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Electric Vehicles Management for carbon neutrality in Europe

Deliverable D4.3
Integration of V2X in Charging Point Operators and Virtual Power Plants Aggregation

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[1] https://ev4eu.eu/

Executive Summary

The Integration of V2X in Charging Point Operators and Virtual Power Plants Aggregation (Deliverable D4.3) provides an overview of the integration of V2X in Charging Point Operators and Virtual Power Plants Aggregation within the project EV4EU. This deliverable has been prepared by the leader of task Integration of V2X in Charging Point Operators and Virtual Power Plants Aggregation – GEN-I.

Table of Contents

List of Figures

List of Tables

Acronym

BRP	Balance Responsible Parties
CA	Consortium Agreement
CC BY	Creative Commons license (credit must be given to the creator)
CC0	Creative Commons Public Domain Dedication
CC-BY-NC/ND	Creative Commons license (credit must be given to the creator, only non-Commercial uses of the work are permitted, no derivates or adaptations of the work are permitted)
CPO	Charge Point Operator
CSMS	Charging Station Management System
DER	Distributed Energy Resources
EC	European Commission
eMSP	eMobility Managed Service Provider
ESS	Energy Storage Systems
FAIR	Findable, Accessible, Interoperable and Reusable principles
IM	Innovation Metrics
IP	Intellectual Property
IPR	Intellectual Property Rights
mFRR	manual Frequency Restoration Reserve
RES	Renewable Energy Sources
RR	Replacement Reserve
TRL	Technology Readiness Level
V1G	Grid to charge the vehicle
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
V2H	Vehicle-to-Home
VPP	Virtual Power Plant
WP	Work Package

1 Introduction

The main objective of this task is to develop smart charging methods and control mechanisms that optimise both the satisfaction of electric vehicle (EV) users and the overall efficiency of the energy system. This includes maximising the use of renewable energy sources (RES) by utilising the unused storage capacity of EVs, while minimising the need for grid upgrades and additional power generation. The EV4EU project aims to develop strategies for the management of vehicle-to-everything (V2X) systems at different levels, from the household and building level to large-scale V2X management challenges for the optimal functioning of virtual power plants (VPP), the latter being the focus of Task T4.3.

On a broader scale, the flexibility offered by V2X can be merged with other distributed energy resources (DER) and monitored by a VPP. The project will, in this task, also address the management of V2X within a VPP portfolio, taking into account RES and energy storage systems (ESS). The aim is to offer energy and services on the markets or directly to grid operators, creating additional value for EV users. The strategies used for V2X management, together with coordination with RES, are intended to limit the increase in consumption at peak times to a maximum of 2% at national level. In addition, the integration of V2X flexibility into VPP services is expected to lead to a 10% reduction in energy bills (without dedicated infrastructure for new V2X installations).

1.1 Scope and Objectives

This task is dedicated to the integration of V2X into the strategies of Charge Point Operators (CPOs) and VPP. The main objective is to formulate energy management algorithms that facilitate the aggregation of different resources in VPPs, such as V2X, RES and ESS. The proposed methods incorporate a probabilistic distribution function to account for uncertainty in service participation and help the VPP define its strategy. This probabilistic behaviour is integrated into a stochastic optimisation problem that takes into account the social welfare of the aggregated actors.

A novel energy management algorithm for VPPs considers the following:

- the effect of spatial and temporal constraints on aggregation,
- the optimisation of VPP’s aggregation based on charging patterns and local conditions,
- the coordination of V2X with other resources,
- the impact of V2X on the social welfare of users,
- the impact of V2X on VPP's profits and risk management, and
- maximising benefits for customers (e.g. EV owners) in both business-to-consumer (B2C) and business-to-business (B2B) scenarios.

The algorithms and methods, presented in the D4.3, will be used and tested in the Slovenian DEMO. Due to this reason, the proposed and described services have been developed based on Slovenian legislation and rules.

1.2 Structure

This document can generally be divided into two parts. The first focuses on the integration of V2X into VPP's portfolio and the second introduces the integration of V2X into the management of charging stations (CS) by CPO. Before we dive into these topics, this Chapter 1 serves as an introduction to the subject matter, scope, objectives, structure, and relationship to other tasks of the project. Chapter 2 focuses on the integration of V2X into VPP´s portfolio. In Chapter 3, we present the overview of how V2G integrates into the operations of a charging point operator. The integration of Vehicle-to-Grid (V2G) technology into charging point operations involves collaboration and communication between various stakeholders, including electric vehicle (EV) owners, charging point operators (CPOs), and potentially other entities like utility companies. Finally, Chapter 4 summarises the most important points of this document and concludes the work.

