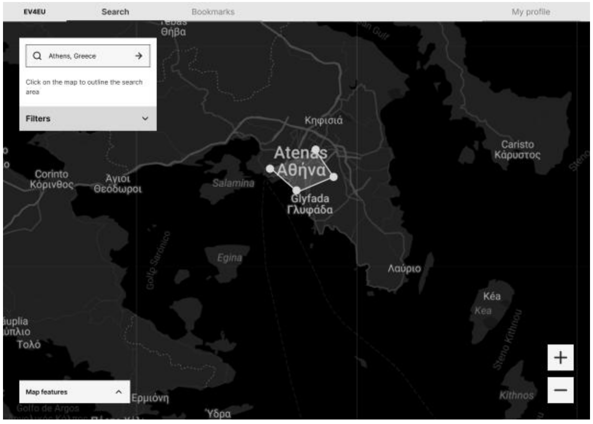

Figure 25: Search screen – Step 5.

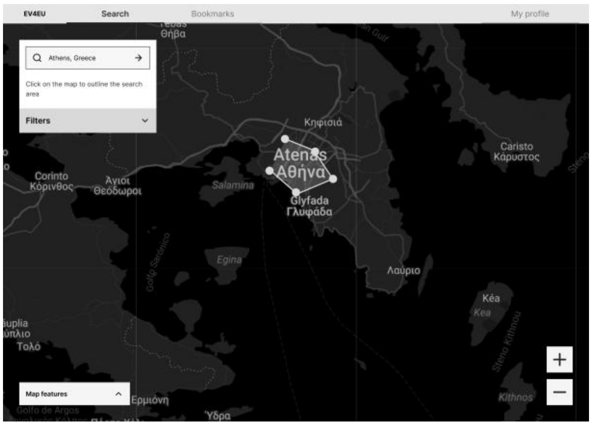

Figure 26: Search screen – Step 6.

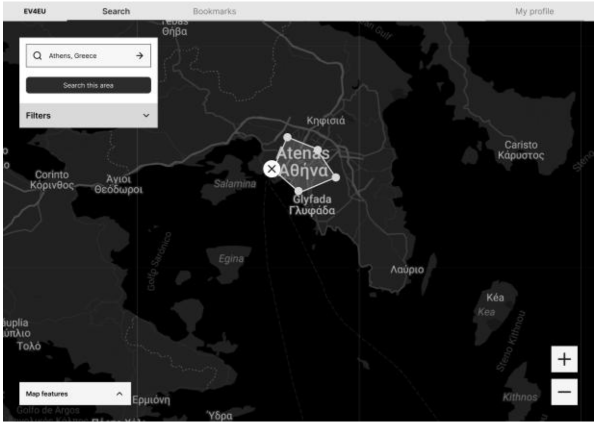

Figure 27: Search screen – Step 7.

Figure 28: Search screen – Loading.

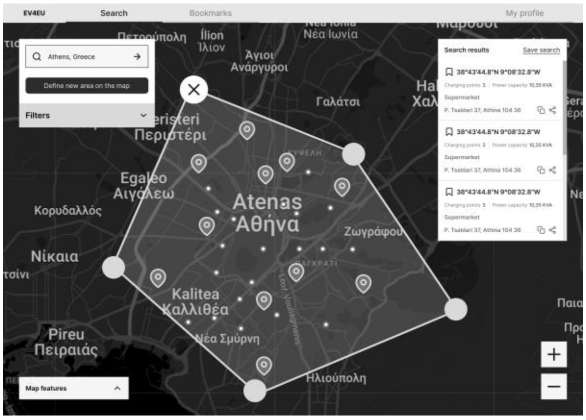

Figure 29: Search screen – Results.

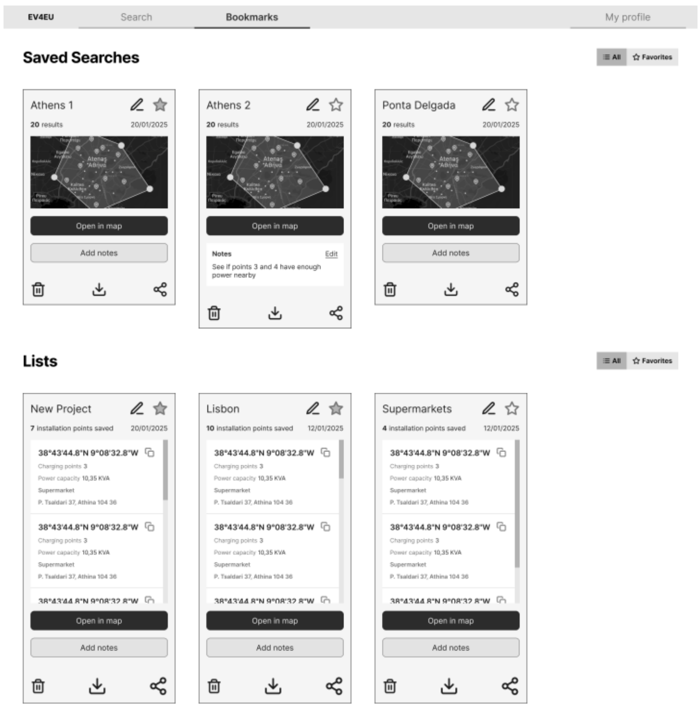

Figure 30: Bookmarks page – Landing.

