



Standards and protocols gap analysis

Project deliverable D5.5



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Authors	Jordan Sautreau (Trialog) Didier Bollen (Goodmoovs) Michel Bayens, Jonel Timbergen (EV Roaming Foundation)
Internal reviewers	Yannick Huc (Trialog) Michel Bayings, Roland Ferwerda (EV Roaming Foundation)
Document approval	Frank Geerts (ElaadNL)

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Contents

1	DELIVERABLE ADMINISTRATIVE INFORMATION	2
1.1	LEGAL DISCLAIMER.....	2
2	EXECUTIVE SUMMARY.....	5
2.1	KEY WORDS.....	5
2.2	SUMMARY.....	5
3	LIST OF ABBREVIATIONS AND ACRONYMS.....	6
4	PURPOSE OF THE DELIVERABLE.....	7
4.1	ATTAINMENT OF THE OBJECTIVES AND EXPLANATION OF DEVIATIONS.....	7
4.2	INTENDED AUDIENCE	7
5	STRUCTURE OF THE DELIVERABLE & LINK WITH OTHER WORK PACKAGES.....	8
6	ISO 15118.....	9
6.1	STATUS	9
6.2	SCALE CONTRIBUTION	9
6.3	GAP ANALYSIS STATUS.....	9
6.4	NEXT STEPS.....	10
7	OPEN CHARGE POINT PROTOCOL (OCPP)	11
7.1	STATUS	11
7.2	SCALE CONTRIBUTION	11
7.3	GAP ANALYSIS STATUS.....	12
7.4	NEXT STEPS.....	12
8	OCPI	13
8.1	STATUS	13

8.2	SCALE CONTRIBUTION	13
8.3	GAP ANALYSIS STATUS.....	13
8.4	NEXT STEPS.....	14
9	TOMP-API	15
9.1	STATUS	15
9.2	SCALE CONTRIBUTIONS	15
9.3	GAP ANALYSIS STATUS.....	15
9.4	NEXT STEPS.....	15
10	CONCLUSION	16
11	APPENDIX - EVROAMING FOUNDATION - OCPI 3.0 MAPPING TO SCALE'S SMART CHARGING NEEDS	17
11.1	EXECUTIVE SUMMARY	17
11.2	LIST OF ABBREVIATIONS AND ACRONYMS	19
11.3	PURPOSE OF THE ANALYSIS	21
11.4	GOALS OF MAPPING OCPI 3.0 POWER REGULATION ON SCALE'S SMART CHARGING NEEDS.	23
11.5	SMART CHARGING USE CASES DESCRIBED IN OCPI 3.0 MAPPING WITH THE FUNCTIONAL USE CASES	32
11.6	ARCHITECTURE	47
11.7	DATA MAPPING	56
11.8	CONCLUSIONS	64
11.9	REFERENCES	64
11.10	ABSTRACT WHITE PAPER.....	65
11.11	WHITE PAPER OUTLINE	65

2 Executive Summary

2.1 Key words

Electric vehicles, smart charging, bidirectional charging, V2X, ISO 15118, OCPP, OCPI, interoperability

2.2 Summary

The SCALE project is an impactful initiative in the electromobility ecosystem, influencing the development and refinement of standards and protocols. The project partners have been actively involved in the technical committees and working groups of all the standards mentioned in this document, ensuring that the insights from the project are integrated into the industry frameworks.

During the project, new versions of standards and specifications were released. The SCALE project had a tangible impact on the content of these updates, addressing gaps and enhancing the overall robustness of the protocols. This involvement has ensured that the standards meet the practical needs of the industry.

The SCALE project provided valuable feedback from field tests and testing labs. This feedback helped extending and refining the protocols, and ensuring they are effective in real-world scenarios. By incorporating real-world data and experiences, the project has helped to create standards that are more resilient and better suited to the needs of end-users.

One of the key challenges confirmed during the project is the strong need for synchronization between different protocols. To avoid redundancy and incompatibilities, it is essential to define clear and precise scopes for each protocol. This synchronization ensures that all aspects of electromobility, from vehicle communication to energy infrastructure, are covered comprehensively and efficiently. This document highlights the importance of coordinated efforts among various stakeholders to create an interoperable electromobility ecosystem.

Almost all the identified gaps have successfully been addressed in the published protocols. The remaining gaps have been shared with the relevant protocol entities, who are now working on implementing the SCALE use cases to fill these gaps. This collaborative approach ensures that the standards continue to evolve and improve, addressing the needs of the industry.

This document is relevant for all actors within the electromobility ecosystem, including manufacturers, service providers, and regulators. It provides an overview of the current state of electromobility standards and protocols, as well as those that will be available shortly. This information is crucial for stakeholders to understand what is available and what is on the horizon, supporting them to make informed decisions and investments.

3 List of abbreviations and acronyms

Acronym	Meaning
AC	Alternating Current
AFIR	Alternative Fuels Infrastructure Regulation
BRP	Balance Responsible Parties
CPO	Charge Point Operator
DC	Direct Current
DER	Distributed Energy Resources
eMSP	e-Mobility Service Provider
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
OCA	Open Charge Alliance
OCPI	Open Charge Point Interface
OCPP	Open Charge Point Protocol
SCALE	Smart Charging Alignment for Europe
SoC	State Of Charge
V2X	Vehicle-to-Everything

4 Purpose of the deliverable

4.1 Attainment of the objectives and explanation of deviations

The objectives related to this deliverable have been achieved in full and as scheduled.

4.2 Intended audience

4.2.1 SCALE Consortium partners

The primary audience for this deliverable is the project partners involved in the development and implementation of V2X services. They can use this deliverable to upgrade their implementations deployed in the pilots to match with the latest protocols available and enhance interoperability.

4.2.2 E-mobility actors

The document, featuring a comprehensive status of protocols and specifications in the electromobility ecosystem and identifying remaining gaps greatly benefits e-mobility actors. It outlines the opportunities within newly released protocols, so e-mobility actors get valuable insights into how implementing may impact develop new services.

4.2.3 Standardization bodies

This document provides standardization bodies with a comprehensive overview of remaining gaps in protocols. This information incites standardization bodies to refine and update protocols, shaping an interoperable ecosystem.

4.2.4 Regulators

Regulators play a crucial role in shaping the future of electromobility, ensuring that the deployment of bidirectional services is efficient, and equitable. Understanding the status and upcoming versions of electromobility protocols is critical for regulators to make informed decisions that foster innovation while maintaining high standards of safety and interoperability. This document provides a comprehensive overview of the current landscape and future developments in electromobility protocols to create policies that support the growth of electric vehicle infrastructure and development of bidirectional features.

5 Structure of the deliverable & link with other work packages

This document summarizes the actions undertaken in the task “T5.5 – Standardisation of smart charging and V2X”.

This deliverable aims to provide an extensive status of each protocol analysed in deliverable D2.3 and point out the contributions of SCALE partners to these protocols. The objective is to extend the protocols to cover all the data listed in D2.2 to enable massive deployment of V2X services.

For each protocol, this document will detail:

- Leading organization (ISO, IEC, OCA, ...)
- Available versions in May 2025
- The contributions of SCALE partners to the standards and specifications
- Update the gap analysis done in D2.3 with latest versions of standards and protocols
- Upcoming versions of standards and protocols and their expected content

6 ISO 15118

6.1 Status

ISO 15118 is an international standard that defines a communication interface for electric vehicles (EVs) and electric vehicle supply equipment (EVSE). The development and maintenance of the standard are overseen by ISO Technical Committee 22, Subcommittee 31, Joint Working Group 1 (TC22/SC31/JWG 1).

This standard defines:

- Use cases for charging and discharging an electric vehicle with a charging station
- Messages exchanged between the EV and the charging station
- The physical link to exchange the defined messages
- Test cases to validate the standard implementation

The first versions of ISO 15118 have been published in the early 2010s to allow charging vehicles with both AC and DC in a secure way.

Since 2019, new versions of the document have been published to enable bi-directional charging:

- ISO 15118-1:2019: Use cases for bidirectional charging
- ISO 15118-20:2022: Message layer for bidirectional charging

6.2 SCALE contribution

SCALE partners have joined the ISO TC22/SC31/JWG1 meetings to contribute to the upcoming documents of ISO 15118 related to bidirectional charging. To contribute, they have used feedback from the various pilots of SCALE project and interoperability testing in the labs.

