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Electric Vehicles Management for carbon neutrality in Europe

Deliverable D8.3
Open V2X Management Platform test report

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Disclaimer

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[1] https://ev4eu.eu/

Executive Summary

The present deliverable D8.3 “Open V2X Management Platform test report” focuses on the final activities that were carried out to setup the infrastructure of the Greek demonstration. These activities include the following:

- Changes to the backend and the frontend of the O-V2X-MP platform in order to accommodate new features and to improve user experience.
- Changes to the charging infrastructure. This pertains to the electrification of the chargers installed in the context of Task 8.2 (see D8.2 for more details) as well as to the installation of another, identical charging station at the PPC Innovation Hub. The new charger accelerates and facilitates integration tests between the O-V2X-MP platform and the selected model of charging stations.
- Description of the EV that was provided by Aiglon/Citroen to be used in the Greek demo.
- Description of the user engagement strategies that will target colleagues of the involved partners (PPC, HEDNO and Aiglon/Citroen) as well as the general public.
- Description of the questionnaire that will be used for eliciting user feedback in order to improve critical aspects of the O-V2X-MP platform.

The deliverable concludes with an analysis of the risks involved in the subsequent steps of the Greek demo, proposing mitigation measures, as well as with a list of the future developments in the context of Task 8.4.

The deliverable D8.3 has been prepared and edited by PPC, HEDNO and Aiglon/Citroen.

Table of Contents

List of Figures

List of Tables

Acronyms

AC	Alternate Current
API	Application Programming Interface
BUC	Business Use Case
CPO	Charge Point Operator
CSMS	Charging Station Management System
CNN	Convolutional neural network
DL	Deep Learning
DC	Direct Current
DSO	Distribution System Operator
DSS	DSO Support System
EV	Electric Vehicle
HTTP	Hypertext Transfer Protocol
LV	Low Voltage
LSTM	Long Short-Term Memory Neural Network
ML	Machine Learning
OCPP	Open Charge Point Protocol
O-V2X-MP	Open V2X Management Platform
PV	Photovoltaic
V2G	Vehicle-to-Grid
V2H	Vehicle-to-Home
V2L	Vehicle-to-Load
V2X	Vehicle-to-Everything
WP	Work Package

1 Introduction

1.1 Scope and Objectives

The primary goal of Task 8.3 “Open V2X Management Platform test report” is to present the final activities that were required for setting up the Greek demo infrastructure. These activities pertain both to the charging stations and the software systems that will be used in the context of the smart charging scenarios that comprise the Greek demonstration.

More specifically, Task 8.3 focused on the following activities for the Greek demo:

- Updates and changes in the backend of the Open V2X Management Platform (O-V2X-MP platform to enable the addition of new features like the real-time connection with the DSO Support System (DSS)
- Improvements in the frontend of the O-V2X-MP platform to facilitate its use by the novice users that will comprise the majority of the demo participants.
- Completing the setup of the public infrastructure by electrifying the charging stations installed in the Kropia Municipality.
- Installation of an identical charging station at the premises of PPC Innovation Hub to accelerate the (offline) tests for integrating the O-V2X-MP platform with the installed chargers.
- Using an Electric-Vehicle (EV) provided by Aiglon/Citroen in the integration tests of the O-V2X-MP platform as well as in the operating tests for the electrified charging stations.
- Devising an effective plan for attracting demo users both from the colleagues of the contributing partners (PPC, HEDNO, Aiglon) and the general public.
- Defining questionnaires for eliciting feedback from the demo users to ensure the continuous improvement of the O-V2X-MP platform.
- Determining the next steps within the Greek demo.
- Specifying the risks involved in the remaining steps of the Greek demo along with the corresponding mitigation actions.

We elaborate on these activities in the present document, Deliverable 8.3 “Open V2X Management Platform test report”, which is the main outcome of Task 8.3. With its submission the task is completed.

1.2 Structure

The rest of the deliverable is structured as follows: Section 2 delves into the updates made to the backend and the frontend of the O-V2X-MP platform, improving its usability and responsiveness, before releasing it to the demo participants. In Section 3, we discuss the new smart charger that was installed at PPC’s Innovation Hub for offline tests as well as the bureaucratic procedure that was required for electrifying the public charging stations of the Greek demo. Section 4 presents the technical characteristics of the EV provided by Citroen for testing the charging infrastructure and the O-V2X-MP platform, while Section 5 analyses the strategies that will be used for attracting users to the Greek demo. In Section 6, we present the questionnaires that will gather user feedback for the O-V2X-MP platform and the Greek demo, in general. The deliverable concludes in Section 7 with an analysis of the risks and limitations arising from the implementation of the Greek demo.

1.3 Relationship with other deliverables

Deliverable D8.3 describes the final steps that are necessary for preparing the Greek demo. In this sense, D8.3 is relevant with the corresponding deliverables of the other three demos, i.e., D6.3 “Implementation, operation and monitoring of the Azores demo” [2], D7.2 “Slovenian demo commissioning and start-up report” [3], and D9.2 “Danish demo commissioning and start-up report” [4].

Most importantly, D8.3 builds on the previous deliverables of the same work package, namely D8.1 “UC specifications and demonstrator deployment plan” [5] and D8.2 “Greek demonstrator start-up report” [6]. Given that a core part of the Greek demo relies on the O-V2X-MP platform and its smart charging support, D8.3 also builds on D5.5 “Open V2X Management Platform” [7], which presents the platform’s backend, and D5.6 “APIs and APPs allowing V2X user interaction” [8], which presents the platform’s frontend. Finally, the activities described in D8.3 will lay the ground for the next deliverable of the Greek demo, namely D8.4 “Services Activation in Greek demonstration report”.

2 O-V2X-MP Platform Updates

This section provides an overview of the O-V2X-MP platform, highlighting updates and new services both in its backend and in its frontend. More details on these features are provided in a journal publication describing the O-V2X-MP platform [1], which delves into the microservices architecture, the frontend functionalities and the data analytics modules for clustering EV chargers and predicting the daily load (30 days ahead) at charging stations using Machine-Learning (ML) algorithms on real-world data. A summary of these features is provided below.

2.1 Backend updates

To enhance the platform's capabilities and services, several updates and additions were made to the server-side of the project. These improvements were categorized into four main areas:

1. New functionalities, which involve new features that expand the platform’s capabilities.
2. Module enhancements, which optimized existing functionalities by reducing memory requirements, implementing additional Open Charge Point Protocol (OCPP) commands, and adding advanced HTTP operations for improved dashboard interactions and data management.
3. Real-time connections, which establish live data communication between the backend and the frontend as well as the backend and the DSS.
4. Integration enhancements, which ensure that the O-V2X-MP platform can be seamlessly connected to the demo charging stations.

We delve into each type of improvements in the following.

2.1.1 New Functionalities

Two new modules were added to the O-V2X-MP backend:

1. The LoadPrediction module focuses on daily load forecasts, i.e., the overall energy delivered by each charging station per day. This is possible for every charging station connected to the O-V2X-MP platform that has enough historical data. This data is used for training an effective regression model like Linear, Ridge or Lasso Regression as well as Long Short-Term Memory Neural Network (LSTM) and Convolutional Neural Network (CNN) (for more details, please refer to [1]). These regressors are trained through an offline process once every month so that their predictions remain up to date.

   To use this new feature, users simply select one of the available chargers from the corresponding list. Then, the backend applies the best-trained model for that particular charger to its historical data, generating the load prediction iteratively for up to the next 30 days. The predicted load data are sent to the frontend along with the corresponding actual data. The resulting diagram, shown in Figure 1, illustrates the accuracy of the predictions, *which tends to decrease as the prediction horizon extends*. Note that for the prediction of each day, the input to the trained model comprises a window of the 7 latest days, with each day represented by the actual load (or, for future days, the model's predicted load if real data is unavailable).
   Note that this functionality is only provided to administrators (Charge Point Operators (CPOs)). Note also that at the moment, only eight charging stations from DEI Blue (PPC’s commercial network) are supported.

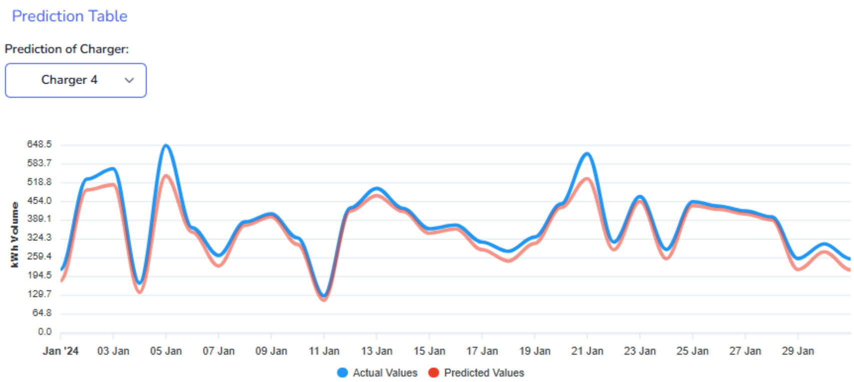


Figure 1. The diagram provided by the load prediction module, which juxtaposes the true charging load (in blue) with the predicted charging load (in red).

2. The MailSending module enables the CPO to send messages to specific email addresses, as shown in Figure 2. This application will be later integrated with the DSO notifications, sending emails and notifications to specific customers about the updated charging tariffs.

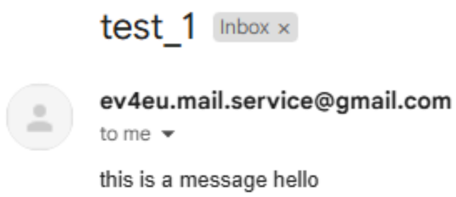


Figure 2. A testing email sent by the MailSending module.

2.1.2 Module Integrations

To meet the requirements for the more complex services to be provided within the Greek demo (e.g., the charging schedule), additions and extensions were made to existing modules of the backend.

Specifically, data collection and updating operations were integrated into many backend modules (e.g., User, idTag) to enhance their functionality. One of the goals was to reduce their memory requirements, thus lowering the response times. This was done by extending the queries issued to the database with additional parameters that filter the retrieved data, reducing the size of the exchanged messages (e.g., between the frontend and the backend).

Additionally, the Simulated Charging Service was extended to support two more OCPP commands: *SetChargingProfile* and *ClearChargingProfile*. These are indispensable for implementing the charging scheduling functionality, where users book time slots in any of the available charging stations in advance. Now, the implementation has been verified in a testing environment but will soon be extended to the real-world settings of the Greek demo.

2.1.3 Real-Time Connections

Using the O-V2X-MP platform in the real-world settings of the Greek demo requires that users are informed about charger availability in real-time and that administrators are continuously aware of the status of each charging station. In practice, this requires a *WebSocket communication* between the platform's backend and frontend. This simultaneous two-way communication, which is now part of the backend, ensures memory efficiency, while helping to avoid conflicts related to charging reservations and charger availability.

