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Deliverable D8.1 UC specifications and demonstrator deployment plan

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Deliverable D8.1
UC specifications and demonstrator deployment plan

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[1] https://ev4eu.eu/

Executive Summary

This report provides a detailed description of the Greek demonstration, its pilot site, its planned activities, its Use Cases and its evaluation plan. It is part of the activities of WP8 and concludes **Task 8.1 "Demonstrator Specification and Planning and KPIs Definition"**. It corresponds to similar deliverables from the other demonstrations (WP6, 7 and 9) and is related to deliverable **D1.5 "Use Case Specifications"** [1]. Moreover, it draws input from deliverable **D5.3 "Open V2X Management Platform – Architecture"** [2] which describes the O-V2X Platform, a key part of the Greek demo.

The pilot site description focuses on analysing the characteristics of the chosen location which has been the pilot site in past projects, such as the Wisegrid [3], Platone [4] and SYNERGY [5] The local energy system of the demo location (Mesogia region of Attica) is in a semi-rural area and includes hundreds of thousands of customers, as well as medium (MV) and low voltage (LV) Photovoltaic (PV) installations. In addition, some customers have smart meters and there are several charging stations operated by project partners. Another highlight in the pilot site is the presence of GIS (Geographic Information System) technology that works in cooperation with the local DMS-SCADA (Distribution Management System - Supervisory Control and Data Acquisition) system. Recently, the site's AMI (Advanced Metering Infrastructure) infrastructure has been augmented with PMUs (Phasor Measurement Unit) which support state-estimation algorithms.

In the context of the Greek demonstration, the project involves three primary actors and four secondary actors. The primary actors are integral to the project's success, with HEDNO serving as the Distribution System Operator (DSO) responsible for monitoring the network, managing Distributed Energy Resources (DER) flexibility, and adjusting tariff prices to alleviate congestion. PPC fulfils the role of the Charging Point Operator (CPO), overseeing public charging stations, participating in flexible capacity contracts, and offering green charging services. The Platform Manager (PM) focuses on developing and maintaining the Open V2X Management Platform (O-V2X-MP), aimed at enhancing the electric vehicle ecosystem and streamlining charging infrastructure management and is undertaken also by PPC. In addition to these main actors, two other actors play essential roles: Citroen, representing the Electric Vehicle (EV) manufacturer, provides valuable insights into EV-related aspects, and EV users, who seek cost-effective and convenient charging solutions while interacting with the CPO's services and the PM's platform. Furthermore, two minor simulated roles, the flexibility market operator and consumers, are instrumental in simulating and overseeing transactions and diverse electrical loads within the project's dynamics.

The Greek pilot project consists of several key phases. It begins with setting specifications for components, including the O-V2X-MP and DSO Platform developed by PPC and HEDNO, LV monitoring infrastructures, and charging point infrastructures, with a target completion date at the end of November 2023. Subsequent phases involve deploying and testing the O-V2X MP's communications with charging stations and EVs, integrating it with DSO systems, and testing information and signal exchange based on standards by the end of May 2024. The commission of the O-V2X-MP platform, integration of management algorithms, LV monitoring system integration with the DSO platform, and communication testing will occur by the end of November 2024. DSO and CPO will test flexible capacity contracts activation and Green Charging, with communication through O-V2X-MP between them, to be completed until the end of February 2025. The project will conclude with the evaluation of new business models, Vehicle to Grid (V2G) vs. Smart Charging (V1G) benefits, and the documentation of knowledge gained for exploitation and marketability strategies until the end of August 2025.

There are two installations of systems and two deployments of tools that are planned by the Greek demo partners. Firstly, HEDNO is leading the installation of LV feeder supervision systems at MV/LV substations to enhance distribution network observability. The system includes measurement devices

for electrical parameters, data concentrators, and communication via cellular networks. Secondly, PPC is responsible for setting up 2 to 5 public EV charging points at various locations within the pilot site, complying with Greek regulations and standards. These charging stations support one-phase or three-phase charging and offer safety features, including ground fault monitoring. They also support user/billing management programs through the Open Charge Point Protocol (OCPP) and are upgradeable to OCPP 2.0 for future innovations in electric mobility, including vehicle-to-grid (V2G) capabilities. In addition to field equipment installations, HEDNO's DSO Support System (DSS) serves as a communication hub connecting with CPO platforms, facilitating practical tests of Business Use Case 4 (BUC 4) and Business Use Case 5 (BUC 5), and improving power distribution network monitoring and resource optimization. Meanwhile, PPC's Open V2X platform acts as a central coordinator, promoting seamless interactions between electric vehicles, charging infrastructure, and the energy grid by offering various services such as CPO and E-Mobility Service Provider (EMSP) services, roaming services, and a billing engine for precise cost management. The platform employs Open Charge Point Interface (OCPI) services for data exchange and integrates Location, Charging Data Records (CDR), Tariff, and Customer Relationship Management (CRM) Application Programming Interfaces (APIs) for station information, session details, tariff flexibility, and user feedback.

The demonstration plan consists of four phases. Phase A focuses on verifying the correct hardware installation of charging stations and LV metering equipment. Phase B emphasizes the verification of communication between various components, ensuring accurate message transmission and resilience against cyberattacks. Phase C aims to validate the cohesive operation of all components within the demo site and the functionality of developed algorithms. For Business Use Case 4 BUC4 (Green Charging), the DSO platform generates price signals based on PV energy forecasts, while for Business Use Case 5 (BUC5) (Flexible Capacity Contracts), the DSO forecasts and provides capacity limit signals to the CPO platform. Phase D involves incorporating the platform into DSO systems and conducting real-scale validation to address interoperability, user responsiveness, impact on distribution network security, and DSO flexibility management. Additionally, at least one V2G charging station will be installed for lab tests and simulations, including reverse power provision tests during the demonstration phase.

Additionally, to the field and deployment activities, the Business Use Cases (BUCs) are described in detailed. Business Use Case 4 (BUC 4) demonstrates how electric vehicles (EVs) can enhance renewable energy integration. It aims to reduce grid constraints, lower medium voltage grid power injection, and delay distribution grid investments. BUC 4 employs Demand Response (DR) to coordinate renewable energy and EV activities. When reverse power flow occurs, the DSO identifies locations for price reductions, communicated to the CPO managing charging stations. The CPO adjusts prices, conveyed to EV owners via the Platform Manager, allowing them to optimize charging based on pricing changes. Two scenarios are tested, one at a single MV/LV substation and another on a broader MV network scale. The process involves issue detection, tariff reductions, communication to CPOs, and notifying EV users for efficient charging decisions. Business Use Case 5 (BUC 5) demonstrates the use of flexible capacity contracts in V2X scenarios, focusing on reducing distribution system constraints, delaying grid investments, and expanding CPO service offerings. In these scenarios, the DSO procures capacity limitation services from CPOs in a medium-term market, activating them either in advance or in real-time to address network congestion. The process includes DSO identification of congestion, communication with CPOs, adjustments of charging station capacity limits, communication with EV owners through the Platform Manager, and EV owners making charging decisions based on preferences, with feedback relayed to CPOs for prompt updates to charging station status.

Finally, the evaluation plan of the Greek demo was created with its main feature being the demo KPIs which are described in detail and mapped to the BUCs. In total there are 15 Key Performance Indicators

(KPIs) covering a range of topics, namely: technical, economic and market, environmental and social, and service related.

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Acronyms

AC	Alternating current
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
BUC	Business Use Case
CDR	Charging Data Records
CO2	Carbon dioxide
CP	Charging Point
CPO	Charging Point Operator
CRM	Customer Relationship Management
CS	Charging Station
CSMS	Charging Station Management System
CSV	Comma-Separated Values
CT	Current transformer
DASA	Data Acquisition and Storage Accuracy
DC	Direct Current
DER	Distributed Energy Resources
DMS	Distribution Management System
DR	Demand Response
DSO	Distribution System Operator
DSS	DSO Support System
DTU	Technical University of Denmark
DUoS	Distribution Use of System
EMSP	E-Mobility Service Provider
ERP	Enterprise resource planning
EV	Electric Vehicle
EVCP	Electric Vehicle Charging Point
EVCS	Electric Vehicle Charging Station
f	Frequency
GA	Grant Agreement
GIS	Geographic Information System
HEDNO	Hellenic Electricity Distribution Network Operator S.A.
HW	Hardware
I	Current
ICT	Information and communication technology
ID	Identification
IPTO	Independent Power Transmission Operator
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
kW	Kilowatt
LV	Low Voltage
MB	Megabyte
MV	Medium Voltage

MW	Mega Watt
OCA	Open Charge Alliance
OCPI	Open Charge Point Interface
OCPP	Open Charge Point Protocol
OICP	Open Interchange Protocol
OPF	Optimal Power Flow
OSCP	Online Certificate Status Protocol
O-V2X-MP	Open V2X Management Platform
P	Active power
PM	Platform Manager
PMU	Phasor Measurement Unit
PPC	Public Power Corporation
PV	Photovoltaics
Q	Reactive power
RES	Renewable Energy System
RFID	Radio Frequency Identification
RIEMO	Registry of Infrastructures and E-mobility Market Operator
S	Apparent power
SCADA	Supervisory Control and Data Acquisition
SS	Secondary Substation
SW	Software
V	Voltage
V1G	Smart Charging
V2G	Vehicle to Grid
V2X	Vehicle to Everything
WP	Work Package

1 Introduction

1.1 Scope and Objectives

Task 8.1 “Demonstrator Specification and Planning and KPIs Definition” aims to outline and describe in detail the Greek demonstration as it is currently planned by the involved partners. Its scope includes all the activities related to the demonstration such as target pilot site where the demonstration will take place, the actors involved and the requirements of the necessary hardware and software infrastructure, the use cases specifications and the KPIs used for the evaluation of its activities.

In summary, the objectives of this deliverable are:

1) Assessment of the current infrastructure in the demo site.
2) Outline of the development, installation, and commissioning of the necessary hardware and software along with the corresponding timeline.
3) Description of the use cases.
4) Presentation of the demonstration evaluation plan.
5) Definition and description of the list of KPIs.

Deliverable 8.1 “UC specifications and demonstrator deployment plan” is the main output of Task 8.1 and with its submission the task is completed.

1.2 Structure

This document is divided into six sections. Section 1 introduces and describes the D8.1. Section 2 provides technical information about the existing pilot site infrastructure. Section 3 provides a detailed description of the Greek Demo, including the roles of actors involved, the installation and deployment processes along with the corresponding demonstration plans and timelines. Section 4 dives into the details of the Business Use Cases to be implemented. Section 5 presents the evaluation plan and specifies the KPIs. Section 6 provides conclusions on this deliverable.

1.3 Relationship with other deliverables

Deliverable D8.1 presents the detailed description and implementation of the Use Cases in the Greek Demo. It was prepared in parallel with the corresponding deliverables of the other EV4EU demos. Hence, this deliverable is relevant with **D6.1 “Implementation plan for the Azores demo”**, **D7.1 “Detailed definition and implementation plan of Slovenian Demonstrator”** and **D9.1 “Use case specification, development, installation, commissioning, demonstration, and evaluation planning for the Danish demo”**. Each one of the above describes and defines the demonstration that will be implemented by Portugal, Slovenia and Denmark respectively.

This Deliverable follows and is based on the regulation aspects presented in **D1.3 “Regulatory opportunities and barriers for V2X deployment in Europe”** [6] and the business modelling categories implemented in **D1.4 “Business models centred in the V2X value chain”** [7]. In addition, it consolidates and finalizes the corresponding Use Cases described in **D1.5 “V2X Use-cases repository”** [1].

The Open V2X Management Platform (O-V2X-MP) is a basic component in the Greek Demo as well as the information exchange that it utilizes between the different use cases of the pilot, thus information from **D5.1 “Information Exchange needs to enable different UCs”** [8] and **D5.3 “High-level design of Open V2X Management Platform (O-V2X-MP)”** [2] is also included as input.

Moreover, the KPIs which are specified in this deliverable will be used in **D8.5 “Analysis of Results”**, and of course information included in the present document will be utilized by the **D5.5 “Open V2X Management Platform – Development”**.

2 Pilot site description

2.1 Overview of the pilot location characteristics

The existing infrastructure in East Attica (the wider area that includes Mesogia) is a strategic choice for our research initiative. Building upon the synergies established in previous studies, such as the Wisegrid [3], Platone [4] and SYNERGY [5] projects, East Attica offers a promising foundation for a successful pilot application. Several Medium Voltage/Low Voltage (MV/LV) substations are conveniently located in proximity to the Electric Vehicle Charging Points (EVCPs). Additionally, the presence of telemetered MV consumers further enhances our monitoring, observability and data collection capabilities.

2.2 General data about the local energy system

In East Attica, Hellenic Electricity Distribution Network Operator S.A. (HEDNO) serves approximately 245,840 customers via its LV and MV networks, which include households as well as small, medium, and large industrial establishments. Specifically, this semi-rural region has about 245,145 Low Voltage and 695 Medium Voltage consumers connected to the local energy system. This area also takes advantage of several renewable energy installations, such as Photovoltaic (PV) systems, including net metering and rooftop PVs.

In terms of the adoption of renewable energy sources (RES), there are over 200 PV producers and 40 PV net metering installations with a total installed power of 27.043 MW, all of which are linked to the Distribution Network. Moreover, there are 20.7 MW of PV plants awaiting the green light for connection to the Distribution Network. However, it is worth noting that there are currently no wind farms integrated into the Mesogia’s Distribution Network.

Regarding the electric vehicle charging infrastructure, there are presently 42 public charging points managed by Public Power Corporation (PPC) in the Mesogia region (red marked area in Figure 2.1). This information is in accordance with the data submitted to the Government's Registry of Infrastructures and E-mobility Market Operator (RIEMO), Figure 2.1.