6.3 Gap analysis status

The deliverable D2.3 has identified the following gaps in ISO 15118-20 (see section 8.2.2.2 of D2.3):

- Grid codes to ensure compliance with local grid codes based on local grid measurements.
- V2X state of health to have information related to the remaining budget from the absolute V2X warranty constraints so that they can be included in the optimization problem.
- Round trip efficiency to avoid injection that can result in low charging power whereby the round-trip efficiency of the on-board inverter could be low.
- Allowance to discharge to get the explicit consent of the driver to perform bidirectional charging.
- EVSE active power in DC Charging.

Based on ISO 15118-20 Amendment 1 from 2024-09-30, we can identify that the following gaps have been covered:

- **Grid codes integration** by extending ISO 15118-20 with AC DER service and message content exchanged between the EV and the charging station.
- **V2X state of health** is indirectly covered with the addition of the parameter “EVSessionTotalDischargeEnergyAvailable”. The EV can indicate the total energy value that can be discharged during the session. Once this value reaches the value of 0, the EV may block any attempt to discharge to protect the battery health.

Based on ISO 15118-20 Amendment 1 from 2024-09-30, we can identify that the following gaps have not been covered:

- **Round trip efficiency.** This criterion is not added to ISO 15118 because the charging station retrieves the EV charging and discharging capabilities during the charging session. Therefore, it can use this data to evaluate the relevancy of discharging the vehicle or not.
- **Explicit consent of the driver to discharge.** This feature is not in ISO 15118 scope and depends on car manufacturer policy.
- **EVSE active power in DC Charging**

6.4 Next steps

As mentioned in section 6.1, the ISO 15118 standard has been extended to cover bidirectional charging but the tests in the field have highlighted missing data on the message layer, specifically on the grid codes topic. A grid code is a set of technical rules and requirements that govern the operation, connection, and interaction of all entities within an electrical power system. These codes ensure the reliable, secure, and efficient operation of the power grid. They are established by regulatory bodies, system operators, or industry organizations and are essential for maintaining the stability and integrity of the electrical grid.

To understand the impact of grid codes on ISO 15118, two situations shall be distinguished:

- **AC Charging:** power is handled by the vehicle's on-board charger. Then it is the responsibility of the EV to apply the local grid codes. As an EV is mobile, it needs to retrieve the grid codes of its current location. Then the EV needs the charging station to transmit these data.
- **DC Charging:** power is handled by the charging station. Then it is the responsibility of the charging station to apply the grid codes of its location. As a DC charging station is not mobile, its location is known in advance and the grid codes can be implemented directly into the charging station.

The ISO committee is working on an amendment to ISO 15118-20 to integrate grid codes for AC charging by adding a new service (AC_DER) and extended messages to transmit grid codes information.

The committee is also defining the test cases for ISO 15118-20:

- ISO 15118-21: test cases to be applied to and correctly handled by EVs and EVSEs independently of a particular charging type (AC, DC, pantograph, wireless charging).
- ISO 15118-23: test cases to be applied to and correctly handled by EVs and EVSEs for DC charging and discharging

These test cases are required for a mass deployment of ISO 15118-20 to harmonize the different implementations and limit the interoperability issues.

7 Open Charge Point Protocol (OCPP)

7.1 Status

The Open Charge Point Protocol (OCPP) is an application protocol designed to standardize communication between charging stations and Charging Station Management Systems (CSMS) handled by the Open Charge Alliance (OCA). OCPP enables various functionalities, including remote management, monitoring, and control of charging stations. It supports various features like smart charging, load balancing, vehicle authorization, billing, etc.

The following versions of OCPP have been published:

- **OCPP 1.6:** Released in 2015, this version is widely implemented by charging station manufacturers and CSMS providers worldwide. It is considered as the first production proof version of OCPP.
- **OCPP 2.0.1:** Released in 2019, OCPP 2.0.1 introduces enhanced device management to support all types of charging stations, security measures, native integration of ISO 15118-2 and its use cases. This version has been published as IEC 63584 in 2024.
- **OCPP 2.1:** Released in 2025, OCPP 2.1 is built over OCPP 2.0.1. It integrates natively ISO 15118-20 and its use cases such as bidirectional charging and advanced smart charging algorithms. This version was developed during the SCALE project including contributions from SCALE partners.

The OCA operates an independent certification program to ensure compliance with the OCPP specification. Certification is available for OCPP 1.6 and OCPP 2.0.1, helping vendors ensure their products meet the required standards

7.2 SCALE contribution

SCALE partners have joined the OCA working group meetings to contribute to OCPP 2.1 on the following topics:

- Guarantee the interoperability between OCPP 2.1 and ISO 15118-20
- Guarantee the interoperability between OCPP 2.1 and upcoming version of ISO 15118-20 Amendment 1 with grid codes integration
- Bidirectional use cases: application of grid codes by the charging station, transmission of charging and discharging information

To contribute, they have used feedback from the various pilots of SCALE project and interoperability testing in the labs.

7.3 Gap analysis status

The deliverable D2.3 has identified the following gaps in OCPP 2.0.1 Edition 2 (see section 8.3.2.2 of D2.3):

- **EV minimum charge power** to adapt the power delivered by the EVSE according to the minimum charging power supported by the vehicle.
- **EV Minimum and maximum Energy Request** to ensure that mobility needs are met.
- **Priority charging** to know if the user is allowed to overrule smart or bidirectional charging at any time and switch to the maximum charging speed directly.
- **Minimum and target state of charge** requested by the EV to ensure that mobility needs are met.
- **Session ID** to link a charging schedule to an active charging transaction.

Based on OCPP 2.1 Edition 1, we can identify that the following gaps have been covered:

- **EV minimum charge power** has been added to the V2X parameters sent by the charging station to the supervision system in `NotifyEVChargingNeedsRequest::V2XChargingParametersType`.
- **EV Minimum energy request and maximum energy request** have been added to the V2X parameters sent by the charging station to the supervision system in `NotifyEVChargingNeedsRequest::V2XChargingParametersType`.
- **Target state of charge** has been added to the V2X parameters sent by the charging station to the supervision system in `NotifyEVChargingNeedsRequest::V2XChargingParametersType`.
- **Priority charging**. The charging station can decide depending on the CPO policy to apply priority charging for a specific user and it will notify the supervision system of its decision. OCPP does not define a way to identify users with charging priority. The supervision system can also trigger the priority charging feature. In both cases, the charging station will charge the EV with the highest power possible under circumstances and avoid discharging.

Based on OCPP 2.1 Edition 1, we can identify that the following gaps have not been covered:

- **Minimum state of charge** was not added. The target SoC was considered sufficient to handle the charging and discharging session.
- **Session ID** was not added to the OCPP messages content. The existing smart charging mechanisms already allow to link a charging profile to an active charging transaction.

7.4 Next steps

As OCPP 2.1 has been published in January 2025, there is no major update planned on OCPP. The OCA will publish each year an erratum based on feedback from charging stations manufacturers and supervision systems to enhance the specification quality and interoperability.

The OCA is currently discussing with IEC to publish OCPP 2.1 as an IEC standard. This is crucial to integrate this version into states regulations and accelerate its deployment in the field.

Finally, the OCA is working on a certification program for OCPP 2.1.

8 OCPI

This section relies on the analysis done by the EVRoaming Foundation. The complete analysis can be found in Appendix - EVRoaming Foundation - OCPI 3.0 mapping to SCALE's Smart Charging Needs.

8.1 Status

The Open Charge Point Interface (OCPI) is a protocol designed to facilitate scalable, automated roaming setups between Charge Point Operators (CPOs) and e-Mobility Service Providers (eMSPs). It supports various functionalities, including authorization, charge point information exchange (including transaction events), charge detail record exchange, and the exchange of smart-charging commands between parties. The development and maintenance of OCPI are handled by the EV Roaming Foundation, which ensures the protocol's continuous evolution and improvement.

The following versions of OCPI have been published:

- **OCPI 2.1.1:** Published in 2017, it is a widely adopted standard in the EV charging industry. It is considered as the first production proof version of OCPI.
- **OCPI 2.2.1:** Published in 2023, this version includes Charging Profiles for smart charging and extends roaming information.
- **OCPI 2.3.0:** Published in 2025, it is the latest official release. It supports the latest legislation in the world, including EU AFIR (National Access Points) and US taxes.