Another critical enhancement in the context of D8.3 pertains to the seamless integration with HEDNO's DSS, which monitors power generation and demand in the grid lines powering the charging stations. Whenever the DSO sends an update about the surplus of renewable load (see Business Use Case 4 (BUC4) in [5]) or the limited capacity available for the demo chargers (see BUC5 in [5]), the O-V2X-MP platform notifies the users, as shown in Figure 3 (on the left). Upon clicking on the badge, the users get detailed contents of the messages and then can clear it. This feature enables EV drivers to receive real-time alerts about the latest charger prices (BUC4) and the corresponding capacities (BUC5). It also enables administrators to manually adjust the charging profiles for sets of chargers connected to the same grid line and to develop algorithms for automatically distributing the available capacity among the charging stations in a dynamic way (BUC5).

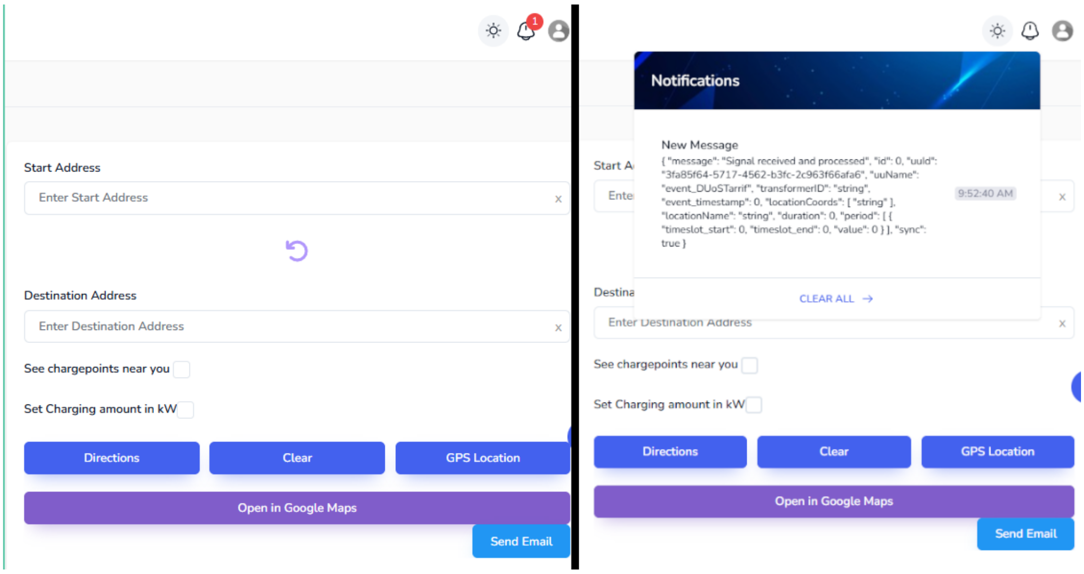


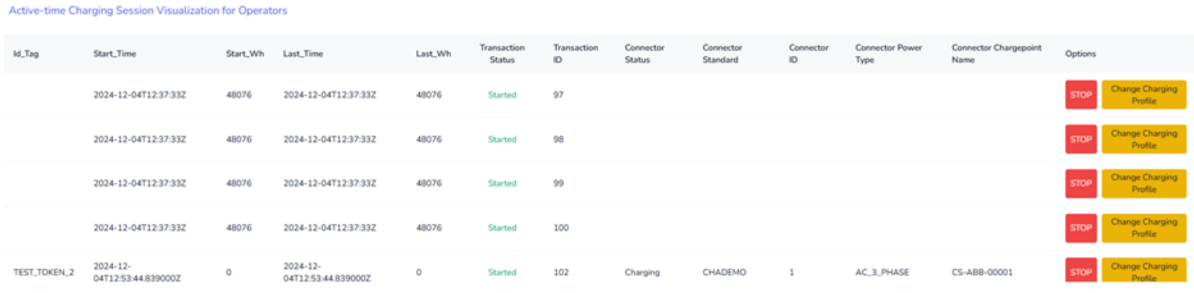
Figure 3. The notification badge informing users about a new message from HEDNO's DSS (on the left) and the detailed content of this message (on the right). Users can clear the notification after reviewing it.

2.1.4 Integration enhancements

So far, the O-V2X-MP platform had only been connected with simulated and physical ABB chargers. During the tests with the new AUTEL charger installed at the PPC Innovation Hub (see Section 3.1 for more details), unexpected behaviour was observed in the table displaying current charging transactions when applying the OCPP *RemoteStartTransaction* command to both a physical charger and a simulated charger. As shown in Figure 4, the physical charger displayed four different active transactions for a single connector, with most of the other fields blank. In contrast, the simulated charger (at the bottom of Figure 4) displayed all fields correctly.

This issue yields several implications:

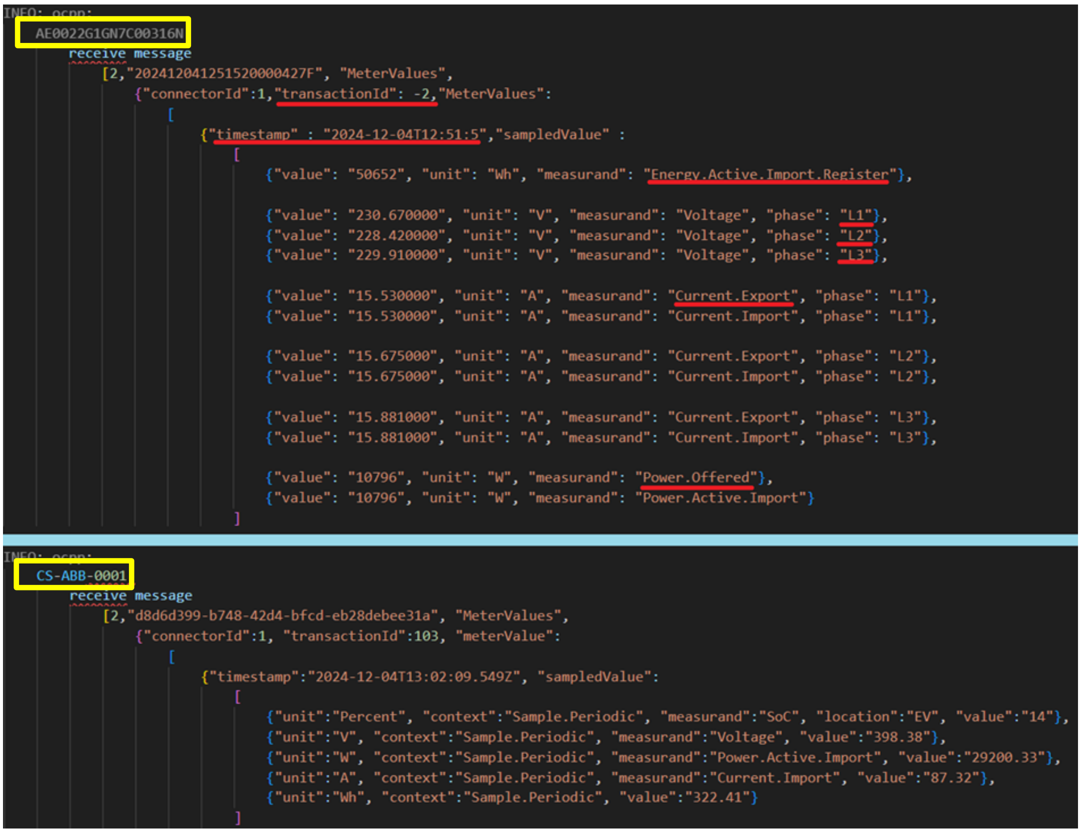
1. The physical charger failed to start charging, despite the *RemoteStopTransaction* command, requiring manual intervention either through the backend or by physically unplugging the charger.
2. The backend was unable to record the transaction history for the physical charger, complicating the tracking and management of charging sessions.
3. The MeterValues form could not display any data for the physical charger, due to configuration differences.


Active-time Charging Session Visualization for Operators

Id_Tag	Start_Time	Start_Wh	Last_Time	Last_Wh	Transaction Status	Transaction ID	Connector Status	Connector Standard	Connector ID	Connector Power Type	Connector Chargepoint Name	Options
	2024-12-04T12:37:33Z	48076	2024-12-04T12:37:33Z	48076	Started	97						STOP Change Charging Profile
	2024-12-04T12:37:33Z	48076	2024-12-04T12:37:33Z	48076	Started	98						STOP Change Charging Profile
	2024-12-04T12:37:33Z	48076	2024-12-04T12:37:33Z	48076	Started	99						STOP Change Charging Profile
	2024-12-04T12:37:33Z	48076	2024-12-04T12:37:33Z	48076	Started	100						STOP Change Charging Profile
TEST_TOKEN_2	2024-12-04T12:53:44.839000Z	0	2024-12-04T12:53:44.839000Z	0	Started	102	Charging	CHADEMO	1	AC_3_PHASE	CS-ABB-00001	STOP Change Charging Profile

Figure 4. Discrepancies between the simulated ABB and the physical AUTEL charger when issuing a remote charging OCPP command *RemoteStartTransaction*.

To resolve this issue, we compared the content of the OCPP messages generated by the physical AUTEL charger (AE022G1GN7C00316C in Figure 5 and Table 1) and the simulated ABB one (CS-ABB-0001 in Figure 5 and Table 1). They appear at the top and the bottom of Figure 5, respectively. We observe that there are significant differences between the two chargers, particularly in the type of Measures and values and phases, as shown in Table 1. This is the root cause of the discrepancies observed in Figure 4. To tackle this challenge, it was essential to observe the behaviour of both the charger and the EV in the phase of connecting, charging and disconnecting.



```
INFO: ocpp:
AE0022G1GN7C00316N
receive message
[2,"2024120412515200004 27F", "MeterValues",
{"connectorId":1,"transactionId": -2,"MeterValues":
[
{"timestamp" : "2024-12-04T12:51:5","sampledValue" :
[
{"value": "50652", "unit": "Wh", "measurand": "Energy.Active.Import.Register"},

{"value": "230.670000", "unit": "V", "measurand": "Voltage", "phase": "L1"},
{"value": "228.420000", "unit": "V", "measurand": "Voltage", "phase": "L2"},
{"value": "229.910000", "unit": "V", "measurand": "Voltage", "phase": "L3"},

{"value": "15.530000", "unit": "A", "measurand": "Current.Export", "phase": "L1"},
{"value": "15.530000", "unit": "A", "measurand": "Current.Import", "phase": "L1"},

{"value": "15.675000", "unit": "A", "measurand": "Current.Export", "phase": "L2"},
{"value": "15.675000", "unit": "A", "measurand": "Current.Import", "phase": "L2"},

{"value": "15.881000", "unit": "A", "measurand": "Current.Export", "phase": "L3"},
{"value": "15.881000", "unit": "A", "measurand": "Current.Import", "phase": "L3"},

{"value": "10796", "unit": "W", "measurand": "Power.Offered"},
{"value": "10796", "unit": "W", "measurand": "Power.Active.Import"}
]

INFO: ocpp:
CS-ABB-0001
receive message
[2,"d8d6d399-b748-42d4-bfcd-eb28debee31a", "MeterValues",
{"connectorId":1, "transactionId":103, "meterValue":
[
{"timestamp":"2024-12-04T13:02:09.549Z", "sampledValue":
[
{"unit":"Percent", "context":"Sample.Periodic", "measurand":"SoC", "location":"EV", "value":"14"},
{"unit":"V", "context":"Sample.Periodic", "measurand":"Voltage", "value":"398.38"},
{"unit":"W", "context":"Sample.Periodic", "measurand":"Power.Active.Import", "value":"29200.33"},
{"unit":"A", "context":"Sample.Periodic", "measurand":"Current.Import", "value":"87.32"},
{"unit":"Wh", "context":"Sample.Periodic", "value":"322.41"}
]
```


Figure 5.The logs of both chargers, the simulated charger (CS-ABB-0001) (Bottom) and the physical charger (AE022G1GN7C00316C) (Top), reveal different configuration values.