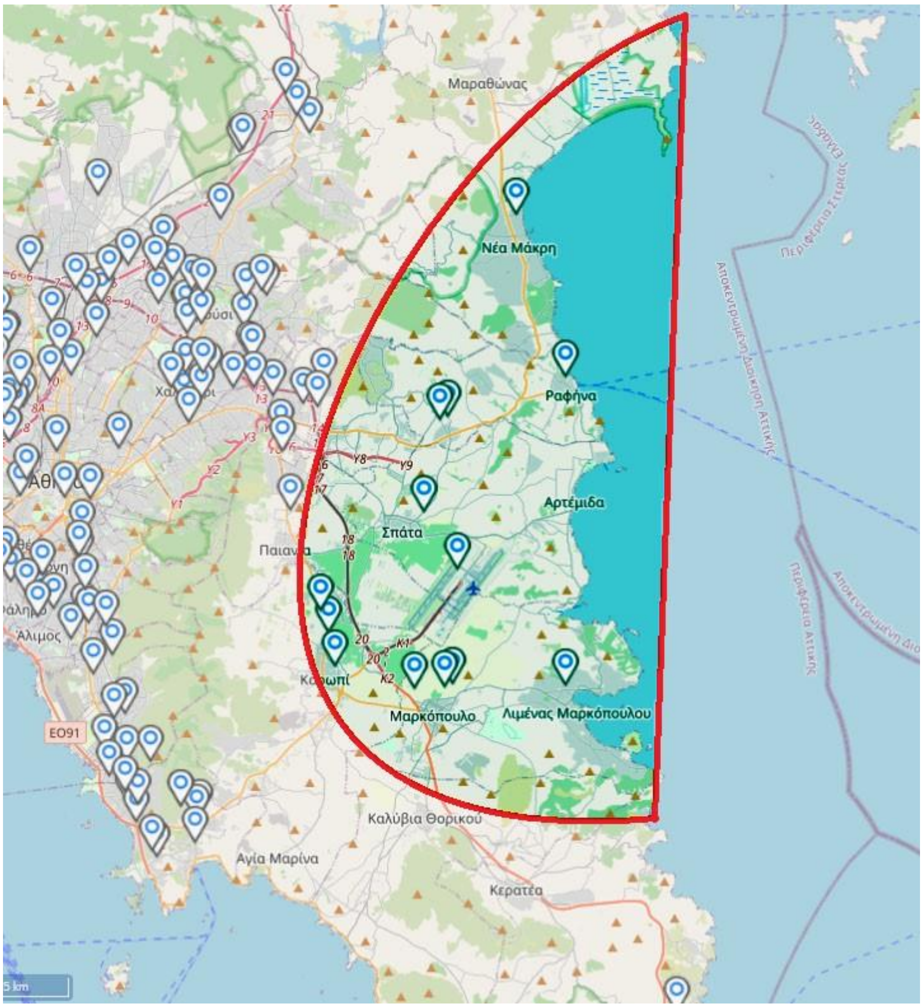


Figure 2.1: EV Charger Points in Mesogia region (Mesogia administration region inside the red area)

The Mesogia region, including the Greek demonstration site, is equipped with Geographic Information System (GIS) technology to support network functions and management operations. This includes the use of DMS-SCADA (Distribution Management System – Supervisory Control and Data Acquisition), *SAP's* ERP (Enterprise resource planning) systems, and other tools. GIS is a versatile solution designed to capture, analyse, manage, and present spatial and geographical network data, offering visual representations of the network's status to enhance operational efficiency. Additionally, GIS plays a crucial role in grid planning, optimization, repair, and maintenance strategies. The Greek Distribution System Operator (DSO) relies on GIS for the monitoring and comprehensive oversight of all three Medium Voltage lines that supply the region.

Furthermore, the Greek DSO has implemented an Advanced Metering Infrastructure (AMI) system that gathers data at 15-minute intervals from smart meters serving both MV and LV customers, as previously mentioned. This data is transmitted to the telemetry centre. The DSO employs DMS-SCADA systems, deploys multiple Phasor Measurement Units (PMUs) at specific locations within the distribution network, and utilizes technologies such as *ERMIS* software to enhance the control and observability of the network.

2.3 Pilot location description

For the Greek demonstration project, a targeted area of the region has been chosen as the testing ground. The distribution network, for the pilot location, focuses on the Primary Substation of Nea Makri which supplies power to seven MV lines. The MV lines extend to Secondary substations located in various areas, supplying to numerous consumers and producers in the Mesogia region. More specifically, the pilot demonstration will utilize some secondary substations along Nea Makri's P210 MV line. That MV line provides electricity to the areas that include two small towns, Nea Makri and Marathon, as well as three villages – Vothonos, Ano Souli and Grammatiko. The majority of the MV/LV substations in that location are aerial type and are linked with 2, 4, 5 or 8 LV feeder. An example of a panel with 8 LV feeders, from a Secondary substation, is presented to the Figure 2.2 with the 3-phase main busbars and the three fuses for each LV line. The installed MV/LV transformers in P210 have nominal apparent power from 50 kVA to 630 kVA, according to the number of feeders and the apparent power requirements of customers.

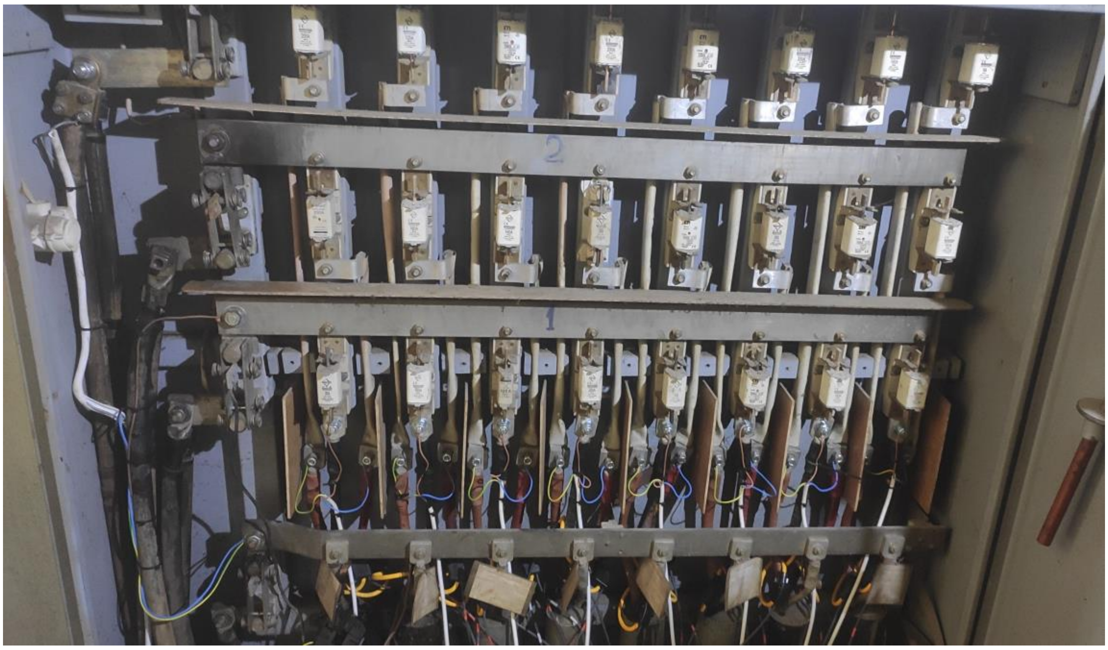


Figure 2.2: Internal Secondary Substation LV feeders

Furthermore, the MV lines of the area P210 and P490 have been previously utilized in the context of the Platone [4] research initiative. In Figure 2.3 the overview of Nea Makri Primary substation is presented with the aforementioned MV lines in the yellow frames from SCADA system. In the scope of that project several PMUs have been strategically positioned to enhance operational insights of the pilot site. Additionally, a state estimation tool has been successfully applied at the pilot site to provide valuable predictions regarding energy production and consumption patterns in the vicinity.

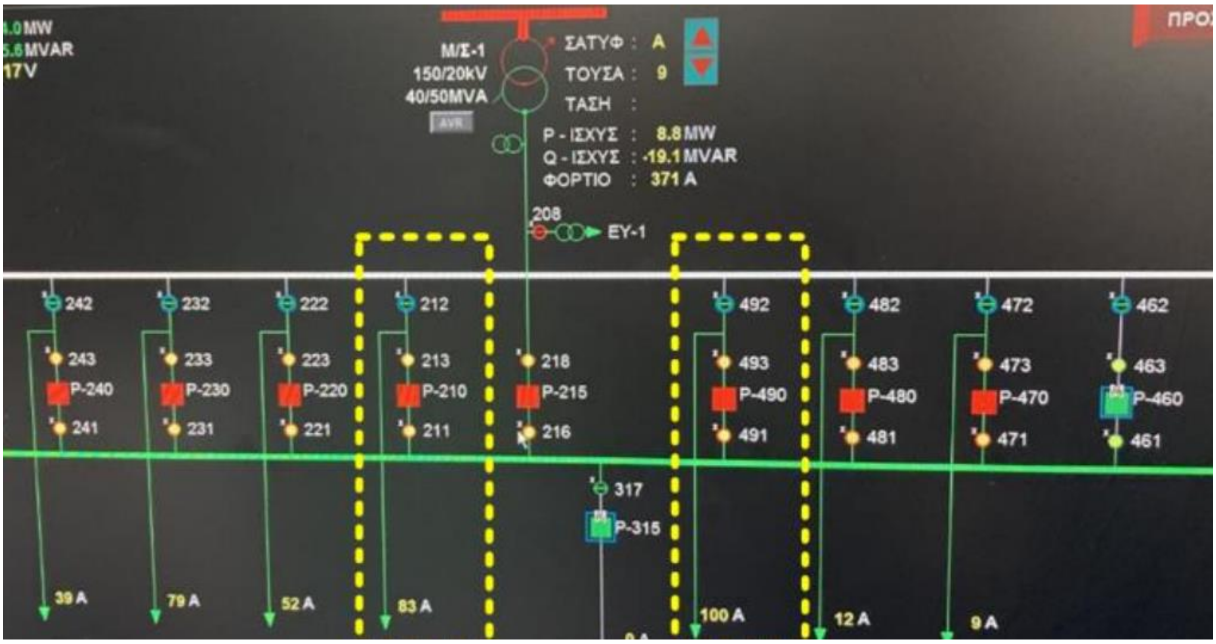


Figure 2.3: Nea Makri substation visualization

According to the mass integration plan of EVs in the energy system, by the Greek Ministry of Energy, the Municipalities have published the *Electric Vehicle Charging Plan*[2]. Based on that plan, the Municipality of Marathon (Nea Makri, Marathon, Grammatiko, etc.) has suggested charging points in specific locations, as pinned in Figure 2.4. More specifically, the proposed charging stations are around 19 and Include both AC and DC vehicle chargers of 22 kW or 50 kW installed capacity power respectively. During the Greek pilot, some of these suggested or other nearby points of interest will be utilized for the installation of the PPC's electric vehicle chargers.

[2] https://mapsportal.ypen.gr/maps/1058#license-more-above

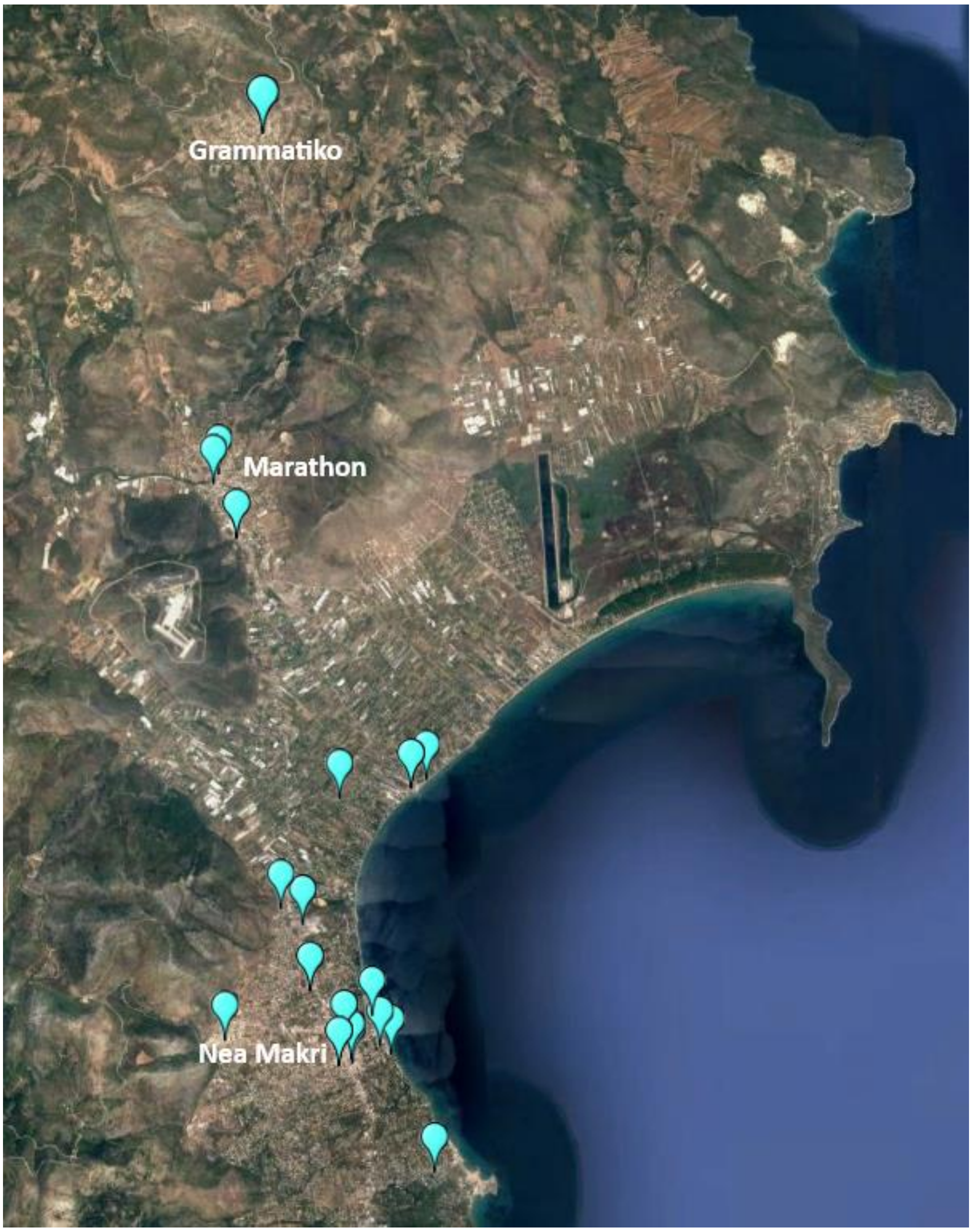


Figure 2.4: Proposed Location of Charging Point in Greek Electric Vehicle Charging Plan

3 Demo description

3.1 Actors

There are three main actor roles and four secondary actors in the Greek demo. The three main actor roles are fulfilled by the two principal participants of Work Package 8 (WP8), HEDNO and PPC. The first main actor role is that of DSO, fulfilled by HEDNO, while the second main actor role is that of the Charging Point Operator (CPO), which is fulfilled by PPC. The third and final main actor role is that of the platform manager, also fulfilled by PPC, as in the Greek demo PPC owns the charging infrastructure and builds the management platform. In addition to these main actors, there are two actors more focused on the electric vehicles (EVs), the EV manufacturer fulfilled by Citroen, and EV users, as well as two additional minor actors which focus on market aspects and are simulated, namely, the flexibility market operator and the consumers.