1.3 Relationship with other deliverables

This task was carried out at the same time as T4.4. Both tasks revolve around VPP. The main objective of task T4.4 is to define services focussing on the participation of EVs in flexibility markets at local and regional level and to present them in the deliverable **D4.4 Impact of mass deployment of V2X in energy markets and services.** Task T4.3 was dedicated to the integration of V2X in CPOs and VPP strategies and algorithms for the best possible implementation of the services defined in **D4.4**.

At the same time, T4.3 had to consider the information from **D1.4 Business models in the V2X value chain** [1], in which the newly developed BMs were described, which served as the basis for the development of the BUCs. These were formulated during task T1.5 and documented in **D1.5 V2X Use-cases repository** [2]. As well as the consideration of the applicable legal framework in which the flexibility market operates, as analysed in the legal repository created in task T1.3 and presented in **D1.3 Regulatory opportunities and barriers for V2X deployment in Europe** [3]. In addition, the insights on EV profile bundling are important to create a set of services adapted to different needs and user behaviour, see **D3.3 EVs use Clustering results report** [4], to ensure optimal bundling through VPPs.

The findings from this task serve as input for **D7.1 Detailed definition and implementation plan of the Slovenian demonstrator** [5]. The strategies defined here will be tested in the Slovenian demonstration project and will therefore be taken into account in the development of the KPIs.

2 Virtual Power Plant (VPP)

A VPP is a cloud-based, decentralized network that aggregates the capacities of various distributed energy resources, such as solar panels, wind turbines, and energy storage systems, to function as a single, unified power plant. Units with flexible power regulation, such as gas power plants, combined heat and power, hydro power plants are also connected to the virtual power plants. These technologies allow for more effective load balancing, grid stabilization, and integration of renewable energy sources.

The activation of the positive or negative flexibility of the units is controlled by the VPP central unit, while the physical units remain operationally and ownership independent. The task of VPP is to relieve the load on the electricity distribution network by smart activation of sources and distribution of electricity in case of network peaks. The combined energy of all VPP units is marketed as an offer on the electricity market.

In the event of a shortage or excess of electricity on the market, the VPP activate the consumption of grid energy sources or production of electrical energy. VPP takes care of the calculation of the request for the activation of the necessary amount of electricity with pre-defined rules for sorting and selecting sources. A sorting protocol based on energy price, activation price, current availability and past activations selects the most suitable resources. Resource activation activates candidates from the resource pool. The resource pool is a set of activation candidates or resources suitable for activation. Sources are connected into pools due to the specifics of the market and the need for activation when one source does not meet all the needs for the required amount of energy. With resource pools, the VPP ensure redundancy if the desired resource does not adapt to the control power of the activation and then the sorting algorithm in the pool can choose another resource for us.

The energy sent to the network is equal to the sum of the energy production or consumption of each production source. [6]

2.1 The VPP concept

As mentioned, a VPP is a cloud-based power plant that combines different DERs (Distributed Energy Resources). It is an advanced system with software components managing data, optimization, forecasting, control, validation, and secure communication.

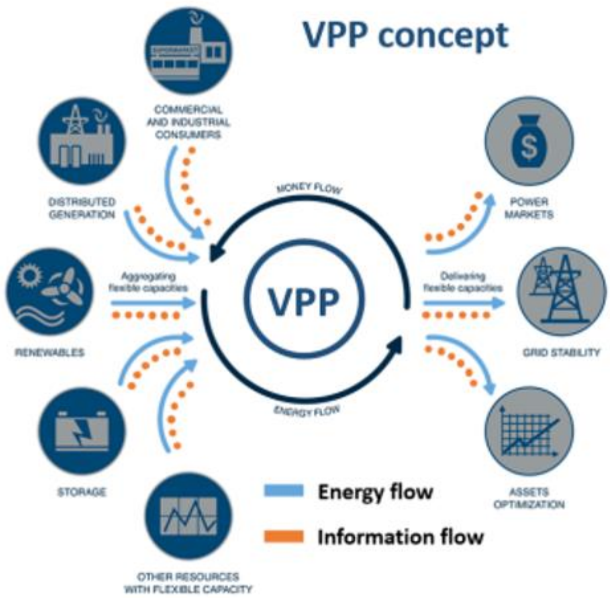

Figure 1: High-level VPP concept [7]

The ICT technology, which includes software and communication services, ensures the VPP control unit and its DERs can connect and share information. Without enough ICT support, the VPP concept cannot work well. The diagram in Figure 1 shows a basic VPP concept, where commercial and industrial consumers, distributed generation, renewables, storage units, and other flexible resources are included. There are three main bidirectional flows between these entities: power flow, data flow, and cash flow. [7]

VPP integration into Slovenian demo is presented in Figure 2.