Table 1. The configuration values for the simulated charger (CS-ABB-0001) and the physical one (AE022G1GN7C00316C).

Field	Log 1 CS-ABB-0001 SIMULATED	Log 2 AE0022G1GN7C00316N AUTEL MAXICHARGER AC	Difference
Unit	**Percent**, V, W, A, Wh	Wh, V, V, V, A, A, A, A, A, A, W, W	Unit names
Measurand	**SoC**, Voltage, Power.Active.Import, Current.Import, Power.Active.Import	**Energy.Active.Import.Register**, Voltage, Voltage, Voltage, **Current.Export**, Current.Import, **Current.Export**, Current.Import, **Current.Export**, Current.Import, **Power.Offered**, Power.Active.Import	Different measurands
Location	**EV**	**Not present**	Location field only in Log 1
Phase	**Not present**	**L1, L2, L3, L1, L2, L1, L2, L3, L3**	Phase field only in Log 2
Timestamp	2024-12-04T13:02:09.549Z	2024-12-04T12:51:5	Different timestamps

More specifically, the solution to this issue involved integrating a code block into the backend system, which provides an optional charging profile id integration to the transaction module. The debugging effort was divided into three main actions:

1. connecting the charger to the EV car,
2. starting remote charging via OCPP, and
3. disconnecting the charger.

The correct execution of each action was verified both in the server logs and the frontend.

More specifically, the objective of the first action was to verify if the charger could transition its status from "Available" to "Preparing" mode when the charging cable was inserted into the EV car's charging port – see Figure 6 (top). The evaluation results are shown in Figure 6 (bottom), where the physical charger successfully changes its status from "Available" to "Preparing".

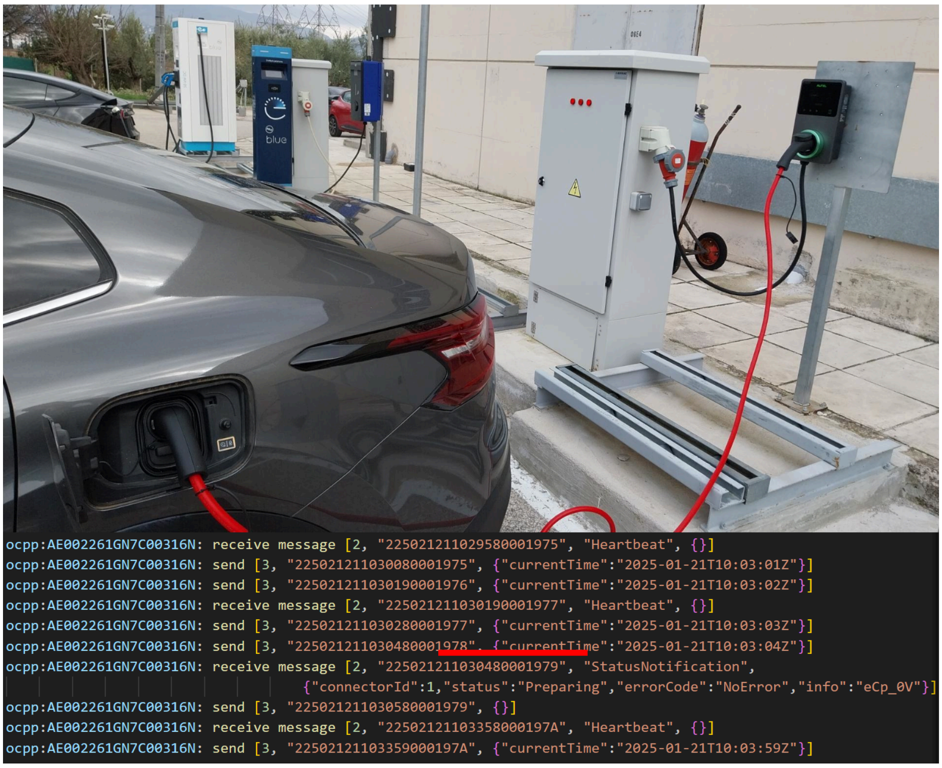


Figure 6. The connection to the charger (at the top) and the immidiate response from the server as the status changed from "Available" to "Preparing" (at the bottom).

With the charger status successfully updated, the next step was to initiate a remote charging operation from the frontend of the O-V2X-MP platform via a OCPP *RemoteStartTransaction* command. The remote charging operation was executed, and both the charger and the frontend displayed the real-time transaction successfully – see Figure 7 (left and bottom). Simultaneously, the backend logged the charging configuration updates per heartbeat – see Figure 7 (right).


```
INFO:ocpp:AE0022G1GN7C00316N: receive message [2, "20250121100526000010986", "MeterValues",
    {"connectorId":1,"transactionId":147, "meterValue":
        [
            {"timestamp":"2025-01-21T10:05:27.000Z","sampledValue":
                [
                    {"value":"51039","u nit":"Wh","measurand": "Energy.Active. Import.Register"},

                    {"value":"228.650000","unit":"V","measurand": "Voltage", "phase":"L1"},
                    {"value":"226.990000","unit":"V","measurand": "Voltage", "phase":"L2"},
                    {"value":"228.290000" ,"unit":"V","measurand": "Voltage", "phase":"L3"},

                    {"value":"0.628000","unit":"A","measurand":"Current.Export","phase":"L1"},
                    {"value":"0.628000","unit":"A","measurand": "Current.Import", "phase":"L1"},

                    {"value":"0.596000 ","unit":"A","measurand": "Current.Export", "phase":"L2"},
                    {"value":"0.596000","unit":"A","measurand": "Current.Import", "phase":"L2"},

                    {"value":"0.637000","unit":"A","measurand": "Current.Export", "phase":"L3"},
                    {"value":" 0.637000","unit":"A","measurand": "Current.Import", "phase":"L3"},

                    {"value":"15","unit":"W","measurand": "Power. Offered"},
                    {"value":"15","unit":"W","measurand": "Power.Active. Import"}
                ]
            }
        ]
    }]
```

Real-time Transaction Options | Finished Transactions

Active-time Charging Session Visualization for Operators

Id_Tag	Start_Time	Start_Wh	Last_Time	Last_Wh	Transaction Status	Transaction ID	Connector Status	Connector Standard	Connector ID	Connector Power Type	Connector Chargepoint Name	Options
TEST_TOKEN_2	2025-01-21T10:05:23Z	51039	2025-01-21T10:06:48Z	51237	Started	147	Charging		1		AE0022G1GN7C00316N	STOP Change Charging Profile

Figure 7. The real-time charging operation is demonstrated across three key areas. On the left, the charger itself confirms the successful initiation of the charging process. On the right, the server's continuous responses provide load values that detail the charging operation's status and performance. At the bottom, the real-time charging operation is also monitored and evaluated through the frontend.

Finally, the disconnection process was checked to ensure that the OCPP *RemoteStopTransaction* command performed correctly. First, the remote command to stop the transaction was executed successfully, halting the charging operation and reverting the charger's status to "Available," as depicted in Figure 8. After completing the tests, the charging cable was disconnected from the EV.

```
INFO: ocpp:AE0022G1GN7C00316N: receive message [2,"20250121102157000010A75", "StopTransaction",
                                                {"idTag":"TEST_TOKEN_2","transactionId":147,"meterStop":53520,
                                                "timestamp": "2025-01-21T10:21:55.000Z", "reason": "Remote"}]
INFO:ocpp:AE0022G1GN7C00316N: send [3,"20250121102157000010A75",{}]
INFO:ocpp:AE0022G1GN7C00316N: receive message [2,"20250121102157000010A76","StatusNotification",
                                                {"connectorId":1,"status":"Finishing","errorCode":"NoError","info":"eCp_9V"}]
ocpp:AE002261GN7C00316N: receive message [2, "22502121102958000 1975", "Heartbeat", {}]
ocpp:AE002261GN7C00316N: send [3, "22502121103008000 1975", {"currentTime":"2025-01-21T21:55.002Z"}]
```

Figure 8. The system logs showing the transition from Charging to Finishing via the OCPP RemoteStopTransaction command.

This stepwise approach ensured that all aspects of the remote charging operation were thoroughly tested and verified that they operate without any errors.

2.2 Frontend updates

This section outlines the updates and the new features added to the user interface of the O-V2X-MP platform. These enhancements apply to the following three main elements of the user interface:

1. In the Dashboard, the new features include filters that restrict the charging stations shown in the map based on the preferred capacity of EV chargers (in kW). To improve session planning, the platform now provides estimations of the routing and charging time, based on the destination and the desired energy provided by the user. By selecting a charge point, users can also inspect its *Capacity Schedule* (i.e., the capacity for each hour of the selected day) as well as its *Tariff Schedule* (i.e., the availability for the selected day). Additionally, a Weather Map has been added alongside the existing ChargePoint Map. Most reports have been moved to the Admin Tools, leaving only the Transaction History accessible for EV users. CPOs benefit from a kWh volume prediction tool, which forecasts energy demand for chargers based on ML and Deep Learning-based (DL) predictive models trained on historical data [1]. Moreover, both CPOs and EV users can inspect the price announcements from the notification badge, which is integrated with the DSS messages, while the Email Test button allows CPOs to communicate important issues with the registered users through emails.
2. In the Profile Overview, all users can now manage and update various charging and tariff-related properties. Both EV users and CPOs can also generate, update, or delete the *charging tags* that are used as the means of identification that is necessary for starting a charging session.
3. The Admin Tools have been redesigned for improved usability, particularly for CPOs. Expanding from the original two sections, its functionalities are now organized into six new ones: ChargePoint Tools, Tariff Tools, Connector Tools, Transaction Tools, Charging Tools, and Account Profiles Tools. This redesign introduces 20 subservices, instead of just 4, significantly enhancing the supported functionalities.

We elaborate on these features in the following.

2.2.1 Dashboard

After signing in, the EV users and CPOs are directed to the platform's main page, known as the Dashboard. This page hosts the most critical services, including the map, charger filters, and routing options. The Dashboard has been enriched with the following features:

1. It supports Capacity and Tariff Schedules.
2. It provides optimal routing instructions for a given destination and desired amount of energy.
3. It integrates a Weather map into the Chargepoint Map.
4. It visualizes the user’s transaction history.
5. It provides load prediction for individual chargers with sufficient historical data.
6. It supports price notification for specific chargers through a notification badge.
7. It enables CPOs to send emails to specific platform users.