The **DSO**'s role is to provide equal service to all consumers while ensuring that the distribution system operates safely and within its technical limitations. Within its responsibilities is to plan appropriate network infrastructure expansions and upgrades, contribute to the design of use-of-system tariffs and manage its equipment (transformers, breakers, etc.). An additional attribute of the said role, that has gained attraction in recent years, is the involvement of DSOs in the coordination and management of Distributed Energy Resources (DER) flexibility. Although, not allowed to directly control DERs or trade energy, several works in the literature, as well as pilot projects, envision a DSO which can buy flexibility from DERs in order to ensure the safe and/or efficient operation of the distribution system. The suggested flexibility products can vary, with flexible capacity limitation contracts being one of the most popular options. Therefore, for the purposes of the Greek demo, HEDNO undertakes the role of a modern DSO who is interested in using all available tools to achieve its goals, including DER (here, public Electric Vehicle [EV] charger) flexibility.

Within the narrative of the Greek demonstration, HEDNO, the DSO, will have to perform a number of actions, demanded by its role. For example, HEDNO will monitor the network, loads and PV generation and identify occasions where excess generation creates network congestion or over-voltages. When and where appropriate, HEDNO will adjust network tariff prices to motivate beneficial DER flexibility responses. Additionally, the DSO acts for the procurement of DER flexibility in the form of capacity limitation contracts. The procurement includes receiving capacity limitation bids and selecting appropriate amounts via optimization. Finally, the DSO role includes the action of activating procured capacity limitations triggered by projected network congestions.

The **CPO** role is to manage the public charging stations dedicated to supplying electric EV owners. It's responsible for the continuous maintenance of these charging stations, securing that they operate seamlessly, providing reliable and convenient charging services to EV users and also Interacts with the DSO for flexibility transactions. Notably, the CPO exercises full ownership and control over the entire charging infrastructure, which includes not only the physical charging stations but also the associated systems and technology.

The actor offers green charging services, indicating a commitment to providing environmentally friendly charging options to the EV users (sourced from renewable energy). When the CPO receives service requests from the DSO following the detection of Reverse Power it identifies the Charging Stations (SS) within the designated zone and informs the EV owners for the updated pricing and the location. Additionally, the CPO participates in flexible capacity contracts auctions as a bidder via the Market Operator and during activation of the contract, it enables the EV user to charge his vehicle. These contracts are designed to optimize the use of energy resources and adapt to the evolving needs of the power grid. Finally, the CPO maintains the ongoing compatibility of the charging network with the management platform.

The **platform manager**'s (PM) role includes the development and maintenance of the Open V2X Management Platform, which is responsible for the efficient operation of the public charging network. Key objectives include addressing issues such as the fragmented backend system, limitations on electric vehicle adaptability, and the unreliability of the charging infrastructure. The platform aims to facilitate Vehicle to Everything (V2X) services provision and improve charging infrastructure management. It also seeks to expand platform utilization and incorporate extra features for enhanced electric vehicle flexibility, ultimately contributing to the overall enhancement of the electric vehicle ecosystem.

The platform manager's actions are centralized around the ownership and administration duties of the platform and maintaining the ongoing compatibility of the charging network and the power grid with the management platform. During capacity contracts' activation, the actor utilizes power capacity data in Charging Stations (CSs) to inform EV owners of their charging choices. Additionally, it calculates the charging session options and communicates them back to the CPO. Secondly, for green charging, the PM provides EV users with up-to-date pricing information sourced from the CPO, enabling charging decisions.

In addition to the main actors, there are a few auxiliary actors. First is that of the **EV manufacturer** which is fulfilled by Citroen. This actor monitors the demo implementation and Business Use Case (BUC) outcomes and provides feedback and directions. Moreover, provides insights into the degradation of EV batteries, the charging and discharging processes, and effective strategies for prolonging the lifespan of EVs. In addition, it will contribute on the understanding and optimizing the performance of EVs.

The second role is that of the **EV user**. The EV user aims to charge hers/his EV with the least amount of cost or discomfort. Furthermore, they engage with the CPO by utilizing their services and infrastructure, such as plugging their electric vehicles into the charging points and utilizing the CPO's application to monitor their EV's charging behaviour and data. The EV user acts by responding to different charging prices and by requesting a charging session by the platform manager.

Two minor simulated roles are that of the flexibility market operator and consumers. The flexibility **market operator** plays a pivotal role in simulating and overseeing transactions between the DSO and CPO, ensuring the verification of transactions, bids, and market clearing processes. Lastly, **consumers** are also simulated within this context, representing a diverse array of electrical loads that contribute to the overall dynamics of the system.

3.2 Planned timeline

The Greek pilot starts with setting the specifications regarding the components of the Greek Demo. These specifications are showcased at the present deliverable (D8.1) and relate to the O-V2X-MP and the DSO Platform, developed by PPC and HEDNO respectfully. Additionally, HEDNO sets the requirements for the LV monitoring infrastructures/devices that will be installed in the chosen secondary substations. At the same time, specifications for charging point infrastructures are described to support electric vehicle charging in the Demo by PPC. These targets will be met by February 2024. During this time working algorithms/tools will be deployed to be used by the DSO, according to WP4.

The next task includes the deployment and testing of the O-V2X-MP's communications with the charging stations and the EVs. In addition, the O-V2X-MP will integrate with the DSO systems and information and signal exchange will be tested according to the related standards. These tasks will be completed by June 2024 under D8.2.

Moving on, the commission of the O-V2X-MP will take place in line with deliverable D8.3. The platform will integrate the algorithms (developed by Technical University of Denmark [DTU]) aiming to the management of EVs. Also, the LV monitoring system will integrate with the DSS platform and the communication testing between the two will commence. In the course of this deliverable, algorithms and software tools will be tested as described in WP2 as well as the development of the V2X co-simulation platform will take place according to WP3. These tasks will be carried out by December 2024.

Next, the commencement of preparation of deliverable D8.4 is scheduled. DSO and CPO will carry out tests regarding the activation of services. These services refer to the flexible capacity contracts activation and procurement as well as Green Charging. Communication tests through O-V2X-MP between the two actors are essential. The DSO will transmit the relevant data to the CPO via the O-V2X-MP. The CPO will then oversee these services and relay the information to the respective electric vehicle owners. These targets will be met by March 2025.

Furthermore, there will be the evaluation of the impact of the new business models and concepts according to two perspectives, namely flexible capacity contracts and Green Charging Additionally, the benefits of Vehicle to Grid (V2G) in contrast to Smart Charging (V1G) will be examined. The findings from both the demonstrator and simulations will be collected and subjected to further analysis. The aforementioned evaluations will be conducted as part of deliverable D8.5 by May 2025.

Finally, knowledge gained from WP8 will be documented in deliverable D8.6 regarding the exploitation of the solution and the marketability strategies. It shall be delivered by August 2025. In Figure 3.1, all the mentioned deliverables of Greek demo WP8 are presented.

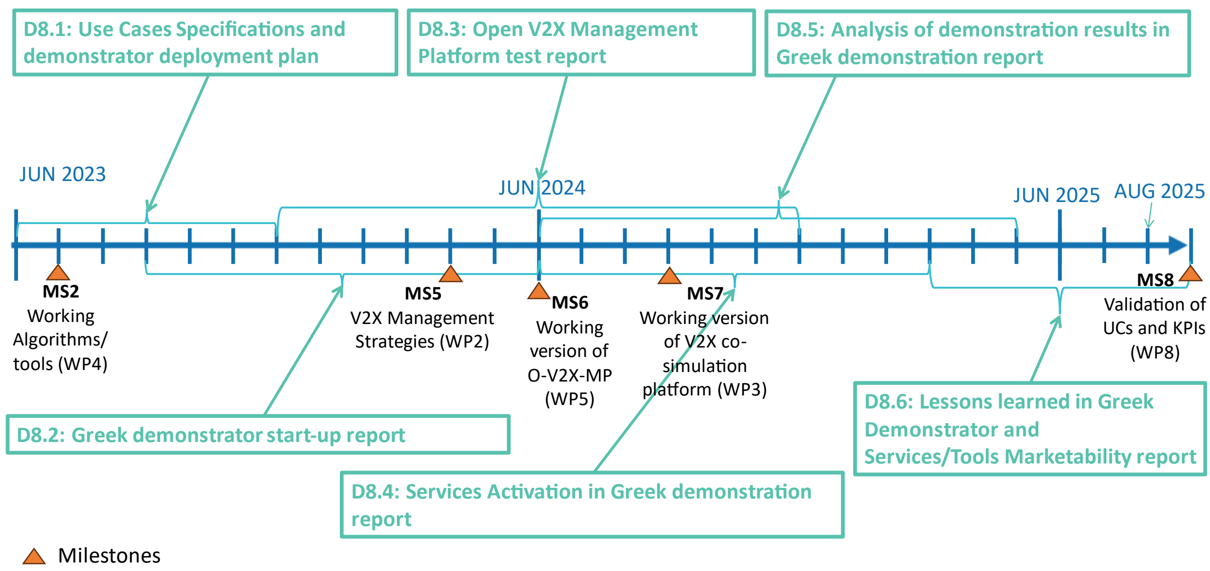


Figure 3.1: WP8 timeline with deliverables and milestones of the Greek demo

3.3 Installation and deployment

There are two main installation and two deployment tasks in the Greek demo. HEDNO will set up the LV feeder supervision system which will be accompanied by the installation of EV chargers by PPC. Parallel to the installation, PPC will develop the Open V2X platform, and the DSO (HEDNO) will deploy a visualization tool.

The Greek demo is divided into two main categories of tasks, installation and deployment tasks, with each category comprised of two tasks. HEDNO leads the installation of the LV feeder supervision system, involving the physical setup of hardware components while PPC focuses on installing EV chargers, ensuring the integration of charging infrastructure. At the same time, PPC is also in charge of deployment of the O-V2X-MP, emphasizing the software design and programming necessary for seamless communication among electric vehicles, charging infrastructure, and the energy grid. Similarly, HEDNO is working on setting up a visualization tool (DSO Support System [DSS]), which involves designing a software interface crucial for making informed decisions within the distribution network and communicating signals at the O-V2X-MP. This clear separation between installation and deployment ensures a focused and organized approach to the Greek demo.

3.3.1 Installations

In the framework of the Greek Demo, HEDNO is installing LV supervision systems, while PPC is setting up an extensive network of EV charging points, both contributing to the advancement of sustainable energy infrastructure in Greece.

HEDNO undertakes the installation of LV supervision systems at MV/LV substations as a crucial aspect of the Greek Demo. This will be a commercial equipment that supports the Greek Demo with the primary objective of enhancing the observability of the distribution network. These installations are designed to accommodate different configurations, considering both indoor and outdoor settings and varying numbers of LV feeders. With the aid of efficient data processing, overseen by HEDNO, the system enables monitoring of critical electrical parameters, identification of potential faults, and seamless data transmission through a telecommunication infrastructure.

At the same time, PPC is responsible for the installation of a network of strategically positioned EV charging points across the pilot site. These charging points are equipped with an array of sophisticated safety features and certified energy measurement counters. With a focus on installation flexibility and adaptability, the charging points are designed to seamlessly integrate into various environments, offering a convenient and accessible charging solution for users across diverse locations within the pilot site.

3.3.1.1 MV/LV supervision

One of the main objectives of the Greek demo is to enhance the distribution network's observability. The main medium to achieve this goal is the installation of LV feeder supervision systems at MV/LV substations. HEDNO will lead the effort in this installation. The MV/LV substations of HEDNO's distribution grid are categorized in two types depending on whether they are housed indoors or outdoors. In addition, most indoor substations have 8, 12 or 16 LV 3-phases feeders to supply LV customers. The outdoor types can range from 1 to 5 LV feeders but for demonstration purposes, substations with 4 or 5 feeders are preferred, such as the substation in Figure 3.2. The system should be able to be mounted either on a wall or on a Din-rail, for indoor or outdoor substations, respectively. Moreover, it should comply with the existing standards on Ingress Protection. The LV monitoring system is composed of a) measurement devices for the electrical parameters (most common are voltage and current) and b) a central unit that processes and streams/sends data via the telecommunications infrastructure.

Figure 3.2: Outdoor Secondary Substation with 5 LV feeders. Transformer (left) and LV Combiner Box (right)

Typically, each system can measure bi-directional current up to 600A per phase. The two most common current measurement devices are Rogowski coils or current transformers (CTs). Rogowski coils, are flexible AC current transformers designed for easy setup into tight spaces and can be wrapped around irregular shaped conductors or wires. They have a very low ratio error Class 1 or 0.5 that means 1% or 0.5% deviation at measuring current. However, they come with higher costs. CTs are rigid objects and not all substations have enough space to accommodate them. However, they are much more cost effective than Rogowski coils. Moreover, voltage measurements are collected either through mains 3-phase busbars or from each feeder separately and they, typically, come with Class 1 or 0.5 accuracy.