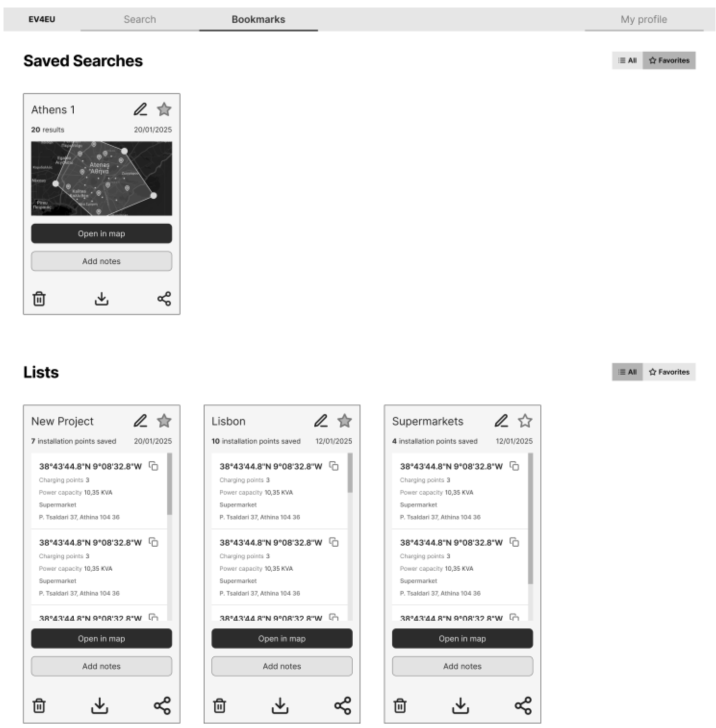

Figure 31: Bookmarks page – Favourite saved searches selected.

APPENDIX C: Generic script for platform's end-user interviews

Introduction to create rapport:
Hello, thank you for taking the time to talk with us today. We are exploring views on V2X technology to understand its adoption, perception, and practical impact. This work will guide the development of a platform for optimal charging station deployment. Feel free to share your opinions and ideas honestly. There are no right or wrong answers – we are not evaluating your performance; it's our solution and technology that needs your feedback so we can deliver a useful service for everyone. Any questions? Let's begin!

1 – Experience with V2X Technologies:
1. Can you describe your current experience with electric vehicle charging stations? And with V2X-related technologies?
2. Have you been directly involved in developing V2X infrastructure? If so, what challenges did you face?

2 – Perception of Utility and Adoption:
1. In your opinion, what is the practical utility of V2X technology? In what ways do you anticipate it being used?
2. Do you think V2X will be widely adopted in the near future? What factors might support or hinder this process?

3 – Stakeholder Needs for the Platform:
1. Given that a platform is being created to inform where to install new charging stations, what specific concerns or needs should be addressed when deciding where to install V2X-compatible stations?
2. How do you evaluate the importance of factors such as grid capacity, frequency of use, or accessibility in your planning processes?
3. What features would you like to see in this platform to better support stakeholders like yourself?
4. What other stakeholders could be involved, and why? What do you think they would need?

4 – V2X Impact:
1. In a scenario where V2X is adopted by Electric Vehicle drivers, how do you think V2X might impact energy management, cost efficiency, or user satisfaction?
2. Do you associate any specific benefits or risks with implementing V2X in your sector?

5 – Recommendations and Future Expectations:
1. Do you have suggestions for improving the implementation of V2X technologies in the field or increasing user acceptance of this technology?

6 – Think-aloud test (usability test with the platform's interface):
We will ask you to complete some tasks, and we'll observe you while doing them. But you are not being evaluated. It's okay if you can't do some things. The goal is to identify the problems with our platform, so we can improve it. We want to know what you think. Be honest, don't be afraid to hurt our feelings. While performing the tasks, keep thinking out loud. Tell us what's going through your mind. If you have questions, don't hesitate to ask us. For now, any questions?

7 – Final Questions:
1. Is there any other feedback you would like to share regarding V2X technology that we haven't covered?

2. Is there anything else you would like to share about your experience?

Wrap-up:
Thank you for sharing your knowledge and experience with us today. We appreciate your time!

Table 24: Generic script for platform's end-user interviews.

Tasks	Questions	What to look for
1. First screen – register and login	Before we enter the platform, share with us what you hope to find when you enter the homepage? What do you hope to be able to do? And what would you like to be able to do on this platform? ***Do the task: Login on the platform and enter the homepage***	Expectations regarding the homepage, primary tasks and potential uses.
2. Search screen – first approach	Was this what you expected to find? Do you miss something? Look calmly and carefully at the page, what do you hope to be able to do through this platform? How?	Expectation vs. reality, what is the initial expectation of possibilities and recognition of potential use.
3. Perform a search	In the course of your work, what type of information is typically useful to search for? How do you usually do it? How would you do it through this platform? And what would you expect to find if you did? ***Do the task: Search on the map*** Does it match your expectations? Is anything missing? Anything unexpected that could prove useful? Would this functionality be useful in a typical work scenario? Are there any other features that could make your workday easier but are not available on this platform?	Real usage scenarios, usability, and ease of use of the search function on the platform, as well as filtering options.
4. Organization of locations and resources in the interface	Imagine you wanted to save this area or a specific point to access again later—how would you do that on this platform? What would you expect to find in "Saved Locations"? How is it useful for you to be able to save locations? How would you prefer to access them? ***Do the task: go to the "Saved Locations" tab*** Is this what you expected to find in this section? Would you prefer it to be different? Is anything missing? Is there any particularly useful functionality? Do you often share the coordinates of a location with a colleague? In what scenarios? How do you usually do it? How do you typically organize your charging locations? Is there a protocol or mandatory method for doing so? How do you identify them? And search for them?	Real scenarios of resource and information management, useful functionalities, missing functionalities, frequent use cases, potential collaboration, and work processes with other colleagues.