More specifically, the updated Dashboard allows users to select a charger and view its Capacity and Tariff Schedules. As illustrated in Figure 9, these features allow users to find the most cost-effective charger based on the cheapest-to-distance ratio among available options.

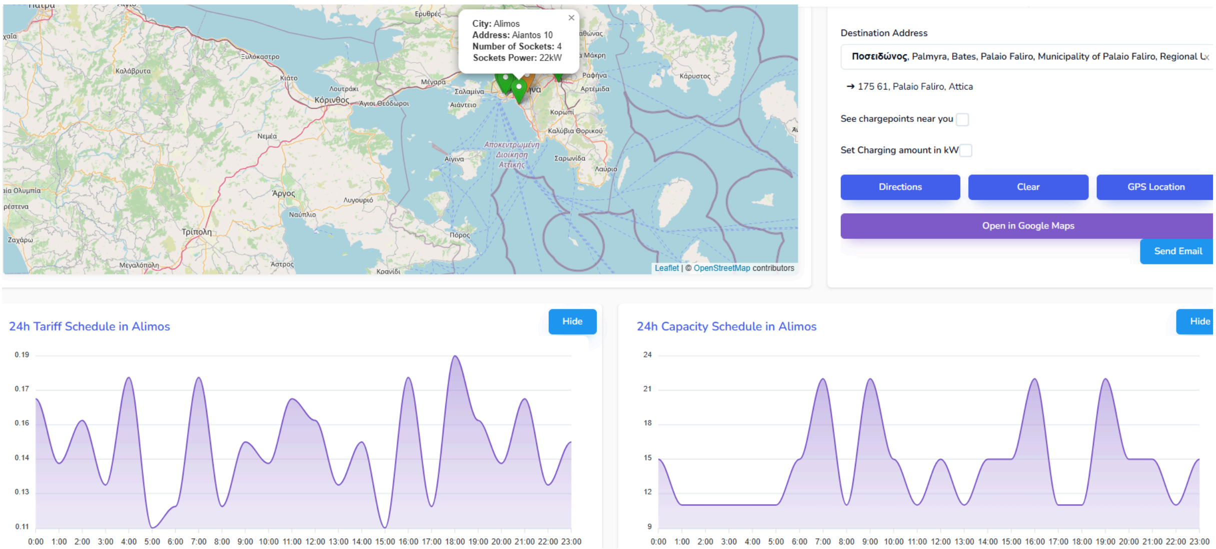


Figure 9. The 24-hour Capacity Schedule (on the left) and Tariff Schedule (on the right), which are displayed when selecting a charger through the Dashboard's map (at the top).

Moreover, the platform users and administrators can optimize their charging sessions by entering their destination along with the desired amount of energy (in kW). The O-V2X-MP platform then calculates an approximate charging and routing time, supporting users to determine which charging station best suits their needs in terms of time efficiency. This feature is illustrated in Figure 10. Our goal is to improve the time estimation algorithms in the context of Task 8.4.

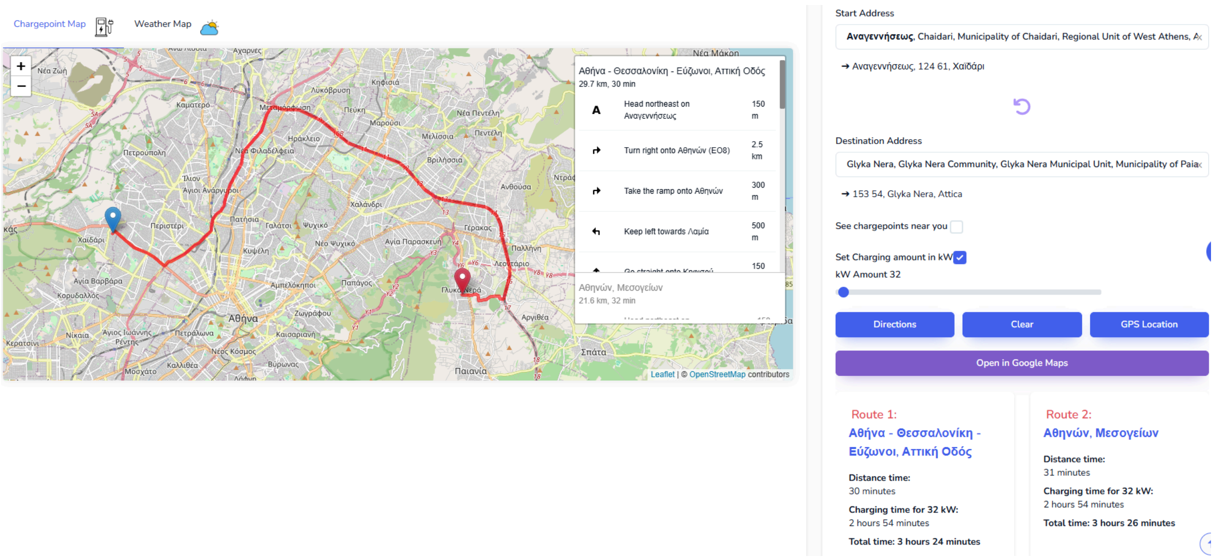


Figure 10. The estimation of routing and charging times after selecting a destination and the desired amount of energy.

Additionally, the Weather Map has been integrated into the ChargePoint Map to help users to organize their travels and/or charging sessions based on the weather conditions. Users can switch between the Weather Map and the ChargePoint Map as needed. This feature is demonstrated in Figure 11, which depicts the Weather Map in the place of the ChargePoint Map.

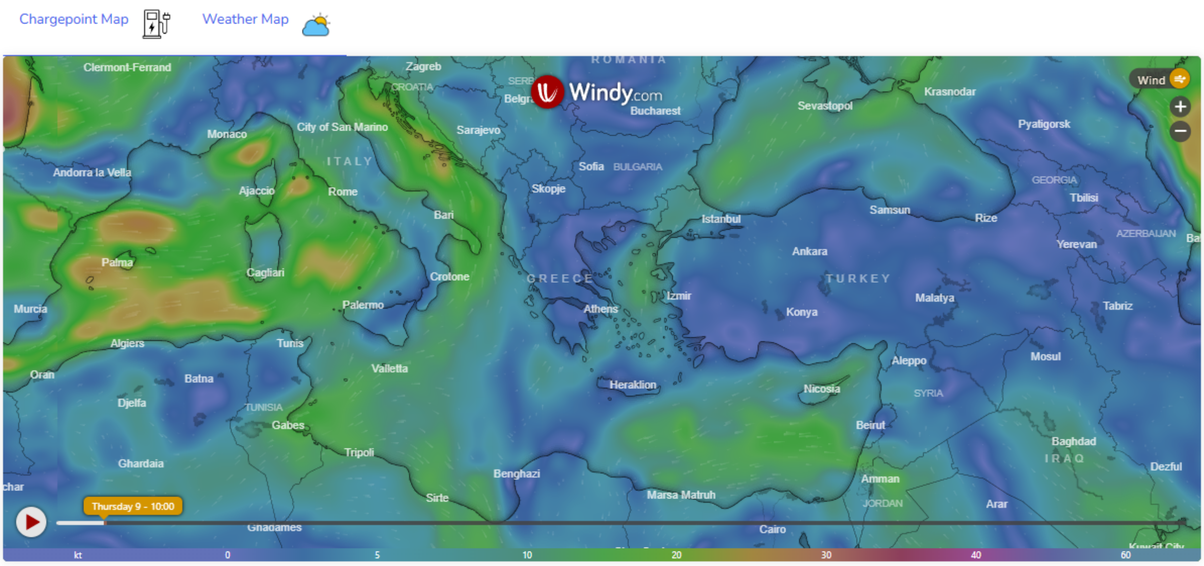


Figure 11. The Weather Map is depicted.

Another new feature for EV users is the Transaction History, which displays the time and consumed energy of their charging sessions, as shown in Figure 12.

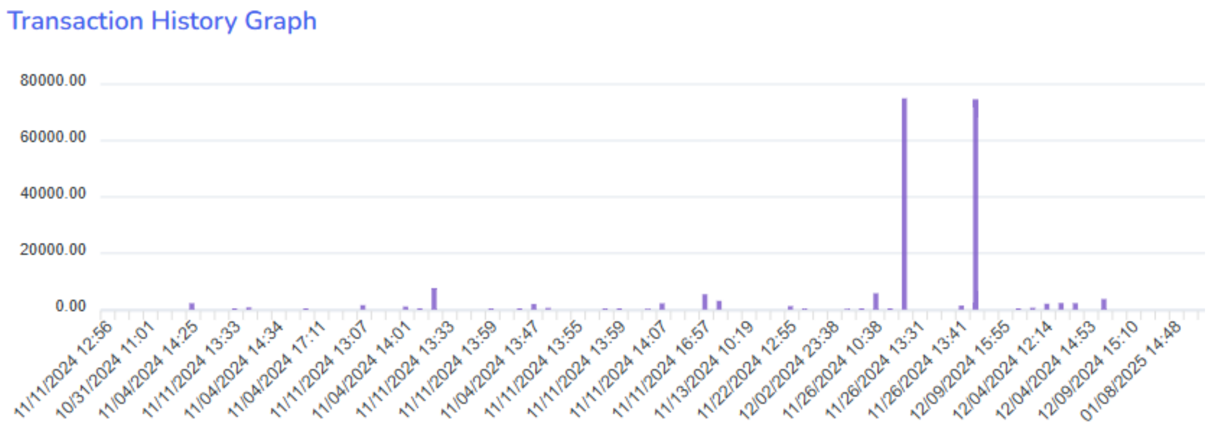


Figure 12. The Transaction History of an EV user.

A new feature exclusively provided to CPOs is the load prediction. Its goal is to forecast the energy demand per hour or day for any charger selected via the map, based on regression models that have been trained on its historical data using ML or DL [1]. This functionality holds the potential to provide CPOs with insights into the overall load in a network of charging stations. The only requirement is that the chargers of interest have accumulated enough charging sessions, allowing for predictions of high accuracy. Note that this feature is part of the Dashboard rather than the Admin Tools because it focuses on insights and reporting rather than management.

Another feature common to both EV users and CPOs is the price announcement for specific chargers through the notification badge in Figure 3. This is triggered by the DSS, based on the energy generation of renewables. The DSS is connected to the O-V2X-MP platform with web socketing, which allows for automatically updating the current power status of specific chargers. In the future, this feature will be integrated into the 24-hour Tariff Schedules in Figure 9, providing real-time information to users.

The latest update to the Dashboard pertains to the Email Sending Feature, which allows CPOs to send test emails to their registered addresses, as shown in Figure 2. Once fully implemented, this feature will work alongside with the notification badge for price announcements to inform both EV users and CPOs in real time about the latest tariffs via email.