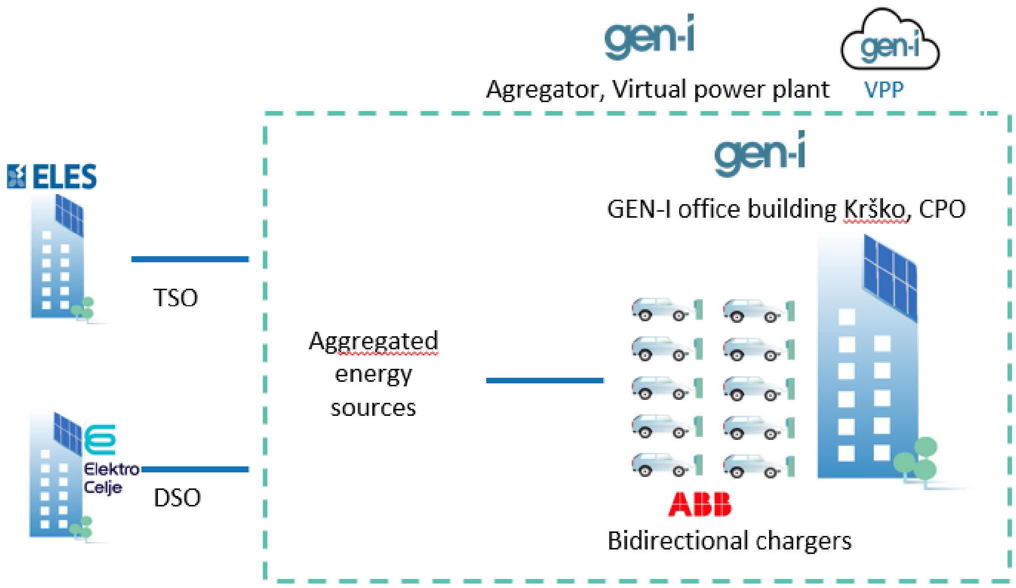

Figure 2: Integration of VPP into Slovenian DEMO

Flexibility pooling is decoupled from energy supply, so aggregation is possible across many different balance responsible parties (BRP). VPP system aggregates geographically DERs, including renewables, demand response and storage units. Flexibility is additionally characterized by its location. The VPP system will be operated by a flexibility operator, which can be an independent market player, but also a retailer. Flexible units can be acquired and pooled by the flexibility operator. Aggregated flexibility is used for commercial purposes (mFRR or RR market operated by TSO). This is represented in the diagram in Figure 3. [9]