Tasks	Questions	What to look for
5. Accessing Account Data	Imagine you needed to access your account details—how would you do that? What would you expect to be possible on this page? What would be essential for you to find there? ***Do the task: go to the "My Account" tab*** Is this what you expected to find? Would you organize the information differently? How? Is any information missing? Is there any information you consider unnecessary? In what scenarios do you typically access this page during your work?	Account management, utility, and corresponding scenarios. Mandatory, necessary, useful, and dispensable information. Task prioritization. Final recap of platform perception. Final notes, points for improvement, missing elements, and most important actions.

APPENDIX D: Heuristic Analysis – overview of results

In this Appendix, a more detailed list of results is provided, enumerating all issues identified by experts in each heuristic of each model used.

Nielsen's 10 Usability Heuristics

#01 – Visibility of System Status (79.25%; Good – Minor improvements needed):

- The "Choose area on the map" and "Search this area" buttons look the same and are in the same location, confusing the next step.
- There is no clear way to save a search; iconography alone is insufficient.
- Users receive no feedback after performing actions, making it unclear if the action was successful.
- Some screens, like the map screen, lack headers that describe their contents.
- The map view lacks back and forth buttons, preventing users from switching menu items without losing information.
- The system's status (On/Off) and actions available are not indicated on the map screen.
- In the results or saved searches lists, many icons are not marked as selected or not, requiring better evaluation during UI work.
- Suggestion to rename "Bookmarks" to "Search History", to better match real-world terminology.

#02 – Match Between System and the Real World (80.25%; Good – Minor improvements needed):

- Filtering options for points of interest should follow a logical order, such as alphabetical, to avoid implying some points are more important than others.
- There is ambiguity in the fields available between bookmarks and "My Profile". Bookmarks should have what has been saved. The "My Profile" could have a kind of search history by date/coordinates/specific landmarks.
- Menu titles are not grammatically parallel; "Search" is an action, "Bookmarks" indicates a list, and "My profile" changes to first-person discourse.
- "Lists" and "Saved Searches" are unclear and uncommon in their definition and functionalities.
- The main actions "Define area on map" and "search this area" require sequential button clicks.
- The buttons look the same and are in the same location, making the flow confusing.

#03 – User Control and Freedom (59.25%; In the threshold between: Poor – Significant usability concerns/Moderate – Noticeable usability issues):

- Selecting points on the map is problematic, especially when trying to visualise the best location, requiring users to start over.
- Deleting a "Saved Search" or "List" lacks confirmation, which is critical.
- The filtering options are missing a "deselect all" button.
- There is no undo or redo function on the map.

#04 – Consistency and Standards (89.75%; In the threshold between: Good – Minor improvements needed/Excellent – Fully compliant):

- Identifying all types of urban features on the map can be challenging due to the variety of icon types.
- Menu choice names and action names are inconsistent in grammatical style and terminology, leading to differences in tone between pages like "Define area on the map" and "Saved Searches".

- Icons lack labels.
- The “Search” tab lacks context, which can confuse first-time users. Adding a contextual title and optional supporting description is recommended.

#05 – Error Prevention (71.5%; Moderate – Noticeable usability issues):

- The delete option is placed alongside frequently used, low-risk actions in the list and saved search menus, increasing the risk of accidental deletion.
- Although not shown in the wireframe, deleting a list or saved search is irreversible, and a confirmation prompt is crucial.

#06 – Recognition Rather than Recall (91%; Excellent – Fully compliant):

- There is no visual distinction between saved searches and user-created lists, making them hard to differentiate.
- The filtering menu for points of interest is overly long, lacks visual breaks, has no search function, and follows no clear order, making it tiring to use.
- Inactive menus and call-to-action buttons are not visually disabled (e.g., greyed out), a topic which was not yet addressed in the current wireframes.

#07 – Flexibility and Efficiency of Use (50%; Poor – Significant usability concerns):

- The interface does not differentiate between novice and expert users; filter selection is underemphasized and lacks tailored guidance for different experience levels.
- Manual coordinate entry isn’t supported – users must select locations on the map, which is cumbersome due to zoom limitations and increases the risk of errors.

#08 – Aesthetic and Minimalist Design (90%; Excellent – Fully compliant):

- Filter items lack visual cues, making them harder to interpret at a glance.
- There is no clear or visible way to save progress or settings.
- The search page lacks contextual information to guide the user.

#09 – Recognise, Diagnose, and Recover from Errors (91.75%; Excellent – Fully compliant):

- Some prompts are too long or unclear, making them difficult to understand quickly.

#10 – Help and Documentation (68.75%; Moderate – Noticeable usability issues):

- Some information is incomplete, which can compromise the user experience.
- There is no clear help or guidance. Inline help icons (like “i” or “?”) could improve usability.
- Polygon search lacks contextual cues, making it harder to use effectively.
- No “Search History” is available, which may confuse new users who do not know how to save their searches.
- The “Search” page lacks instructions or context, leaving novice users unsure of what to do.

ISO 9241-110: Interaction Principles

#01 – Suitability for the User’s Tasks (41.75%, Poor – Significant usability concerns):

- It is unclear whether filters should have default selections or if all options should be pre-selected. Usability testing is recommended to uncover this issue.
- When placing a reference point (coordinate), users can’t remove or reset it. Ideally, users should be able to undo any point, starting from the most recent.

- Manual coordinate entry isn't supported – users must rely on map selection, which is error-prone due to zoom limitations.
- The system is constrained by algorithmic requirements (e.g., needing coordinates), and the current workaround is not user-friendly or precise.
- The primary action button ("Search this area") is hidden behind an extra step, reducing discoverability.
- The distinction between "Saved Searches" and "Lists" is unclear.
- The interface does not adapt to different user roles or experience levels (e.g., novice vs. expert users).