As mentioned earlier, the system includes a main unit that acts as a data processor and concentrator, as shown in Figure 3.3. The Data Concentrator is responsible for collecting accurate and reliable data from LV feeders such as apparent (S), active (P) and reactive (Q) power consumptions, in addition, of course, to voltage (V), current (I), frequency (f), power factor. These measurements are important to overview the behaviour of substation loads and, when applicable generation. In addition, the system should be able to identify and report faults as well as raise the corresponding events and alarms.

The LV supervision system should be able to communicate with a central server/platform through cellular communication network (3G/4G) or other telecommunication infrastructure when available. The system sends data packages at regular intervals to the server/platform and has internal memory for saving data in case of connection loss.

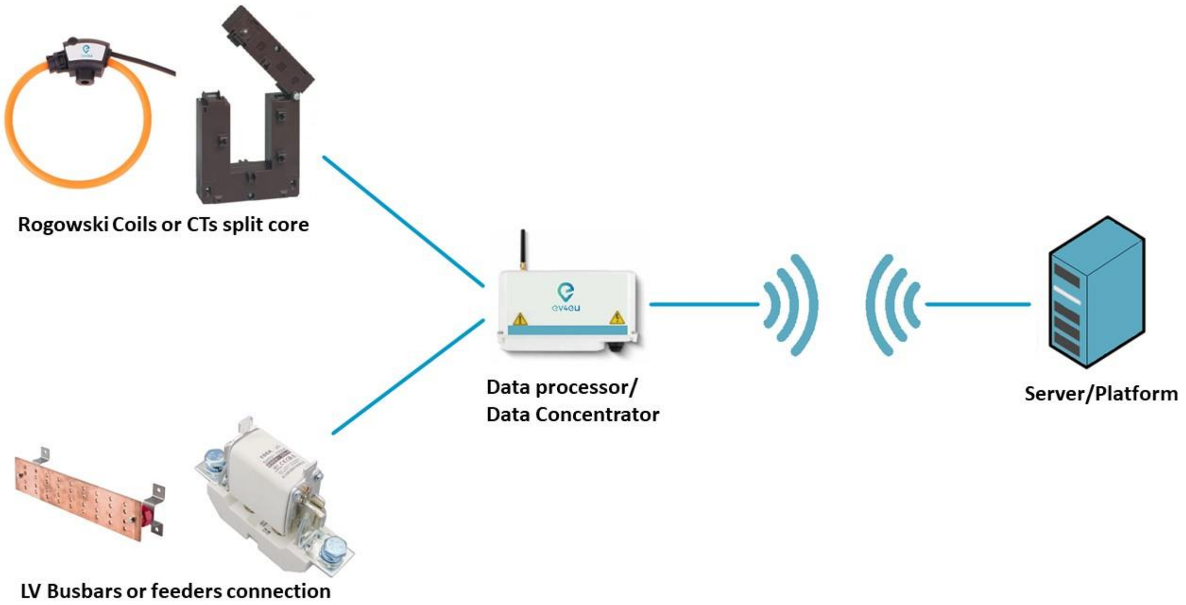


Figure 3.3: Schematic LV monitoring Architecture

3.3.1.2 Charging point

The second installation planned for the Greek demo is that of EV charging points (CPs), undertaken by PPC. Within the framework of the Greek pilot, PPC will be responsible for setting up a range of 2 to 5 public CP positioned across different areas within the pilot site. These charging stations will be strategically placed in various places, including commercial, urban, and industrial environments, with the objective of gathering comprehensive user profile data. It is essential to emphasize that the installation of these charging points will comply with all relevant Greek regulations and standards.

The two types of EV charging points, which will be used, will supply EVs a) with one phase charging and a maximum of 7.4 kW power or b) with three phase charging and a maximum of 22 kW power [9]. The charging stations will support Mode 3 sockets, see Figure 3.4, with up to 32A charging current at one or three phases, according to IEC 61851-1 [10] about EV conductive charging systems.

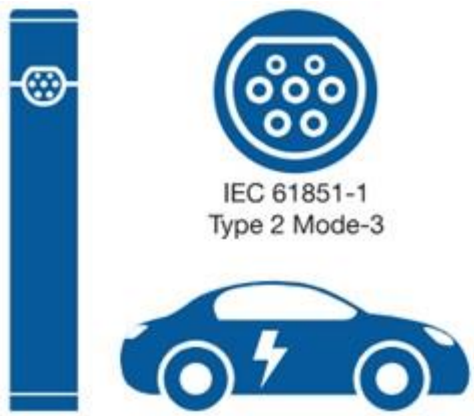
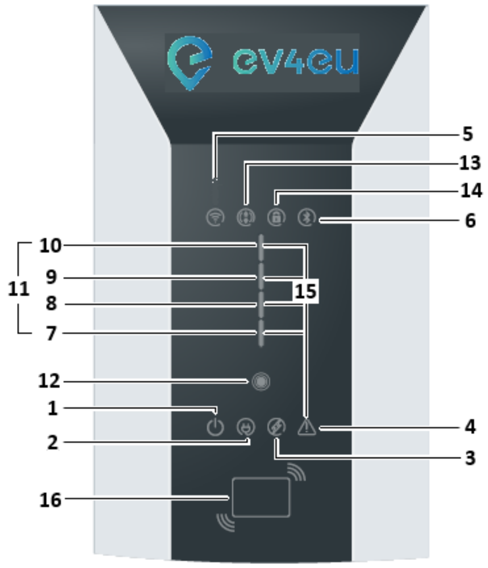


Figure 3.4: Type 2 Mode 3 socket [3]

These CPs can be mounted on walls or poles, adapting seamlessly to different installation environments achieving installation flexibility. Remarkably, while the charging equipment, Figure 3.5, is installed, it is important to note that the charging cable will not be included as part of the CP. An interesting feature is their parent/child operational capability. One CP parent connected to the communication network through Ethernet, Wi-Fi, 3G/4G or Modbus, can support connectivity for as many as 8 to 9 child CPs, making this system highly scalable and adaptable to varying infrastructure needs.



1 Status LED - Power ON
2 Status LED - Vehicle connected
3 Status LED charging active
4 Status LED - Error
5 WI-FI LED
6 Bluetooth LED
7 Time delay LED - 2 h, cold restart
8 Time delay LED - 4 h
9 Time delay LED - 6 h
10 Time delay LED - 8 h
11 Multifunction display for charging status
12 Touch Button
13 Remote control
14 Front panel locked
15 Error states
16 RFID

Figure 3.5: Greek Demo Charging Point

In addition, these CPs will be equipped with integrated certified energy measurement counter, with class B rating that is ±1% deviation at measuring parameters. To ensure the durability and robustness of the equipment, they are designed with an IP 56 degree of protection according to IEC 60529 standards, rendering them resilient to environmental conditions. Moreover, they have IK 10 degree of impact resistance according to EN 62262, emphasizing their rugged build quality.

Safety is paramount in EV charging, and these units prioritize it with features such as undervoltage, overvoltage, and overcurrent protection. Furthermore, they are equipped with ground fault monitoring systems that cover both the DC and AC circuits of the CPs, offering a comprehensive safeguard against electrical anomalies, ensuring not only efficient charging but also the safety of the connected vehicles and infrastructure.

Moreover, they support communication with a user/billing management program though Open Charge Point Protocol (OCPP) 1.6 and have the capability of upgrading to 2.0 as soon as it becomes available, without requiring extra hardware equipment. The OCPP 2.0 is the future of E-mobility towards V2G and in the context of the development of the reward system it provides extra innovation to the project contexts.

3.3.2 Deployments

The Greek Demo will showcase significant technological progress through the implementation of two crucial systems: the DSO Support System (DSS) developed by HEDNO, and the Open V2X platform developed by PPC. HEDNO's DSS platform is set to serve as a comprehensive communication hub with the CPOs platform, playing a pivotal role in the practical testing of BUC 4 and BUC 5. Its utility encompasses efficient monitoring and control of the electric power distribution network, offering a decision support system for improved operational precision and resource optimization. On the other hand, PPC's Open V2X platform will act as a central orchestrator, facilitating seamless coordination between electric vehicles, charging infrastructure, and the energy grid. With a focus on providing comprehensive services, the platform will ensure seamless transactions, and efficient communication through the integration of various protocols.

3.3.2.1 DSO Support System

The first deployment task is that of the DSO Support System (DSS) developed by HEDNO. The DSS platform will function as a central point for communication with the CPOs platform, allowing for practical testing of the BUC 4 and BUC 5 algorithms. Following the validation of these algorithms, EV4EU will gather and assess data from the entire system, playing a role in shaping definitive conclusions.

The utility of DSS is multi-dimensional. A DSS is a collection of applications designed to monitor and control the electric power distribution network efficiently and reliably. It acts as a decision support system to assist the control room and field operating personnel with the monitoring and control of the electric distribution system. The DSS improves the efficiency and precision of many tasks, ranging from simple, such as network visualisation, to more advanced, such as dynamic decision-making on resources optimisation. In the centre of a DSS lies a software platform which can host all the required functionalities and interface with field equipment and other platforms.

There is a wide range of functionalities a DSS platform can provide. In particular, the DSS platform of HEDNO will accomplish two main objectives: network monitoring and visualisation. Specifically, there is need for accumulating and organising heterogeneous data ranging from network topology and electrical characteristics to field measurements both historical and real-time.

In other words, the main and general purpose of the DSS Platform is to import and accumulate scattered, raw and heterogeneous data from various sources and process it, in order to produce and export compact, structured information, according to standardized and widely used formats. Thus, it will improve network knowledge and visibility, while also aiming towards achieving interoperability with other systems. The DSS Platform will include three main functionalities, namely a) Network Visualization; b) Data Storage and Visualization and c) Listing and access to the various technical characteristics of the Network components. Figure 3.6 depicts roughly the flow of information, with regard to the inputs and outputs of each process (functionality), operating in the core of the DSS.

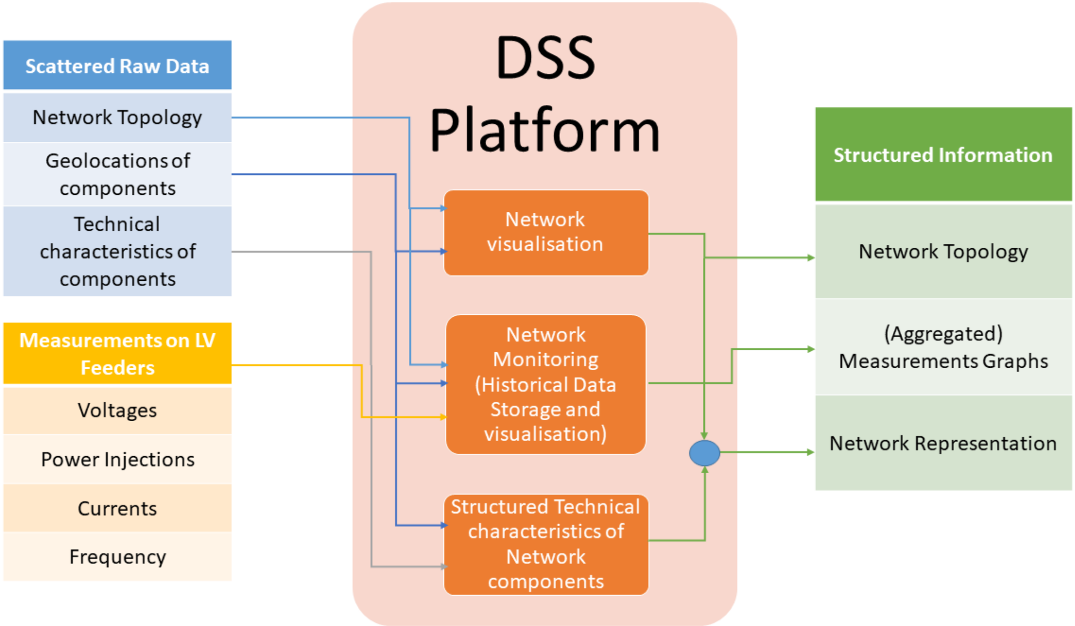


Figure 3.6: Overview of the DSS high level architecture

The Distribution Network visualisation is one important feature of the DSS platform. Specifically, the graph which describes the MV network topology will be overlaid on a geographical map. Using GIS technology, the MV network buses' exact locations will be shown as nodes on the map, which will be connected with edges according to the network topology. These edges will correspond to the Distribution Network lines. Apart from these, other important components of a distribution network can be visualised in this setting, namely circuit breakers, feeders, substations and distribution level transformers. To sum up, this kind of visualisation tool will be very helpful in order to obtain a good overview of the network at a glance. The network topology, along with the corresponding geolocations, will be available for export in a compact and standardised format.

The DSS platform will also include a Data Storage and Visualisation tool along with the Network Visualisation component. It will enable operators to access past performance data, with respect to the network topology. This historical context is helpful for predictive maintenance and long-term planning. In particular, real-time data visualisation and plots of past data coming from this system will be available to the user. The data list includes voltages, currents, as well as active and reactive power injections on each MV/LV substation, aggregated and for individual LV feeders. Furthermore, the option to implement simple data processing and aggregation will be available, in order to provide more insightful and informative plots, such as network voltage profiles and consumption/generation/power injection curves corresponding to each bus, or a selection of MV buses, aggregated over specific time periods. Plots and sets of measurements, may be extracted in the form of a widely used format.

Lastly, the technical characteristics and constraints of specific components of the network will be incorporated in the network visualisation tool. Specifically, maximum capacity limit, line impedance and other available technical characteristics regarding network lines will be shown. As far as network buses are concerned, information like bus type, voltage upper and lower limit, the number of LV Feeders and the power limit of transformers installed on each bus will be available. If there are measuring devices on specific feeders, this will be shown too, while historical analysis tools like those mentioned in the previous paragraph, may be provided for the specific Feeders. All this information should also be available for export in a widely used format. It can be combined with the network topology and geolocation information, derived from the network visualisation functionality, to provide a more complete and detailed network representation.

3.3.2.2 Open V2X platform

The second deployment task is that of the Open V2X platform prepared by PPC. The Platform acts as the centre for coordinating various methods and strategies within the Greek demo, the main architecture of it is presented in Figure 3.7 [4]. Its primary function is to facilitate interaction between EVs, charging infrastructure, the energy grid and other systems/platforms.

