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Deliverable D5.6
APIs and APPs allowing V2X user interaction

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Disclaimer

This document has been produced in the context of the EV4EU[1] project. Views and opinions expressed in this document are however those of the authors only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the grating authority can be held responsible for them.

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[1] https://ev4eu.eu/

Executive Summary

The present deliverable D5.6 “APIs and APPs allowing V2X user interaction” focuses on the graphical user interface, i.e., the frontend, of the O-V2X-MP platform that has been developed by PPC in the context of the Task 5.7. It accompanies the source code that has been publicly released through the project’s GitHub account[2]. To facilitate the use and understanding of the source code, the deliverable provides a high-level overview of the functionalities offered by the first version of the platform’s frontend.

More specifically, the frontend consists of a dashboard that supports two different types of users:

- The administrators, who are responsible for the management of a network of charging points.
- The end users, i.e., the EV drivers, who are interested in finding the nearest available charging stations that offer the lowest prices.

We elaborate on the actions that are common to both types of users as well as on the operations that are specific to each one. It is also explained how these actions and their implementation cover the functional and the non-functional requirements that have been specified in the previous tasks of WP5 as well as in deliverable D3.2. Special care will also be taken to enrich the dashboard with more advanced operations in the context of WP8 to accommodate the smart charging scenarios of the Greek pilot. These future extensions are detailed at the end of the present deliverable.

Note that detailed instructions for running and testing the dashboard are provided through the dedicated code repository.

The deliverable D5.6 has been prepared and edited by PPC.

[2] https://github.com/EV4EU/ov2xmp_dashboard

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Acronyms

API	Application Programming Interface
CDR	Charge Detail Record
CPO	Charge Point Operator
CRUD	Create, Read, Update, Delete
CSMS	Charging Station Management System
DSO	Distribution System Operator
DSS	DSO Support System
eMSP	eMobility Service Provider
EV	Electric Vehicle
FTP	File Transfer Protocol
GUI	Graphical User Interface
HTTP	HyperText Transfer Protocol
JSON	JavaScript Object Notation
JWT	JSON Web Token
OCA	Open Charge Alliance
OCPI	Open Charge Point Interface
OCPP	Open Charge Point Protocol
O-V2X-MP	Open V2X Management Platform
RES	Renewable Energy Sources
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything
WP	Work Package

1 Introduction

1.1 Scope and Objectives

In the context of Task 5.5, PPC developed the backend of the O-V2X-MP platform, an open-source, web-based information system for managing a network of charging points based on the Open Charge Point Protocol (OCPP). An overview of its architecture and functionalities was provided in Deliverable D5.5.
In this deliverable, it is presented the graphical user interface (GUI) that facilitates the use of the O-V2X-MP backend by two types of users:

1. The charging point operators, who act as administrators, being responsible for the remote control, the monitoring, and the maintenance of charging stations.
2. The Electric Vehicle (EV) drivers, who are common users that want to identify and navigate to the most suitable charging station in terms of time and financial cost.

The source code of the O-V2X-MP GUI has been publicly released at https://github.com/EV4EU/ov2xmp-gui. This document explains how the code can be used to set the frontend running and elaborates on how the implementation addresses a set of functional and non-functional requirements. The latter are satisfied by the operations that correspond to each type of user. Each operation is illustrated through a screenshot of the corresponding window, thus demonstrating the intuitive interface that is suitable both for novice and expert users, offering complex operations without requiring any prior experience. For this reason, only the minimum input is required from the users in each operation, e.g., when an EV driver is searching for the most suitable EV charger or when the administrator updates the tariffs. This minimal approach allows for meeting the non-functional requirements of the frontend, such as its scalability and the high efficiency (i.e., low response time).

1.2 Structure

The document is divided into seven sections. Section 1 introduces and describes the present deliverable. Section 2 briefly describes the OCPP protocol, which defines the communication between charging stations and the O-V2X-MP platform. It also describes the main characteristics of the O-V2X-MP backend, on top of which the dashboard is deployed. Section 3 provides an overview of the dashboard's technical characteristics along with the two main types of users that are supported, i.e., the administrators and the EV drivers. Section 4 elaborates on the operations that are shared by both types of users, while sections 5 and 6 elaborate on the exclusive operations of the EV drivers and the administrators, respectively. Note that special care is taken to illustrate each operation through a screenshot of the corresponding window. Finally, Section 7 presents the overall conclusions and delves into the future extensions that will be carried out in the context of WP8 (i.e., the Greek demo).

1.3 Relationship with other deliverables

The present deliverable relies on all previous deliverables of WP5. More specifically, it is based on the requirements specified in D5.1 "Information Exchange needs to enable different UCs" [1] as well as on the V2G communication architecture and the standardization activities described in D5.2 "Standardization gap analysis for new V2X related Business Models" [2]. D5.6 also implements the frontend described in the coarse-grained architecture of D5.3 "High-level design of Open V2X Management Platform (O-V2X-MP)" [3], while the user management functionalities of the frontend

leverage the cybersecurity mechanisms described in D5.4 “Cyber-security and Privacy analysis for V2X services” [4]. Finally, the frontend described in D5.6 operates on top of the backend described in D5.5 “Open V2X Management Platform” [5], while addressing the functional requirements defined in D3.2 “Apps and Tools design principles promoting EVs and V2X adoption” [6].

2 Preliminaries

As explained in D5.5, the O-V2X-MP platform supports the two main versions of the OCPP protocol, namely versions 1.6 and 2.0.1. The latter is indispensable for the smart charging and Vehicle-to-Everything (V2X) scenarios of the EV4EU demonstrators. In the following, we provide a brief overview of the OCCP protocol and discuss the main aspects of the O-V2X-MP backend that are used by the frontend operations presented in sections 3 to 6.

2.1 Open Charging Point Protocol

The OCPP is a standardized communication protocol designed to facilitate seamless data exchange between EV chargers and a Charging Station Management System (CSMS). Developed and maintained by the Open Charge Alliance (OCA), OCPP has been established as an open-source protocol, ensuring vendor neutrality and fostering interoperability within the EV charging infrastructure.
In summary, OCPP defines a message structure and a set of functionalities that govern the communication flow between EV chargers and the CSMS. This enables:

- *Monitoring and Control*: The CSMS can remotely monitor the status of EV chargers, including power delivery, connector availability, and fault conditions. Additionally, control commands can be issued to initiate, stop, or schedule charging sessions.
- *Metering and Billing*: OCPP facilitates the exchange of energy consumption data between the EV chargers and the CSMS, enabling accurate metering and subsequent billing of EV drivers.
- *Plug & Play Compatibility*: An OCPP-compliant EV charger can seamlessly integrate with any OCPP-compliant CSMS, regardless of the specific vendor.

The current iteration, OCPP 2.0.1, represents a significant advancement over previous versions. It introduces enhanced functionalities encompassing improved device management, advanced transaction handling, and a wider range of use cases catering to the evolving needs of the EV charging landscape.
An overview of the evolution of OCPP, from its introduction in 2009 to its latest update in 2023, is presented in Figure 1. Below, the two main versions, 1.6 and 2.0.1, which are supported by the O-V2X-MP platform are presented.

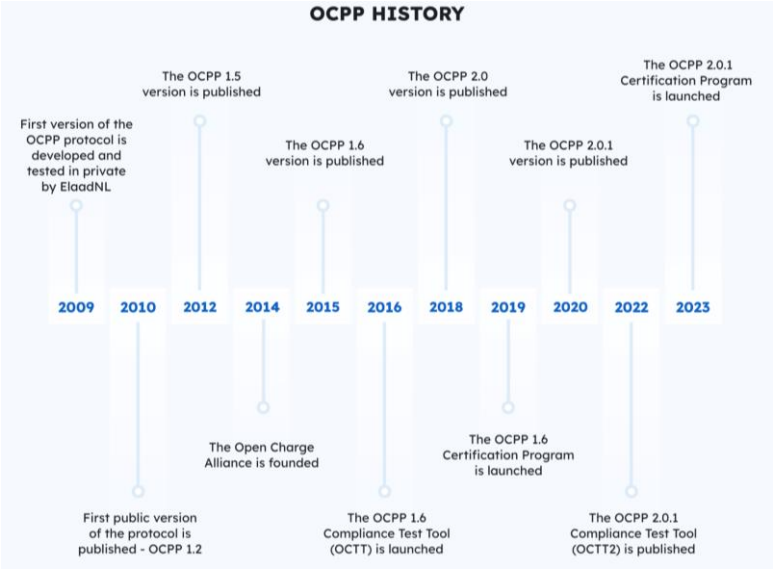


Figure 1. Historical overview and versions of the OCPP protocol [7].

2.1.1 Version with OCPP 1.6

OCPP 1.6, released in 2015, is a pivotal version of OCPP [8]. While superseded by OCPP 2.0.1, OCPP 1.6 remains widely deployed due to its robust feature set, established market presence as well as its low complexity.
O-V2X-MP supports all OCPP 1.6 operations. In more detail, the following OCPP 1.6 messages, coming from the EV charger, can be processed by the O-V2X-MP:

- *BootNotification*: It runs during the initiation of the charging station to signal its availability to the CSMS and to provide information about its capabilities.
- *Heartbeat*: It is periodically transmitted by the charging station to confirm its operational status and connection to the CSMS.
- StatusNotification: It notifies the CSMS about the status of the charging station.
- *Authorize*: It is a command issued by the charging station to the CSMS whenever a customer plugs their EV to initiate the customer authorization process.
- *StartTransaction*: It initiates the charging session, after user authorization, conveying details about the charger, the customer, and the charging parameters.
- *StopTransaction*: It notifies the CSMS about the termination of the charging session, including relevant details.
- *MeterValues*: It retrieves the current energy consumption of the charging station.
- Notification messages like *DiagnosticsStatusNotification* and *FirmwareStatusNotification*.