2.2.2 Profile Overview

The tab next to the Dashboard is dedicated to the profile management of users and administrators. This section enables them to manage their personal information, to update their charging and tariff preferences, and to generate, update, or delete charging tags, which are essential for initiating charging transactions. These features provide users with greater control over their charging activities and ensure seamless management of their preferences. The functionalities available in this tab are illustrated in Figure 13.

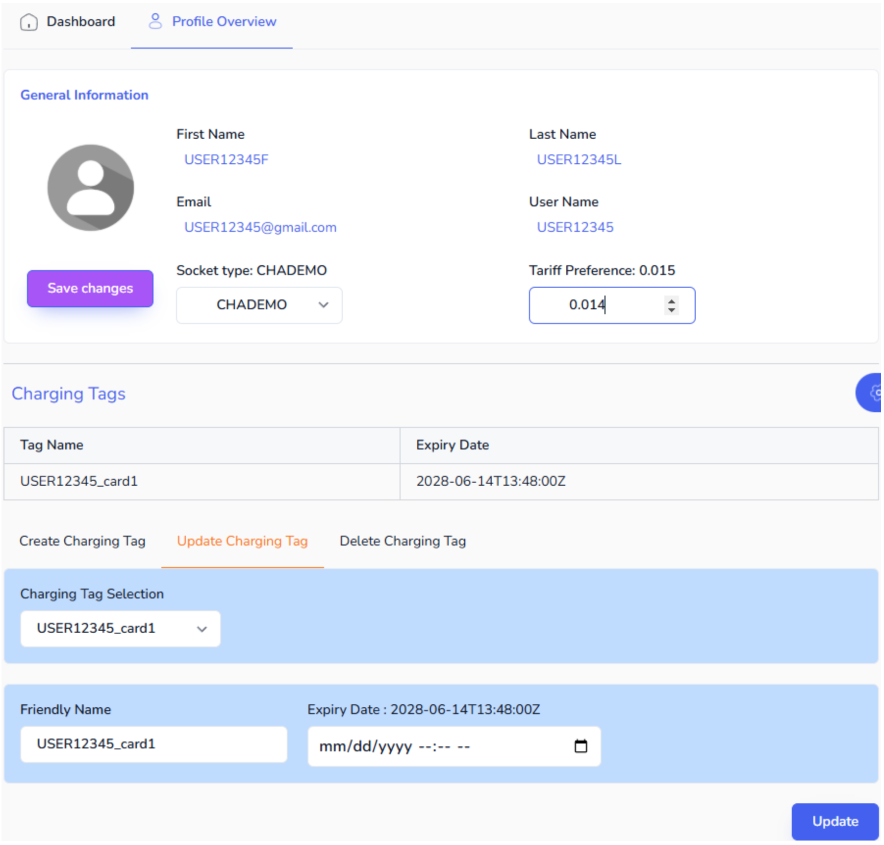


Figure 13. The profile management functionalities.

2.2.3 Administrator Interface

The Admin Tools windows of the frontend is specifically designed for CPOs, allowing them to apply various backend functionalities through a more user-friendly interface. This updated page comprises the following six main services:

1. The *Chargepoint Tools* allow for managing the information about charging stations and their location. In fact, this service enables CPOs to create, update, and delete location data, as well as to add new charging points, modify existing ones, and remove charging points as needed. CPOs can also adjust the status of charging points, marking them as under maintenance or setting them to fault mode for service purposes. These six sub-services are illustrated in Figure 14 and Figure 15. This service also includes a Charging Station Diagnostics table, offering a

comprehensive overview of the actual status of chargers. This table provides valuable insights for CPOs, enhancing their ability to monitor and manage charging points effectively.

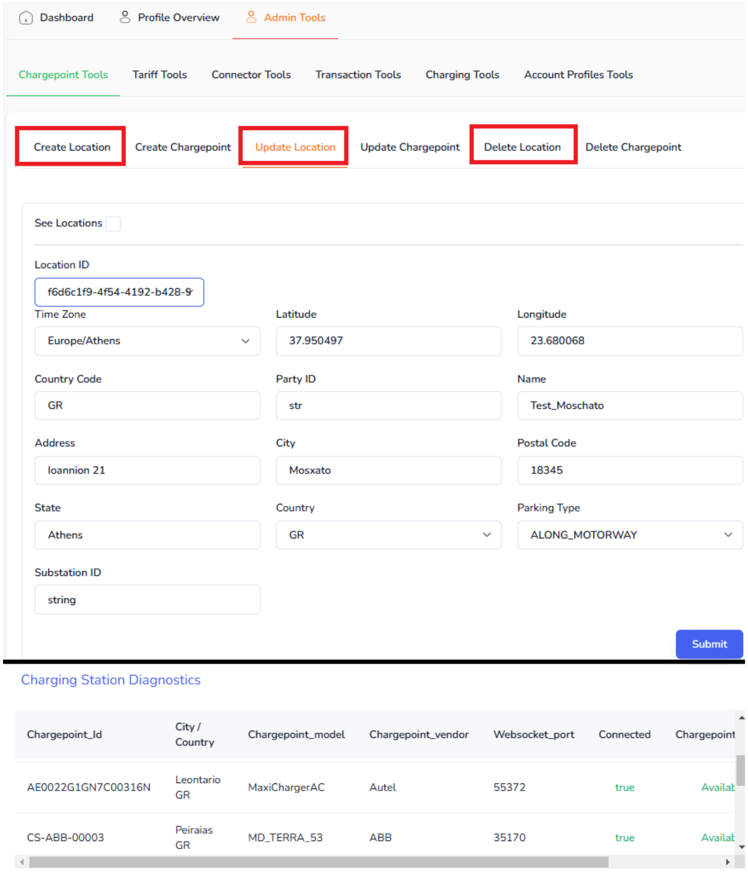


Figure 14. The options provided to CPOs by the ChargePoint Tools for managing the locations of chargers.

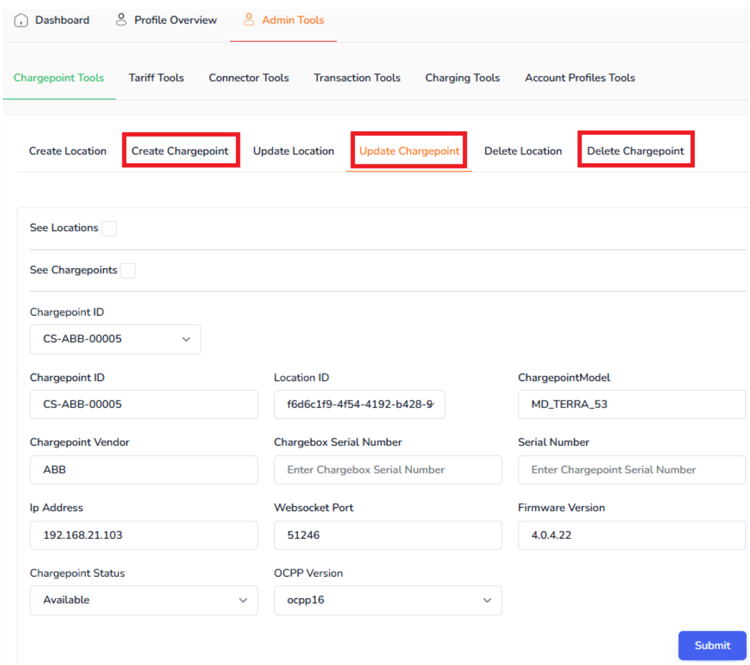


Figure 15. The options provided to CPOs by the ChargePoint Tools for managing the information of chargers.

2. The *Tariff Tools* are dedicated to managing the tariffs associated with each charger. With this service, CPOs can create, modify, and delete *tariff elements*, which represent the pricing features along with optional restrictions. CPOs can also manage the *main tariff*, which includes additional pricing information[2]. These functionalities are illustrated in Figure 16 and Figure 17, respectively. Overall, this service provides comprehensive management options for the tariffs, allowing CPOs to handle all aspects of pricing configuration.

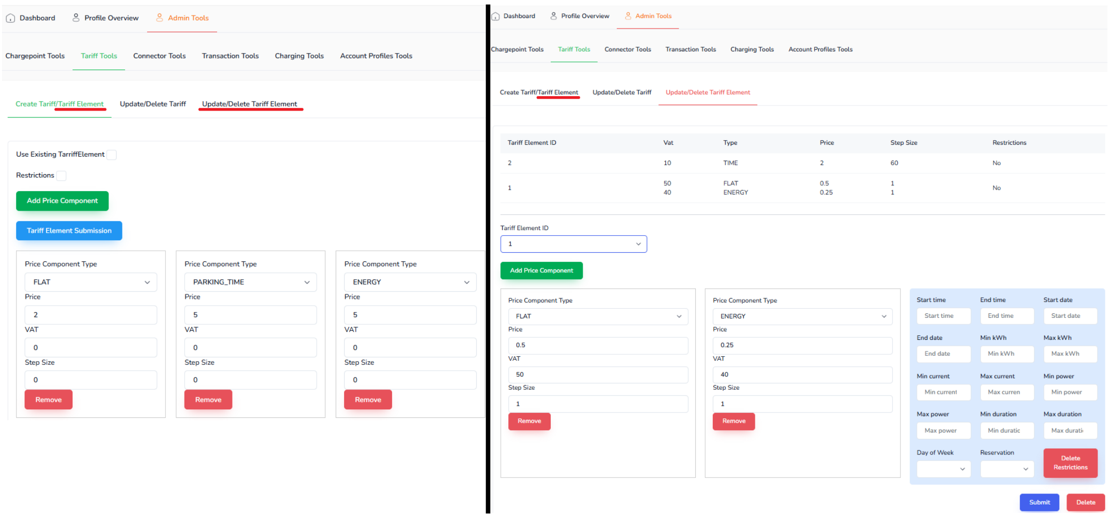


Figure 16. The options provided to CPOs by the Tariff Tools for tariff element management.

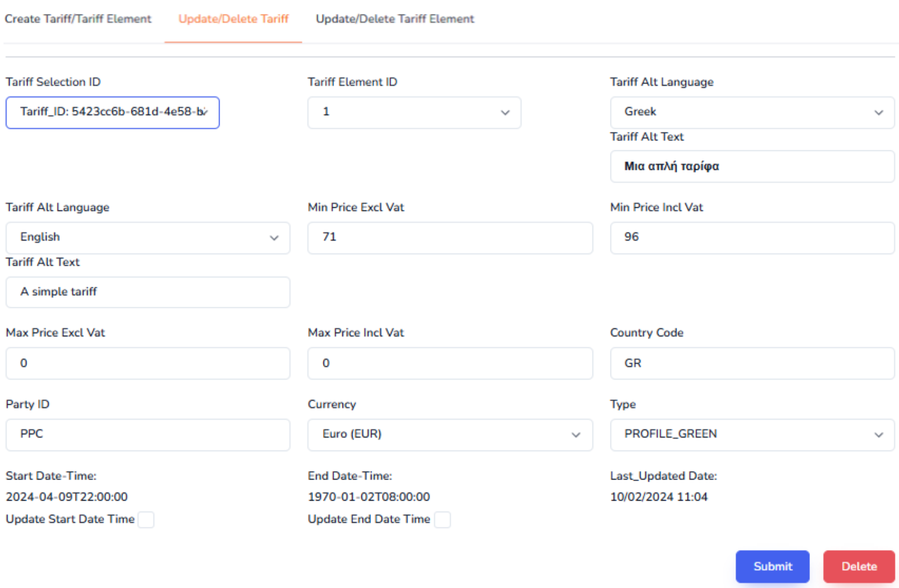


Figure 17. The options provided to CPOs by the Tariff Tools for the management of the main tariff.