8.2 SCALE contribution

SCALE partners have worked closely with the EVRoaming Foundation to identify strengths, limitations, and opportunities for OCPI protocol evolution. Based on the SCALE's project deliverables, the current draft version of OCPI v3.0 extends support for smart charging through features like Charging Profile Control and metering values management. The complementarity between OCPP and OCPI has also been identified.

8.3 Gap analysis status

The deliverable D2.3 has identified the following gaps in OCPI 2.2.1 (see section 8.4.1.2 of D2.3):

- Local frequency to comply with local grid codes.
- Local Voltage to comply with local grid codes.
- Feed-in/injection tariff to optimize the charging cost while meeting charging needs.
- Capacity Period
- Highest measured peak consumption
- BRP ID to facilitate BSP switching processes.
- EV related Data to optimize the charging session and follow the EV constraints.

These gaps are not handled in the current draft version of OCPI v3.0. However, the EVRoaming Foundation has considered the feedback from the SCALE project and has classified the missing data into two categories: potential addition and desirable.

Potential addition corresponds to functionalities that are currently missing from OCPI but could be valuable additions. These gaps represent opportunities for potential enhancements or extensions to the OCPI protocol

in future versions. Further investigation and discussion within the OCPI community would be needed to determine feasibility and priority.

Desirable addition means that the required functionality is not currently present but could be addressed by modifying or expanding existing OCPI use cases or messages. These gaps suggest areas where the current protocol could be improved to better meet the needs of smart charging and V2X services within the SCALE project.

The following gaps have been identified as potential additions to OCPI:

- Local frequency
- Local voltage
- Highest measured peak consumption
- BRP ID to facilitate BSP switching processes

The following gaps have been identified as desirable additions to OCPI:

- Feed-in/injection tariff to optimize charging cost
- Capacity Period
- EV related Data to optimize the charging session and follow the EV constraints

8.4 Next steps

The EVRoaming Foundation has published the OCPI 3.0 draft in 2024 and this version is still under review. There is no official timeline for the publication of this version.

The EVRoaming Foundation is also working on a whitepaper dedicated to power regulation using OCPI. The content of this whitepaper is based on a differential analysis between OCPI current and planned features and the outcomes of SCALE data analysis. This document identifies the remaining gaps and proposes a roadmap to address these gaps within OCPI and in close collaboration with other electromobility standards and specifications.

9 TOMP-API

9.1 Status

The TOMP-API is an open specification intended for the planning and availability of vehicles, particularly shared cars, but can also be used to facilitate energy services of shared BEV's such as smart charging and vehicle-to-grid (V2G). It provides information about the availability of shared cars to Mobility as a service platform so mobility demand and supply can be matched.

9.2 SCALE contributions

In the SCALE project, the TOMP-API is extended beyond its initial capabilities to facilitate energy functions. The TOMP API is used for providing reservation and vehicle data and used to create an optimal charging profile, in SCALE that is done by partner Enervalis. Enervalis acts as an aggregator and creates an optimal charging profile and communicates this via OCPI to the charging station to initiate an optimal charging profile for a shared car.

Thus, the TOMP API provides data on when an EV is available for energy services, when the next reservation is planned and how full the battery should be (SoC) at the start of the next trip. This makes it possible to forecast a charging profile based on actual reservations.

9.3 Gap analysis status

TOMP API was not analyzed in D2.3 so there is no reference for comparison. TOMP API is not versioned and there is no governance detail.

9.4 Next steps

There are no upcoming versions of the TOMP API planned, the current state is the final version.

10 Conclusion

The project has significantly contributed to the advancement of electromobility protocols by leveraging feedback from extensive data analysis and field tests. This iterative process allowed to refine and extend recently published and upcoming standards, ensuring they meet the practical needs of the ecosystem.

One of the key challenges in developing electromobility protocols is the need for synchronization among various protocols. Defining clear and precise scopes for each protocol is essential to avoid gaps or redundancies. This coordination ensures that all aspects of electromobility, from vehicle communication to charging infrastructure, are covered comprehensively and efficiently.

Despite the progress made, the publication of standards remains a slow process. Additionally, the massive adoption of these standards by the market is also slow due to the complexity and cost associated with implementing and validating new protocols.

Public regulation plays a pivotal role in promoting interoperability and fostering an open and wide market. They can accelerate the adoption of electromobility standards by creating policies that encourage compliance and interoperability.

In summary, while significant strides have been made in developing and refining electromobility protocols, ongoing efforts are needed to synchronize these protocols, expedite their publication, and encourage their adoption through supportive public regulations. This holistic approach is the key to achieving a seamless and efficient bidirectional and smart charging ecosystem that benefits to all the actors.

11 Appendix - EVRoaming Foundation - OCPI 3.0 mapping to SCALE's Smart Charging Needs

11.1 Executive summary

11.1.1 Project Summary

The SCALE (Smart Charging Alignment for Europe) project is a Horizon Europe initiative aimed at advancing smart charging and Vehicle-to-Everything (V2X) technology across Europe. The project seeks to create an integrated EV charging ecosystem that enhances grid stability, promotes renewable energy adoption and enables bidirectional charging. With 13 use cases across four innovation clusters—Vehicle-to-Home, Vehicle-to-Business, Vehicle-to-Depot, and Vehicle-to-Public—SCALE addresses the growing need for intelligent EV charging solutions. The project brings together 29 consortium partners, including cities, technology providers, and research institutions, to facilitate large-scale adoption of V2X technologies.

A key component of the project is the usage of the Open Charge Point Interface (OCPI) 3.0, particularly its Power Regulation Module, to support smart charging and V2G functionality. The EVRoaming Foundation leads the efforts to verify OCPI 3.0 Power Regulation capabilities with SCALE's smart charging needs through three main tasks: (1) reviewing the OCPI 3.0 Power Regulation Module and identifying gaps with existing smart charging standards, (2) ensuring compatibility with V2G services, and (3) drafting a whitepaper outlining mass deployment requirements. This initiative will help address critical challenges such as dynamic energy pricing, real-time load balancing, and interoperability among EV infrastructure stakeholders.

As an add on, an initial mapping to the recent version of the OCPP specification has been added in regards to bidirectional power transfer. This analysis further explores into the specifics of aligning OCPI 3.0 with SCALE's smart charging needs by examining various use cases, actor roles, and architectural considerations. It includes a detailed mapping of SCALE's functionalities to OCPI use cases, an analysis of the Power Regulation Module, and a comparison with OCPP 2.1 with regards to smart charging. The analysis also addresses data mapping, potential future developments in data sharing, and identifies gaps and recommendations for protocol enhancements. Finally, it provides conclusions, references, and annexes, including a draft abstract for a white paper, outlining key questions, hypotheses, and a summary of findings to support the widespread adoption of smart charging and V2X technologies across Europe.

11.1.2 Results

The project results include a detailed assessment of the OCPI 3.0 Power Regulation Module, identifying key functionalities that might enable smart charging and bidirectional power transfer. This analysis presents an assessment of the OCPI 3.0 Power Regulation Module and its alignment with the SCALE project's objectives. The analysis reveals that OCPI 3.0 introduces crucial functionalities like Charging Profile Control and MeterSample object replication, enabling dynamic real-time management of smart charging sessions and facilitating communication between Smart Charging Service Providers (SCSPs), eMobility Service Providers (EMSPs), and Charge Point Operators (CPOs) for optimized energy transfer.

While OCPI 3.0 supports some essential smart charging aspects, particularly data exchange and coordination, it has *intended* limitations in directly controlling charging stations, with features like managing maximum charge rates being primarily governed by protocols like OCPP, OpenADR, IEC61850 and others.

Gaps were identified in supporting real-time grid interaction, vehicle-specific constraints, and several requirements for smart charging and V2X services envisioned by SCALE, such as local grid compliance and dynamic feed-in tariffs. However, the analysis also suggests potential extensions to OCPI messages to handle discharging profiles and expands the role of SCSPs for better integration with grid management and energy markets.

The analysis further examined the relationship between OCPI 3.0 and OCPP 2.1, noting that OCPP focuses on charge point operations, while OCPI handles communication between business entities, emphasizing the need for further interoperability and alignment between the two. Overall, OCPI 3.0 plays a significant but not exclusive role in enabling smart charging and V2X services, excelling in data exchange and coordination while underscoring the necessity of a multi-protocol approach for a comprehensive smart charging ecosystem.