It offers a range of services, including CPO Services for managing charging stations and ensuring their availability. E-Mobility Service Provider (EMSP), gives access to charging points and integrates Customer Relationship Management (CRM), ERP, and invoicing systems for specific areas. Roaming Services enable transactions with partners across Europe, allowing EV drivers to charge in partner networks, even from other EMSPs. Integration with these services relies on protocols like Open Interchange Protocol (OICP) and Open Charge Point Interface (OCPI) for connectivity with roaming hubs such as *Hubject*[3] and *GIREVE*[4].

The platform's billing engine handles EV charging cost rates, including one-time fees, consumption-based charges, and time-based fees. The CPO sends Charging Data Records (CDRs) to EMSPs, who collect payments from drivers and settle with the CPO. The engine accommodates AC and DC chargers, exports CDRs in user-friendly formats, and allows tariff customization. This engine is crucial for accurate cost management in EV charging.

The platform utilizes Open Charge Point Interface (API) Services for communication and data exchange. The Location API retrieves charging station information, categorizing them by status. Public locations are open, private are restricted to specific users via Radio Frequency Identification (RFID), and semi-public may have time restrictions. The CDR API exports session details in Comma-Separated Values (CSV) and JavaScript Object Notation (JSON) formats, including station's Identification (ID), start/stop times, energy usage, duration, cost, and user details via RFID tags. The Tariff API supports different tariff categories, including CPO and EMSP tariffs, with flexibility in pricing units. The CRM API enables user feedback and input collection for platform improvement.

[3] https://www.hubject.com/

[4] https://www.gireve.com/

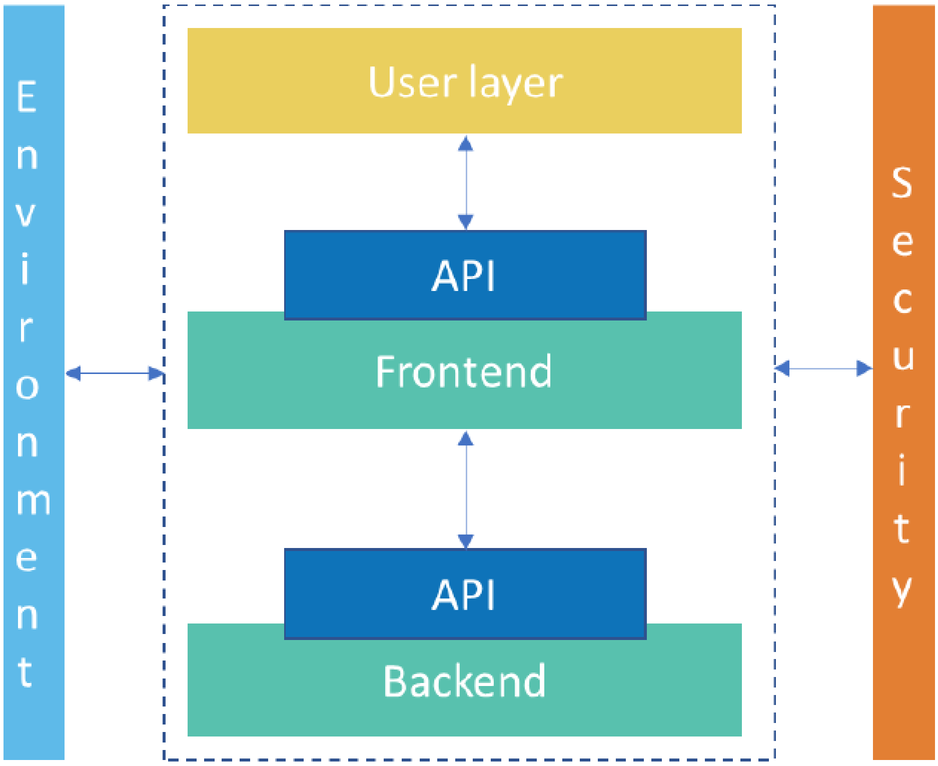


Figure 3.7: Main structure of the O-V2X-MP platform [4]

Backend is a central component designed for managing and monitoring charging stations, supporting OCPP versions 1.5, 1.6, and 2.0.1. It handles critical commands like "Authorize" for customer validation, "Start Transaction" to begin charging sessions, and "Stop Transaction" to end them. The "Heartbeat" mechanism maintains connectivity. Furthermore, it integrates with ISO 15118, enabling features such as "Plug & Charge" for RFID-free charging, "Certificate Management" for secure installations, "Smart Charging" for energy optimization, and precise "Metering" for usage tracking.

Scalability is a key consideration, ensuring that it can meet the needs of large CPO networks while maintaining transaction efficiency, thus guaranteeing the reliability and efficiency of the entire charging infrastructure.

The frontend is a user-friendly interface for operators and users to manage charging sessions. It includes features like an interactive map to find charging stations, initiating/terminating sessions, managing payments, and real-time monitoring. It supports various OCPP standards, displays active charging session data, offers tariff adjustments, provides station diagnostics, and records energy consumption data. User authentication details and environmental data are also displayed. A versatile dashboard allows for data analysis, tracking metrics like electricity usage and charging sessions for informed decision-making.

Regarding the EV communication architectures, several key entities play pivotal roles, namely the vehicle itself, the charging station, and the Charging Station Management System (CSMS). The CSMS assumes responsibility for remotely controlling, monitoring, and maintaining the charging stations. Additionally, it is tasked with resolving any faults or issues that may arise in these stations. Moreover, the CSMS has the capability to gather remote diagnostics from the charging stations, providing insights into their health status, real-time availability, and audit logs.

The communication between EVs and CS follows the IEC 61851 standard. Meanwhile, the interaction between CSs and CSMS is governed by the OCPP protocol.

3.3.3 Installation and deployment timeline

As it has extensively been described in the above chapters, the Greek demo is composed in general of a hardware (HW) installation and a software (SW) development phase. Each one of those is divided into two subcategories. Namely the SW development consists of the Open V2X Platform which is ownership of the CPO, PPC and the DSO support system which is prepared by HEDNO. Respectively, both platforms require also the appropriate HW equipment which will collect and provide them with the appropriate data and technical information. Hence, PPC has in its authority the deployment of the appropriate charging points - EV chargers, in the pilot area and HEDNO will install the required monitoring system in dedicated points of interest on its MV and LV grid that will supply energy to the pilot site.

In the Table 3.1 below, the timeline of the installation and the deployment of the above-mentioned SW and HW equipment is depicted with reference to each month. The total duration of deployment of the Greek pilot has been set to 20 months, starting from June 2023 (month 13) and concluding in January 2025 (month 32). Providing that way, plenty of time until the conclusion of the validation phase of all the demonstrators which is set for August 2025 (month 39).

On the deployment side, the Open V2X Platform has a pivotal role Taking into consideration the part role this platform has, being the central point of communication between all the SW & HW equipment, the actors taking place in this pilot, the data collection/processing and of course the accurate cost & tariff management, requires enough time for the complete development of the tool. Also, after the finalization of the O-V2X-MP's development, adequate months are required for the integration with the CPs that will be installed in the demo site and the DSS. All in all, the O-V2X-MP requires 9 complete months to fully develop and is expected to finish by February 2024 (month 21). Its integration with the rest of field equipment and systems, which will take place in parallel, is expected to last around 17 months for completion, until January 2025 (month 32).

The other crucial tool that has the major role of network visualization, collection and storing of system's data and analysis of the installed technical equipment, is the DSS developed by HEDNO. This important tool is responsible for the communication and exchange of technical information between the O-V2X-MP and the MV and LV monitoring equipment installed in pilot's grid. During the development of the O-V2X-MP, the DSS will begin the integration procedure between the two platforms which will require 17 months for completion and will last until January 2025 (month 32), as previously also mentioned.

Of course, each of the previously mentioned platforms cannot operate and produce the required data without all the appropriate field equipment installed. Critical components of the DSS are the MV and LV monitor equipment which will be integrated on existing substations. On the other hand, CPO will receive data from the Charging Points (CP) that the users will utilize to charge their EVs. The installation of the HW equipment in both sides is a time-consuming procedure since it interferes with existing network of HEDNO and PPC, resulting in the allocation of 12 months for the installation, with the starting point taking place from mid to end of the O-V2X-MP's development and specifically in December 2023 (month 19) and ending in November 2024 (month 30), see also Table 3.1.

The above presented timeline utilizes an adequate period for the completion of both installation and development phases of this project. It provides also enough months until the due date of conclusion of the demonstrator for testing of the complete Greek pilot.

Table 3.1: Installation and Deployment Gantt chart

Istallation and Deployment		M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39
		JUN 2023	JUL 2023	AUG 2023	SEP 2023	OCT 2023	NOV 2023	DEC 2023	JAN 2024	FEB 2024	MAR 2024	APR 2024	MAY 2024	JUN 2024	JUL 2024	AUG 2024	SEP 2024	OCT 2024	NOV 2024	DEC 2024	JAN 2025	FEB 2025	MAR 2025	APR 2025	MAY 2025	JUN 2025	JUL 2025	AUG 2025
1	**Open V2X Platform (O-V2X-P)**																											
1.1	O-V2X platform working version																											
1.2	O-V2X platform integration with field components																											
1.3	O-V2X platform integration with other systems																											
2	**DSO Support System (DSS)**																											
2.1	DSS integration with O-V2X platform																											
3	**LV monitoring system**																											
3.1	LV monitoring system installation																											
4	**Charging Points**																											
4.1	Charging Points installation																											

3.4 Demonstration plan

The demonstration plan encompasses a comprehensive set of actions designed to validate the precise placement, effective communication, proper functioning, and successful achievement of the project's primary goals and objectives for all components within the demo site.

The first phase (phase A) of the demonstration process involves verifying the correct placement and functionality of the hardware installation. During this phase, the following examinations will be conducted:

A) The appropriate installation and operation of the charging stations, both the normal AC charging stations and the V2X charging stations. This consists of:

   1. Check that the charging station is appropriately mounted, grounded and wired.
   2. Check that the socket is functional, and a charging session can normally start, pause, and end.
   3. Confirm that the relay protections operate normally.

B) The appropriate installation and operation of the metering equipment at the LV side of the secondary MV/LV substations. This consists of:

   1. Check that the CTs or Rogowski coils are well placed.
   2. Check that the wiring connections are well placed at the substation buses.
   3. Ensure all wiring is safely organized, eliminating any functional or safety hazards within the substation.
   4. Inspect all connections within the metering system, including the metering device's power supply.
   5. Validate the accuracy of fundamental metering measurements (Voltage, Current, frequency).

This initial stage of the demonstration process focuses on ensuring the precise installation and operational integrity of hardware components critical to the project's success.

The second stage (phase B) of the demonstration plan will centre on the verification of the communication among the diverse entities, components and platforms that take part in the Greek demo. The verification of the communication between the different components encompasses three distinct layers:

   1. Ensure that the components successfully identify and establish communication channels with one another.
   2. Verify that the relevant messages, signals, and measurements are accurately transmitted, received, and correctly interpreted among the various components of the demo site.
   3. Ensure that the communication is continuous, uninterrupted, and resilient against cyberattacks, where applicable and necessary

The primary communications to be verified within the Greek demo site, include the following:

A) Communication between the advanced metering infrastructures installed at the secondary substations and the DSS / SCADA of HEDNO. This one-way communication channel should provide measurements from the LV side of the secondary substations near real-time, regarding active (P), reactive (Q) and apparent (S) power, as well as the voltage (V), current (I) and frequency (f). Subsequently to the test of the communication establishment, the frequency of the received measurements (at least once per hour) and the visualization of the data in the DSS/SCADA/platform of the DSO will be examined.

B) Communication between the PPC platform and the DSO platform. This communication will be facilitated using the Open Charge Alliance (OCA) protocols Online Certificate Status Protocol (OSCP) and OCPP. The initial phase of testing this bidirectional communication involves confirming the capability of both platforms to send, receive, and interpret messages utilizing the OSCP and OCPP protocols. Subsequently, the second step entails verifying the accurate translation of received messages.

C) Communication between the charging points and the PPC platform. Validate seamless communication and the accurate delivery of messages.

The third phase (phase C) of the demonstration is dedicated to guaranteeing the operational functionality of the entire demo site as a cohesive system, successfully accomplishing its intended objectives and yielding the anticipated outcomes. This validation procedure requires the autonomous and collaborative operation of all components participating in the demo site.

The first step of this validation stage is to ensure that the developed algorithms are functional and generate the requisite messages/signals to be delivered from the DSO platform, and compatible with the CPO platform. The integration of these algorithms is crucial for grid optimization and efficient EV charging. Also, the algorithms should receive input from the metering devices, historical data, etc. in order to run the forecast modules, identify the potential congestions and produce accurate signals.

In the case of BUC4, referred as Green Charging, the DSO platform should generate a price signal for the Distribution Use of System (DUoS) tariffs for the next hours, based on the forecasts for PV energy production. Subsequently, the price signals will be delivered to the PPC platform, where they will be transformed into actual price signals. The final price signals will be formatted to be distributed to the end users.

In the case of BUC5, denoted as Flexible Capacity Contracts, the algorithm operating within the DSO platform will conduct forecasting and congestion analysis for a predefined future timeframe, providing the CPO platform with capacity limit signals, for varying time periods. CPO will translate these capacity limit signals to price signals allocated to the different charging stations of its network. This information should be readily accessible to end users, enabling them to make informed decisions regarding pricing variations throughout the day and across different charging stations, thereby selecting the optimal charging option.

Finally, the demonstration plan targets incorporating the platform into DSO systems and operating it on a real demonstration scale within a practical validation setting (phase D). The goal is to assess the suggested solution across the complete operational process, which encompasses addressing interoperability concerns with DSO systems, assessing user responsiveness, analysing its impact on the secure functioning of the distribution network, and evaluating its contribution to DSO flexibility management.

Within the context of the demo site, at least one V2G charging station will be installed, to be incorporated in lab tests and simulations, including actual components of distribution grids. For the demonstration purposes. For the demonstration phase of the project, the verification tests applied to the other charging stations, will also be conducted for the V2G charging station, along with a test that the station is capable to provide reverse power to the grid/building/home.