Moreover, the O-V2X-MP can send the following OCPP 1.6 messages:

- *Reset*: It is used for restarting an EV charger.
- *RemoteStartTransaction*/*RemoteStopTransaction*: Used by the EV user to start and stop an EV charging transaction through an app (e.g., a mobile app).
- *ReserveNow*: Issued by the CSMS, on behalf of the EV user, to reserve an EV charger connector.
- *CancelReservation*: Used to cancel a reservation.
- *ChangeAvailability*: Used by the Charge Point Operator (CPO) to manually change the availability of an EV charger (e.g., to render it unavailable for preventing EV users from using it).
- *ChangeConfiguration*: It is used for changing a configuration parameter on the targeted EV charger.
- *ClearCache*: Clears the authorization cache of the targeted EV charger.
- *UnlockConnector*: Manually unlocks an EV charger connector.
- *GetConfiguration*: Retrieves the value of one or multiple configuration parameters from an EV charger.
- *GetCompositeSchedule*: Retrieves the composite schedule of the given duration.
- *ClearChargingProfile*: Deletes a charging profile from the targeted EV charger.
- *SetChargingProfile*: Sets a charging profile to the targeted EV charger and connector.
- *GetDiagnostics*: Instructs the EV charger to upload log files to a specific HyperText Transfer Protocol (HTTP) or File Transfer Protocol (FTP) server.
- *UpdateFirmware*: Instructs the EV charger to download a firmware upgrade from a specific HTTP or FTP server.
- *TriggerMessage*: Instructs the EV charger to send a specific OCPP message to the CSMS.
- *GetLocalListVersion*: Retrieves the version of the local authorization list installed on the EV charger.
- *SendLocalList*: Sends a new local authorization list to the specified EV charger.

2.1.2 Version with OCPP 2.0.1

This is the latest version of OCPP, released in 2020 [9], conveying the numerous enhancements and additional functionalities in terms of enhanced device management, support for Plug & Charge, communication reliability, better security with integrated authentication and encryption support, and future-proof design.

At the time of writing this deliverable, no compliant OCPP 2.0.1 EV chargers nor fully featured simulators were available. Therefore, the implementation of OCPP 2.0.1 has been limited into the following operations: *BootNotification*, *Heartbeat*, and *StatusNotification*.

2.2 Backend Overview

As described in deliverable D5.5, the O-V2X-MP platform integrates multiple containers and components (according to the C4 model terminology[3]), which exchange data and collaborate with each other to manage the EV charging infrastructure and complete user tasks. Figure 2 depicts the component diagram of O-V2X-MP, which contains a short description per component (more details are provided in deliverable D5.5).

[3] https://c4model.com/

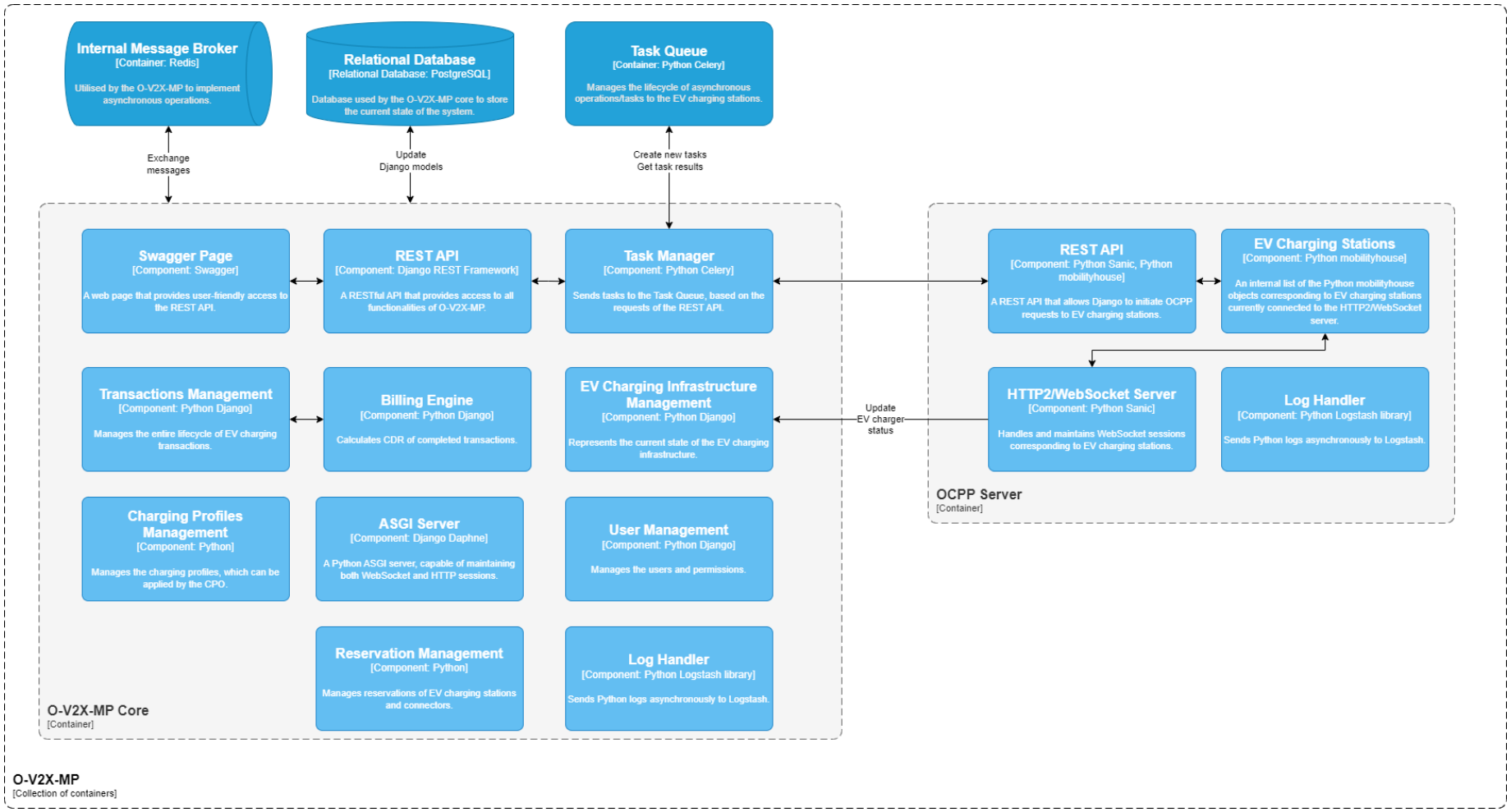


Figure 2: The Container Diagram of the O-V2X-MP platform.

2.2.1 O-V2X-MP Class Diagram

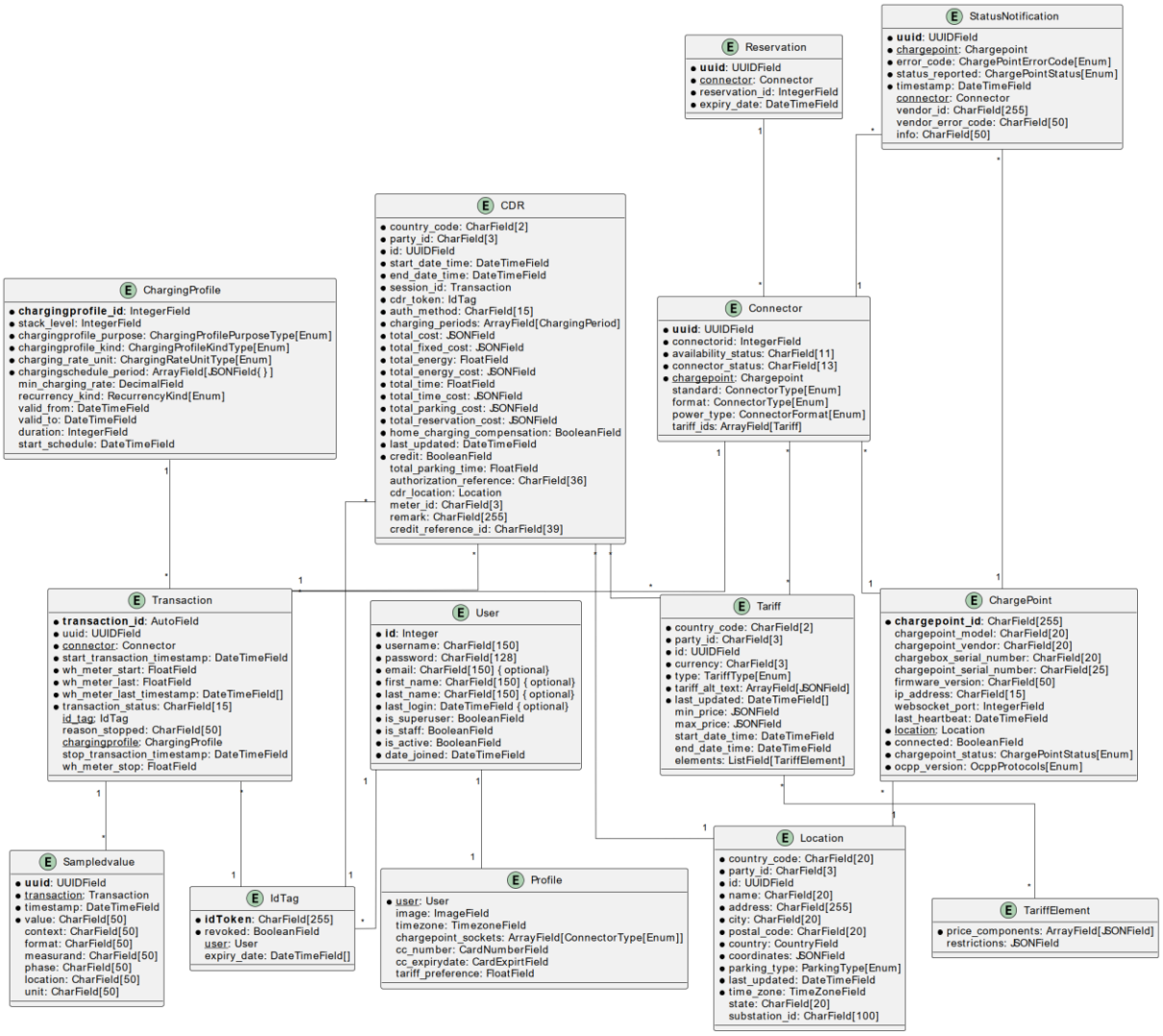


Figure 3: The class diagram of the O-V2X-MP platform.