#02 – Self-Descriptiveness (25%, Critical – Non-compliant or unacceptable):
- The distinction between "Saved Searches" and "Lists" is unclear.
- Action labels are missing – icons alone are not intuitive enough to convey meaning.
- There are no instructions, and the transition from "Define area on the map" to "Search this area" is subtle and easy to miss.
- First-time users receive no onboarding or guidance.

#03 – Conformity with User Expectations (50%, Poor – Significant usability concerns):
- The transition from "Define area on the map" to "Search this area" is subtle and lacks clear instructions.
- It is unclear whether the icons used in list cards follow common placement conventions.
- Save and cancel actions do not align with typical user expectations or mental models.
- There is no "Back" function, limiting navigation flexibility.
- The distinction between "Saved Searches" and "Lists" is unclear.

#04 – Learnability (36%, Critical – Non-compliant or unacceptable):
- Icons lack labels – while many are familiar, not all are immediately clear or free from ambiguity.
- There are no tooltips or usage instructions, which are necessary for clarity.
- The switch from "Define area on the map" to "Search this area" is subtle and not clearly communicated.

#05 – Controllability (50%, Poor – Significant usability concerns):
- The system supports only a single workflow, with no alternative methods for inputting data or saving lists/searches.
- Users cannot modify selected map points without restarting the entire process.
- There are no undo or redo options available.
- Irreversible actions lack confirmation prompts.

#06 – Use Error Robustness (37.5%, Critical – Non-compliant or unacceptable):
- The delete icon for lists should be visually distinct to prevent confusion or accidental clicks.
- Critical actions lack confirmation prompts, increasing the risk of unintended irreversible changes.

#07 – User Engagement (95%, Excellent – Fully compliant):
- Users can personalise their experience by creating favourite lists and adding notes.
- The platform offers a fully immersive experience with a full-screen map.
- Drawing directly on the map appears engaging, though this should be validated through user testing.

APPENDIX E: Partners methodology – scripts and results

In this Appendix, a more detailed list of the defined surveys and obtained results is provided from the application of the methodology defined by each partner as part of the mitigation efforts regarding the end-user of the city-level co-simulation platform.

Elektro Celje Scripts and Results

Results from the interviews with CPOs

According to the interviews, Slovenia is still in the early adopter phase of electromobility, with electric vehicles accounting for less than 10% of the vehicle fleet. This significantly influences the strategic approach to infrastructure deployment, which must be both economically viable and commercially attractive. These CPOs mainly pursue business opportunities through B2B partnerships, installing charging stations at corporate parking lots, shopping centres, and on municipally owned land. Rural areas are generally not of interest, as EV owners in such locations usually have access to private charging options, reducing the demand for public infrastructure.

The most suitable locations for public charging stations are parking lots of shopping centres located near larger residential areas or apartment complexes. However, these CPOs face several obstacles when deciding on site placement. One of the main challenges is the insufficient connection capacity of the electricity distribution network. Procedures with the DSOs are often inconsistent, and in some cases, unreasonably long or even non-responsive. Investing in a secondary transformer substation is not financially viable for the operators, making access to adequate network infrastructure essential for project implementation.

Additional issues include ICEVs parking in spaces designated for EV charging, thus blocking access to the infrastructure. Another concern relates to charging points located within enclosed or gated parking areas of shopping centres, which often become inaccessible during nights, Sundays, and public holidays when the centres are closed.

Despite these challenges, these CPOs view the future positively, particularly in light of funding calls for the co-financing of EV charging infrastructure, including associated equipment, and regulatory requirements mandating a minimum number of EV charging points in newly built parking facilities.

In the event of a centralised planning platform being developed, the most valuable information for these CPOs would include available grid connection capacity at specific locations and data on urban and construction plans. Such information would enable more efficient and better-informed planning of new infrastructure investments.

Results from the interview with DARS

An interview regarding the deployment of EV charging infrastructure along Slovenia's motorway network was conducted with DARS. The discussion focused on the criteria used for selecting charging point locations, current challenges and barriers in infrastructure deployment, and potential informational needs that a centralised planning platform could address.

Traffic volume was identified as the key factor in determining suitable locations for charging infrastructure. On the motorway network, the only relevant users are transit drivers, which means the feasibility of installing charging points is directly linked to traffic intensity on specific sections. DARS develops strategic infrastructure plans in five-year cycles. In 2025, the company will adopt its new strategy for the 2026-2030 period, with a special focus on charging infrastructure for electric trucks and the deployment of high-capacity fast chargers.

Currently, a few fast chargers have already been installed on the motorway network by the TSO, but DARS acknowledges that this will be insufficient for future needs. One of the major challenges to expanding the infrastructure that was mentioned is the lack of available grid connection capacity within the distribution network. As a result, DARS is currently working exclusively with the TSO, since DSOs are unable to provide the capacity required for high-power charging, particularly for electric trucks. To ensure an adequate power supply, additional transformer substations will need to be constructed along the motorway corridor.

In addition to electricity supply, deploying charging points for electric trucks will require the development of supporting infrastructure, such as sanitary facilities, showers, and restaurants, all of which will demand further investment. Land acquisition also poses a significant challenge due to the high costs and the need to obtain various permits, including construction permits. Another concern of DARS is vandalism, which has already affected existing infrastructure.

Regarding the potential use of a centralised planning platform, DARS expressed no particular interest. They indicated that they currently lack a clear understanding of what kind of content or functionalities such a platform could offer that would be particularly useful for their planning processes.