3. The *Connector Tools* are crucial for initiating a connector and making it available to real charging scenarios. This service offers an overview of connector information along with the optional associated tariff (note that a connector can operate without a tariff integration, but only in a

[2] A tariff element is a subcomponent of the main tariff. While the main tariff provides a general framework for charging a customer by setting the pricing plan, including minimum and maximum price boundaries, the tariff element focuses on the finer details, such as the type of service, the initial price, VAT, and any restrictions or conditions applied.

testing environment). It also allows users to modify each connector individually, providing flexibility in managing charging configurations. These functionalities are depicted in Figure 18.

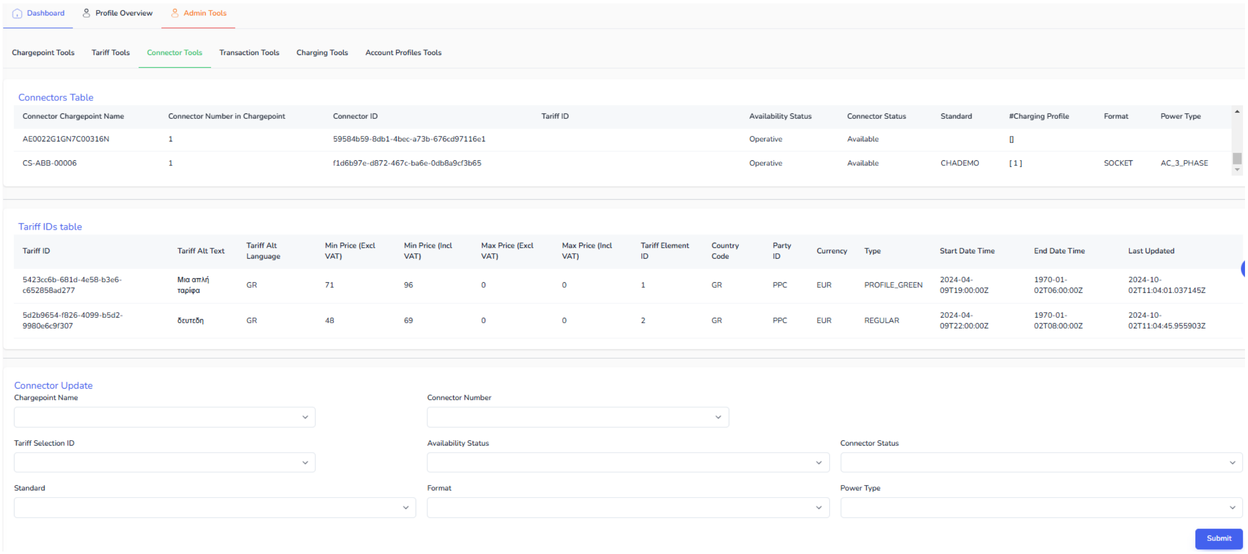


Figure 18. The Connector Tools that associate tariff information with each connector.

4. Once a connector is initialized and monitored through the Connector Tools, the CPOs can use the *Charging Tools* to create, modify, and delete charging profiles for the connectors, as shown in Figure 19.

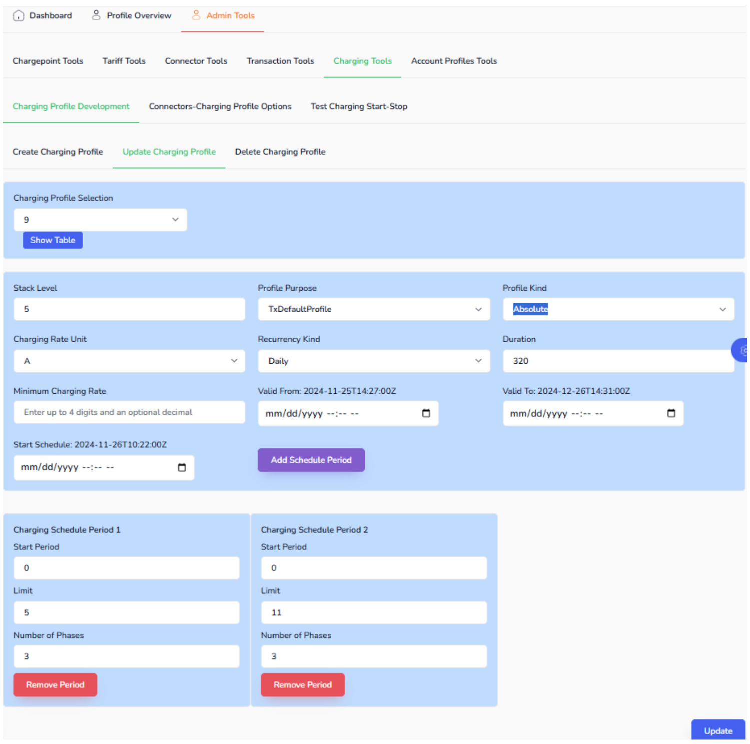


Figure 19. The options provided to CPOs for managing charging profiles through the Charging Tools.

This service also allows for associating a charging profile with any connector, as shown in Figure 20. It even allows for testing the connectors by remotely starting or stopping a charging session via OCPP commands, as depicted in Figure 21.

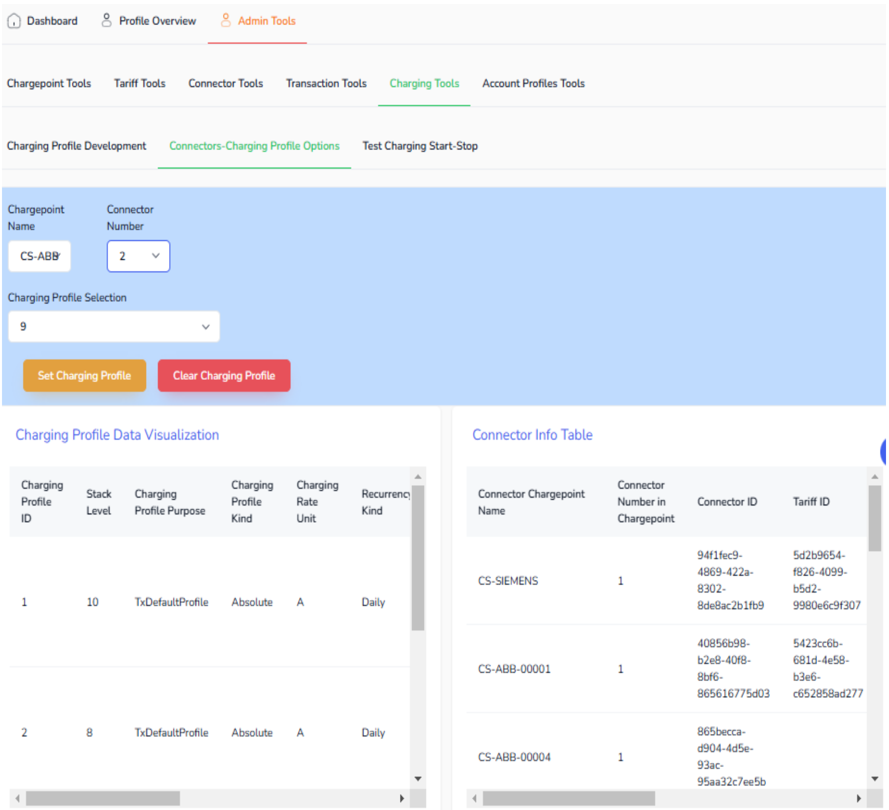


Figure 20. Using the Charging Tools to associate a charging profile with a connector.

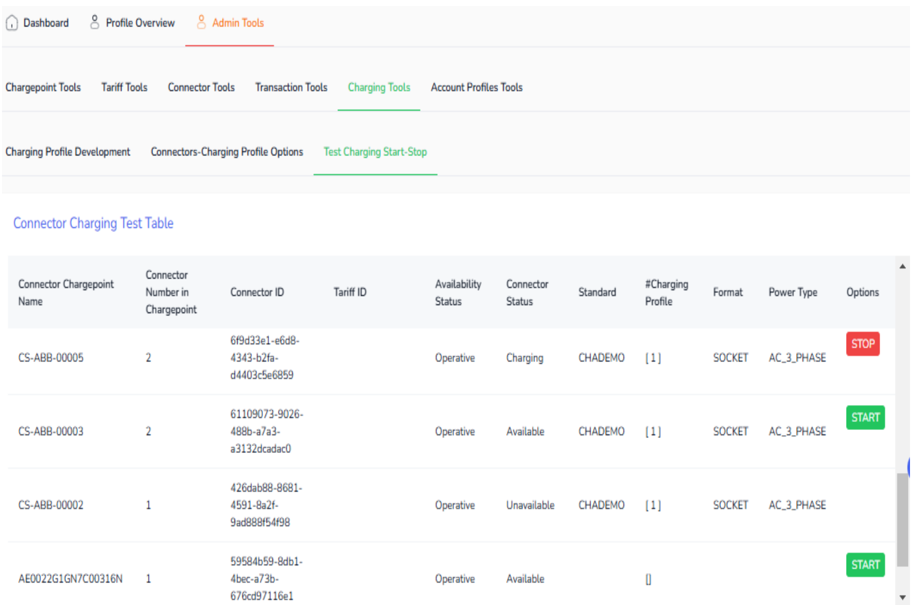


Figure 21. Using the Charging Tools to remotely test the charging operations on an integrated charging station.

5. Charging sessions are treated as a live transaction and can be monitored through the *Transaction Tools* service. This service includes a Real-time Transaction tab, where ongoing and started transactions are displayed along with a diagram visualizing the energy delivered over time. This tab is shown in Figure 22.