Figure 3 depicts the updated class diagram of O-V2X-MP (mentioned as Entity-Relations diagram in deliverable D5.5). In summary, compared to D5.5, these are the main additions that have been introduced:

- The *Tariff* and *TariffElement* entities have been added to represent the tariffs that can be applied to EV charger connectors, determining the billing of the charging transactions. Their definition follows the Open Charge Point Interface (OCPI) 2.2.1 specification[4].
- The Charge Detail Record (CDR) entity has been introduced to model a CDR, i.e., the "invoice" that the CPO sends to the e-Mobility Service Provider as a compensation for a charging transaction by an EV user. The CDR definition follows the OCPI 2.2.1 specification.

[4] https://evroaming.org/app/uploads/2021/11/OCPI-2.2.1.pdf

- Additional attributes have been added to the Connector, namely the “standard”, “format”, “power_type” and “tariff_ids” attributes. The last attribute allows connectors to be associated with tariffs. It should be noted that these attributes follow the OCPI 2.2.1 specification.
- The “chargepoint_sockets” and “tariff_preferences” attributes have been introduced to the user’s profile. The former is utilised by the frontend to show only the compatible connectors to the EV user for charging, while the latter can be utilised for notifying the EV users about tariff discounts.
- The Location entity has been extended according to the OCPI 2.2.1 specification.

2.2.2 REST API

The “REST API” component provides an Application Programming Interface (API) that allows external applications to utilise the HTTP to access and interact with the resources of the O-V2X-MP backend. The REST API is built via the Django Rest Framework, a software library that parses the source code of the REST API endpoints and automatically generates its OpenAPI schema. The REST API component is also used by the O-V2X-MP frontend as the main interface for interacting with the backend.
For user-friendly interaction, a Swagger page exists, which is the only “frontend” web page rendered and provided by the backend. This page parses and visualises the OpenAPI schema prepared by the Django Rest Framework, enabling users and developers to access the entire REST API as well as to inspect the OpenAPI schema and experiment with the available requests. This page is instrumental in facilitating developers to learn how to operate the REST API, how to issue the HTTP requests and how to process the HTTP responses.
The following screenshots summarise the operations available through the O-V2X-MP REST API:

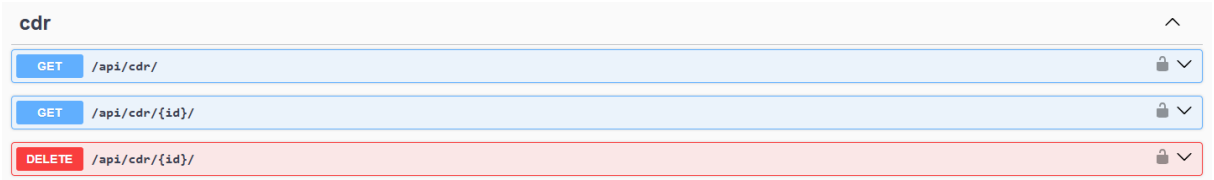


Figure 4: The CDR Operations provided by the O-V2X-MP backend.

Figure 4 depicts the operations available for CDRs. These are JavaScript Object Notation (JSON) documents that are generated after a transaction is completed. Administrator are allowed to retrieve and delete CDRs, but cannot create or modify CDRs, since they are created automatically by the billing engine.

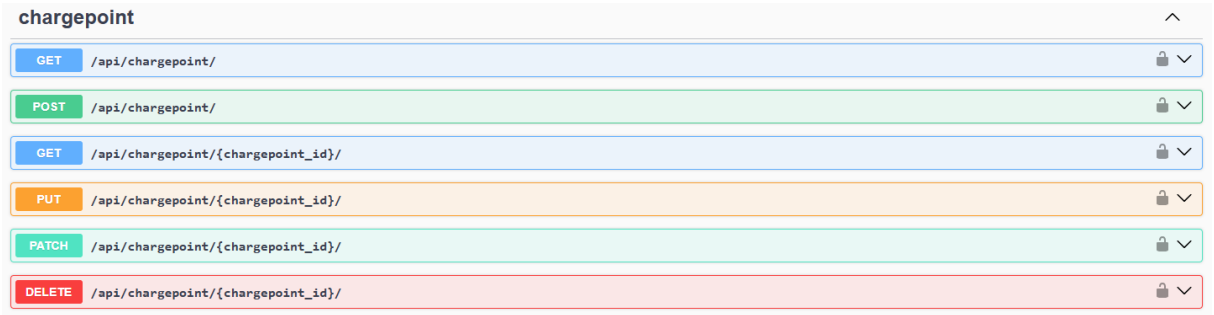


Figure 5: The chargepoint operations provided by the O-V2X-MP backend.

Figure 5 depicts the available operations for charge points (EV chargers). The administrator can perform all the standard CRUD (Create, Read, Update and Delete) operations on EV chargers, however, their attributes are changed automatically by the backend, when the EV charger connects to the OCPP server.

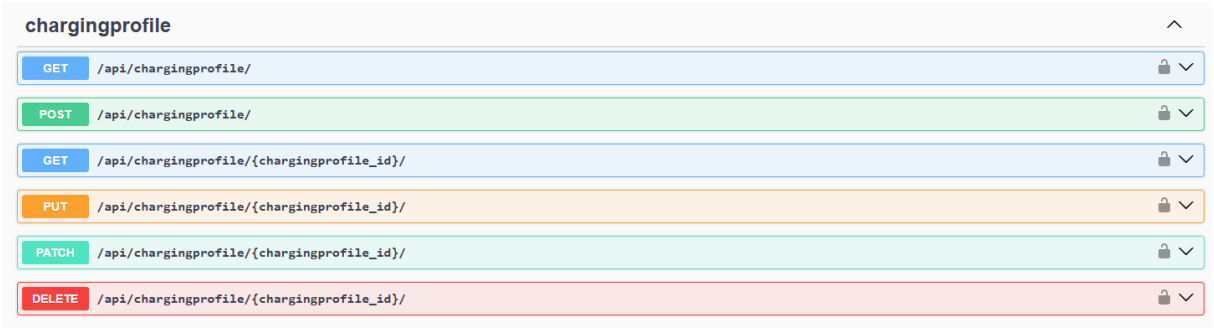


Figure 6: The charging profile operations provided by the O-V2X-MP backend.

Figure 6 depicts the operations available for charging profiles. The administrators can perform CRUD operations on them.

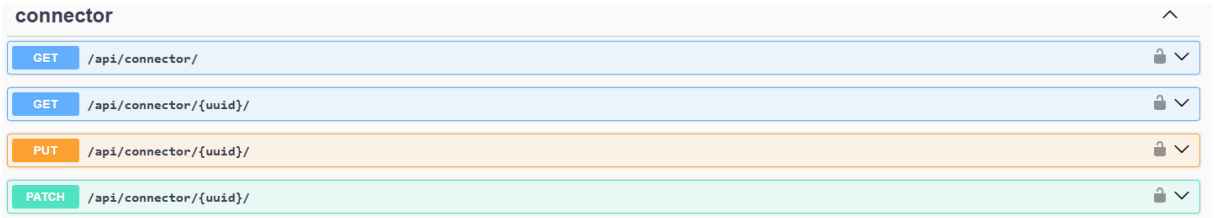


Figure 7: The connector operations provided by the O-V2X-MP backend.

Figure 7 depicts the operations available for connectors. The administrator can retrieve the connectors, modify their attributes (including the socket type, the power type etc), and associate them with tariffs. However, the administrator cannot delete or create connectors: they are deleted automatically if the associated EV charger is deleted and are created automatically when an EV charger sends *StatusNotification* messages.

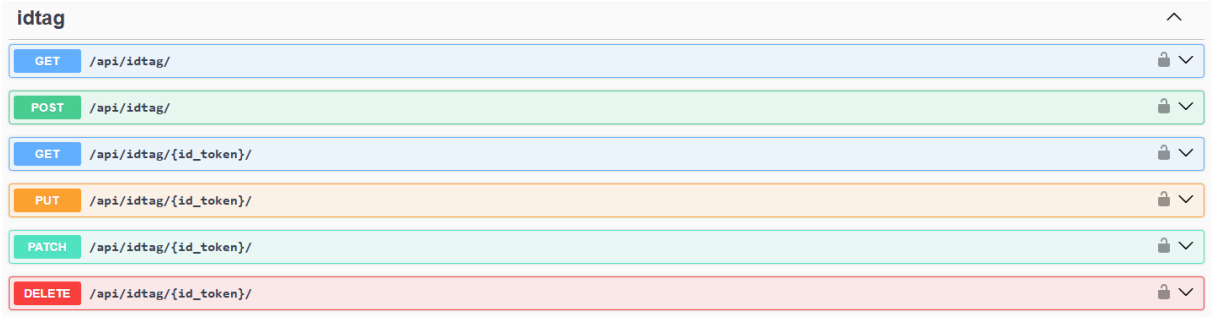


Figure 8: The IdTag operations provided by the O-V2X-MP backend.

Figure 8 depicts the operations available for ID tags. Administrators can perform CRUD operations on them.

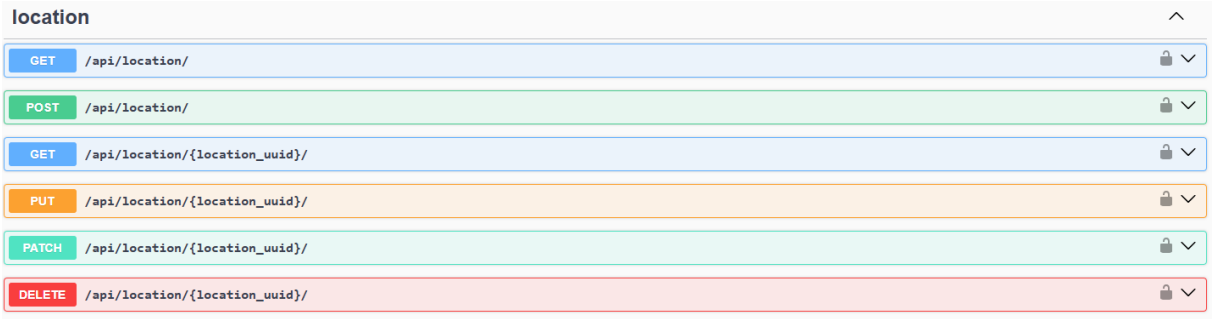


Figure 9: The location operations provided by the O-V2X-MP backend.