Results from the interviews with the Development and Investment Departments of Elektro Celje

As part of an informal interview with the Development and Investment Departments of Elektro Celje (one of Slovenia's DSOs), the current situation regarding the connection of EV charging infrastructure to the electricity distribution network was discussed. Company representatives highlighted a significant increase in the number of applications for connection approvals for charging stations, with an increasing number of cases where the requested connection capacity cannot be granted or the applications are denied due to insufficient available network capacity.

The shortage of capacity is primarily the result of the large number of self-supply solar power plants that were connected to the grid in recent years, where investments in network upgrades have not kept pace with demand, and this trend continues. It is also important to note that, when issuing approvals, Elektro Celje considers not only realised connections but also already issued approvals. This practice allows investors to retain unused approvals for up to four years, which can hinder competition and limit opportunities for other potential investors. In cases where the requested connection capacity exceeds 600 kW, Elektro Celje includes a provision in the connection approval stating that the investor must construct their own SS. The company does not invest in areas where it has no strategic interest. All applications for connection approvals are processed within the legally prescribed deadline of three months.

When they undertake network reinforcements or the construction of new SSs, they frequently encounter lengthy procedures for obtaining permits and approvals related to energy infrastructure. An additional challenge is the increase in material costs observed in the years following the COVID-19 pandemic, which has further reduced the financial resources available for investment. Another issue raised was the growing incidence of the "Not in my backyard" phenomenon, where landowners oppose the placement of energy infrastructure on their property due to concerns about a potential decrease in land value.

Regarding the potential use of a centralised platform for planning and deploying charging infrastructure, they expressed the need for access to information on planning investments in the field of e-mobility. Such data would be essential for long-term investment planning in the distribution network.

HEDNO Scripts and Results

Questions in the survey

Section 1: Planning of the optimal installation of EV chargers

Definition and development of a city-level co-simulation platform for V2X aims to develop a co-simulation platform that should allow the joint simulation of the city traffic, the distribution network, and the V2X management strategies, to ultimately help with the decision of the best placement for EVSEs at the city level. The development methodology of the platform comprises four main stages: Stage 1 – Vehicle traffic simulation; Stage 2 – Definition of the energy requirements from the simulated EVs and typical recharging sites; Stage 3 – Integration of the distribution grid network; Stage 4 – Estimation of the number of EVSEs, their locations, and their capacity.

1. Choose your organisation:
    a. Municipality Planning Department
    b. DSO E-Mobility Department
    c. CPO
    d. Energy Agency

2. What tools exist today regarding the decision to install public charging points, and their challenges and barriers?
   Describe briefly in a few words (e.g., bureaucracy, site limitations, network congestion, etc.)

3. Would the existence of a planning platform for public charging point installation be beneficial?
    a. Yes
    b. No
    c. Maybe

4. What added benefits would such a platform bring?
   Describe briefly in a few words (e.g., quicker procedures, fewer people/departments involved, etc.)

5. Considering the platform's user profile, what needs to they have?
    a. Simple systems, usable by many different profiles (requiring less technical knowledge)
    b. Complex systems, usable by planning experts (requiring more technical knowledge)

6. What types of criteria are regularly used in deciding on public charging point installation?
   Select as many as you find appropriate and feel free to add any additional criteria under option 'Other'.
    a. Based on location planning
    b. Based on client request
    c. Based on the organisation's plan
    d. Other: [*Text input*]

7. What type of information is crucial to have before making the decision? *Describe briefly in a few words (e.g., site's grid topology, no. of installed chargers, etc.)*

Section 2: After deciding on the installation location, what needs to be done?

8. What information is critical to move the process forward?
   Describe briefly in a few words (e.g., acceptance from the municipality/grid operator, etc.) and the chronological order of each process

9. Which and how many departments are involved during the process?
   State the departments involved in your organisation and the total number of them

10. Does it involve a lot of bureaucracy?
    a. Yes
    b. No

11. Is there a possibility for improvement, or are the processes too rigid and unchangeable?
    a. Yes
    b. No

Results of the survey

Question 2 – What tools exist today regarding the decision to install public charging points, and their challenges and barriers?

- DSO (HEDNO): Currently, the relevant stakeholder applies for a new supply for electromobility without any previous knowledge whatsoever on the grid capacity at the specific location. However, HEDNO is obliged to provide the requested supply in any case. Depending on the local grid and location characteristics, it may take longer for a supply to be constructed.

- CPO (PPC): Current tools include grid data systems, municipal GIS platforms, and traffic studies from regional authorities. Main challenges are complex Greek bureaucracy across multiple ministries, lengthy grid connection procedures, archaeological restrictions, coastal zone limitations, fragmented municipal permitting, language barriers in documentation, and seasonal tourism fluctuations affecting demand forecasting.

Question 3 – Would the existence of a planning platform for public charging point installation be beneficial?

- Yes, from both participants

Question 4 – What added benefits would such a platform bring?

- DSO: With a planning platform, we could be more proactive on the future network needs by reinforcing the network beforehand, thus saving time on the construction of the respective supplies.

- CPO: Given Greece's complex administrative structure and multiple regulatory bodies, a unified platform would be essential for PPC's expansion strategy. It will offer:
    - Streamlined HEDNO coordination
    - Faster municipal approvals
    - Integrated archaeological clearance tracking
    - Simplified Ministry of Environment procedures
    - Reduced coordination between prefectures
    - Centralised tourism data integration
    - Automated NSRF funding application tracking

Question 5 – Considering the platform's user profile, what needs do they have?

- Both answered: Simple systems, usable by many different profiles (requiring less technical knowledge)

Question 6 – What types of criteria are regularly used in deciding on public charging point installation?

- DSO: HEDNO does not install charging points. HEDNO constructs the supplies for the charging points when the respective applications have been submitted.