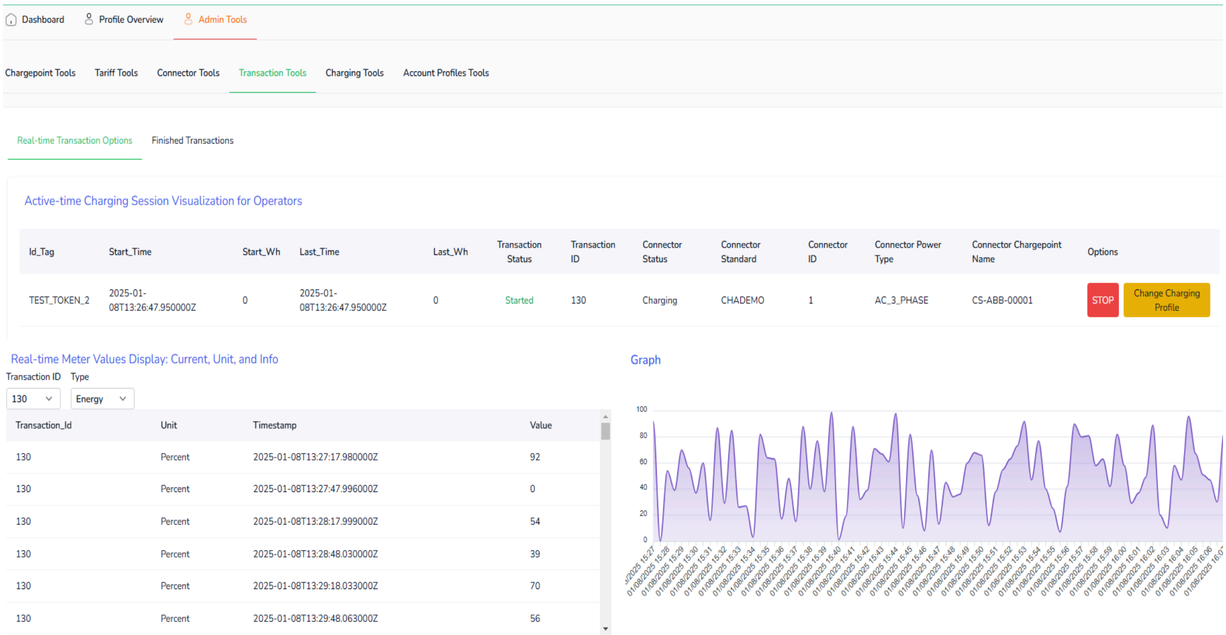


Figure 22. The Transaction Tools reporting the status of charging sessions in real-time along with the delivered energy over time.

The Transaction Tools also include the Finished Transactions tab, which lists the completed transactions, providing the option to download and export the transaction data as a spreadsheet file. These functionalities are displayed in Figure 23.

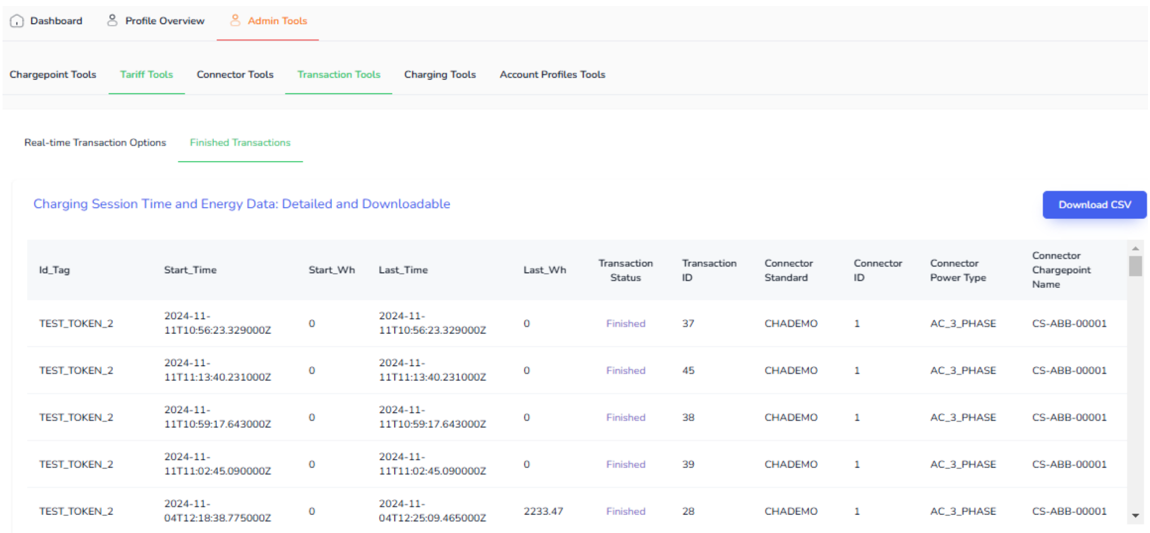


Figure 23. The Finished Transactions tab of the Transaction Tools provides CPOs with a list of the completed transactions. Additionally, this list can be exported as a spreadsheet file.

6. The Account Profiles Tools allow CPOs to create, modify, or delete user accounts within the platform. Additionally, CPOs have the option to assign a user as a CPO, which corresponds to the role and permissions of a platform administrator. This service, which is illustrated in Figure 24, provides an efficient way for CPOs to manage their account information and ensure the platform is tailored to their operational needs.

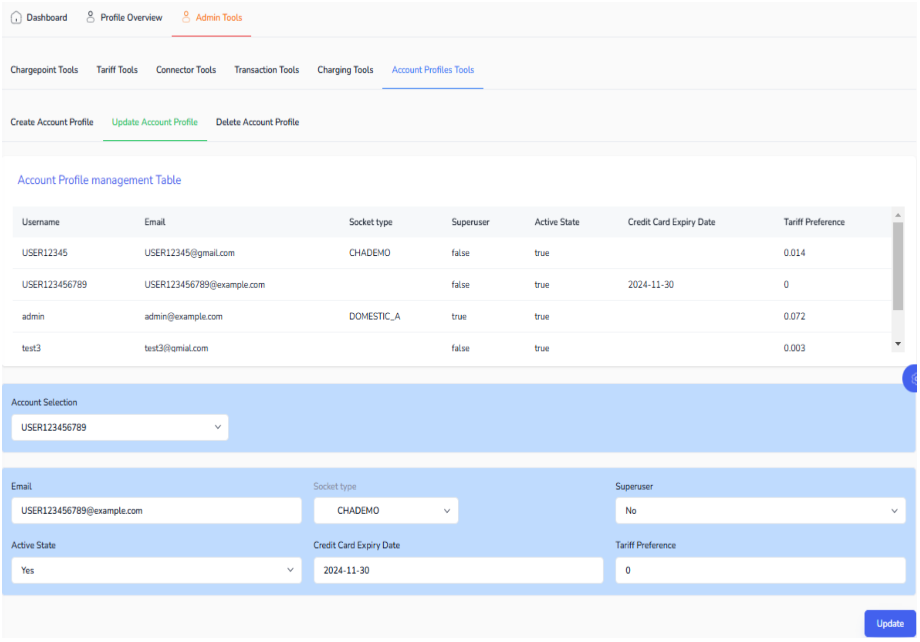


Figure 24. The Account Profiles Tools allow for managing user account, i.e., for creating, updating (with certain restrictions on the fields), and deleting existing user accounts.

3 Infrastructure updates

3.1 Smart Charger at Innovation Hub

The bureaucratic delays in the electrification of the installed charging stations caused delays to their integration with the O-V2X-MP platform. Given that the platform has only been tested with charger simulators and ABB chargers, integration tests were required to ensure the correct communication with the installed chargers. To accelerate these tests, PPC installed an identical charging station (Autel MaxiCharger 22kW AC) at the premises of its Innovation Hub, in the E-Mobility Lab[3]. The procurement and the installation were concluded within the first two weeks of November, 2024. The installed charger is shown in Figure 25. Preliminary tests were performed in the second half of November, 2024. The charger was successfully connected with the O-V2X-MP platform, but there were incompatibilities with the format of the messages sent by the charger, as explained in Section 2.1.4 in more detail.

Figure 25. The Autel MaxiCharger AC installed at the PPC Innovation Hub for testing purposes.

Overall, the additional charger at the PPC Innovation Hub allowed for carrying out crucial tests, while progressing with the electrification of the installed charging stations at the Kropia Municipality. The charger will also allow PPC employees to act as platform users that will test and provide valuable feedback for the O-V2X-MP platform. It will also enable us to perform additional tests in a fully controlled environment, whenever the platform is extended with new features and updates.

[3] https://innovationhub.dei.gr/en/services/testing/other/e-mobility-laboratory/

3.2 Electrification process

For each of the charging station, the actions in Table 2 were carried out by PPC.

Table 2. The steps that were required for installing each charging station.

Step	Responsible partner	Description	Status
1	Kropia Municipality	Agreement with the mayor and the technical service	Completed
2	Kropia Municipality	Application for installing the charger	Completed
3	Kropia Municipality	Trenching permit	Completed
4	Technical Chamber of Greece	Application for installation permit	Completed
5	PPC	Installation works	Completed
6	HEDNO	Application for issuing a supply number	Completed
7	HEDNO	Inspection and connection to electricity pillar (via underground cable)	Completed
8	HEDNO	Application for connection contract	Completed
9	HEDNO	Submission of solemn declaration by the installer	Completed
10	HEDNO	Application for electricity supply contract	In progress
11	HEDNO	Application for electrification	In progress
12	HEDNO	Electrification	In progress
13	Ministry of Infrastructure and Transportation	Application for registering the charging station to the registry of public chargers	In progress

4 Testing car

To perform extensive tests with the O-V2X-MP platform and the charging infrastructure of the Greek demo, Aiglon provided an EV to be used by PPC and HEDNO until the end of the project. The EV is a Citroen e-C4 X, shown in Figure 26, with the technical characteristics of Table 3[4]:

Figure 26. The EV provided by Aiglon for performing the necessary tests for the Greek Demo

Table 3. Technical characteristics of the EV provided by Aiglon for the tests of the Greek demo.

Battery	
Capacity	54 kWh
Battery Type	Lithium-ion
Number of Cells	102
Nominal Voltage	377 V
Charge Port	Type 2
Charge Power	11 kW AC
Charge Time (0%-100%)	5h30m
Charge Speed	63 km/h
Fast Charging	
Charge Port	CCS
Charge Power (max)	100 kW DC
Charge Power (10%-80%)	78 kW DC
Charge Time (10%-80%)	29 min
Charge Speed	490 km/h
Autocharge Supported	Yes
Bidirectional Charging (V2X / BPT)	
Vehicle-to-Load (V2L) Supported	Yes
Max. Output Power	3.7 kW AC
Exterior Outlet(s)	1 x Type 2 (Adapter)
Vehicle-to-Home (V2H) via AC Supported	No
V2H via DC Supported	No
Vehicle-to-Grid (V2G) via AC Supported	No
V2G via DC Supported	No

[4] https://ev-database.org/car/3050/Citroen-e-C4-X-54-kWh

The EV has already been used for ensuring that the O-V2X-MP platform connects with the Autel charging stations used in the Greek demo. The next tests will be performed in all demo chargers to ensure their proper functionality and their connection with the O-V2X-MP platform. The same tests will be periodically carried out during the Greek demo to proactively detect hardware and connection issues.

5 User Engagement approaches

A core part of the Greek demo involves attracting users to charge their electric vehicles in one of the five public charging stations at the Kropia Municipality, while encouraging them to engage more deeply with the O-V2X-MP platform. Users will have the option to participate in a comprehensive experience by exploring all platform features listed in Section 2 or simply to charge their vehicles, allowing the platform to observe and analyse consumer behaviour. To ensure a large user base, we will employ a multi-faceted approach that targets two user groups: employees of the Greek partners and the public. We elaborate on the corresponding actions in the following.