List of figures

Figure 1: OCPI development

Figure 2: Roles in the V2X ecosystem

Figure 3: Overview of the data exchange protocols

List of tables

Table 1: Acronyms

Table 2: Intended audience

Table 3: Examples of Smart Charging Service Providers

Table 4: OCPI Smart Charging use cases

Table 5: OCPI applicability

Table 6: Smart Charging functionality mapping

Table 7: Smart Charging mapping to OCPP

Table 8: OCPI Protocol gap analysis on smart charging

Table 9: Message mapping

11.2 List of abbreviations and acronyms

Acronym	Meaning
BPT	Bidirectional Power Transfer
BRP	Balance Responsible Party
BSP	Balancing Service Provider
CSMS	Charge Station Management System
CPO	Charge Point Operator
CSP	Control Service Provider
DSO	Distribution Grid Operator
EMS	Energy Management System
eMSP	e-Mobility Service Provider
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
HDV	Heavy Duty Vehicle
FSP	Flexibility Service Provider
JSON	JavaScript Object Notation
OCA	Open Charge Alliance
OCPI	Open Charge Point Interface
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
SCALE	Smart Charging Alignment for Europe
SCSP	Smart Charging Service Provider
SoC	State of Charge
TSO	Transmission System Operator
V2L	Vehicle-to-load

V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything
XML	Extensible Markup Language

Table 1: Acronyms

11.3 Purpose of the analysis

11.3.1 Attainment of the objectives and explanation of deviations

The Open Charge Point Interface (OCPI) protocol, owned and maintained by the EVRoaming Foundation has become a crucial massively adopted protocol between the Charge Point Operator (CPOs) and Service Providers (MSPs). Part of the SCALE project is to check if and how OCPI fits for smart and bi-directional charging. The objectives related to this task have been achieved in full and as scheduled.

A separate White Paper will be developed to further detail these findings. This paper will include insights and contributions from the Open Charge Alliance, which owns and maintains the Open Charge Point Protocol (OCPP), to provide a comprehensive overview of the protocol landscape in the context of smart charging.

11.3.2 Intended audience

Role	Who
SCALE consortium partners	Everyone with interest.
Regulators (all kinds from EU, national, to regional/local level)	Smart and bidirectional charging can contribute significantly to the deep decarbonisation of our electricity system while minimising the capital investment needed to increase the capacity of our grid infrastructure to accommodate these electricity flows.
E-Mobility actors (vehicle manufacturers, EMSP, CPO and SCSP).	Those interested in how these companies can broaden their offerings with enhanced charging service offerings that meet customer needs to Increase independence, have financial value, or reduce in emissions
Energy Market actors (DSO, TSO, energy suppliers, BRP, CSP/BSP)	Those who want to understand how smart charging can prevent or resolve congestion, and those who are interested in how EVs fit into balancing services.
Standardization bodies	Those who want to understand the usage of protocols in the smart & bidirectional charging ecosystem.

Table 2: Intended audience

11.3.3 Structure of the analysis and links with other work packages and SCALE deliverables

This analysis explores how the Open Charge Point Interface (OCPI) 3.0 can support the smart charging goals of the SCALE project (Smart Charging Alignment for Europe). SCALE is a Horizon Europe initiative that brings together cities, technology providers, and researchers to accelerate the adoption of smart charging and bidirectional power transfer (V2X) technologies. The goal is to create a smarter, more flexible charging system that helps balance the grid, integrate renewable energy, and optimize EV charging in real-time.

This analysis builds upon the findings of **Project Deliverable D1.4**, which outlined the “multi-actor system and architecture for V2X use cases”, as well as the control topology of that same deliverable which describes that data is available and can be exchanged effectively between different roles is considered essential to enable smart charging services. A control topology provides insight into how data circulates between different roles in the market, and it also reveals the current protocols and standards used for data exchange.

This analysis also elaborates on the discussion in **Project Deliverable D2.2** “Specifications and IT Use-Case definition for V2X services” which discusses the use cases, the basis on which document is formed to be able to form a mapping to OCPI 3.0. In project **Project deliverable D2.3** “Update protocol definition” a gap analysis with the existing protocols for energy services has been initiated, this analysis aims to continue on that.

In chapter 4, we dive into how OCPI 3.0 fits into this vision—mapping its capabilities to real-world smart charging use cases, from managing energy at the EV level to coordinating large-scale grid interactions.

In chapter 5, we map the smart charging use cases with OCPI functionalities from the perspectives of the different roles like Charge Point Operators (CPOs), e-Mobility Service Providers (eMSPs), Smart Charging Service Providers (SCSPs), and Aggregators—all of whom help make seamless, smart charging to the EV driver possible. We also break down how OCPI 3.0 integrates with OCPP 2.1, how it handles charging profile management, and how it enables real-time meter readings to keep all stakeholders informed.

Finally, we look at what’s next for OCPI—what works well today, what gaps remain, and how future updates could make smart and bidirectional charging even more efficient.

11.3.4 Context for Conducting Gap Analysis (from a SCALE/OCPI Perspective)

To systematically identify and address gaps between the SCALE project's needs and the capabilities of OCPI, the following situations are taken into account :

- A. Functionality Exists (with Message XYZ):** This category identifies instances where the required functionality is already supported by OCPI, specifically through the existing message "XYZ." This means the need is met, and implementation can proceed using the identified message.
- B. Functionality Does Not Exist, Outside OCPI Scope:** This category indicates that the required functionality is not supported by OCPI and is deemed outside the protocol's intended scope. These gaps will likely need to be addressed through alternative solutions or protocols, rather than modifications to OCPI.
- C. Functionality Does Not Exist, Potential Addition to OCPI:** This category identifies functionalities that are currently missing from OCPI but could be valuable additions. These gaps represent opportunities for potential enhancements or extensions to the OCPI protocol in future versions. Further investigation and discussion within the OCPI community would be needed to determine feasibility and priority.
- D. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable:** This category highlights gaps where the required functionality is not currently present,

but could be addressed by modifying or expanding existing OCPI use cases or messages. These gaps suggest areas where the current protocol could be improved to better meet the needs of smart charging and V2X services within the SCALE project.

11.4 Goals of mapping OCPI 3.0 Power Regulation on SCALE's smart charging needs

11.4.1 Objectives of this analysis

The Open Charge Point Interface (OCPI) protocol is a de-facto standard for transactional related communication between CPO's and Service Providers (e.g. Smart Charging Service Providers, e-Mobility Service Providers, etc). These parties use data for the communication towards and with the Electric Vehicle owner and/or driver.

The goal of this analysis is to provide guidance for implementers how OCPI can play a role in implementing smart charging use cases beyond the scope of the CPO, EVSE and an EV. The analysis provides a framework and suggestions for an OCPI based mapping, so that standards can be utilized in the best possible combined manner.

As described in other SCALE documents, e.g. in **Project Deliverable D1.4**, a multi actor system and architecture is foundational in a shared task environment, this holds especially true in more complex V2X use cases, in which the stakes, efforts and perspectives of multiple actors need to be considered simultaneously.¹

In this analysis, the term V2X (vehicle-to-anything) is used to describe bidirectional power transfer between an EV and various entities, such as the grid (V2G), a home (V2H), a building (V2B), or an appliance (V2L). In the context of OCPP specifically, V2L is excluded since it does not involve communication between the charging station and a CSMS.

V2H and V2B are specialized cases of V2G, focusing on using the EV battery as a power source for a home or building. This can serve two purposes: reducing or preventing power consumption from the grid during peak periods or providing backup power in the event of a grid outage. By leveraging V2X technology, EVs become key assets in energy management and grid stabilization efforts.

¹ Source: SCALE, D1.4_Multi-actor-smart-charging-and-V2X-system-architecture-.pdf

11.4.2 Project Objectives for the EVRoaming Foundation for SCALE

The EVRoaming Foundation is the IP owner of the OCPI protocol and is responsible for the maintenance and developments of the specification, which is executed together with its contributors and input from the market.

While writing this analysis, the EV roaming foundation took the following project-objectives into consideration.