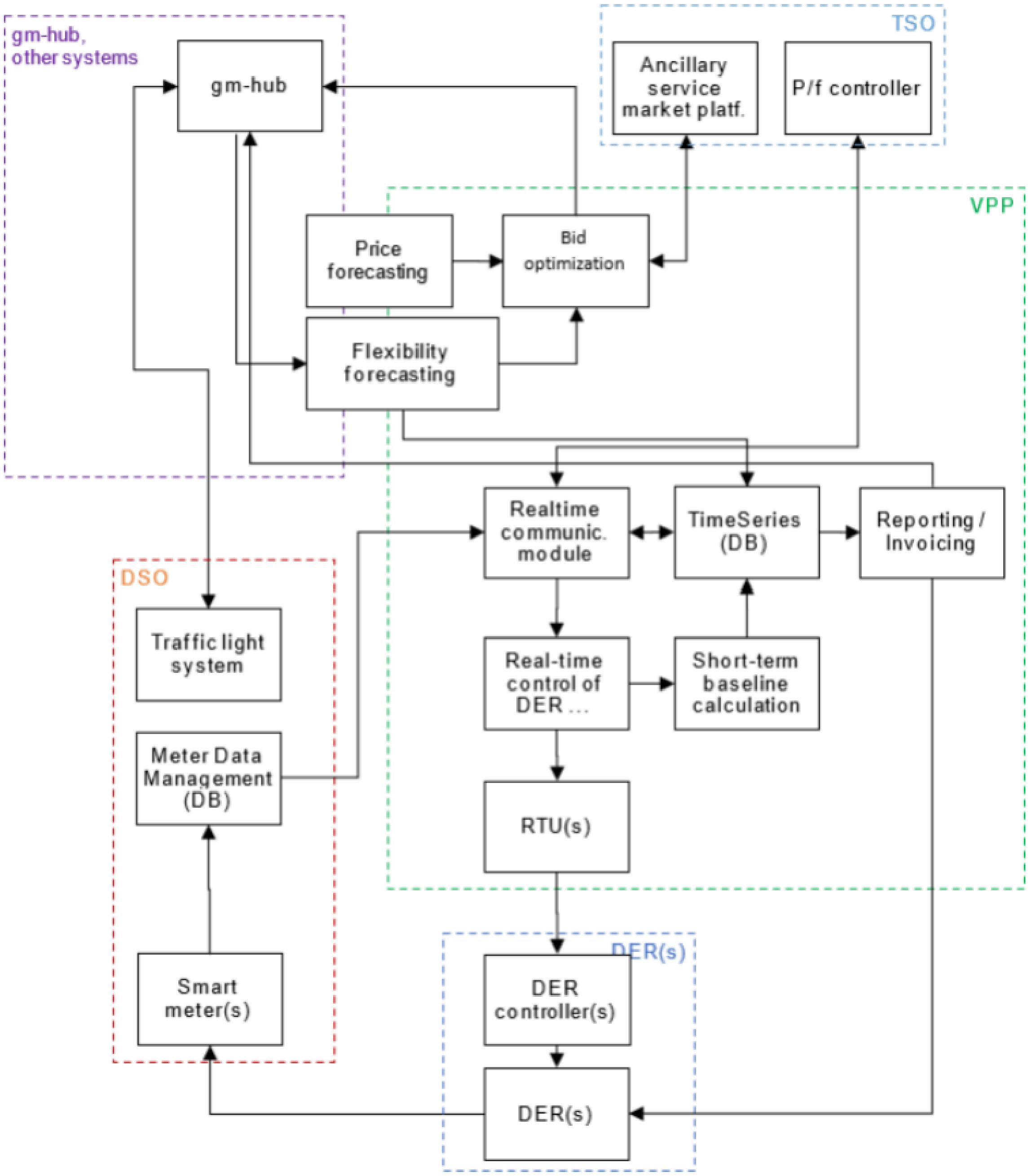

Figure 3: Integration of the VPP into DSO and TSO platforms [9]

2.2 RTU integration

The integration of Remote Terminal Units (RTUs) into VPPs is a critical step in enhancing the functionality, control, and performance of these distributed energy systems. RTUs serve as key components in monitoring and controlling various assets within a VPP. In this discussion, we will explore how RTUs are integrated into VPPs, the benefits of such integration, and the considerations involved. [11]

- Understanding RTUs:
  - **Role of RTUs:** RTUs act as communication hubs, collecting data from diverse energy assets such as solar panels, wind turbines, energy storage systems, and other distributed energy resources (DERs) within the VPP.
- Integration Process:
  - **Communication Protocols:** Ensure that RTUs and other devices within the VPP communicate seamlessly. Common communication protocols include Modbus, DNP3, IEC 60870, or IEC 61850.
  - **Data Standardization:** Implement standardized data formats to ensure uniformity in the data collected from different assets. This facilitates efficient processing and analysis.
  - **SCADA Systems:** Integrate RTUs with Supervisory Control and Data Acquisition (SCADA) systems, allowing centralized monitoring, control, and visualization of the VPP's performance.
- Data Acquisition and Monitoring:
  - **Real-Time Data:** RTUs facilitate the collection of real-time data, including power output, voltage, current, and environmental conditions from various distributed assets.
  - **Sensor Integration:** RTUs often interface with sensors and meters to capture granular data, providing insights into the operational status and health of individual components.
- Control and Command Functions:
  - **Remote Control:** RTUs enable remote control of assets within the VPP, allowing operators to adjust settings, modify parameters, and optimize the performance of individual devices.
  - **Load Balancing:** With insights provided by RTUs, VPP operators can dynamically balance loads, ensuring efficient utilization of energy resources.
- Cybersecurity Considerations:
  - **Secure Communication:** Implement robust cybersecurity measures to secure communication between RTUs and the central control system, protecting against unauthorized access and potential cyber threats.
  - **Data Encryption:** Utilize encryption protocols to safeguard sensitive data transmitted between RTUs and the central infrastructure.
- Benefits of RTU Integration:
  - **Optimized Operation:** RTUs enhance the VPP's ability to operate efficiently by providing real-time data for decision-making and control.

  - **Fault Detection and Diagnostics:** The continuous monitoring enabled by RTUs allows for the early detection of faults or anomalies, enabling timely diagnostics and maintenance.
  - **Resilience and Reliability:** Integrating RTUs improves the overall resilience and reliability of the VPP by enabling rapid responses to changing grid conditions or fluctuations in energy production.
- Scalability and Flexibility:
  - **Scalable Architecture:** Design the integration to be scalable, allowing for the addition of new assets or the expansion of the VPP without significant reconfiguration.
  - **Flexibility:** Ensure the integration supports a diverse range of assets and is adaptable to changes in the energy landscape.
- Regulatory Compliance:
  - **Compliance Standards:** Adhere to relevant regulatory standards and compliance requirements governing the integration of RTUs into VPPs. This may involve ensuring data privacy, grid code compliance, and adherence to industry-specific regulations.
- Monitoring and Maintenance:
  - **Health Monitoring:** Implement continuous health monitoring of RTUs to ensure their proper functioning and establish protocols for regular maintenance and updates.
- Training and Documentation:
  - **Training Programs:** Develop training programs for operators to effectively use and maintain the integrated RTUs.
  - **Documentation:** Maintain comprehensive documentation on the integration process, including configurations, protocols, and cybersecurity measures.