Figure 9 depicts the operations available for locations. Administrators can perform CRUD operations on them.

Figure 10: The OCPP 1.6 operations provided by the O-V2X-MP backend.

Figure 10 depicts the OCPP 1.6 operations an administrator can initiate to an EV charger. Every OCPP operation is initiated via a POST request, where the ID of the EV charger must be specified at the URL path. If the OCPP operation is initiated with the sync option disabled, a task is created which can be queried by the administrator to inspect the status and return information from the OCPP operation.

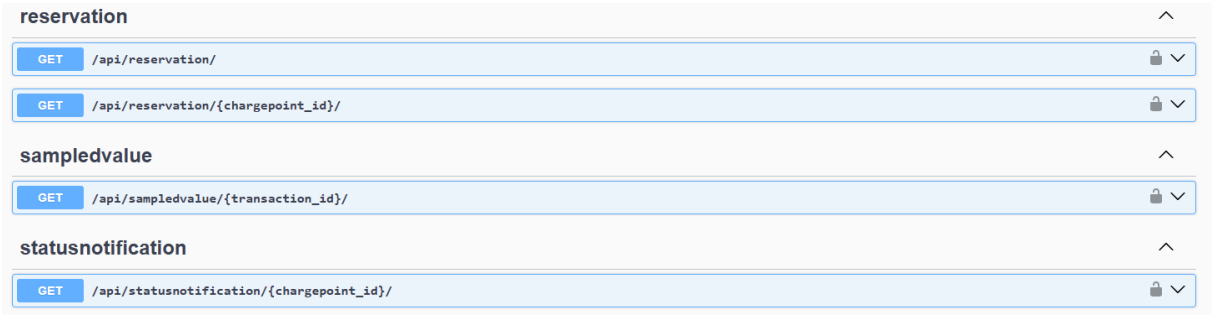


Figure 11: The reservation, *SampledValues* and *StatusNotification* operations provided by the O-V2X-MP backend.

Figure 11 depicts the available operations on reservations, *SampledValues* and *StatusNotification*. The administrator has read-only access on them. It should be noted that reservations are created by the administrator only through the corresponding OCPP operation (Figure 10).

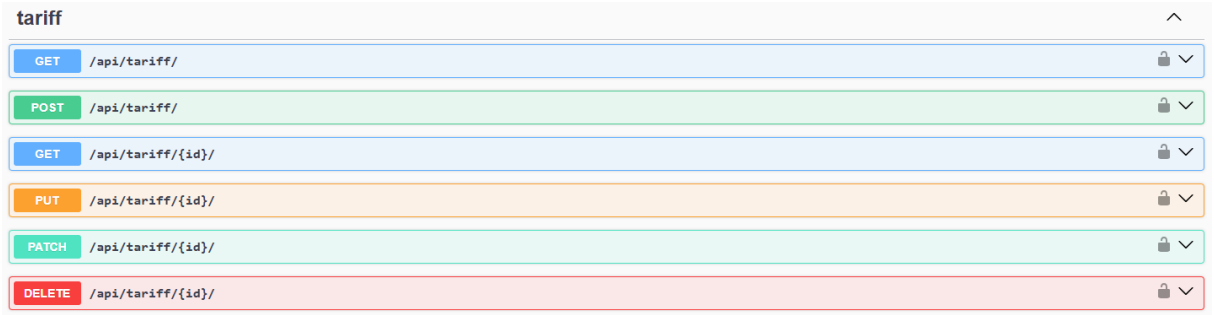


Figure 12: The *Tariff* operations provided by the O-V2X-MP backend.

Figure 12 depicts the operations available for tariffs. Administrators can perform CRUD operations on them as well as to add tariff elements on them.

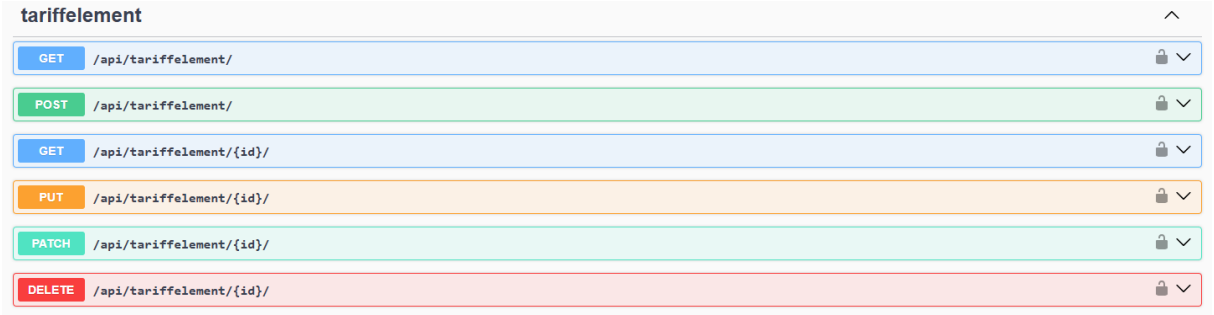


Figure 13: The *TariffElement* operations provided by the O-V2X-MP backend.

Figure 13 depicts the operations available for tariff elements. Administrators can perform CRUD operations on them.

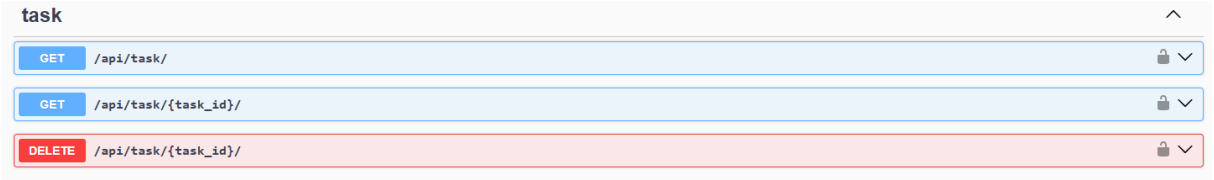


Figure 14: The task operations provided by the O-V2X-MP backend.

Figure 14 depicts the operations available for tasks. The administrator can retrieve or delete tasks, but cannot create them, because they are automatically created by the backend when the user initiates an asynchronous OCPP operation.

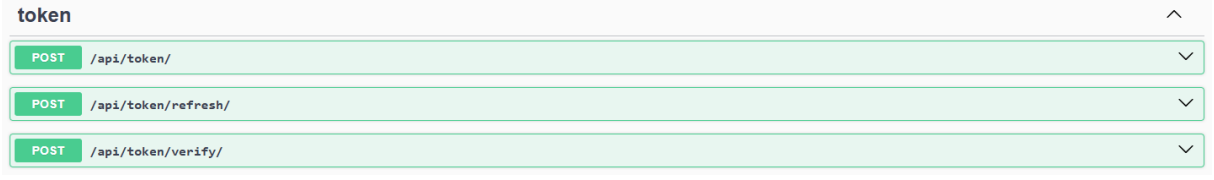


Figure 15: The authentication token operations provided by the O-V2X-MP backend.

Figure 15 depicts the operations available for authentication token. Through POST requests, frontend users provide their login credentials and receive a JSON Web Token (JTW). This endpoint is used by the frontend for implementing the login mechanism.

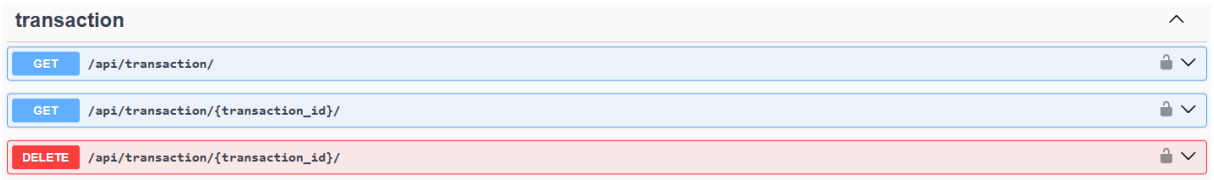


Figure 16: The transaction operations provided by the O-V2X-MP backend.

Figure 16 depicts the operations available for charging transactions. Administrators can retrieve or delete transactions, but cannot create them, because they are automatically created by the backend when an EV charger signals the starting of a transaction.

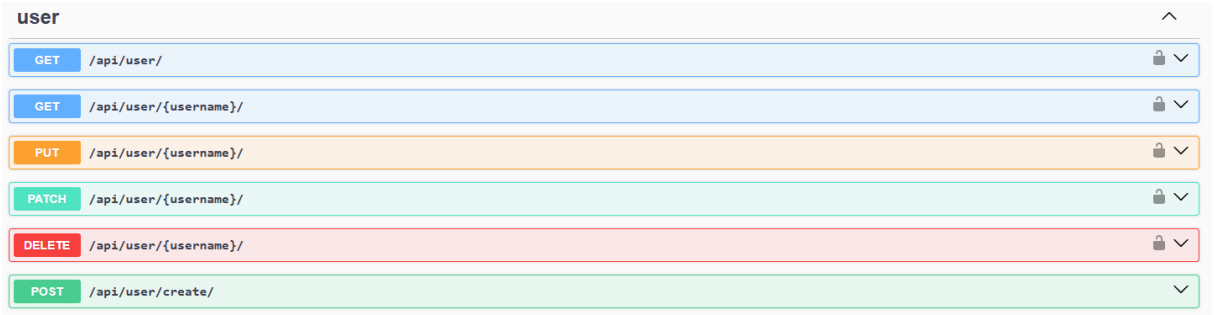


Figure 17: The user operations provided by the O-V2X-MP backend.