In the following Table 3.2, the basic steps of the demonstration are summarized:

Table 3.2: Demonstration list of phases

Demonstration phases		Relation to BUC
A	**Verification of hardware installation functionality**	
A1	Appropriate installation and operability of AC charging stations	
A2	Appropriate installation and operability of V2X charging station (lab environment)	
A3	Appropriate installation and operability of substations' metering equipment	
B	**Verification of communication between the different components**	
B1	Substations metering equipment – HEDNO DSS	
B2	Charging stations (AC & V2G) – PPC platform	
B3	PPC platform – HEDNO platform	
B4	PPC platform – end users	
C	**Operation of the demo site as a system**	
C1	Operational functionality of the algorithms	
C2	Data import from the demo site to the algorithms	
C3	Messages transmission and interpretation	
C4	Generation and delivery of price signals for varying grid tariffs to PPC platform	BUC4
C5	Interpretation to actual price signals and appropriate visualization	BUC4
C6	Forecast and congestion analysis execution	BUC5
C7	Capacity limit signals generation	BUC5
C8	Limit signals interpretation to price signals and allocation to charging stations	BUC5
D	**Actual integration of the platform the DSO systems**	

4 Use Cases tested in the Greek Demo

4.1 Methodology

A methodology for business use cases is designed to provide a structured and systematic approach for understanding, documenting, and analysing the functional requirements and operational aspects of complex systems and processes. It is a crucial tool that helps organizations gain a comprehensive view of how systems interact with external entities to achieve specific goals, making it indispensable for system design, development, and evaluation.

To describe the BUCs, the approach of IEC 62559 standard has been utilized. This international standard offers a well-defined and universally recognized approach for capturing and describing the functional requirements of complex systems. The so called “Use Case Methodology” is determined by a template in the IEC 62559-2:2015. The outcomes of this process are presented in deliverable D1.5 “V2X Use Case Repository” [1].

In this deliverable the effort carried out in D1.5 is being facilitated, in order to analyse the BUCs to be tested in the Greek demo site. A short presentation of the main scope and objectives will be followed by the summarized overview of each BUC and the different scenarios. The focus of this deliverable is to present the Business Use Cases diagrams that visualize the general architecture of the Use Cases, followed by an analysis of the diagrams and the scenarios adjusted to the Greek demo site.

The specific roles of the different actors/domains that participate in the Greek demo are presented and described in detail in subsection 3.1.

4.2 Description of Use Cases

4.2.1 BUC4: DR Services for RES and EV coordination

Scopes and Objectives

The goal of BUC 4 is to demonstrate how EVs can provide additional benefits that are related to higher RES penetration levels with better efficiency and security for the system (Figure 4.1). The goals include minimizing constraints in the distribution system, reducing power injection into the medium voltage grid, and postponing investments in distribution grids.

BUC Overview

BUC 4 utilizes Demand Response (DR) services to coordinate RES and EV activities. Upon detecting reverse power flow, the DSO identifies locations for price reductions, which are then communicated to the CPO managing the charging station network. The CPO promptly adjusts charging station prices, relayed to EV owners by the Platform Manager through the O-V2X-MP. This empowers EV owners to manage charging flexibilities based on updated pricing, enhancing RES and EV integration within the distribution system.

BUC Scenarios Analysis

There are two scenarios that will be tested in the context of the Greek demonstration:

Scenario 1: In scenario 1, the scope is more local and is focused on a single MV/LV substation. In this scenario, there is an abundance of small PV generation and low demand. The result is that there are reverse power flows from the LV to the MV network which are undesirable by the DSO for security and safety reasons.

Scenario 2: In scenario 2, the scope is broader and includes a section of the MV network. In this scenario, there is also an abundance of PV generation from PVs located both in the LV and the MV network, and low demand. Here, the result is reverse power flows along an entire branch of the MV network that led to slow voltage variation issues, namely overvoltage.

The strategy for addressing both problems is similar, with the only change being the scope of its implementation (under a single MV/LV substation vs part of the MV line). The timeline of the execution is as follows.

a) The DSO detects the issue by monitoring the network via its DSS.
b) It identifies which areas are affected or can assist in the issue mitigation and decides on a temporary reduction of tariffs for that location.
c) The new tariffs are communicated to all CPOs in the area via a communication between the DSS and the O-V2X platform.
d) The CPOs receive the information on location and tariff reduction via the platform.
e) They identify which CSs are affected.
f) Then, they update the price for charging in those stations.
g) The O-V2X platform visualises the updated prices in the charging sessions available to the user.
h) The platform sends notifications to nearby EV users notifying them about the price reduction.
i) The EV users receive the new prices for charging.
j) The EV users decide on whether they could shift their charging towards the affected CSs and the current time period.

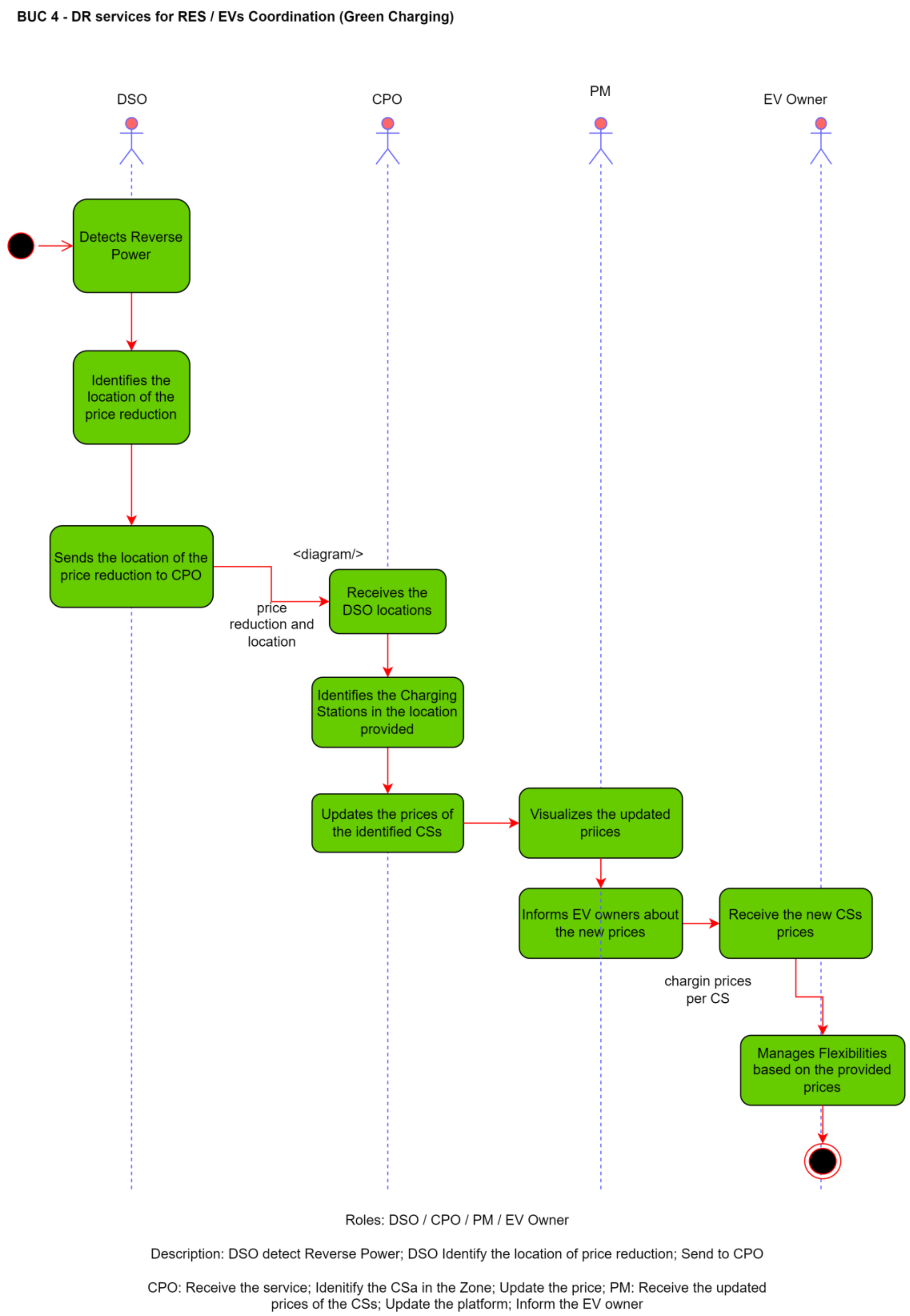


Figure 4.1: BUC 4 – DR services for RES / EVs Coordination (Green Charging)

4.2.2 BUC5: Dynamic V2X Capacity Contracts Procurement and Activation

Scopes and Objectives

BUC5 aims to demonstrate the utilization of flexible capacity contracts in V2X scenarios, showcasing their potential in supporting the DSO activities (Figure 4.2). The objectives include reducing constraints in the distribution system, postponing investments in the distribution grid, and expanding the range of services that can be offered by the CPO.

BUC Overview

Flexible capacity contracts facilitate flexibility offer from CPOs to DSOs. Namely, during the *procurement phase*, the DSO participates in a medium-term monopsony market where it can buy capacity limitation services from the CPOs. The CPOs offer these services in the form of bid curves that have been constructed using data analytics and projections of their incurred cost for offering such services. When this market is cleared, the procurement phase ends, and the DSO has a contract with the CPOs that allow him to request capacity limitation services activation for the day-ahead or real-time with a pre-agreed cost.

BUC Scenarios Analysis

During the *activation phase*, the DSO identifies network congestions and activates capacity limitation from the DSOs. Two scenarios will be tested corresponding to two different time horizons:

Scenario 3: The DSO identifies potential congestion on the MV/LV substation for the next day (day-ahead). It activates the capacity limitation service for the entire day.

Scenario 4: The DSO observes congestion conditions on the MV/LV substation in real-time. It activates a capacity limitation service for the next time period.

Regarding both scenarios, the execution will be processed according to the following timeline:

a) The DSO identifies the projected day-ahead network congestion, (or the congestion detected instantaneously), serving as the primary trigger for subsequent actions.

b) Then it identifies possible contributors to provide the service.

c) The DSO then communicates the specific service requirements, notably the capacity limits, to the CPO involved in the process.

d) The CPO receives those capacity limits to evaluate them.

e) Next, the CPO identifies the appropriate CS within the targeted location.

f) The CPO adjusts the CS's power capacity limits to align with the communicated requirements.

g) Additionally, the CPO engages with the PM, where the second visualizes the updated information across the system.

h) Leveraging the O-V2X-MP, the PM facilitates effective communication with the EV owners. Initially, the EV owners request to receive charging session choices.

i) The PM receives the request and calculates those charging session choices. The output is delivered back to the EV Users.

j) Then, the EV owners receive the charging session's choices provided by the Platform.

k) Next, the EV owners make their decisions based on their preferences and inform they inform the Platform.

l) The PM receives the chosen charging session from the EV Owner.

m) Finally, the PM further relays the selected charging session information back to the CPO, allowing for prompt updates to the CS status.

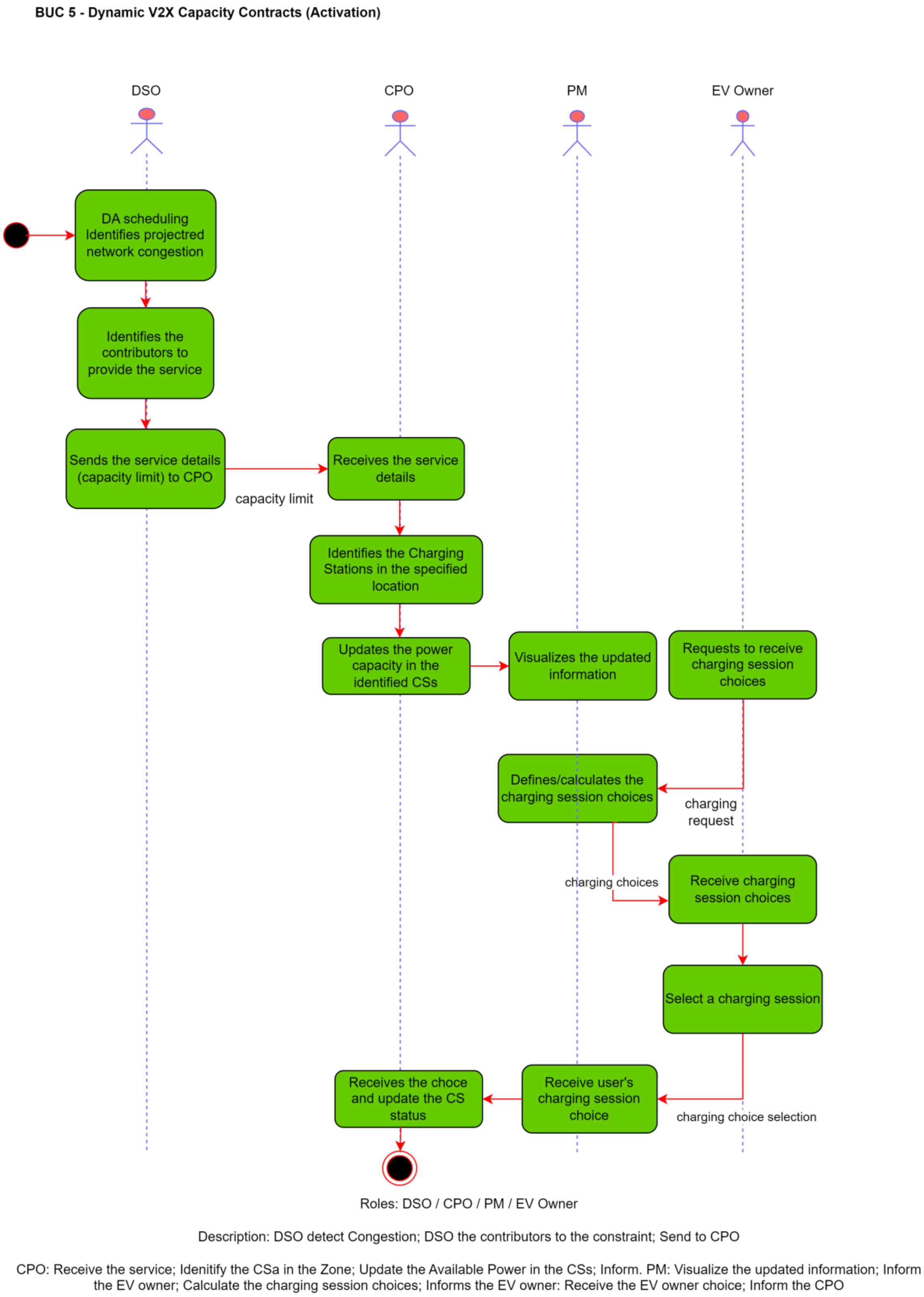


Figure 4.2: BUC 5 - Dynamic V2X Capacity Contracts (Activation)

5 Preliminary definition of Key Performance Indicators (KPIs)

5.1 Evaluation plan

The evaluation plan aims to provide a comprehensive definition of KPIs with a robust analysis that are applicable to the Greek demo. With the methodological approach, the majority of the KPIs are linked with the BUCs related to the demo. The KPI analysis incorporates the description of the KPI, a detailed definition of the formula and the measurement process, as well as an indicative target to assess the success of the project's objectives, when the KPIs are calculated.