In conclusion, the integration of RTUs into VPP is a crucial aspect of optimizing the performance, control, and reliability of distributed energy systems. Careful consideration of communication protocols, data standardization, cybersecurity, and scalability are essential to create a robust and efficient VPP infrastructure.

2.3 Understanding Vehicle-to-Grid Technology:

Vehicle-to-Grid technology enables bidirectional energy flow between electric vehicles and the power grid. Traditionally, EVs have been considered as energy consumers, drawing power from the grid to charge their batteries. However, with V2G technology, these vehicles can not only take energy from the grid but also feed excess energy back into it when needed. V2X will be integrated in the flexibility management platform in a similar way of a storage system but taking into account the needs of the users.

2.4 Integration Benefits:

- Grid Stability and Reliability:

By incorporating V2G charging stations into VPPs, the grid gains increased flexibility and reliability. The bidirectional flow of electricity from EVs can help balance supply and demand, providing grid operators with a valuable tool to stabilize the system.

- Peak Demand Management:

V2G technology allows electric vehicles to discharge stored energy during peak demand periods, reducing strain on the grid. This peak shaving capability can mitigate the need for expensive infrastructure upgrades to handle sudden spikes in energy consumption.

- Renewable Energy Integration:

Virtual Power Plants, when coupled with V2G charging stations, facilitate the seamless integration of renewable energy sources. By utilizing excess energy generated during periods of high renewable output, EVs can store and redistribute this energy during periods of low generation, ensuring a more consistent and reliable power supply.

- Economic Incentives for EV Owners:

The integration of V2G charging stations into Virtual Power Plants can provide economic benefits to EV owners. Through participation in demand response programs, owners can earn incentives by allowing their vehicles to contribute to grid stability.

- Environmental Impact:

The increased adoption of V2G technology within VPPs aligns with global efforts to reduce carbon emissions. By optimizing the use of renewable energy and promoting cleaner transportation, the integration contributes to a more sustainable and environmentally friendly energy ecosystem.

2.5 Challenges and Considerations:

While the integration of V2G charging stations into Virtual Power Plants holds immense promise, several challenges must be addressed. These include regulatory frameworks, standardization of V2G protocols, and ensuring cybersecurity to protect against potential vulnerabilities in the bidirectional communication between vehicles and the grid.

The combination of Vehicle-to-Grid technology and Virtual Power Plants marks a significant step towards a more resilient, sustainable, and efficient energy future. As the world continues to transition towards cleaner energy solutions, the integration of EVs into the power grid serves as a powerful example of how innovation can transform not only the transportation sector but also the broader energy landscape. The synergy between V2G charging stations and VPPs is a testament to the potential of smart, interconnected systems in shaping the future of energy.

3 Integration of V2X in Charging Point Operators

The integration of V2X technology into charging point operations involves collaboration and communication between various stakeholders, including EV owners, charging point operators (CPOs), and potentially other entities like utility companies. Here is an overview of how V2G integrates into the operations of a charging point operator:

- Hardware and Software Integration:
    - **V2G-Enabled Charging Infrastructure:** Charging point operators need to deploy charging stations that support bidirectional power flow, allowing energy to be drawn from the grid to charge the vehicle and returned to the grid when needed.
    - **V2G Communication Protocols:** Charging stations and the vehicles must communicate using standardized protocols to facilitate bidirectional power flow. Common protocols include Open Charge Point Protocol (OCPP 2.1) for charging stations and ISO 15118-20 for V2X communication.

- V2X Technology:
    - **Bidirectional Energy Flow:** V2X enables bidirectional energy flow between electric vehicles and the grid. This means that energy can not only be drawn from the grid to charge the vehicle (V1G) but can also be supplied back to the grid when the vehicle is not in use. More specifically, the following modes are supported[2]:
        - Vehicle to home (V2H) is a concept related to the bidirectional flow of energy between an electric vehicle (EV) and a residential home.
        - Vehicle-to-Building (V2B) involves the bidirectional flow of energy between an EV and a building or commercial facility.
    - Vehicle-to-Grid (V2G) is a technology that enables EVs to interact with the electric grid, allowing for a bidirectional flow of electricity between the vehicle's battery and the grid.
    - **Communication Capabilities:** V2X technology allows EVs to communicate with charging infrastructure, grid operators, and other smart devices. This communication is crucial for coordinating energy exchange and managing grid stability.