Figure 17 depicts the operations available for user management.

For all the aforementioned endpoints, the REST API client can apply search and filtering. In particular, through GET parameters, the results (rows) can be filtered in order to match specific criteria. Moreover, the GET parameter `fields` can be used as a GET parameter to specify the features (columns) that the client needs from the queried object. The combination of row and column filtering aims to optimise the REST API requests and reduce the computational overhead on the backend.

3 Frontend Overview

The frontend was designed and developed such that it meets the following **non-functional requirements**:

- *Scalability* with respect to the number of users and the number of integrated charging stations.
- *High efficiency* (i.e., low run-times) so that all operations are carried out without delays.
- *Modularity* to enhance the reuse of core components (e.g., the curves corresponding to tariffs and capacity limits). This reduces the code base and facilitates its maintenance.
- *Extensibility* to reduce the development effort and time for adding new functionalities that are necessary for the smart charging and V2X scenarios of the EV4EU demos.
- *Usability* in the sense that it enables users and administrators to perform any operation with a few clicks. Special care should be taken to support novice EV drivers that have no expert knowledge.

Note that the first two requirements are met through a zero-intelligence interface, i.e., by moving all complex functionalities (i.e., joins between different database tables) to the backend.

3.1 Technical Characteristics

The O-V2X-MP dashboard is a dynamic and multifunctional web application designed that leverages the **Node.js** runtime environment[5] along with the **Vue.js** JavaScript framework[6]. These frameworks were combined through the VRISTO[7] template. To cover all functional requirements, the dashboard incorporates the following libraries:

- Leaflet[8] for rendering maps,
- Leaflet Routing Machine[9] for adding routing capabilities,
- OpenWeatherMap[10] to display weather information on the map,
- Axios[11] for handling HTTP GET/POST requests, and
- the Advanced Encryption Standard (AES) library from CryptoJS[12] for encrypting sensitive content in GET/POST methods using Axios.

By integrating these libraries and frameworks, the EV4EU dashboard ensures a robust, secure, and user-friendly experience.

3.2 Installation Guide

The O-V2X-MP Dashboard can be locally launched through the following steps:

- Download the code from the project's Github repository.
- Extract the files to a preferred folder.
- Download and install Node.js and npm by following the instructions at https://nodejs.org/en.

[5] https://nodejs.org/en
[6] https://vuejs.org/
[7] https://vristo.sbthemes.com
[8] https://leafletjs.com
[9] https://www.liedman.net/leaflet-routing-machine
[10] https://openweathermap.org
[11] https://axios-http.com
[12] https://www.npmjs.com/package/crypto-js

- Open a command prompt and execute:
  - npm install -g @vue/cli
  - npm install axios
  - npm install cors
  - npm install leaflet
  - npm install --save leaflet @vue-leaflet/vue-leaflet
  - npm install crypto-js
  - npm install --save leaflet-routing-machine
  - npm install @fortawesome/fontawesome-svg-core @fortawesome/free-solid-svg-icons @fortawesome/vue-fontawesome
  - cd your_preferred_folder
  - npm run dev
- Open a browser and navigate to the "Sign In" window, which should be available at: http://localhost:5173/auth/boxed-signin.
- To log into the system, use the credentials of a bult-in test user:
  - Username:USER12345
  - Password: USER12345

Note that the O-V2X-MP dashboard automatically connects to the O-V2X-MP backend, which runs at: http://iotlab.trsc-ppc.gr:8088/api. The proper functionality of the dashboard requires that there are no network restrictions to this connection.

3.3 Functional requirements

The O-V2X-MP dashboard is intended to serve two types of accounts:

1. the *EV drivers,* and
2. the *CPOs*.

For short, the former accounts are simply called *users* and the latter *administrators*. In this context, the functional requirements are distinguished into three categories: those targeting both user types, those applying exclusively to EV drivers and those crafted for CPOs. We elaborate on each category in the following.

3.3.1 Generic functionalities

The following operations are common to both administrators and common users:

- Account authentication: the basic login functionality for accessing the platform.
- Charging station overview: any account can view and select any of the available charging stations to inspect its precise location and technical characteristics as well as its tariff and capacity at any given day.
- Weather prediction: the map visualizing the location of the charging stations can be enriched with a prediction of weather conditions, which typically affect the capacity of the battery and of the charging time.

These generic operations complement the type-specific ones described below, ensuring a holistic set of operations for both user types.

3.3.2 User functionalities

The main operations offered to EV drivers are the following:

- Sign Up: users can easily register to the platform for free.
- Routing Options: users can navigate to the closest and cheapest charging stations.
- User history: users can observe their charging statistics through intuitive diagrams.
- Preferences: users can declare and manage personal preferences about
    - charging preferences: users can specify characteristics of their EV such as the capacity of its battery and the connector type, which determines their charger characteristics.
    - payment preferences: users can set the maximum charging cost (per kWh) so that EV charging stations above this cost are automatically excluded.

  These preferences allow for customizing all dashboard operations accordingly, e.g., in line with the user's EV characteristics.

These functionalities are provided through a streamlined and user-friendly interface tailored to each EV owner, thus optimizing her charging experience.

3.3.3 Administrator functionalities

The main operations offered to CPOs are the following:

- Charging station management: CPOs can view, modify, add and delete entire charging stations as well as individual sockets (i.e., connectors).
- Real-time monitoring: CPOs have access to the real-time status and diagnostics information per charging station.
- Tariff management: CPOs can adjust tariffs in real-time.
- DSO integration: CPOs are responsible for maintaining a real-time connection with Distribution System Operators (DSOs) to support the smart charging scenarios of the EV4EU demos (e.g., the demand-response and the dynamic capacity contracts of the Greek demo).
- User management: CPOs can create, view, update and delete user accounts.

These functionalities are designed to facilitate the efficient management and maintenance of the O-V2X-MP backend through a reliable and user-friendly interface.

4 Generic Functionalities

In this section, we delve into the core functionalities of the O-V2X-MP dashboard, which are shared by both types of accounts.

4.1 Login Form

Registered users can easily access the O-V2X-MP dashboard by providing the credentials they declared during the registration (their email address corresponds to their username). The login form appears in Figure 18:

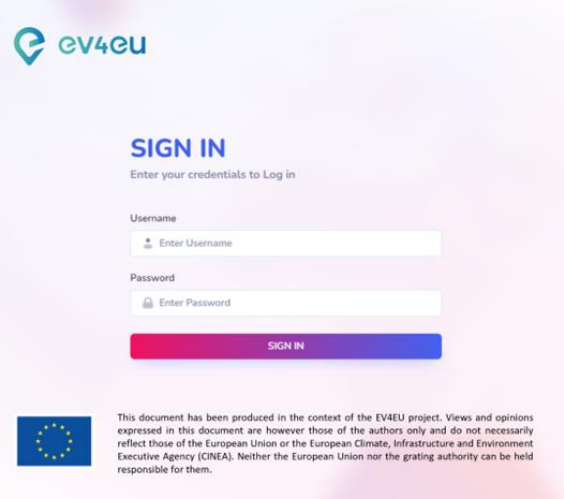


Figure 18. The Login Form.

Note that password reset is also supported. More specifically, in case a user has forgotten her password, she can click on the "Forgot Password?" option under the Sign In button. The screen shown in Figure 19A appears to automatically send a password recovery email to the address specified by the user. The email contains a link to the menu shown in Figure 19B, where the user can provide a new password.

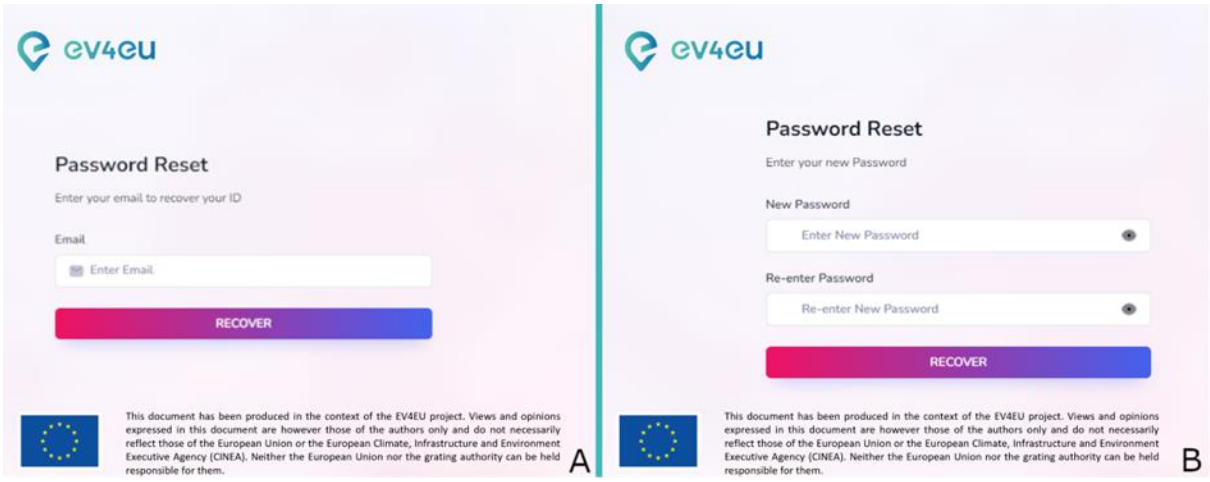


Figure 19. The password reset functionality.

4.2 View Charging Stations

The core functionality of the O-V2X-MP frontend is the visualization of EV chargers on the map. To this end, the central, largest part of the screen is occupied by a map. The map is centralized to the location of the user, as it is determined by the (approximate) information provided by the browser based on the client IP. Every charger near this location is indicated through a marker, whose colour indicates its status:

- Green markers denote active charging stations.
- Orange markers indicate charging stations that are unavailable, i.e., occupied by another EV driver.
- Red markers denote charging stations that are out of order or out of capacity.

Note that users are not presented with charging stations that are incompatible with the preferences they have declared.
By clicking on a specific marker, the following information is provided to the user:

- The exact location of the charging station.
- The number of sockets.
- The type of sockets (e.g., CCS2)
- The nominal power of sockets (e.g., 22kW).