- Describe roles & responsibilities of a Smart Charging Service Provider in the context of offering V2X services
- Map OCPI 3.0 Power regulation module on SCALE's smart charging needs
- Review SCALE's existing deliverables gaps analysis, protocols and architecture.
- Requirement analysis of the data sharing needs covered by the existing protocol.
- Checking on gaps between SCALE project requirements on Smart Charging and OCPI 3.0
- Investigate how the "power regulation module" can work with the already existing OCPI 2.2.1 (for the already existing market?)² :

11.4.2.1 Implications for OCPI Governance

This analysis highlights several areas where the OCPI protocol, while functional for many smart charging use cases, may require **clarification, extension, or formal governance mechanisms** to support emerging V2X services and smart grid integration. From the perspective of the EVRoaming Foundation, the following governance implications are particularly relevant:

1. Protocol Scope Clarification

OCPI's role as a B2B protocol for eMobility interoperability should be reaffirmed, particularly in distinguishing it from device-level control protocols like OCPP. However, the expanding role of actors like SCSPs introduces new expectations around real-time interaction, which must be carefully scoped within OCPI's intended domain.

2. Standardization of Extended Roles (e.g., SCSP)

The Smart Charging Service Provider role, while described in OCPI 3.0, would benefit from formal inclusion in governance documents and implementation guidelines. This includes clarifying data rights, responsibilities in session management, and interoperability boundaries with EMSPs and CPOs.

3. Candidate Extensions for Consideration by the OCPI Community

Several technical enhancements identified in this analysis could be proposed for community discussion and prioritization:

- Discharging tariff types (e.g., **DISCHARGED_ENERGY**)
- Directional tariff metadata (**IN, OUT, BIDIRECTIONAL**)
- Consent-based EV data sharing (e.g., battery health, preferences)
- Support for external setpoints and frequency-based adjustments These are not

² Note: OCPI v2.2.1 will get possibilities for extensions which will be released as v2.3

commitments to inclusion, but signal areas where SCALE has defined real-world needs that may require formalization.

4. Use of Business Agreements vs Protocol Features

Some flexibility needs, such as variable heartbeat intervals or meter sample frequency—are better resolved through bilateral business agreements than embedded in protocol logic. The governance framework should help define which operational parameters are in-scope for OCPI vs. left to commercial negotiation.

11.4.3 Introduction to OCPI 3.0

The OCPI (Open Charge Point Interface) in the SCALE project is primarily highlighted for its role in enabling interoperability between charging point operators (CPOs) and e-mobility service providers (eMSPs). This interoperability is vital for creating a seamless charging experience for electric vehicle drivers, allowing them to charge at various stations operated by different CPOs using their preferred eMSP services.

OCPI version 2.2.1 and version 2.3 currently support data exchange for fundamental operations in electric vehicle (EV) charging. However, the SCALE documents indicate areas where OCPI requires enhancement to fully support V2X functionalities, which are expected in OCPI 3.0; exactly these enhancements will be covered in this report. Vehicle-to-Everything (V2X) technology, which includes Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) capabilities, enables electric vehicles to not only consume energy but also to return it to the grid or power homes, offering significant potential for grid stabilization and energy management.

The current use of OCPI 2.2.1 and 2.3, have (intended) limitations as it supports basic communication between CPOs and eMSPs, allowing for the exchange of data such as tariffs, session details, and availability. However, it lacks direct support for V2X parameters, which limits its applicability for bidirectional charging scenarios.

The [EVRoaming Foundation](https://evroaming.org/)³ has been working on OCPI 3.0 to address these limitations. OCPI 3.0 aims to include V2X parameters, which will be essential for more advanced functionalities like energy feedback to the grid (Vehicle-to-Grid, V2G). This upcoming version is anticipated to meet the interoperability needs of more complex V2X use cases as discussed within SCALE.

While OCPI facilitates communication between business entities like CPOs and eMSPs, the Open Charge Point Protocol (OCPP) governs the communication between charging stations and their central management systems.

Both protocols are essential for a comprehensive smart charging ecosystem, and their alignment is crucial for seamless operation. This SCALE's analysis on OCPI should highlight possible gaps with current versions of OCPI (v2.2.1 and v2.3) and the new Power Regulation module of OCPI v3.0 support with the needs for Smart Charging and V2X as described in the SCALE project.

The Power Regulation Module of the new OCPI 3.0 version contains OCPI's extensions to handle Smart Charging and V2X parameters. The analysis will also elaborate whether this is sufficiently aligned with the OCPP (Open Charge Point Protocol), which already accommodates advanced smart charging needs. This report will go into the specific gaps between current OCPI versions and the requirements for V2X functionalities, examine the enhancements introduced in OCPI 3.0's Power Regulation Module, and provide an analysis of its alignment with OCPP 2.1.

Additionally, it will offer recommendations for future developments to ensure comprehensive support for smart charging and bidirectional energy transfer.

The below figure 1 depicts the development of OCPI adding new functionalities in version 3.0.

³ <https://evroaming.org/>

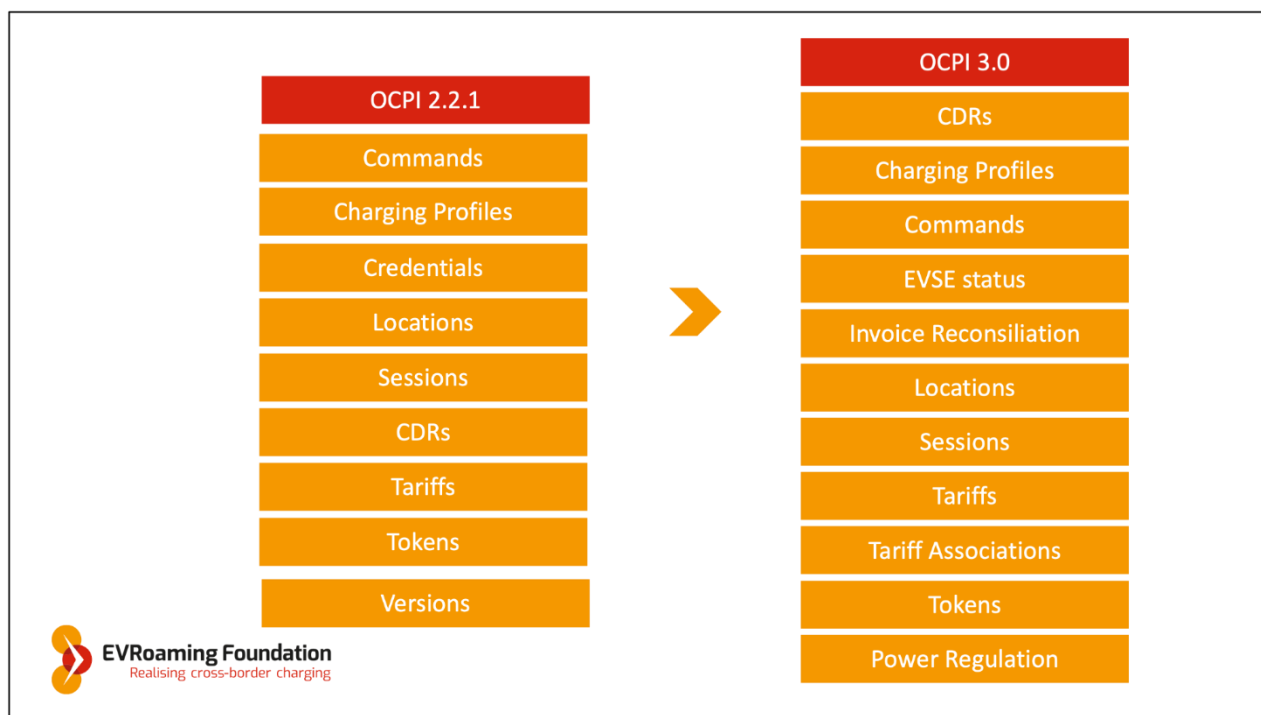


Figure 1: OCPI development

11.4.4 Power Regulation module in OCPI 3.0

The Power Regulation Module in OCPI 3.0 is designed to facilitate dynamic and real-time control of smart charging sessions by enabling communication between service providers and Charge Point Operators (CPOs). This module aims to optimize energy transfer based on grid conditions, user preferences, and other factors.