- Charging Point Infrastructure [12]:
    - **Upgrade Existing Charging Stations:** Charging point operators may need to upgrade existing charging stations or deploy new V2G-enabled stations. This involves integrating the necessary hardware and software components for bidirectional energy flow.
    - **Smart Charging Infrastructure:** CPOs can deploy smart charging infrastructure that supports V2X capabilities. This infrastructure allows for advanced energy management and control, facilitating bidirectional energy flows between various stakeholders.

[2] Vehicle-to-Vehicle (V2V) is another V2X technology, which enables the direct communication between vehicles on the road. We omit it, though, as it does not apply to charging point operators.

- **Optimized Charging:** Integration with V2X technology enables CPOs to optimize charging schedules based on Demand & Response services and renewable energy availability to dynamically balance the demand and offer of energy on power grids.

- V2G Services and Aggregation:
    - **V2G Service Provision:** Charging point operators can offer V2G services to EV owners, enabling them to participate in grid services such as:
        - peak shaving, which is the practice of reducing or shifting electricity consumption during periods of high electricity demand, known as peak hours),
        - load balancing, which aims to maintain a stable and reliable electricity supply by preventing congestion in specific areas of the grid), and
        - frequency regulation, i.e., the process of maintaining the electric grid's frequency at its nominal value (e.g., 50 Hz or 60 Hz) by adjusting the supply and demand of electrical power.

These services require implementing the necessary software to enable V2G functionalities in the charging infrastructure.

- User Interface and Billing Systems:
    - **User Interface:** Charging point operators must update user interfaces to inform EV owners about the availability of V2G services, associated benefits, and the potential impact on their charging routines. For ease of use, these interfaces can be offered through mobile phone applications with intuitive, wizard-like GUIs that support all V3G services provided by the charging point operators.

Billing Systems: Charging point operators need to adapt their billing systems to account for bidirectional energy flow. This includes defining pricing structures for V2G services and incorporating them into the overall billing process.

- Grid Integration and Communication:
    - **Grid Communication:** Charging point operators need to establish communication channels with grid operators to exchange information about grid conditions, demand response needs, and other relevant data.
    - **Grid Services:** V2G-enabled vehicles can provide grid services, such as balancing and ancillary services, to support the stability and reliability of the electrical grid. Charging point operators play a key role in facilitating these interactions.
    - **Grid Support:** Integration of V2X in CPOs and VPPs provides, by offering flexibility in managing energy supply and demand, enhancing grid stability, and supporting renewable energy integration.
    - **Grid Flexibility Services:** CPOs, which manage the charging stations, can enter into contracts with DSOs to provide grid flexibility services. These services involve adjusting the charging patterns of electric vehicles to support the stability of the local distribution grid.

- Regulatory Compliance:
  Regulatory Framework: Charging point operators must navigate the regulatory landscape to comply with standards and regulations governing V2G services. This may involve obtaining approvals and adhering to specific guidelines set by regulatory authorities.

- Security and Privacy Considerations:
  Cybersecurity Measures: Charging point operators need to implement robust cybersecurity measures to protect V2G-enabled infrastructure from potential cyber threats.
  - **Data Privacy:** Ensure compliance with data privacy regulations, as V2G involves the exchange of sensitive information between vehicles, charging infrastructure, and grid operators.

- Educating Stakeholders.

- **Stakeholder Awareness:** Charging point operators play a crucial role in educating EV owners about the benefits of V2G, addressing any concerns they may have, and promoting the adoption of bidirectional charging.

Successful integration of V2G into charging point operations requires a coordinated effort among CPOs, technology providers, regulators, and other stakeholders to create a seamless and secure ecosystem that maximizes the potential of V2G services. More specifically, the following requirements should be addressed:

- **Standardization:** Standardization of communication protocols and interoperability is crucial to ensure seamless integration of V2X across different CPOs and VPPs.
- **Regulatory Framework:** Clear regulatory frameworks, national and international (EU-wide), are needed to address issues related to energy market participation, compensation mechanisms, and data privacy.
- **EMS:** The integration requires advanced Energy Management Systems (EMS) that can communicate with both CPOs and VPPs. These systems optimize the use of EVs for grid services while considering individual user preferences and constraints.

In summary, the integration of V2X technology in CPOs aggregation holds the potential to create a more flexible, responsive and sustainable energy ecosystem by leveraging the energy storage capabilities of electric vehicles. This is highlighted in the following figure, which illustrates part of the V2X capabilities that can be integrated into the CPs[3]: the bidirectional flow of energy between EVs and CPs, i.e., grid to vehicle (G2V) and vehicle to grid (V2G), can ensure grid stability, during the day, depending on the energy generation by the renewable sources.