The corresponding interface is illustrated in Figure 20.

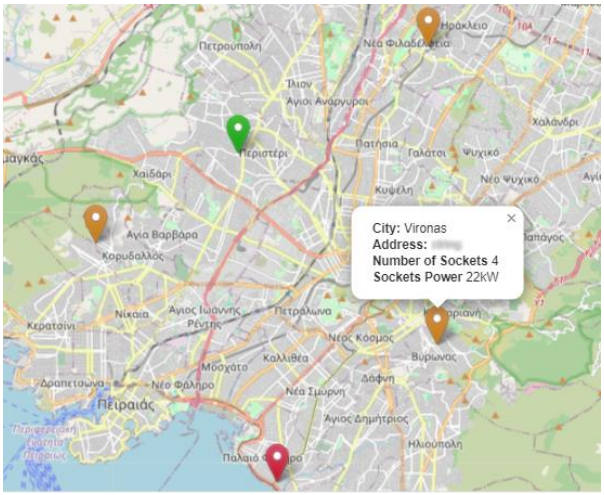


Figure 20. Charge point overview.

4.2.1 Daily tariff schedule

A critical aspect of each charging station is its tariff, which determines the overall charging cost. Tariffs are dynamic, because they depend on the power generation of renewables (RES). In demand response scenarios, the objective is to promote green charging, aligning the charging load of EVs with RES power generation. Whenever there is a reverse power flow, due to excessive power generation from solar and/or wind farms, the DSO identifies locations for price reductions that are then communicated to the O-V2X-MP platform, which adjusts the tariffs of the nearby charging stations accordingly. To accommodate this functional requirement, the O-V2X-MP dashboard presents the evolution of tariffs on a particular day as shown in Figure 21.

Figure 21. Example of the daily tariff schedule.

Note that Figure 21 uses time intervals of 1 hour. Note also that there is no solar power generation during night-time, hence the tariffs are reduced during daytime.

4.2.2 Daily capacity (Schedule)

Another critical and dynamic aspect of charging stations is their capacity. To reduce the constraints on the distribution system in cases with excessively high loads, the DSO can save capacity for other services by procuring and activating contracts with the CPO that reduce the capacity of specific charging stations for the day ahead or even in real-time (with a pre-determined cost). For example, this might involve halving the power of EV chargers (e.g., from 22kW to 11kW), which inevitably doubles the duration of the charging sessions. To inform users about the capacity of a particular charging station on a particular day, the following interface is used:

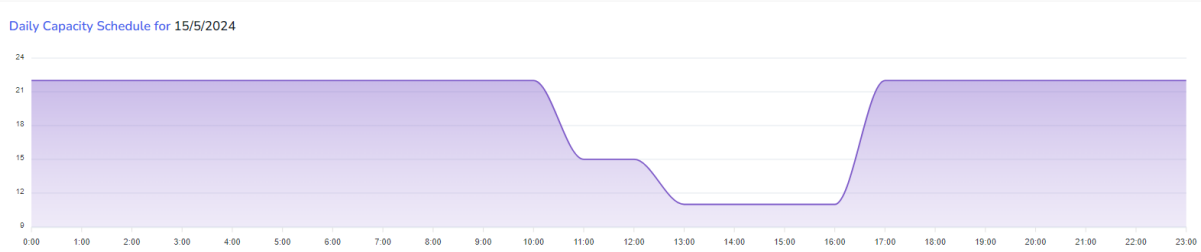


Figure 22. Example of the daily capacity schedule.

Similar to Figure 21, time intervals of 1 hour are used. Note that the capacity is reduced during peak hours.

4.2.3 Weather conditions

Another useful generic functionality is the provision of climate information, because weather conditions affect the battery performance and capacity, thus altering the charging time and the power requested by EV users. This information is extracted for free from OpenWeatherMaps[13] and is shown to users through the interface in Figure 23.

[13] https://www.openweathermap.org

Figure 23. The interface of the weather conditions.

5 User Functionalities

The operations available to EV drivers are explored in the following sub-sections.

5.1 Sign up Form

Before using the O-V2X-MP dashboard, the users must register themselves. To minimize the volume of sensitive information that is processed by the O-V2X-MP platform, the registration requires only the following information from the user:

- E-mail address
- Password
- First Name (optional)
- Last Name (optional)
- Tariff preference
- EV power type

Note that even though no personal information is required, the user content is stored in encrypted form, using the AES standard, which offers high levels of security. The menu shown to the user appears in Figure 24:

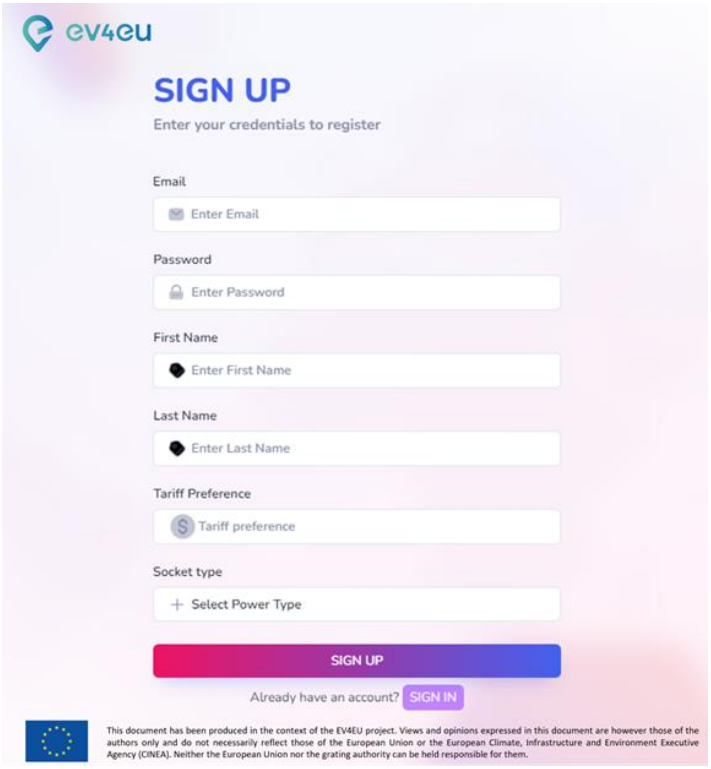


Figure 24. The sign-up form.

Note that the tariff preference indicates the maximum charging cost that the EV driver is willing to pay. Chargers with a higher cost are automatically excluded from the charging point overview in Figure 20. Note also that the power type should be filled in with the charging connector type of the user's EV (e.g., CCS2 or CHAdeMo).

5.2 User preferences

The window in Figure 25 allows for updating the information that is provided by the user during the sign-up, as shown in Figure 24. Note that all fields can be updated, except for the email, which acts as the unique identifier of user accounts.

Figure 25. The user preferences window.

5.3 Routing

The most common operation for an EV driver is looking for the most suitable charging station. Three characteristics of the available chargers determine this decision: their tariffs, their capacity and their location. The first two characteristics are provided through the interfaces described in Sections 4.2.1 and 4.2.2. For the third characteristic, the O-V2X-MP dashboard offers routing instructions between any two points indicated by the user: the start location can be selected either automatically, through the location lookup based on the IP address, or manually, by clicking on the desired location. Similarly, the destination location is selected by a subsequent click on the desired location that does not necessarily correspond to an EV charger. Alternatively, the user can type in an exact address in the Start and Destination fields respectively, as shown in the right part of Figure 26.

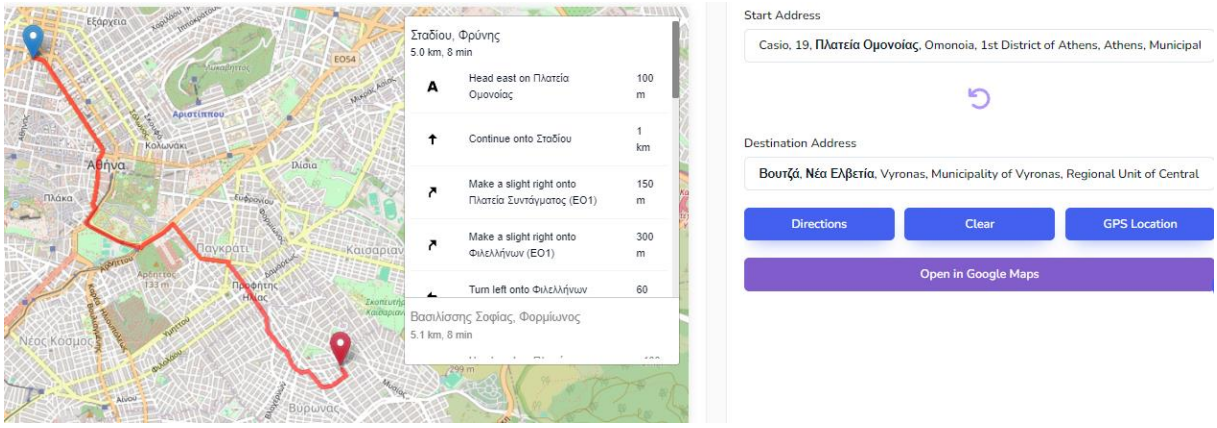


Figure 26. Example of routing.

As depicted in Figure 26, the routing instructions are quite detailed, include the overall distance and the estimated travelling time, thus facilitating users to plan their trip. Note also that O-V2X-MP facilitates the provision of live routing instructions through Google Maps[14]: after selecting the start and destination locations, the user simply presses the "Open in Google Maps" button, which initiates the GPS-based navigation.

[14] https://www.google.com/maps

5.4 Charging History

Charging history is instrumental for EV drivers that rely on public charging stations with varying prices. By monitoring their charging costs, they can budget for their mobility expenses and compare the costs across different stations or times of day in order to identify the most affordable options. In other words, understanding when and where charging is most cost-effective can help drivers to optimize their charging schedules. Moreover, a detailed charging history facilitates EV drivers to identify the root cause of charging issues that may arise, e.g., due to a faulty charger, a problem with the EV or its battery, or even an error in the charging settings.