- CPO: Based on location planning, client request, organisation's plan, tourism flow analysis (islands/mainland), EU funding availability, proximity to PPC's substations, seasonal demand patterns, ferry terminal locations, archaeological zone restrictions, and coastal development regulations.

Question 7 – What type of information is crucial to have before making the decision?

- CPO: Grid capacity and connection points, municipal zoning restrictions, archaeological service clearances, tourism seasonal patterns, ferry schedules and routes, substation proximity, EU funding eligibility, coastal zone regulations, and Greek EV adoption rates by region.

Question 8 – What information is critical to move the process forward?

- CPO: The critical information is the following:
    1. Municipal building permit approval – Town planning department clearance
    2. Grid connection agreement – Technical specifications and connection timeline
    3. Archaeological service clearance – Heritage impact assessment completion
    4. Environmental impact assessment – Ministry of Environment approval (if required)
    5. Fire department safety approval – Installation safety compliance
    6. Road authority permits – For any street/sidewalk modifications
    7. Utility clearances – Coordination for underground services
    8. Final municipal operation license – Business operation permit

Question 9 – Which and how many departments are involved during the process?

- DSO: Within HEDNO, the construction of a supply requires the cooperation of several departments. Initially, the application is processed by the network users' department. Then it is forwarded to the construction department, which, in turn, in most cases, cooperates with external contractors for the actual construction.

- CPO: The departments involved are:

  Internal: 7 departments (Network Development Department, Legal & Regulatory Affairs, Project Management Office, Technical Engineering Department, Procurement Department, Real Estate Department, Environmental Compliance Department)

  External: 13 departments/authorities (Grid Operator – Grid connection approval, Municipal technical services – Building permits, Municipal Town Planning Department – Zoning approvals, Ministry of Culture – Heritage clearances, Fire Department – Safety approvals, Regional Authority - Environmental permits, Ministry of Environment & Energy – Environmental impact (if required), Road Authority/Prefecture – Street modification permits, Telecommunications – Utility coordination, Local Water Company – Water utility clearances, Local Electricity Company – Local grid, Cadastral Office – Land registry verification, Chamber of Commerce – Professional licensing)

Question 10 – Does it involve a lot of bureaucracy?

- Both answered positively.

Question 11 – Is there a possibility for improvement, or are the processes too rigid and unchangeable?

- Both answered positively, mentioning that there is room for improvement.

INESC-ID Scripts and Results

Questions for the informal conversations

1. Are you familiar with the EVSE planning in your organisation?
2. What can you tell about this process?
3. Do you consider that having a platform based on real data could facilitate the process of determining the optimum number of EVSEs, their rated power, and their location?

Questions in the survey

1. What methodologies does your organisation use to decide where to install an EVSE?
   1.1. Do you use any tool/platform to help with this decision?
   1.2. Do you install EVSEs by request?
2. How does your organisation currently select the number of ports and the power to be installed?
   2.1. Do you consider the power grid and the popularity of the location?

2.2. Do you use any metrics to evaluate the proposed locations?

3. Is the current process for deciding where to install EVs quick, or does it involve an intensive study to identify the best locations?

   3.1. Does it involve extensive bureaucratic processes with more than the organisation?

4. Would your organisation be interested in accessing a tool that considers vehicle traffic and the electrical grid to determine the optimum number, power, and locations for installing new EVSEs based on empirical data?

5. How could the co-simulation platform help your organisation?

   5.1. In the planning/deployment phase?

6. Are the current features of the developed co-simulation tool sufficient for your organisation?

   6.1. What other benefits would you like to include in such a platform?

   6.2. Would you prefer a more technical approach with more adjustable variables? Or is there value in simplicity and directness?

PPC Scripts and Results

Custom Questionnaire for DEI BLUE

1. What are the roles of people who will use this platform?

   1.1. Would DEI BLUE teams benefit from a platform supporting charger site planning? If so, which teams would use it?

   1.2. Would such a tool be more useful during the planning, approval, or deployment phase?

   1.3. Which of the following features would be most useful in a platform designed to support your charger rollout strategy?

   Please select all that apply, and feel free to add any others you find relevant:

   a. Interactive charger location map
   b. Visual overlay of grid capacity (low/medium voltage)
   c. Prioritisation scoring of potential sites (e.g., traffic, visibility, accessibility)
   d. Permit status tracking (e.g., municipality, DSO)
   e. Forecasted demand heatmaps (e.g., tourist zones, EV usage clusters)
   f. Integration with internal business criteria (e.g., Return on Investment (ROI) estimators, commercial filters)
   g. Alerts for high-opportunity or high-risk
   h. Exportable reports for internal planning
   i. Other (please specify): [*Text input*]

2. What challenges and barriers exist today regarding the decision to install public charging points?

2.1. What are the most common challenges you face when attempting to deploy chargers in public spaces?

2.2. How often do bureaucratic or administrative delays affect your timeline?

2.3. Are grid connection issues from DSOs a recurring obstacle?

3. Would the existence of a planning platform be beneficial? What concrete benefits would the platform bring?

3.1. Do you currently use any internal or external tools to manage charger proposals, permit tracking, or grid feedback? If not, do you believe a centralised platform covering these aspects would bring added value to your planning activities?

3.2. Could such a tool reduce your team's time spent coordinating with municipalities or DSOs?

3.3. What kind of dashboards or metrics would be valuable to have in real time?

4. Do users need simple or complex systems? (Refers to the implementation since these teams do build the end-to-end workflow)

4.1. When using a planning platform, how would you prioritise the following features for your team's needs? Please rank from 1 = Most important to 4 = Least important.

4.1.1. A highly visual interface for intuitive interaction

4.1.2. Advanced technical filters for planners and engineers

4.1.3. Detailed results showing installation or technical feasibility

4.1.4. Ability to export simulation results in different formats

5. What types of criteria are regularly used to decide on charger locations?

5.1. What are your top three criteria when selecting a new site for a charger (e.g., traffic flow, visibility, energy cost)?