1. **Charging Profile Control:** Service providers, such as SCSPs or eMSPs, can set charging profiles that specify the energy transfer rates during charging sessions. This allows for dynamic management, where the CPO adjusts energy levels in response to grid demands and EV needs.
2. **MeterSample Objects:** OCPI 3.0 introduces the **MeterSample** object, which records data such as energy, power, and current during a charging session. This data, relayed to service providers, enables monitoring and control feedback, making the process interactive and ensuring providers have near-real-time visibility into the charging session's status.
3. **Subscription-Based Data Replication:** Parties can subscribe to receive continuous updates on charging sessions. For example, once a profile is set, **MeterSamples** are sent to the SCSP or eMSP to ensure the requested energy levels align with actual usage.
4. **Enhanced Interoperability with OCPP:** The Charging Profile mechanism in OCPI aligns with OCPP's functionality but extends it by allowing third-party access, ensuring flexibility for different smart charging setups.
5. **Asynchronous Operation:** Given the potential latency in charging station connections, OCPI 3.0's calls are designed to function asynchronously, supporting efficient processing without overloading networks. This means that requests don't require immediate responses, allowing for efficient processing and preventing network overload, especially when managing numerous charging sessions simultaneously.

This model provides OCPI 3.0 users with control over EVSEs in V2X settings, allowing smart charging and V2G functions, despite the module currently supporting only "maximum limit" profiles rather than full bidirectional V2G.

11.4.5 Smart Charging actors relevant for V2X services

The successful implementation of smart charging and Vehicle-to-Everything (V2X) services relies on the collaboration and coordination of several key actors. Each plays a distinct role, contributing to a dynamic and efficient energy ecosystem. This section outlines the primary stakeholders and their responsibilities in the emobility landscape.

11.4.5.1 eMobility Service Provider (EMSP)

The contracting party and point of contact for EV drivers is their EMSP. EMSPs aim to make EV charging convenient for drivers by providing access to a large network of charging stations via a charge card or app - and in the future, via Plug & Charge using digital certificates. EMSPs bundle transactions for charging over a period into one invoice and often offer multiple payment methods.

Through an EMSP app, EV drivers can find available charging stations, check rates, and sometimes even make reservations for a charging station. The EMSP role can be fulfilled by various companies, including energy suppliers, charging station operators, leasing companies, fuel card issuers, and others. EMSPs can play an important role in facilitating smart charging as they are often the single point of contact to the EV driver. The EMSP is therefore in many cases the only market-role that has access to important smart charging inputs like the desired state of charge, time of departure/arrival, charging preferences (e.g. to optimise on price/renewables), or sometimes even the current state of charge (where this cannot yet be retrieved via another way).. To create optimal smart charging profiles and ensure transparency to customers, an EMSP needs to be well-connected to other market-players like a CPO, OEM and aggregator.

11.4.5.2 Charge Point Operator (CPO)

A CPO installs and maintains charging stations from one or more manufacturers so that electric vehicles can charge. The CPO is responsible for operating the hardware.

CPOs may be the owner of the charging infrastructure (typically the case for public charge stations) but may also do the operations for charge stations owned by others (typically the case for home and office charge stations). The CPO benefits from high charge station utilisation and wants to minimise costs and maximise revenues. Smart charging can account for this, optimising charging based on electricity prices, grid fees or grid capacity. For example, Lower grid fees can be achieved by (virtual) clustering of EVSEs or adjusting charging to the available grid capacity.

11.4.5.3 Aggregator

The aggregator is a new market role created by European legislation to allow small prosumers to participate in flexible markets. An aggregator bundles many small assets and offers the aggregated volume on one of the flexibility markets on behalf of its customers, with the aim of making a profit or reducing overall energy costs. An aggregator may offer its service to any party that requires flexibility, this could be the BSP, CSP, BRP, Energy Supplier, DSO or TSO (the last two only in case there is no SCSP active). The aggregator role may be fulfilled by an independent party or may be fulfilled by a market party like an Energy Supplier, BSP, CPO, etc. For some flexibility markets, a minimum bid size is required. In this case smart charging and V2X requires an aggregator to combine many charging sessions into a larger flexible power portfolio.

11.4.5.4 Smart Charging Service Provider (SCSP)

In OCPI 3.0, an SCSP is an entity that manages and optimizes the charging of electric vehicles (EVs) in a way that aligns with grid demands, user preferences, and other external factors. SCSPs play a crucial role in the smart charging ecosystem by implementing advanced charging strategies, such as load balancing, demand response, and vehicle-to-grid (V2G) services, ultimately to improve grid efficiency and reduce costs.

Below are listed some companies who act like a Smart Charging Service Provider.

Examples
Corinex : Specializes in grid flexibility solutions that empower Vehicle-to-Grid (V2G) technology. Their systems optimize the EV charging process, enabling vehicles to intelligently create, communicate, store, and predict energy and data at charging stations or for in-home applications.
E-Flux by Road : Supports smart charging methods, including load balancing techniques like static and dynamic load balancing, as well as vehicle grid integration strategies such as grid-aware smart charging and vehicle-to-home (V2H) setups. These methods promote safety, efficiency, and grid optimization.
ABB : Offers V2G technology that unlocks the energy stored in EV batteries, allowing households and fleets to support the grid during peak demand. This technology enables utilities to access renewable energy stored in vehicles, facilitating better load balancing and mitigation of grid bottlenecks.
eMotorWerks (a subsidiary of Enel X) : Provides smart EV charging solutions that integrate demand response capabilities, allowing for grid balancing and optimization of charging times to align with renewable energy availability and grid conditions.

GridBeyond: A multinational company specializing in the optimization and operation of distributed energy resources. They develop energy technologies, artificial intelligence, real-time automation, software, and services to support the transition to net-zero, including smart EV charging solutions.
Nuvve: Focuses on V2G solutions, enabling EVs to discharge electricity back to the grid, thus providing grid services such as frequency regulation and load balancing.
Jedlix: Jedlix is a smart charging service provider that optimizes electric vehicle (EV) charging by integrating renewable energy sources and balancing grid demand. Through its platform, Jedlix enables EV owners, energy companies, and grid operators to reduce costs and enhance sustainability by intelligently scheduling home and public charging.

Table 3: Examples of Smart Charging Service Providers

11.4.5.5 Key Roles and Responsibilities of an SCSP in OCPI 3.0:

1. **Charging Session Control:** SCSPs can influence the **charging profiles** of ongoing sessions by communicating with the Charge Point Operators (CPOs) to adjust power levels, timing, and duration based on real-time grid and energy market conditions.
2. **Real-Time Data Access:** SCSPs receive data updates on **charging sessions** (e.g., energy use, session status) and use this information to make dynamic adjustments to meet demand and user preferences.
3. **Grid Interaction and Congestion Management:** SCSPs help manage grid load by controlling charging in response to congestion or other grid constraints, supporting the stability of local and national energy systems.
4. **V2G and Energy Market Integration:** Some SCSPs enable V2G, where EVs can return energy to the grid. This functionality also allows SCSPs to leverage EVs as flexible grid resources, participating in energy markets and providing ancillary services.

In this context, the SCSP could use OCPI to coordinate and optimize EV charging with grid demands, enhancing energy efficiency and supporting a more sustainable charging ecosystem.

11.4.6 Suggestions for SCSP role extension and gap analysis OCPI

Based on the current OCPI 3.0 framework and the needs of the SCALE project, we recommend expanding the role of SCSPs to include the following:

1. **Subscription to Locations and Sessions:** SCSPs should have the ability to subscribe to specific locations and charging sessions managed by different CPOs. This would allow them to proactively manage power regulation across a wider network of charging points. For example, an SCSP could subscribe to all public charging stations in a city to optimize charging based on local grid conditions.
2. **Aggregator and Energy Service Broker Functions:** SCSPs could take on responsibilities typically associated with aggregators and energy service brokers. This includes bundling flexible charging capacity from multiple EVs to offer services to grid operators, or managing energy transactions on behalf of EV owners.
3. **EMSP-Delegated Charging Profiles:** When charging profiles are delegated from an eMobility Service Provider (EMSP) to an SCSP, the EMSP should provide a standardized charging schedule using the OCPI `MeterSample` receiver class. This schedule should include:

- **timeStamp**
- **EVSE_ID**
- **session_id**
- **charging_profile_id**
- **readings**

These elements ensure clear communication and execution of charging plans between EMSPs and SCSPs.

The charging profile which needs to be created by an EMSP and be forwarded to the SCSP, might need more definition to be processed as a “standard” object as now only a free string (CiAsciiString 1..36) consisting of 36 characters, not a charging profile as such. In contrast, a charging profile in OCPP 2.1 is defined in the next section.