To this end, the O-V2X-MP frontend provides users with the diagram in Figure 27, which displays the dates of all charging sessions along with the corresponding delivered energy. Note that the user will be able to tailor this diagram to the time period of interest.

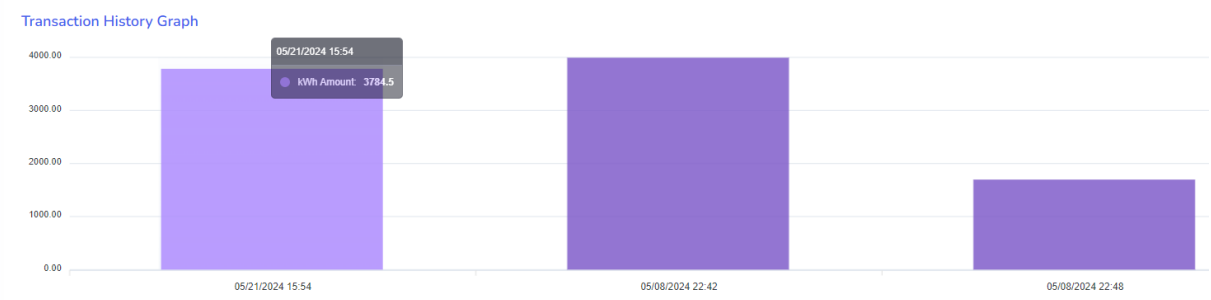


Figure 27. The personal charging history diagram.

6 Administrator Functionalities

In this section, the administrative operations available to CPOs are elaborated. It should be noted that there is no interface for registering administrators, unlike the sign-up form in Figure 24 for end users, because CPOs are added only through the O-V2X-MP backend for security reasons.

6.1 Update charging station information

CPOs are responsible for maintaining the information about the available charging points up to date. As explained in Section 2.2.2, this is automatically done to some extent, when the EV charger connects to the OCPP server. In many cases, though, this needs to be manually carried out. To this end, the O-V2X-MP dashboard offers the interface in Figure 28, which allows for updating all fields describing a particular EV charger. The fields are organized into two groups: those pertaining to the location of the charger (at the top of Figure 28), and those pertaining to its technical characteristics (at the bottom of Figure 28). The administrator can alter any of these fields.

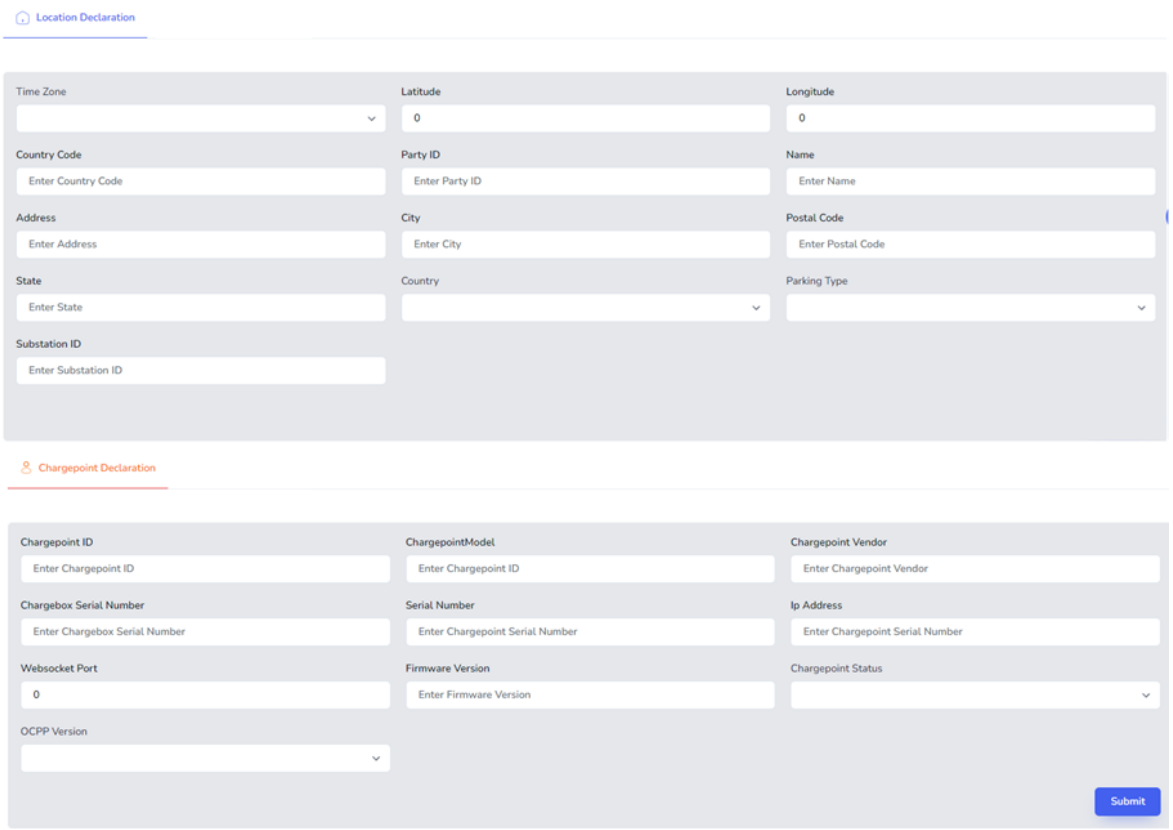


Figure 28. Updating charging station information, a) location of the charger; b) technical characteristics.

6.2 Monitor charging stations and sessions

CPOs need to continuously monitor the status of the charging stations and their charging sessions in order to ensure their availability and uptime, preventing downtimes that frustrate EV drivers and loose revenues for the charging station owners. Monitoring also helps CPOs to identify and address issues with charging speeds, power delivery, and overall efficiency with the aim of improving the experience of EV drivers. Indeed, customer satisfaction and loyalty can be enhanced by quickly identifying and

resolving issues faced by users (like charging errors, network problems, and payment failures). Finally, monitoring contributes to the detection and prevention of cyberattacks, protecting user data and financial information.

To this end, the O-V2X-MP dashboards provides the interface in Figure 29 with an overview of the status of all charging stations connected to the platform. More information and operations are made available upon selecting a particular charging station.

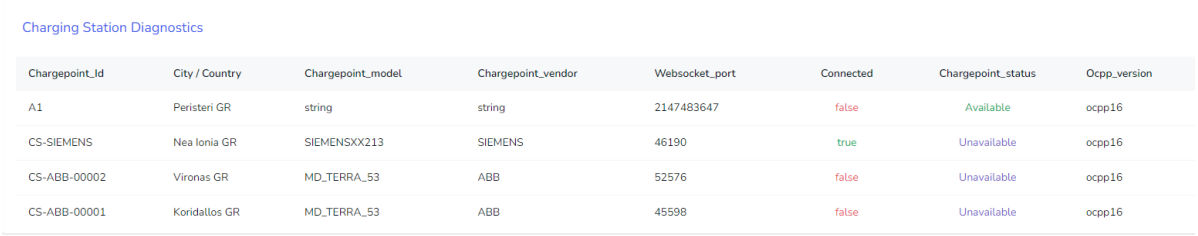


Figure 29. Overview of charging stations' status.

Monitoring is also facilitated by Figure 30, which provides an overview of the ongoing charging sessions.

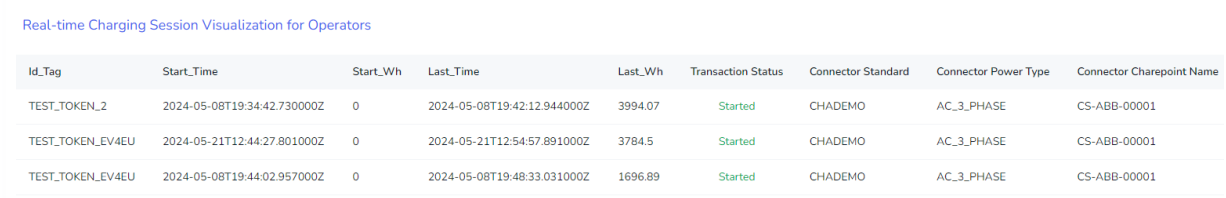


Figure 30. Overview of the active charging sessions.

More information is provided by selecting a particular charging session. This is illustrated in Figure 31 which analytically reports the power that is delivered in the context of a selected charging session. The report is fine grained, with time intervals of 30 seconds. The upper part of the interface lists the absolute values of the delivered power, while the lower part visualizes the corresponding diagram.

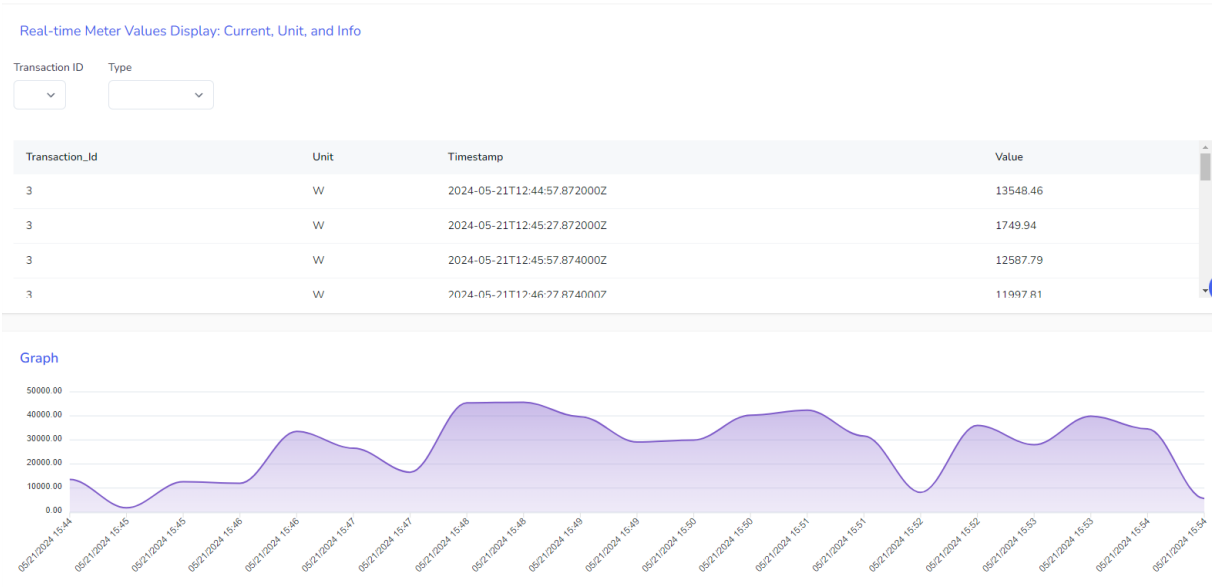
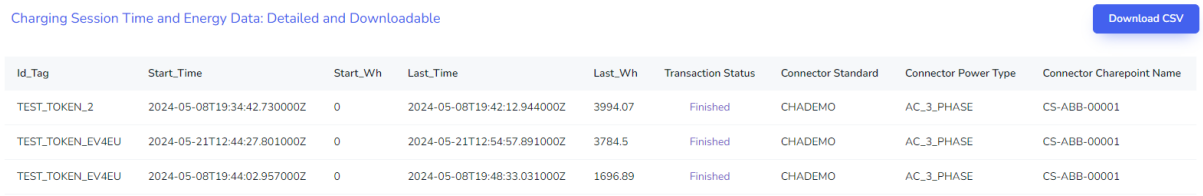


Figure 31. Power delivery per charging session.