5.2. Do you use internal business rules or site scoring systems when evaluating candidate locations?

6. What information is crucial before deciding?

6.1. What information must you collect before committing to a new installation?

6.2. Is there any information that municipalities or other partners fail to provide which would be useful to receive earlier?

7. What information is critical after selecting a location?

7.1. After selecting a location, what steps are needed to start deployment?

7.2. What information do you wait for from other stakeholders before initiating works?

8. How many people/departments are involved?

8.1. Which internal teams or subcontractors are typically involved in the end-to-end charger installation process? Please list them and briefly describe their role if possible – e.g., planning, civil works, permits, etc.

8.2. Is coordination between internal teams streamlined, or does it require project-by-project management?

9. Is the process agile or bureaucratic?
    9.1. Are there administrative steps that often slow down your charger deployments?
    9.2. Are delays more often internal, from partners (e.g., DSO, municipality), or both?
10. Can the process be streamlined?
    10.1. In your opinion, which parts of the planning-to-installation process could be simplified?
    10.2. Would a platform that supports pre-validation of locations (e.g., via grid checks or zoning filters) speed things up?

Custom Questionnaire for HEDNO

1. What are the roles of people who will use this platform?
    1.1. Has HEDNO implemented any specialised tools or grid planning?
        1.1.1. What are the benefits of enabling charger siting decisions?
        1.1.2. How would the integration of a grid planning tool within a platform create operational value for HEDNO?
    1.2. Which departments or job roles within HEDNO would most likely interact with such a tool?
    1.3. What kind of outputs or insights would make the tool useful for your operations?
2. What challenges and barriers exist today regarding the decision to install public charging points?
    2.1. What are the most common grid-related constraints that affect whether a charger can be installed at a proposed location?
    2.2. Are there recurring delays or obstacles in coordinating with municipalities or charging point operators?
    2.3. How often do the proposed locations need to be changed due to network capacity issues?
3. Would the existence of a planning platform be beneficial? What concrete benefits would the platform bring?
    3.1. How useful would it be to have a shared tool showing both municipal planning proposals and grid availability?
    3.2. Would such a tool help reduce communication delays or errors between HEDNO and the charger's operators/municipalities?
    3.3. What types of technical data (e.g., local capacity, transformer availability) should the platform include for it to be actionable?
4. Do users need simple or complex systems? (Refers to the implementation since these teams do build the end-to-end workflow)
    4.1. Does HEDNO currently utilise any grid planning tools in a platform?
        4.1.1. If yes, what challenges or limitations have you encountered with the current management system?

4.1.2. What would be most beneficial for DSO engineers?

4.1.3. Do your DSO engineers generally prefer simplified visual interfaces or more detailed technical modules when working with planning tools?

4.2. Would it more valuable if the platform provided record data of charging sessions and EV user charging behaviour?

5. What types of criteria are regularly used to decide on charger locations?

5.1. What are the top technical criteria that determine whether a location is suitable for a new charger connection?

5.2. Are there internal thresholds (e.g., voltage drop, load balance) that you use to assess each request?

6. What information is crucial before deciding?

6.1. What minimum information must a CPO or municipality provide to HEDNO before grid feasibility can be evaluated?

6.2. Are there specific documents, maps, or forecasts you always request?

7. What information is critical after selecting a location?

7.1. Once a charger location is agreed upon, what additional steps must HEDNO complete before grid connection?

7.2. What timelines and dependencies (e.g., civil works, permit clearance) typically affect your internal process?

8. How many people/departments are involved?

8.1. How many different HEDNO teams are involved from the moment a location request is submitted until the connection is delivered?

8.2. Are regional units autonomous, or do they require central approvals for charger installations?

9. Is the process agile or bureaucratic?

9.1. From your experience, what parts of the process are the most time-consuming or procedural?

9.2. Are there steps that could be simplified with better tools or shared data?

10. Can the process be streamlined?

10.1. In your opinion, what aspects of HEDNO's involvement in charger deployment could be simplified without compromising safety or technical standards?

Custom Questionnaire for Municipalities

1. What are the roles of people who will use this platform?

1.1. Which departments or staff within your municipality are involved in decisions related to EV charger locations?

1.2. Does your team currently use any specialised tools or platforms for evaluation and managing charger sitting proposals?

1.2.1. What challenges do you experience with charger siting evaluation, and what benefits would an improved solution provide for your team?

1.3. At what stage would such a platform be most helpful (e.g., site proposal, permit evaluation, post-approval coordination)?

2. What challenges and barriers exist today regarding the decision to install public charging points?

2.1. What are the most common challenges you face when reviewing or approving public EV charger installations?

2.2. Are there regulatory or procedural steps that commonly slow down the decision-making process?

2.3. What external actors or factors (e.g., PPC, HEDNO, civil works) typically cause delays or complications?

3. Would the existence of a planning platform be beneficial? What concrete benefits would the platform bring?

3.1. Would a planning platform help your municipality make more informed or faster decisions about charger siting?

3.2. What features would make such a platform most useful to your department? (e.g., maps, zoning filters, status tracking)