The assessment criteria are organized into distinct dimensions, recognizing the multifaceted nature of the project's impact. This includes technical considerations such as the reduction in operational constraints and demand fluctuations, alongside environmental assessments like the impact on emissions. Additionally, the plan addresses social aspects, as demonstrated through the evaluation of user participation and satisfaction, enabling a comprehensive understanding of the project's societal implications.

Furthermore, the plan incorporates service-related indicators, examining the utilization of flexibility and the requested flexibility by the relevant entities, which are crucial in evaluating the effectiveness of the operation tools. The evaluation plan also encompasses economic and market-related considerations, evaluating the ICT costs and the economic impact on the involved stakeholders, providing insights into the project's financial viability and its implications for the market.

By considering a diverse array of factors and KPIs, the evaluation plan aims to provide a comprehensive assessment of the project's performance, ensuring that all significant aspects are taken into account.

The list of the KPIs may potentially be expanded, as the demo deployment and demonstration progress, to embody all the addressed objectives and issues of the Greek demo.

5.2 KPI description and BUC mapping

5.2.1 Technical related KPIs

5.2.1.1 KPI_GR_01 – Reduction in RES curtailment

BASIC KPI INFORMATION

KPI NAME	Reduced RES curtailment	**KPI ID**	KPI_GR_01
KPI TYPE	Technical	**RELEVANT BUCs**	BUC 4
RELATED PROJECT OBJECTIVE(S)	To develop planning and real-time operation tools to be used by DSOs considering V2X impact and flexibilities.		
RELATED GREEK DEMO OBJECTIVE(S)	To test the activation and impact in user behaviour of different services, including DR programs and Green Charging.		
OWNER	HEDNO		
KPI DESCRIPTION	The indicator compares the amount of energy from Renewable Energy Sources (RES) that is not injected to the grid (even though it is available) due to operational limits of the grid, between the Green Charging scenario and the Business-as-Usual scenario.		
KPI FORMULA	$$\Delta C_{RES}^{\%} = \frac{\Delta C_{RES}}{\sum_{t \in T} \sum_{i \in I} E_{g_{i,t}}^{BaU}}$$ $$\Delta C_{RES} = \sum_{t \in T} \sum_{i \in I} E_{g_{i,t}}^{BaU} - \sum_{t \in T} \sum_{i \in I} E_{g_{i,t}}^{GC}$$ $E_{g_{i,t}}^{BaU}$: energy curtailment of the i-th RES facility at period t in Business-as-Usual scenario (kWh) $E_{g_{i,t}}^{GC}$: energy curtailment of the i-th RES facility at period t in the Green Charging scenario (kWh) I: set of RES facilities under consideration T: set of time intervals of the period under consideration (excluding periods of scheduled maintenance and outages).		
UNIT OF MEASUREMENT	%		
TARGET / THRESHOLDS	Reduction by 20%; The use of Demand response mechanisms by the DSO in cooperation with CPOs will incentivise certain behaviours from the EVs owners, which will lead to an optimal dispatch with the least possible RES generation curtailed. Spatio-temporally variable EV charging options will be offered to consumers, in relation to the corresponding RES production which may cause reverse power flow		

	issues in specific network buses at specific time periods. However, since there is no direct load control and EV owners' behaviour may be inelastic, the reduction of RES generation curtailment is expected to be 20%.
MEASURED/INPUT DATA	Voltage magnitudes at the top of distribution feeders, power injections from distributed generation units and aggregated consumer demand at MV/LV transformer level and will be available. This measurements data, along with the network topology, will be used in order to calculate the Optimal Power Flows (OPF) in the distribution network. The OPF will be calculated under the Business-as-Usual scenario and the Green Charging Scenario Two main assumptions will be made: a) mass deployment of EVs and b) mathematical modelling of the EV users' behaviour and preferences. In the Business-as –Usual scenario, no flexibility from EV owners will be available, and EV charging will be considered as an inflexible load, whereas in the green charging Scenario, EV users' flexibility will be taken into account. As a result, the necessary components or the calculation of this specific indicator, namely ${E_g}_{i,t}^{BaU}$ and ${E_g}_{i,t}^{GC}$, will be computed directly from these simulations.

5.2.1.2 KPI_GR_02 - Peak load demand reduction/increase

BASIC KPI INFORMATION

KPI NAME	Peak load demand reduction/increase	**KPI ID**	KPI_GR_02
KPI TYPE	Technical	**RELEVANT BUC(S)**	5
RELATED PROJECT OBJECTIVE(S)	Flexible capacity contracts with EVs: Design flexible capacity contracts to avoid, reduce or delay investments in the distribution systems. These contracts D4.2 can be established, mainly with aggregators, CPOs, and large fleet operators. Real-time operation decision support tools: Develop decision support tools allowing the activation of flexibilities available at each moment in the network. The tools should be integrated into the distribution management systems and GR operated by the DSO.		
RELATED GREEK DEMO OBJECTIVE(S)	To demonstrate the services that are supported by the O-V2X-MP, including charging capacity limitation.		
OWNER	HEDNO		
KPI DESCRIPTION	This KPI measures the average reduction/increase of the load demand during the peak power demand due to the integration of EVs experienced over a specific period.		

KPI FORMULA	$$\Delta P_{max} = \sum_{i \in I} \frac{P_{max_i}^{BaU} - P_{max_i}^{UC}}{\lvert I \rvert}$$ $$P_{max_i}^{BaU} = \max_{t \in T} P_{i,t}^{BaU}$$ $$P_{max_i}^{UC} = \max_{t \in T} P_{i,t}^{UC}$$ $P_{i,t}^{BaU}$: demand load at transformer i on timeslot t in the Business-as-Usual scenario $P_{i,t}^{UC}$: demand load at transformer i on timeslot t in the BUC 5 scenario If the peak load demand decreases after implementing the services as per the BUC, a reduction is observed. Otherwise, there is an increase. I: set of transformers under consideration $\lvert I \rvert$: the cardinality of I, namely the total number of transformers T: set of time intervals of the period of peaks under consideration
UNIT OF MEASUREMENT	Kilowatts (kW)
TARGET / THRESHOLDS	Reduction below MV/LV transformer loading threshold.
MEASURED/INPUT DATA	Using the LV monitoring system installed at the transformer, the analysis and differentiation of load peaks will be performed before and after the implementation of the BUC's scenarios.

5.2.1.3 KPI_GR_03 - Number of Charging Points [General KPI]

BASIC KPI INFORMATION

KPI NAME	Number of Charging Points	**KPI ID**	KPI_GR_03
KPI TYPE	Technical	**RELEVANT BUC(S)**	4, 5
RELATED PROJECT OBJECTIVE(S)	Integration of V2X in Smart Grids.		
RELATED GREEK DEMO OBJECTIVE(S)	Deployment and testing of the Open V2X management platform for public Charging Points.		
OWNER	PPC		
KPI DESCRIPTION	The indicator presents the number of charging points installed in the pilot.		

KPI FORMULA	$C_{CPs} = n, n \in \mathbb{N}$ C_{CPs}: counter of CPs n: number of CPs (#) $\mathbb{N}$: set of natural numbers
UNIT OF MEASUREMENT	Number (#)
TARGET / THRESHOLDS	The indicator showcases the total installed charging points in the grid that are fully functional. This KPI should be within the suggested number of charging points proposed in the Greek pilot, between 2 and 5 charging points.
MEASURED/INPUT DATA	-

5.2.1.4 KPI_GR_04 – Number of LV monitoring equipment

BASIC KPI INFORMATION

KPI NAME	Number of LV monitoring equipment	**KPI ID**	KPI_GR_04
KPI TYPE	Technical	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	Contributes to planning and real-time operation tools using by DSO.		
RELATED GREEK DEMO OBJECTIVE(S)	Measurements from Secondary Substations which is important for DSO to request flexibility from CPO (BUC5) and to detect the reverse flow energy (BUC4).		
OWNER	HEDNO		
KPI DESCRIPTION	This KPI measures the number of Low Voltage monitoring equipment which will be installed in HEDNOs' Secondary Substations to provide data to DSO platform.		
KPI FORMULA	$C = n, n \in \mathbb{N}$ C: number of LV monitoring equipment in operation $\mathbb{N}$: set of natural numbers		
UNIT OF MEASUREMENT	Number (#)		
TARGET / THRESHOLDS	The target is to install the LV monitoring equipment at least in three Secondary Substations and set it in fully operated mode.		
MEASURED/INPUT DATA	-		

5.2.1.5 KPI_GR_05 - Data Acquisition and Storage Accuracy (DASA)

BASIC KPI INFORMATION

KPI NAME	Data Acquisition and Storage Accuracy (DASA)	**KPI ID**	KPI_GR_05
KPI TYPE	Technical	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	Real-time operation decision support tools		
RELATED GREEK DEMO OBJECTIVE(S)	To validate that the measurement data are collected and stored properly, for further process.		
OWNER	HEDNO		
KPI DESCRIPTION	This KPI assesses the precision and reliability of data collected from metering infrastructures installed at secondary substations. It focuses on ensuring that measurements from the substations are captured, recorded, and processed with a high degree of accuracy, completeness, and consistency. A series of data includes valid values of all the expected data (V, I, f, P, Q) at a certain time. To consider a series of data as accurate it should contain all the expected data, and the values of these data are within a specific reasonable range.		
KPI FORMULA	Data Accuracy (%) = (Accurate Series of Data Points / Total expected series Data Points) x 100		
UNIT OF MEASUREMENT	%		
TARGET / THRESHOLDS	95% during a month period of time, in the context 95% of the expected data has been collected and stored properly		
MEASURED/INPUT DATA	Voltage (V), Current (I), frequency (f), Active Power (P), Reactive Power (Q) from the secondary substations		

5.2.1.6 KPI_GR_06 – Data sampling frequency

BASIC KPI INFORMATION

KPI NAME	Data sampling frequency	**KPI ID**	KPI_GR_06
KPI TYPE	Technical	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	Real-time operation decision support tools.		
RELATED GREEK DEMO OBJECTIVE(S)	Reduced data sampling time period and capacity accuracy in flexibility contracts and green charging.		

OWNER	HEDNO, PPC
KPI DESCRIPTION	The time period in which the CPs and the LV monitoring system send measurements and data packages from the field to the Server/platform.
KPI FORMULA	$$T = t$$ t: time period for sampling data setting or configuring the equipment and the telecommunication with the target intervals.
UNIT OF MEASUREMENT	Time (minutes)
TARGET / THRESHOLDS	≤ 5 minutes/per data packages
MEASURED/INPUT DATA	This indicator is straightforward and does not require computation. The sampling time is a parameter that depends on the specifications of the measuring devices and the communication infrastructure.

5.2.2 Environmental and Social related KPIs

5.2.2.1 KPI_GR_07 - Impact on Carbon dioxide (CO2) emissions

BASIC KPI INFORMATION

KPI NAME	Impact on CO2 emissions	**KPI ID**	KPI_GR_07
KPI TYPE	Environmental	**RELEVANT BUC(S)**	BUC 4
RELATED PROJECT OBJECTIVE(S)	To show that the massive use of EVs will significantly contribute to carbon neutrality targets.		
RELATED GREEK DEMO OBJECTIVE(S)	To examine that the proposed solution, contributes to CO2 emissions mitigation		
OWNER	HEDNO		
KPI DESCRIPTION	This KPI evaluates the reduction in carbon dioxide (CO2) emissions achieved by using clean, renewable energy sources for EV charging, contributing to sustainability and addressing climate change. For the KPI, the assumption that the additional kWh used for charging EVs during the daytime (when there is RES surplus generation) would otherwise been consumed for charging the EVs during the night of the same day.		
KPI FORMULA	$$GHGER = \sum_{h \in H} \Delta C_{RES}(h) * CEC(h)$$ $GHGER$: Green House Gas Emissions Reduction H: the set of hours of the time period under study $\Delta C_{RES}(h)$: The reduction of RES curtailment (as calculated at KPI_01) at hour h $CEC(h)$: the Carbon Emission Coefficient during each hour h of the period under study; it reflects the average emissions of CO2 for 1 kWh taking into consideration the generation mix of Greece at that hour (extracted from Independent Power Transmission Operator [IPTO]) (gCO2/kWh)		
UNIT OF MEASUREMENT	g CO2		
TARGET / THRESHOLDS	> 0		
MEASURED/INPUT DATA	RES curtailment reduction ($\Delta C_{RES}(h)$), average CO2 emissions per kWh for the Greek generation mix ($CEC(h)$)		

5.2.2.2 KPI_GR_08 - EV user participants

BASIC KPI INFORMATION

KPI NAME	EV user participants	**KPI ID**	KPI_GR_08
KPI TYPE	Social	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	The project will demonstrate how the extensive use of V2X technologies affects user behaviour. The O-V2X MP is set to incorporate a series of algorithms designed for the effective management of EVs. These algorithms will be accessible to EV users, enabling them to assess the performance of these tools.		
RELATED GREEK DEMO OBJECTIVE(S)	Users will primarily be sourced from the pilot site's region, although individuals from other intriguing areas will be taken into account, to enable a comprehensive analysis.		
OWNER	PPC		
KPI DESCRIPTION	The quantity of EV users who will utilize the project-related charging stations to recharge their vehicles at least once.		
KPI FORMULA	$$N_U = n, n \in \mathbb{N}$$ N_U: number of EV users $\mathbb{N}$ is the set of natural numbers		
UNIT OF MEASUREMENT	Number (#)		
TARGET / THRESHOLDS	At least 4		
MEASURED/INPUT DATA	The O-V2X-MP will track the distinct count of EV users who charge their vehicles at the designated project-related charging stations.		