[3] Figure originally published in REHMAN, Muhammad Abdul, et al. "A comprehensive overview of vehicle to everything (V2X) technology for sustainable EV adoption". Journal of Energy Storage, 2023, 74: 109304.

3.1 The activation process

The activation process, as defined by DSO or TSO, refers to the initiation of a specific load-frequency control action, such as aFRR and mFRR, aimed at maintaining grid stability and balance. In Slovenia, there are five DSOs (Elektro Ljubljana, Elektro Gorenjska, Elektro Maribor, Elektro Celje and Elektro Primorska) and one TSO (ELES). The VPP activation process and the engagement of its aggregated DERs commence when a TSO or DSO issues a set point signal to a balance service provider, typically an aggregator managing the VPP system, instructing it to provide the necessary balancing energy. Activation can be positive or negative, irrespective of the load-frequency control action. To comprehend the activation process from the VPP perspective, it is essential to define positive and negative activation.

Positive activation occurs when there is an electricity shortage in the grid, forcing the engagement of additional generation units or a reduction in load consumption. During negative activation, certain DERs must decrease generation or increase consumption (loads) to align with the specified set point.

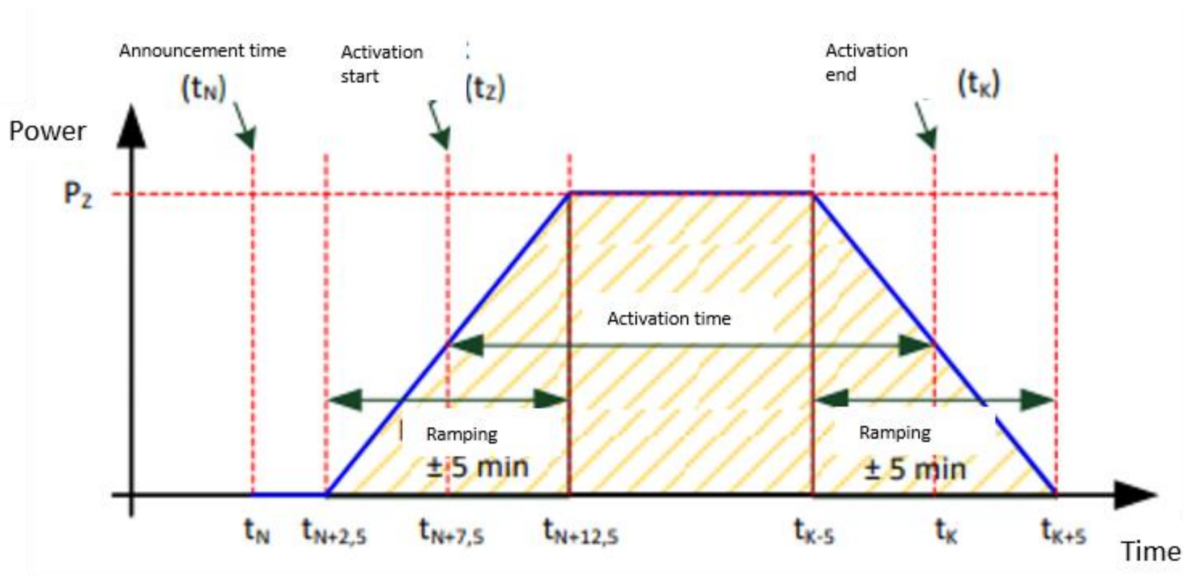

Figure 4: rRPF activation response [10]

3.2 Signal lists

3.2.1 The list of required signals for VPP

In Table 1, the conversion of the parameters of the electric charging station into general parameters are described. A general "availability" parameter, written as [Release], is added, which is also used for all units.

Table 1: List of required signals for VPP

Device signal	General signal	Conversion
[Device ID]	[Resource group ID]	Checks to which resource group the device ID belongs
[Power]	[Power]	The signal is only copied Power->Power
[Power]	[AvailablePowerNegative]	This parameter will represent the difference between the power of the charger (make this parameter manually adjustable) and the current power. Therefore, if the current power is equal to 0kW and the battery is not full, but we can activate 10kW charging, the result will be "-10kW".
[Power]	[AvailablePowerPositive]	The current power signal is copied, i.e. if the charger is charging with 10kW, the charger can be disabled by 10kW, which represent positive regulation
[DeviceIsAvailable]	[Release]	The value is mapped. The possible states are 0 and 1, where 1 means that the device is ready for activation.