5.1 PPC, HEDNO and Citroen employees

The first user group that will be targeted comprises the employees the partners implementing the Greek demo, namely PPC, HEDNO and Citroen.

Starting with PPC, more than 20 employees at its Innovation Hub are already driving EVs. A short presentation will be shared with them, explaining the goals of the EV4EU project and the availability of the new charging station (see Figure 25). They will be encouraged to use it to charge their EVs through the O-V2X-MP platform. These users won't participate in BUC4 and BUC5 [5], given that the new charger is not connected with the same grid line as the ones installed at the Kropia Municipality. However, they will provide valuable feedback for the O-V2X-MP platform as well as valuable user data, which will enable us to build more accurate models of the charging curves for popular EV models.

Additionally, we will contact colleagues living in Athens through corporate mailing lists, informing them about the Greek demonstration that is carried out in the Kropia Municipality (there will be no reference to the new charging station at the Innovation Hub, given that the access to its premises is restricted). Short information will be shared about the EV4EU project in general and about the Greek demo in particular. Emphasis will be placed on encouraging them to exploit the lower prices for green charging (in the context of BUC4 [5]) and to explore the dynamic capacity of charging stations (in the context of BUC5 [5]). We will also encourage them to share their experiences and suggestions for improvements via email.

5.2 Public

To ensure high participation from the public, we will devise the following three types of strategies:

1. **Social media advertising**. A social media campaign will be devised to boost the engagement of EV drivers from all over Athens. A core part of this campaign will be a unique hashtag like #ChargeUpWithEV4EUinAthens in platforms like X (former Twitter) and social networks like Facebook and LinkedIn. This hashtag will be used in messages posted in popular groups focusing on e-mobility[5]. The messages will describe the EV4EU project and the goals of Greek demo, focusing on the environmental benefits of EVs. Most importantly, users will be encouraged to use the public charging stations at Koropi free of charge, stressing that this is only possible through the O-V2X-MP application. Emphasis will be placed on clarifying the simple process that is required for registering a new user and for scheduling and carrying out a charging session.
2. **User Experience Benefits**. Every user registered in the O-V2X-MP platform will be allocated a specific amount of free energy per month (e.g., 50kWh). No charging will be possible beyond that limit unless the user participates in the loyalty program. To encourage the repeated

[5] Such as https://www.facebook.com/groups/ElectricCarGreece

participation in the Greek demo, while boosting its visibility in social media, users will earn rewards in the form of more free energy (few kWh) whenever they share a post or a story on their account in the social media. They will only need to add a link to this post to their user profile via the O-V2X-MP platform. A similar reward will be given to users that send email invitations to their friends with information about the EV4EU project and the Greek demo. A "first-charge free" promotion will be offered to those who sign up on the platform after receiving this email. This approach creates a welcoming entry point for new users while fostering loyalty among existing ones.

3. **Real-world promotions**. Enhancing the visibility of the charging stations is key to engaging first-time users and increasing awareness. Clear, eye-catching signage with simple instructions can help those unfamiliar with the charging process. Ensuring that stations are well-marked and visible for pedestrians and drivers in the high-traffic areas they are located will attract users who might not be actively seeking charging spots. Special care will be taken to promote the EV4EU project, with its logo and QR codes pointing to its website.

6 Questionnaires for gathering user feedback

To maximize user satisfaction, special care will be taken to frequently elicit feedback from demo participants and to incorporate their suggestions into the O-V2X-MP platform, making the necessary updates in the Dashboard and the backend, if necessary. To this end, the following questionnaire has been prepared and is available at the EV4EU Dashboard Experience form:

1. **Routing Functionality**. On a scale of 1 to 5, how satisfied are you with the routing functionality in the EV4EU Dashboard for planning your trips?
2. **Transaction Load History**. On a scale of 1 to 5, how useful do you find the Transaction Load History feature for tracking your charging sessions?
3. **Message Notifications**. On a scale of 1 to 5, how helpful are the message notifications provided by the EV4EU Dashboard?
4. **Charger Search Options**. On a scale of 1 to 5, how easy is it to search for a charger using the EV4EU Dashboard?
5. **Google Maps Button Functionality**. On a scale of 1 to 5, how useful is the integration of Google Maps for navigating to chargers?
6. **Weather Map**. On a scale of 1 to 5, how helpful is the weather map feature in planning your charging activities?
7. **Personal Information Management**. On a scale of 1 to 5, how satisfied are you with the Personal Information Management features of the EV4EU Dashboard?
8. **Bookmark Charger Functionality**. On a scale of 1 to 5, how convenient is the Bookmark Charger feature for saving your favourite charging locations?
9. **ChargePoint reservation**. On a scale of 1 to 5, how straightforward and effective do you find the process of reserving a charger through the EV4EU Dashboard?
10. **Improving the Dashboard**. What features or enhancements would you suggest for the EV4EU Dashboard to improve the user experience?
11. **Challenges Encountered**. Have you faced any difficulties or challenges while using the EV4EU Dashboard? If yes, please describe them briefly.

The first nine questions are obligatory, with higher scores indicating higher user satisfaction, i.e., 1 = Very Dissatisfied, 2 = Dissatisfied, 3 = Neutral, 4 = Satisfied, 5 = Very Satisfied. The last two questions are optional and open-ended, enabling demo participants to bring up any issue that is important, requiring improvements.

This questionnaire will be presented to demo participants through the O-V2X-MP dashboard whenever they complete a charging session. It won't be compulsory, but they will be encouraged to fill it in. To maximize the elicited feedback, the questionnaire will also be shared with all registered users periodically – in particular, once every month.

It is worth noting that this questionnaire will be coupled with WP3 (Task 3.1) questionnaires about user perception of EVs in general. In all cases, special care will be taken to translate all questions and answers in English.

7 Conclusions

In this deliverable, we delved into the latest activities that were carried out to finalize the setup of the Greek demo. These activities were focused on the software and the hardware infrastructure of the demo as well as on user participation.

Regarding the software infrastructure, we described the new features that were added to the O-V2X-MP platform. The backend was enriched with features including the LoadPrediction and the MailSending module, the support for more OCPP commands and the real-time connection with the DSS. Most importantly, after minor changes in the code, the backend was successfully integrated with the charging stations used in the Greek demo, through an identical charger installed at the PPC Innovation Hub. The platform's frontend was also enriched with a series of new features for both common users (EV drivers) and administrators (CPOs). The former can now see the capacity and tariff schedule per charging station and manage their profile information, while the CPOs are now equipped with tools that enable them to manage ChargePoint, tariff, transaction, and account information.

Regarding the hardware infrastructure, we described the EV provided by Aiglon/Citroen and the new charging station that were used for preliminary, offline tests with the platform. We also elaborated on the remaining steps for the electrification of the installed chargers as well as on two core aspects of user participation: (i) the questionnaire that will be used for eliciting user feedback about the use of the O-V2X-MP platform and the overall user experience of demo participants, and (ii) the user engagement strategies that will target both the public and colleagues from Greek partners.

Below, we explain the next steps in the implementation of the Greek demo and the risks that may hinder their successful completion.

7.1 Risk Management

Table 4 lists the risks that may arise in the subsequent implementation steps of the Greek demo. Each risk is associated with a mitigation action that minimizes the impact upon risk materialization.

Table 4. Analysis of the risks involved in the further steps of the Greek demo.

Risk	Mitigation action(s)
Integration of the public charging stations at the Kropia Municipality with the O-V2X-MP platform.	The integration of the O-V2X-MP platform with the selected model of EV chargers has been accomplished through the identical charging station installed at the PPC Innovation Hub. The deployment of the public charging stations has been completed, but the last steps for their electrification are still pending. According to the plan, the electrification of the public charging stations and their integration with the O-V2X-MP will be accomplished by the end of February 2025 (M33).
Lack of sufficient O-V2X-MP platform users. Lack of sufficient user data.	A comprehensive and multi-faceted strategy has been devised to maximize user participation in the Greek demo. Two user groups are targeted: colleagues from the involved project partners (i.e., PPC, HEDNO, and Aiglon/Citroen) and the public. Multiple activities will target each user group, from emails to social media campaigns. Emphasis will be placed on clarifying how simple it is to use the O-V2X-MP platform and the demo chargers, along with the advantages

	for the participants (e.g., free charges). PPC will also move the O-V2X-MP platform to its corporate cloud infrastructure to ensure the high availability, minimizing the downtimes that might discourage users.
Longer development cycles for the algorithms implementing the scenarios of BUC4 and BUC5.	Multiple algorithms for each scenario will be developed and tested. This effort is already in progress, focusing on established algorithms from the literature with open-source implementation. These algorithms will be integrated into the O-V2X-MP platform, laying the ground for extending them with novel ones of higher performance.
Limited availability of EV chargers, due to hardware failures, damages, vandalism etc.	PPC will fully exploit the 5-year guarantee that was provided by the vendor of the charging points. PPC will also continue its collaboration with the subcontractor that installed the charging stations, ensuring that damages are repaired as soon as possible.

7.2 Next steps

In the context of Task 8.4, a series of activities will focus on improving the infrastructure presented above. Starting with the O-V2X-MP platform, we will improve both the backend and the frontend, with a focus on enhancing functionality, user experience, and operational efficiency.

Regarding the backend, efforts will focus on integrating the five double public chargers into the platform, ensuring stable 4G communication. To minimize downtimes, the O-V2X-MP will migrate to the PPC corporate cloud, taking special care to ensure its robustness and low response time when accessed by multiple users at the same time. The backend will also be enriched with algorithms that support the demand response scenarios of BUC4 [5] and with algorithms that serve BUC5 [5], distributing the available capacity among the active charging sessions through advanced scheduling. To provide the platform users with more accurate time estimations, we will also develop algorithms that estimate EV charging times based on weather conditions, battery status, and historical data. Finally, administrators will be equipped with tools for the real-time monitoring and management of the connection with the DSS.

The frontend will undergo a series of upgrades to improve user interaction and streamline operations. Transitioning the platform to a single-page application will provide a seamless, modern experience for users. A key enhancement will be the redesign of the charger map view, shifting from charge point representation to individual connector representation. This will eliminate confusion caused by grouping multiple connectors under the same pin on the map and will offer detailed pop-ups displaying connector-specific information such as address, status, tariff price, capacity, and bookmarking options. Additional features will include a reservation timetable that factors in user-selected time, required kW, or other charge options. These changes will provide users with clearer insights into connector availability and will improve their ability to plan charging sessions efficiently. Moreover, the frontend will offer customizable map rendering options, enabling users to view all chargers/connectors, only available chargers/connectors, or bookmarked chargers/connectors.

On the DSS side, the database schema will be finalized to store information from LV monitoring tools, while new algorithms will detect Photovoltaic (PV) overproduction and transformer congestion for BUC4 and BUC5 [5]. A comprehensive grid tariff scheme will further optimize DSS operations.

Overall, these improvements aim to support smarter charging operations, efficient grid management, real-time data exchange, and robust predictive tools. These features are crucial for supporting the BUCs of the Greek demo.

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