5.2.3 Service related KPIs

5.2.3.1 KPI_GR_09 –Utilised flexibility

BASIC KPI INFORMATION

KPI NAME	Utilised flexibility	KPI ID	KPI_GR_09
KPI TYPE	Service	RELEVANT BUCs	BUC 5
RELATED PROJECT OBJECTIVE(S)	To develop planning and real-time operation tools to be used by DSOs considering V2X impact and flexibilities. To propose and evaluate different business models options promoting the integration of V2X in electricity markets and power systems.		
GREEK DEMO OBJECTIVE(S)	To test the activation and impact in user behaviour of different services, including flexible capacity contracts and DR programs		
OWNER	HEDNO		
KPI DESCRIPTION	The indicator computes the total amount of flexibility offered by the EV users in the form of selecting a charging session from the options available during the activation of the capacity contract service. In this case, flexibility has the form of load shifts. That means that an EV user may shift his consumption towards or away from a time period.		
KPI FORMULA	$$F_{total} = \sum_{t \in T} \sum_{i \in I} F_{i,t}$$ $F_{i,t}$: energy consumed or curtailed by a user in charging point i at time period t, because of the activation of a capacity contract I: set of RES facilities under consideration T: set of time intervals of the period under consideration (excluding periods of scheduled maintenance and outages).		
UNIT OF MEASUREMENT	kwh		
TARGET / THRESHOLDS	If we consider a total amount of a priori flexibility F^0_{total} potentially offered from the EV users, then the target should be a high percentage of F^0_{total}.However, EV users flexibility may not coincide perfectly with network needs, a 40% of F^0_{total} can be considered adequate. This target may be adjusted in the future, according to the nature of the network data and EV users' preferences, which cannot be known in advance.		
MEASURED/INPUT DATA	Voltage magnitudes at the top of distribution feeders, power injections from distributed generation units and aggregated consumer demand at MV/LV transformer level and will be available. This measurements data, along with the network topology, will be used in order to calculate the Optimal Power Flows (OPF) in the distribution network. Two main assumptions will be made: a) mass deployment of EVs and b)		

	mathematical modelling of the EV users' behaviour and preferences. The capacity contract service will also be incorporated in this simulation. As a result, the necessary components for the computation of this indicator, namely $F_{i,t}$, will be derived from this simulation

5.2.3.2 KPI_GR_10 – EV User Satisfaction

BASIC KPI INFORMATION

KPI NAME	EV User Satisfaction	KPI ID	KPI_GR_10
KPI TYPE	Service	RELEVANT BUCs	BUC 4,5
RELATED PROJECT OBJECTIVE(S)	To Evaluate the engagement of the users in V2X adoption.		
GREEK DEMO OBJECTIVE(S)	To test the activation and impact in user behaviour of platform's different services.		
OWNER	PPC		
KPI DESCRIPTION	This KPI measures the satisfaction of users with respect to their interaction with O-V2X-MP. The KPI will be measured from a questionnaire that will be distributed to the participants. Each question will accept a range from 0 to 10 (greater number indicates higher satisfaction). Therefore,		
KPI FORMULA	$$S = \frac{\sum_i^n q_i}{n}$$ q_i denotes the score for the i-th question. n denotes the total number of questions.		
UNIT OF MEASUREMENT	Percentage %		
TARGET / THRESHOLDS	> 90%		
MEASURED/INPUT DATA	A custom questionnaire will be prepared using the EU Survey tool[5] and will be shared with the EV users participating in the BUCs. Several methodologies will be considered for developing the questionnaire, e.g., After-Scenario Questionnaire, NASA Task Load Index, and test-level satisfaction.		

[5] https://ec.europa.eu/eusurvey/

5.2.3.3 KPI_GR_11 – Requested Flexibility

BASIC KPI INFORMATION

KPI NAME	Requested Flexibility	**KPI ID**	KPI_GR_11
KPI TYPE	Service	**RELEVANT BUC(S)**	BUC 5
RELATED PROJECT OBJECTIVE(S)	Demonstration of V2X impact in power system. Contribution to planning and real-time operation tools using by DSO.		
RELATED GREEK DEMO OBJECTIVE(S)	Testing of activation and impact in user behaviour of flexible capacity contracts. Demonstration of O-V2X-MP charging capacity limitation.		
OWNER	HEDNO		
KPI DESCRIPTION	This KPI measure the amount of requested flexibility capacity by DSO according to the congestion in Secondary Substation at a time interval.		
KPI FORMULA	$E_{Flexibility} = \sum_{i \in I} \sum_{t \in T} \max(P_{i,t} - C_{i,t}, 0)$ I: The total number of the Secondary Substations T: The specific time interval of requested flexibility $C_{i,t}$: Transformer nominal operation power at a specific time interval (t) for Transformer (i) $P_{i,t}$: Power load consumptions at a specific time (t) for Transformer (i) $E_{Flexibility}$: DSO's requested flexibility capacity for a specific time interval (T)		
UNIT OF MEASUREMENT	Capacity (kWh)		
TARGET / THRESHOLDS	The target is for the 1% of total period the Transformer violation limit does not exceed the 30% of that limit.		
MEASURED/INPUT DATA	Transformer congested limit, Loads data from LV monitoring system		

5.2.3.4 KPI_GR_12 – Availability of the O-V2X-MP services

BASIC KPI INFORMATION

KPI NAME	Availability of the Charging Points connectivity with the O-V2X-MP	**KPI ID**	KPI_GR_12
KPI TYPE	Service	**RELEVANT BUCs**	BUC4, BUC5
RELATED PROJECT OBJECTIVE(S)	The design of the open V2X management platform ensures solution scalability and reliability		

RELATED GREEK DEMO OBJECTIVE(S)	To demonstrate the interoperability of the O-V2X-MP for the management and operation of public charging with the existing infrastructure that includes charging stations, user equipment, and DSM.
OWNER	PPC
KPI DESCRIPTION	The indicator measures the percentage of time that the connectivity of O-V2X-MP with the charging points is available. The availability ensures the reliability of O-V2X-MP and the fact that there are no implementation flaws that disrupt the availability of the O-V2X-MP services. External events and circumstances (e.g., bad 4G connectivity or disruptions irrelevant to O-V2X-MP) are excluded from this KPI.
KPI FORMULA	$$A = \frac{Uptime}{Uptime + Downtime} * 100\%$$ $Uptime$: the total time when the connectivity of O-V2X-MP with the charging points is available $Downtime$: the total time when the connectivity of O-V2X-MP with the charging points is not available
UNIT OF MEASUREMENT	%
TARGET / THRESHOLDS	> 99.9%
MEASURED/INPUT DATA	This KPI can be measured by analysing the operational logs of O-V2X-MP to determine possible disconnections during a specific observability window.

5.2.3.5 KPI_GR_13 – Scalability of O-V2X-MP

BASIC KPI INFORMATION

KPI NAME	Scalability of O-V2X-MP	**KPI ID**	KPI_GR_13
KPI TYPE	Service	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	The design of the open V2X management platform ensures solution scalability and reliability		
RELATED GREEK DEMO OBJECTIVE(S)	To demonstrate the interoperability of the O-V2X-MP for the management and operation of public charging with the existing infrastructure that includes charging stations, user equipment, and DSM.		
OWNER	PPC		
KPI DESCRIPTION	The maximum number of EV charging stations (EVCS) that O-V2X-MP can support simultaneously.		

KPI FORMULA	$$EVCS_{max} = n \in N$$ n: The number of EV charging stations that O-V2X-MP can support.
UNIT OF MEASUREMENT	Units (number of EVCSs)
TARGET / THRESHOLDS	>= 25
MEASURED/INPUT DATA	Use one or multiple instances of an EV charging station simulator[6] and configure multiple instances of EVCSs to connect to a production-ready deployed version of O-V2X-MP. While all EVCSs are connected, verify that O-V2X-MP is operational, by trying to execute OCPP commands to the underlying EVCSs. All OCPP operations must be successful.

[6] https://github.com/sap/e-mobility-charging-stations-simulator/

5.2.4 Economical and Market related KPIs

5.2.4.1 KPI_GR_14 – Information Computer Technology (ICT) cost

BASIC KPI INFORMATION

KPI NAME	Information Computer Technology (ICT) cost	**KPI ID**	KPI_GR_14
KPI TYPE	Economical	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	Communications and data exchange between all stakeholders		
RELATED GREEK DEMO OBJECTIVE(S)	Interoperability of the O-V2X-MP for the management and operation of public charging with the existing infrastructure that includes charging stations, user equipment, and DMS.		
OWNER	HEDNO, PPC		
KPI DESCRIPTION	This KPI calculates the total cost incurred from the necessary use of information and communication technologies (HW and SW) to provide the flexibility services. Two formulas are presented, one for the costs of the DSO and one for the CPO.		
KPI FORMULA	The cost of DSO's HW and SW technologies used: $COUT_{DSO} = C_{ommunication\ equipment} + S_{erver} + SW_{\ development} + N_{etwork\ provider} * X + M_{aintenance}$ The cost of CPO's HW and SW technologies used: $COUT_{CPO} = C_{ommunication\ equipment} + S_{erver} + SW_{\ development\ \&\ application} + N_{etwork\ provider} * X + R_{oaming\ hub} * X + M_{aintenance}$ *COUT*: Cost Of Used Technologies (€) $C_{ommunication\ equipment}$: cost of the communication equipment (€) S_{erver}: cost of the server equipment (€) $SW_{\ development/development\ \&\ application}$: cost for the development of the software and/or application used (€) $N_{etwork\ provider}$: fees of the network provider (€) *X*: total months of network provider contract $R_{oaming\ hub}$: fees for the roaming hub (€) $M_{aintenance}$: maintenance cost (€)		
UNIT OF MEASUREMENT	Euro (€)		

TARGET / THRESHOLDS	The target of this KPI is to keep the total cost of the installed information and communication technologies below the allocated budget for equipment and services in order to leave enough resources for the rest of the required equipment.
MEASURED/INPUT DATA	The formulas sum up the total cost of: a) the communication hardware equipment used to facilitate the communication of the platforms with the grid equipment and between each other (modems, switches, antennas, etc.), b) the total server equipment required (PCs, miscellaneous), c) platform software development and end user application development (if applicable), d) network communication provider monthly fees, e) roaming hub provider monthly fees (for CPO) and f) maintenance of the total SW and HW technologies.

5.2.4.2 KPI_GR_15 – EV users' economic impact

BASIC KPI INFORMATION

KPI NAME	EV users' economic impact	**KPI ID**	KPI_GR_15
KPI TYPE	Economical	**RELEVANT BUC(S)**	BUC 4, BUC 5
RELATED PROJECT OBJECTIVE(S)	Demonstrate the impact of mass deployment of V2X technologies considering users behaviour. To evaluate the engagement of the users in V2X adoption.		
RELATED GREEK DEMO OBJECTIVE(S)	To test the activation and impact in user behaviour of different services, including: flexible capacity contracts, DR programs and Green Charging. To investigate the proposed solutions' exploitation plan and marketability strategy, resulting in the broadest possible user acceptance and societal added value.		
OWNER	HEDNO, PPC		
KPI DESCRIPTION	This KPI calculates the average net financial profit or loss of EV users participating in V2X. In specific, EV Users may experience discomfort (pains) or extra financial costs while participating in V2X BUCs. User discomfort can be translated to financial cost and is measured in euros. On the other hand, they may be remunerated for their participation in V2X, via reduced energy prices (gains).		
KPI FORMULA	$$EI_{total}^{EV} = \frac{\sum_{i \in N} EI^{EV}(i)}{\lvert N \rvert}$$ Where, $EI^{EV}(i) = P^{EV}(i) - D^{EV}(i)$, is the economic impact on the i-th EV user participating in V2X (measured in euros), $P^{EV}(i)$, is the financial profit of the i-th EV user participating in V2X (measured in euros),		

	$D^{EV}(i)$, is the discomfort of the i-th EV user participating in V2X (measured in euros), N, is the set of users participating in V2X, while $\|N\|$ is the number of users participating in V2X.
UNIT OF MEASUREMENT	Euro (€)
TARGET / THRESHOLDS	The target is to have a net positive financial impact on the EV users, in order to incentivize participation in V2X. A 10% total cost reduction is considered enough.
MEASURED/INPUT DATA	EV users' preferences will be modelled in the context of an EV parking lot. Their participation in V2X will be simulated by taking into account real network data, which will trigger the activation of DR programs and EV capacity contracts. The economic impact on EV users will be computed by comparing to a simulation following the Business-as – Usual scenario.

6 Conclusions

The analysis conducted in the current deliverable aims to serve primarily as a strategic roadmap for the Greek demo site, throughout the project. The pilot site has been determined and described, followed by a thorough analysis of the hardware installations and software deployment that will take place. The key stakeholders involved in the Greek demo were also described and presented, leading to the analysis of the BUCs relevant to the Greek demo. Based on this groundwork, the timeline of the planned actions was meticulously designed, together with a demonstration plan for validating the functionality of the demo site.

The final part of the deliverable was focused on the development of the appropriate KPIs. This stage is of principal priority in order to assess the extent to which the proposed solutions have been implemented and effectively resolved actual problems. This is a critical step toward achieving the project's objectives and creating a functional system that is both scalable and replicable.

In summary, the main accomplishment of this deliverable is the development of a comprehensive document that includes the main characteristics of the components to be installed and deployed, a precise timeline for all the necessary planned actions till the demonstration and the demonstration plan. This information is accompanied by the analysis of the BUCs steps and the KPIs definition that are essential for evaluating the progress and success of the demo site. Together, these elements form a comprehensive and robust roadmap that guides all project activities until its conclusion.

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