Availability must also be affected by the ratio between the parameters [Capacity] and [TotalCapacity], since we will not discharge the EV battery under e.g. 10% and fillings over 90% (both limits must be arbitrarily adjustable).

3.2.2 The messages from the charging station

The message format is JSON. It is telemetry data sent by the CSMS in the name of the electric charging station. The Table 2 below shows the required monitored data. The table may be changed or supplemented in the future.

Table 2: List of messages from the charging station

Data	Type	Unit	Description
Entity	String	-	The data of this field is always "EVStationTelemetry"
DeviceID	Integer	-	Device identification. In doing so, the ID generated for each device during device registration is sent.
ActivationAcknowledge	Boolean	-	0 – The device did not receive an activation signal (default value) 1 - The device has received an activation signal
Activation	Boolean	-	0 – The device was not activated 1 – The device has responded to activation and is currently activated
DeviceIsAvailable	Boolean	-	0 – Device not available (due to error) 1 – The device is available
AvailablePowerPositive	Decimal	kW	The value by which the device can reduce consumption
AvailablePowerNegative	Decimal	kW	The value by which the device can increase consumption
CurrentCapacity	Decimal	kWh	The current state of charge of the battery in the connected vehicle
TotalCapacity	Decimal	kWh	Nominal capacity of the battery in the connected vehicle
TimestampDevice	DateTime	-	The timestamp in milliseconds in UTC when the measurement was taken on the device.
PowerOn	Boolean	-	0 – the device is switched off 1 – the device is on

3.2.3 Activation inquiry

Message format is JSON. It is the data sent by the GEN-I platform in case of activation of the device. The Table 3 below shows the data we currently want to monitor. The table may be changed or supplemented in the future.

Table 3: List of activation messages

Data	Type	Unit	Description
Entity	String	-	The attribute value is always "EVStationActivation"
ActivationID	Integer	-	Activation identification from GEN-I platform
TimestampCreated	DateTime	-	The timestamp in milliseconds when the activation was created
DeviceID	Integer	-	Identification of the charging station. In doing so, the ID generated for each device by GEN-I platform during device registration is sent.
ActivationRequest	Boolean	-	0 – completion of activation 1 – start of activation
Power	Integer	-	0-Device off 1-Device switched on

3.2.4 Activation acknowledgment

Message format is JSON. It is the data sent by the GEN-I platform in case of activation of the device. The Table 4 below shows the data we currently want to monitor. The table may be changed or supplemented in the future.

Table 4: List of activation acknowledgment

Data	Type	Unit	Description
Entity	String	-	The attribute value is always »EVStationActivationAcknowledge«
ActivationID	Integer	-	Activation identification from GEN-I platform
TimestampCreated	DateTime		The timestamp in milliseconds when the activation was created
DeviceID	Integer	-	Identification of the charging station. In doing so, the ID generated for each device by GEN-I platform during device registration is sent.
ActivationRequest	Boolean	-	0 – completion of activation 1 – start of activation
Power	Integer	-	0-Device off 1-Device switched on

3.2.5 Heartbeat

To monitor the Advanced Message Queuing Protocol (AMQP) connection between CPO and the GEN-I platform, a special "Heartbeat" message is provided, which is sent via the AMQP protocol. The message will be sent automatically every second or at the agreed frequency.

Table 5: List of heartbeat

Data	Type	Description
Entity	String	The attribute value is always »Heartbeat«
TimestampCreated	DateTime	Time stamp when the message was created in the platform
HeartbeatAMQP	Integer	An integer number. (N+1)

4 Conclusions

Within the Task 4.3, we had analysed the integration of V2X into the strategies of Charge Point Operators (CPOs) and Virtual Power Plant (VPP). Chapter 2 presents the integration of V2X into the strategies of VPP. The algorithms and methods for VPP, presented in D4.3, will be used and tested in the Slovenian DEMO. Due to this reason, the proposed and described services will be developed based on Slovenian legislation and rules. The principles of functionalities of the VPP are similar in all of EV4EU's demo sides, but the activation and functioning of the services are different in each country.

The combination of Vehicle-to-Grid technology and Virtual Power Plants marks a significant step towards a more resilient, sustainable, and efficient energy future. As the world continues to transition towards cleaner energy solutions, the integration of EVs into the power grid serves as a powerful example of how innovation can transform not only the transportation sector but also the broader energy landscape. The synergy between V2G charging stations and VPPs is a testament to the potential of smart, interconnected systems in shaping the future of energy.

Chapter 3 gives and overview of the integration of V2X into the strategies of Charge Point Operators. The integration of Vehicle-to-Grid (V2G) technology into charging point operations involves collaboration and communication between various stakeholders, including electric vehicle (EV) owners, charging point operators (CPOs), and potentially other entities like utility companies.

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