11.4.6.1 Charging profiles in OCPP 2.1 a

In OCPP 2.1, a charging profile can vary depending on their purpose. Since the SCSP is consuming a charging profile from the EMSP using OCPI in this case, it could be argued that the ChargingProfilePurpose **ChargingStationExternalConstraints** would make sense to be used here. This is a charging profile which is used when an external system, not the CSMS is setting a charging limit or schedule, the charging station uses this purpose to report such a limit/schedule.

The hierarchy would look the following

- **SetChargingProfile**
 - **ChargingProfileType**
 - **ChargingProfilePurpose**
 - **ChargingStationExternalConstraints**

It is recommended that this hierarchy and structure is kept in OCPI and SCALE as a responsibility of the Smart Charging Service Provider.

11.5 Smart Charging use cases described in OCPI 3.0 mapping with the functional use cases

Vehicle-to-Everything (V2X) communication refers to the wireless exchange of information between a vehicle and various entities that can influence or be influenced by the vehicle's operation. This encompasses several specific communication types:

- **Vehicle-to-Vehicle (V2V):** Direct communication between vehicles to share data such as speed, position, and intended maneuvers, enhancing safety and traffic flow.
- **Vehicle-to-Infrastructure (V2I):** Interaction between vehicles and road infrastructure elements like traffic signals and road signs to optimize traffic management and provide real-time updates.
- **Vehicle-to-Pedestrian (V2P):** Communication between vehicles and vulnerable road users, including pedestrians and cyclists, to improve safety through timely alerts and information exchange.
- **Vehicle-to-Network (V2N):** Connection between vehicles and broader networks, such as cellular networks, to access services like internet connectivity, navigation assistance, and over-the-air updates.
- **Vehicle-to-Grid (V2G):** Interaction between electric vehicles and the power grid, allowing for bidirectional energy flow to support grid stability and enable services like demand response.

In summary, V2X communication aims to enhance road safety, traffic efficiency, and energy management by enabling vehicles to communicate with their surroundings and various stakeholders within the transportation ecosystem.

This definition aligns with the comprehensive overview provided in the article "An Overview on Vehicular Communication Standards" from the Technical University of Munich, which discusses the various facets of V2X communication and its significance in modern transportation systems. ⁴

OCPI use cases on power regulation

- UC 13.01 - Replicate MeterSample objects from one Party to another Party
- UC 13.02 - Set a Charging Profile on a grouping of EVSEs
- UC 13.03 - Set a Charging Profile on a Charging Session
- UC 13.04 - Set Default Charging Profile

11.5.1 OCPI smart charging use cases

The below table maps out the different use cases as described in OCPI. The first column lists the business use cases as described in the OCPI document ⁵. The second column maps the business use case with the technical use cases as described in the other OCPI document.⁶ The third column lists the use case description and the fourth column lists if there are any other OCPI use cases related to the smart charging use cases.

Business use case OCPI 3.1.	Use case ID	Description use case OCPI	Other OCPI related use cases
B7.2, B7.3	UC 13.01	Replicate MeterSample objects from one Party to another for real-time charging data monitoring.	
B7.1, B7.4	UC 13.02	Set a ChargingProfile on a grouping of EVSEs to regulate energy flow across multiple charge points.	
B7.1	UC 13.03	Set Default ChargingProfile for EVSEs, allowing predefined settings for general power control.	UC 05.01
B7.6. B7.6	UC 13.04	Set a ChargingProfile on a single Charging Session for targeted power regulation.	
B7.8	UC 13.05	Get Active ChargingProfile to retrieve the currently applied charging parameters at a session or EVSE.	
B7.1	UC 13.06	Clear ChargingProfile to remove any active power regulation	

⁴ An Overview of Vehicular Communications

⁵ OCPI 3.0-1 Business Use Cases

⁶ OCPI_3.0-2_functional_use_cases

		settings on a charging session or EVSE.	
B7.9			UC07.04, Change charging preferences
B7.10			UC07.05, Notify Session receiver of the active Charging Profile

Table 4: OCPI Smart Charging use cases

11.5.2 SCALE Smart Charging Use cases mapped to OCPI functionalities

The below tables list the SCALE smart charging use cases to associated OCPI use cases. The table aims to show a relation between the smart charging responsibility from an EV perspective and lists whether which use case from OCPI is technically feasible and by which use case.

To the question whether OCPI is involved, three options are provided in the tables as depicted below.

Yes	This functionality is typically supported by messages and data types in OCPI 3.0.
No	This functionality falls outside the scope of OCPI messages and data types and would require significant protocol updates to be supported
Partly	Some aspects of this functionality can be accommodated by existing OCPI features.

Table 5: OCPI applicability

The first section of the table explores the role of an EV in smart charging, including its ability to draw power from a charge station, adjust charging rates based on control signals, and communicate key parameters such as State of Charge, authentication ID, and charging preferences and maps this on the potential use of OCPI. With advanced communication protocols like OCPI and ISO 15118, EVs can further optimize charging by sharing departure times, energy needs, and even enabling bidirectional energy transfer through Vehicle-to-X capabilities.

The second section of the table outlines the key functionalities of a smart charging service of a CPO, including receiving and processing aggregator signals, managing local constraints, securely communicating with charge stations and stakeholders, and transparently informing EV drivers, EMSPs, and aggregators about charging preferences, real-time charge rates, and session pricing impacts.

The third section of the table defines the role of the e-Mobility Service Provider (EMSP) in smart charging, highlighting its responsibility to communicate site constraints, charging behavior, and pricing impacts to EV drivers, potentially using OCPI.

Table 6: Smart Charging functionality mapping

Entity	Smart Charging Functionalities (source: D1.4, §6.3)	OCPI involved?	Linked OCPI Use case
EV	Draw power from a charge station	Partly	UC: 07.02 - Start a Session
	Adjust charge rate based on a signal from the charge station (via IEC61851-1 or ISO 15118)	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session
	In case of high level charging (ISO 15118 AC or DC relatively new see Section 7.2.2)		
	<i>o Share State of Charge with charge station</i>	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	<i>o Share EV authentication ID with charge station</i>	Yes	
	In case of ISO15118 communication the list of items above can be extended to:		
	<i>o option to share desired time of departure with charge station</i>	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session
	<i>o option to share desired amount of kWh charged with charge station</i>	Yes	
	<i>o Receive and communicate EV driver charging preference to charge station</i>	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session
	<i>o Determine and communicate EV battery status to charge station</i>	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session
	In case of ISO15118 combined with V2G capabilities the list of items above can be extended to:		
	<i>o Deliver energy from the EV battery to the charge station</i>		
	Share vehicle information like State of Charge and (if available) State of Health desired SoC, driver preferences etc. with third parties via (custom) APIs.	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session
CPO	Receive smart charging input signals from the Aggregator	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Match information about local constraints (from site or charge station) with Aggregator control signals	Yes	UC: 13.03 - Set a Charging Profile on a Charging Session
	Send smart charging signals to Charge Stations	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session
	Set up fallback smart charging scenarios for charge stations in case of loss of communications.	Partly	UC: 13.03 - Set a Charging Profile on a Charging Session

	Ensure secure communication to both Aggregator and CS	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate with EV driver about charging preferences	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate with EMSP about EV driver's charging preferences	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate with Aggregator about EV driver's charging preferences	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Determine and communicate the impact of smart charging on the session price to the EV driver	Yes	UC: 13.05 - Get Active Charging Profile
	Determine and communicate the impact of smart charging on the session price to the EMSP	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Determine and communicate the impact of smart charging on the session price to the Aggregator	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Receive and communicate real time charge rate of the EV to aggregator	Yes	UC: 13.05 - Get Active Charging Profile
	Communicate smart charging behaviour of charge station to eMSP	Yes	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
Charging Point	Communicate maximum charge rate to the EV	No	
	Change the maximum charge rate for the EV (=smart charging)	No	
	Interrupt charging in case of unsafe situations (e.g. an EV charging at higher power than the maximum charge rate)	No	
	Check and communicate real time charge rate of the EV	Partly	UC: 13.05 - Get Active Charging Profile
	Support autonomous smart charging in offline situations		
	Support communication with a CPO (via OCPP)	No	
	Support local communication e.g. with a Home Energy Management System Smart Meter or other nearby charge stations (no uniform standard available)	Partly	UC: 13.05 - Get Active Charging Profile

	Support absolute steering signal from DSO	No	
EMSP	Communicate local site constraints to EV driver	Partly	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate current and expected smart charging behaviour of charge station to EV driver	Partly	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate with EV driver about charging preferences	Partly	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate with CPO about EV driver's charging preferences	Partly	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Communicate with Aggregator about EV driver's charging preferences	Partly	UC: 13.01 - Replicate MeterSample objects from one Party to another Party
	Determine and communicate the impact of smart charging on the session price to the EV driver	Partly	UC: 13.01 - Replicate MeterSample objects from one Party to another Party

11.5.2.1 Conclusions

As listed in table 6, OCPI plays a significant but not exclusive role in enabling smart charging (within the SCALE project). It excels in facilitating data exchange and coordination between stakeholders such as CPOs, EMSPs, Aggregators and SCSPs, particularly in sharing information related to charging sessions, tariffs, and preferences.