Figure 32 complements the report in Figure 30 by providing an overview of the completed charging sessions. Selecting a particular transaction lead to a detailed report similar to that in Figure 31.



Id_Tag	Start_Time	Start_Wh	Last_Time	Last_Wh	Transaction Status	Connector Standard	Connector Power Type	Connector Charepoint Name
TEST_TOKEN_2	2024-05-08T19:34:42.730000Z	0	2024-05-08T19:42:12.944000Z	3994.07	Finished	CHADEMO	AC_3_PHASE	CS-ABB-00001
TEST_TOKEN_EV4EU	2024-05-21T12:44:27.801000Z	0	2024-05-21T12:54:57.891000Z	3784.5	Finished	CHADEMO	AC_3_PHASE	CS-ABB-00001
TEST_TOKEN_EV4EU	2024-05-08T19:44:02.957000Z	0	2024-05-08T19:48:33.031000Z	1696.89	Finished	CHADEMO	AC_3_PHASE	CS-ABB-00001

Figure 32. Overview of completed charging sessions.

6.3 Tariff Declaration and Adjustment

Tariff management is a crucial operation of CPOs, especially in the context of the EV4EU smart charging scenarios that rely on variable tariffs (e.g., the demand response scenario of the Greek demo, which promotes green charging). By specifying the tariffs for particular charging stations and regions, CPOs can examine the impact of charging cost on the behaviour of EV drivers. This is crucial for attracting more users and maximizing revenue.
To facilitate this operation, the O-V2X-MP platform offers the form in Figure 33, which enables CPOs to create a pricing scheme for a particular connector, charging station or region.

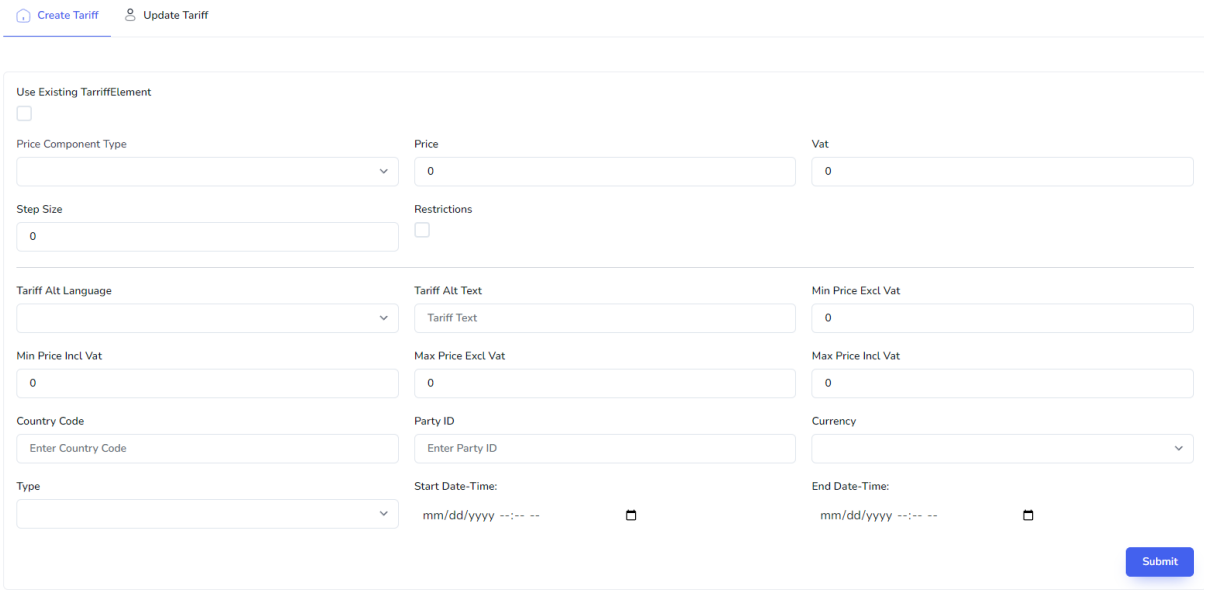


Figure 33. Creating a new tariff.

A similar form is provided for updating an existing tariff, as shown in Figure 34. Note that the upper part allows for selecting one of the stored tariffs. Note also that tariffs are retrieved and visualized through the operations described in Section 4.2.1 and in Figure 21, while the deletion of a specific tariff is available through the red button at the bottom left corner of Figure 34.

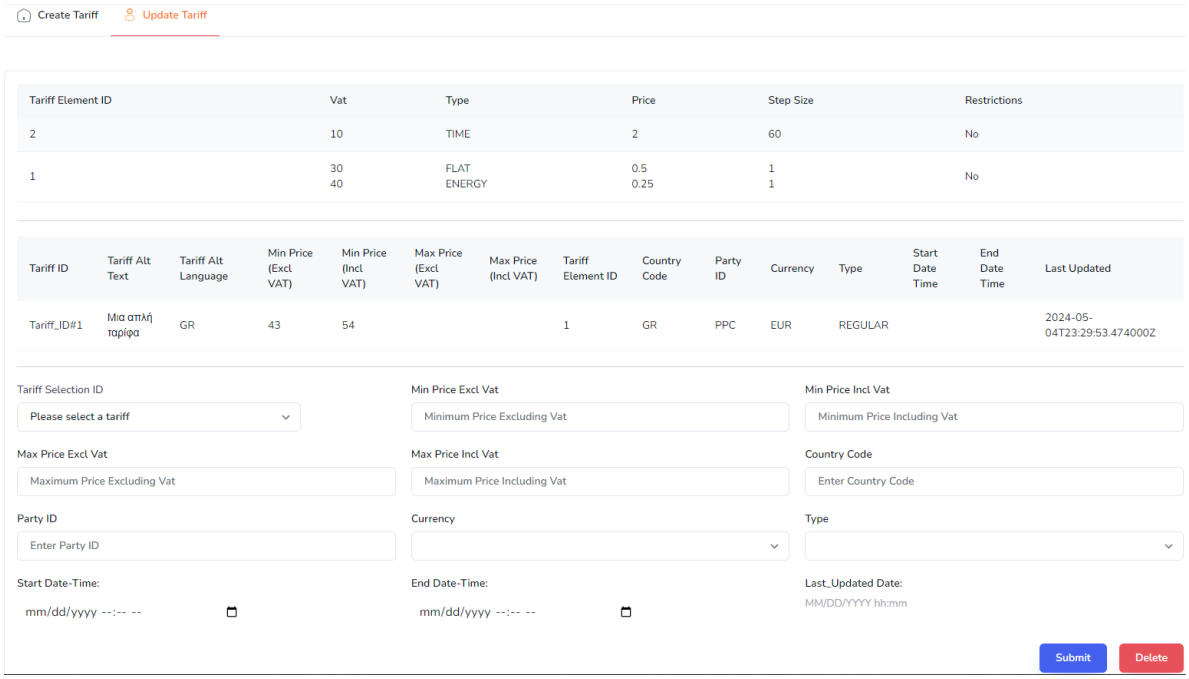


Figure 34. Updating an existing tariff.

7 Conclusions

In this deliverable, it is provided an overview of the O-V2X-MP frontend, which complements the description of the O-V2X-MP backend in deliverable D5.5 [5]. The document began with a description of extensions made in the backend since the submission of D5.5, as well as the REST APIs it provides. Then, it was listed the non-functional requirements that guide its development and provided technical details for installing and running it locally. The functional requirements are distinguished into three types:

1. the *generic* ones, which apply to all types of account and include the authentication and the overview of charging stations along with their daily tariff and capacity schedules and the corresponding weather conditions.
2. the *user* ones, which are crafted for EV drivers and include the registration form, the update of their preferences and most importantly, the routing recommendations and the charging history management.
3. the *administrator* ones, which are crafted for CPOs and pertain to the update of charging station information (i.e., their location and their technical characteristics), the live monitoring of charging stations and sessions as well as to the manual specification and update of tariffs.

More advanced functionalities are planned to be added during WP8, particularly, during Tasks 8.2 and 8.3. This will include the following:

- the ability of administrators to establish and monitor a connection with the DSO Support System (DSS) to retrieve the necessary information for the two smart charging scenarios of the Greek demo, i.e., the demand response one for promoting green charging and the one involving dynamic capacity contracts.
- algorithms for dynamically optimizing the distribution of the available capacity among a network of charging stations connected to the same medium voltage line whenever capacity limitation contracts have been activated by the DSO.
- algorithms for estimating the charging time for a particular EV based on the weather conditions, the status of the battery and the charging curve learned by the O-V2X-MP platform from past charging sessions of the same EV.

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