3.3. Would it be helpful if the platform provided real-time coordination with DSOs and CPOs?

4. What types of criteria are regularly used to decide charger locations?

4.1. What criteria does your municipality use when evaluating a proposed location for a public charger?

4.2. Are there locations you prioritise (e.g., near public buildings, high-traffic areas, underserved neighbourhoods)?

5. What information is critical before deciding?

5.1. What specific information do you require before approving a new charger location?

5.2. Do CPOs usually provide enough detail, or is key data often missing?

6. What information is critical after selecting a location?

6.1. After a site is approved, what steps does your municipality take to facilitate charger installation?

6.2. What coordination is required with public works, road authorities, or utility services?

7. How many people/departments are involved?

7.1. How many municipal departments are involved in the end-to-end process of charger approval and installation?

7.1.1. Could you please enumerate these departments and briefly describe their roles in the process?

7.2. Are these departments coordinated under a single workflow or managed separately per case?

8. Is the process agile or bureaucratic?

8.1. Are there procedural bottlenecks that often delay the installation of public chargers?

8.2. Are there opportunities to improve internal coordination or approval efficiency?

9. Can the process be streamlined?

   9.1. In your opinion, what steps in the process could be simplified through better tools or interagency coordination?

   9.2. Would a shared platform improve collaboration between your municipality, the DSO, and the charging operator?

Additional Questions (for Municipal Mobility Units, if present)

1. What role does your mobility or transport department play in EV charging decisions within your municipality?
2. Are public chargers integrated with other mobility planning initiatives, such as bike lanes, shared mobility, or public transport hubs?
3. Is your municipality currently implementing or aligned with a Sustainable Urban Mobility Plan (SUMP)? If yes, how does EV charging fit into it?
4. Do you have data on citizen mobility patterns that influence where chargers are placed?
5. Are there location types (e.g., park-and-ride zones, modal interchanges) that you consider high priority for charger installation?

Results obtained from the Questionnaire for HEDNO

Question 1.1 – Has HEDNO implemented any specialised tools for grid planning?

- HEDNO has not implemented any specialised tools for grid planning. Should such a tool exist, it would aid towards the faster delivery of power supplies for charging stations. A grid planning tool within a platform would not create any operational value for HEDNO in its current state. However, if e-mobility supplies could be treated in a different manner than ordinary supplies, and special procedures could be employed for them, then HEDNO could minimise the external obstacles and operate more efficiently. For example, if the interested party indicates three possible locations of interest for HEDNO to examine through a specialised tool, then HEDNO could pick the most trouble-free and least network-congested point so that the study and the construction last the smallest amount of time.

Question 1.2 – Which department or job roles within HEDNO would most likely interact with such a tool?

- The studies department.

Question 1.3 – What kind of outputs or insights would make the tool useful to your operations?

- The power supply required, the location and indicative load profiles according to the business model of the charging station.

Question 2.1 – What are the most common grid-related constraints that affect whether a charger can be installed at a proposed location?

- Usually, in densely populated cities, there is limited room for Medium Voltage (MV)/Low Voltage (LV) substations. A request for a large supply in this case can become significantly problematic to handle, since space should be found for the installation of a new one. Another case is a heavily congested line that cannot serve any other significant loads, and a new one should be constructed. Such a new line could travel for many kilometres, thus constituting a time-consuming procedure.

Question 2.2 – Are there recurring delays or obstacles in coordinating with municipalities or CPOs?

- No.

Question 2.3 – How often do proposed locations need to be charged due to network capacity issues?

- The locations do not change. A common case is this: an interested party applies for a supply but is not aware of the indicative cost (especially in bigger supplies). The application is then withdrawn before paying the amount of construction amount.

Question 3.1 – How useful would it be to have a shared tool showing both municipal planning proposals and grid availability?

- This would be of interest mostly for the stakeholders investing in charging point constructions.

Question 3.2 – Would such a tool help reduce communication delays or errors between HEDNO and CPOs/municipalities?

- No.

Question 3.3 – What types of technical data (e.g., local capacity transformer availability should the platform include for it to be actionable?

- Available power capacity per location.

Question 4.1 – Does HEDNO currently utilise any grid planning tools in a platform?

- In its current status, HEDNO examines applications on a first-come, first-served basis and then makes the necessary network reinforcements.

Question 4.2 – Would it be more valuable if the platform provided record data of charging sessions and EV user charging behaviour?

- This could be of interest for the DSO to potentially achieve better planning of the reinforcements.

Question 5.1 – What are the top technical criteria that determine whether a location is suitable for a new charger connection?

- The most important criterion is whether the charger should connect in MV or LV. After that, LV supplies numbered 5, 6, and 7 need more space to construct, while the smaller ones are easy.

Question 5.2 – Are there internal thresholds (e.g., voltage drop, load balance) that you use to assess each request?

- No, only the nominal power is considered.

Question 6.1 – What minimum information must a CPO or municipality provide to HEDNO before grid feasibility can be evaluated?

- Location and power supply.

Question 6.2 – Are there specific documents, maps or forecasts that are always requested?

- Datasheets of the chargers.

Question 7.1 – Once a charger location is agreed upon, what additional steps must HEDNO complete before grid connection?

- Power supply construction.

Question 7.2 – What timelines and dependencies (e.g., civil works, permit clearance) typically affect your internal process?

- In general, obstacles in construction incur to delays.

Question 8.1 – How many different HEDNO teams are involved from the moment a location request is submitted until the connection is delivered?

- Three teams: Network Users, Studies, and Constructions.

Question 8.2 – Are regional units autonomous, or do they require central approvals for charger installations?

- Autonomous.

Question 9.1 – From your experience, what parts of the process are the most time-consuming or procedural?

- The studying phase, when facing obstacles in the construction.

Question 9.2 – Are there steps that could be simplified with better tools or shared data?

- They have an urgent need for detailed monitoring of all the stages from user application to construction and delivery of the supply.

Question 10.1 – In your opinion, what aspects of HEDNO's involvement in charger deployment could be simplified without compromising safety or technical standards?

- Chargers constitute heavy loads requiring equal attention with other types of supplies.