However, OCPI has (intended) limitations in directly controlling charging stations, as features like managing maximum charge rates and handling safety interruptions are primarily governed by other protocols like OCPP. Furthermore, OCPI's support for EV-centric and EMSP-centric functionalities is partial, indicating a need for supplementary protocols or enhancements to OCPI, such as integration with ISO 15118 for advanced charging scenarios and bidirectional energy transfer.

The frequent use of "Partly" in column 3 to describe OCPI's involvement highlights existing gaps that may require protocol updates or extensions to fully support the desired smart charging functionalities. But as explained in section 3.4, not every smart charging use case lays in the "natural scope" of the OCPI protocol.

Overall, OCPI's strength lies in its ability to ensure information flow and coordination, acting as a bridge between different stakeholders, while the actual control of charging stations and EV behavior often relies on other protocols, underscoring the necessity of a multi-protocol approach for a comprehensive smart charging ecosystem.

11.5.3 Power Regulation Module in OCPI

In the Power Regulation module in OCPI 3.0, the key type of replicated data object is the **MeterReading**. A **MeterReading** is a record of the energy, power, current, voltage and/or other quantities related to a Charging Session at a certain time.

Below a JSON schema of the **MeterReading** data type from OCPI is depicted to illustrate how a meter reading is captured in OCPI.

```
{
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "MeterReading",
  "type": "object",
  "properties": {
    "value": {
      "type": "number",
      "description": "The measured value, in the unit given by the unit field"
    },
    "measurand": {
      "type": "string",
      "description": "The quantity that was measured",
      "enum": ["Energy.Active.Import.Register",
        "Energy.Reactive.Import.Register", "Power.Active.Import", "Voltage",
        "Current", "Frequency"]
    }
  }
}
```

```
"unit": {
  "type": "string",
  "description": "The unit in which this meter reading is given",
  "enum": ["Wh", "kWh", "varh", "W", "kW", "V", "A", "Hz"]
},
"component_level": {
  "type": "string",
  "description": "The level of grouping for which the meter reading is
given"
},
"location": {
  "type": "string",
  "description": "At which point in the energy flow relative to the
component the meter reading was obtained"
},
"phase": {
  "type": ["string", "null"],
  "description": "Which phase the reading applies to. When this field is
not given, the measured value is interpreted as an overall value",
  "enum": ["L1", "L2", "L3", "N", null]
}
},
"required": ["value", "measurand", "unit", "component_level", "location"]
}
```

The schema supports smart charging by providing a format to capture real-time energy data at the EVSE level. The **timestamp** ensures accurate time alignment for dynamic load management, while the **evse_id**, **session_id**, and **charging_profile_id** enable the association of energy measurements with specific EVSEs, charging sessions, or customized charging profiles.

The **readings** array allows for granular reporting of energy consumption, production (in V2G scenarios), and other metrics like power and voltage. This enables precise control and monitoring of bidirectional energy flows, optimizing grid stability, charging efficiency, and the integration of renewable energy sources.

With the Power Regulation module, parties (SCSPs but also eMSPs) can send **ChargingProfiles** for a certain Charging Session or grouping of EVSEs to a CPO. These Charging Profiles instruct the CPO what the rate of energy transfer should be at which time during the affected Charging Session or Charging Sessions. After sending the Charging Profiles, the SCSP or eMSP can use Party Issued Object replication to receive the Meter Samples related to the Charging Sessions that they sent Charging Profiles for. This process of influencing and monitoring the rate of energy transfer in a Charging Session is widely known as "Smart Charging".

This module can be used by the eMSP, but can also be used by another party that provides "Smart Charging Services". These Service Providers then depend on the CPO sending Locations and/or Sessions information to them. They need to know which "**Locations**" are available or which "**Sessions**" are ongoing to be able to influence them.

11.5.4 [Link to OCPP 2.1](#)

In the OCPP 2.1, the "Functional Block K Smart Charging", the protocol describes all the functionalities that enable the CSO (or a third party) to influence the charging current/power transferred during a transaction, or set limits to the amount of current/power a Charging Station can draw from the grid.

The following four typical kinds of smart charging will be used to illustrate the possible behavior of smart charging using OCPP (OCPP 2.1 specs, edition1, part 2 specification, page 312):

- Internal Load Balancing
- Central Smart Charging
- Local Smart Charging
- External Smart Charging Control Signals

The OCPP Functional Block Q was newly introduced in OCPP 2.1. (OCPP 2.1 specs, edition1, part 2 specification, page 500) which describes functionalities around bidirectional power transfer.

OCPP 2.1 Bidirectional power transfer use case	Objective of the use case	How OCPI 3.0 enables OCPP for smart charging	Link with OCPI 3.0	Need for update	Rationale
Q01 - V2X Authorization	Authorization of an EV by the CSMS to start a V2X power transfer loop.	OCPI Power Regulation: Contract-Based Charging Authorization	OCPI provides contract- based authorization, ensuring that a V2X transaction is allowed before OCPP executes the power transfer.	n/a	
Q02 - Starting in operationMode ChargingOnly before enabling V2X	To start a transaction with operationMode ChargingOnly, such that it can become a bidirectional session at a later time.	OCPI Smart Charging Preferences	OCPI allows the SCSP to set a charging profile that ensures the EV is initially charged before bidirectional power transfer begins.	n/a	
Q03 - Central V2X control with charging schedule	To allow the CSMS to control the charge and discharge behaviour of an EV with power profiles.	OCPI Charging Profile Control (SCSP → CPO) & Tariff Regulation	OCPI establishes tariff conditions and initial charge scheduling, which OCPP then executes at the CSMS level.	<i>C. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable</i>	<i>To enable the SCSP to propose power profiles to CSMS.</i>

Q04 - Central V2X control with dynamic CSMS setpoint	To allow the CSMS to control the charge and discharge behaviour of an EV by dynamically changing a setpoint (instead of providing a schedule).	OCPI Dynamic Charging Profile Adjustments	OCPI enables SCSPs to set external charging profiles dynamically, which informs how OCPP adjusts setpoints on a session basis.	<i>This requires an OCPI extension for discharging, see section 5.4.1 for a suggestion)</i> <i>D. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable</i>	<i>To inform the (SC)SP and EV driver about updated dynamic profiles.</i>
Q05 - External V2X setpoint control with a charging profile from CSMS	CSMS explicitly allows an External System to control the charge and discharge behaviour of an EV for a certain period of time.	OCPI Smart Charging Event Management (DSO/SCSP → CPO)	OCPI does not transmit grid signals (e.g. imbalance price, congestion pricing), influencing setpoints at the CSMS level is not done using OCPI.	<i>C. Functionality Does Not Exist, Potential Addition to OCPI</i>	<i>To inform the (SC)SP and EV driver about updated charge profiles.</i>
Q06 - External V2X control with a charging profile from an External System	An External System controls the charge and discharge limits or setpoint of a charging station via a ChargingStationExter	OCPI Power Grid Regulation (SCSP → CPO) & Party Issued Object Replication	OCPI enables external market signals or DSOs to influence CSMS scheduling by MeterSample Objects, but since the CSMS is bypassed in this use	<i>C. Functionality Does Not Exist, Potential Addition to OCPI</i>	<i>To inform the (SC)SP and EV driver about updated charge profiles.</i>

	nalConstraints charging profile.		case, no OCPI involvement is expected		
Q07 - Central V2X control for frequency support	To allow an EV to be used for frequency support, with control at the CSMS.	OCPI Real-Time Grid Balancing Data (SCSP → CPO)	OCPI enables SCSPs to feed real-time frequency control data, which is then executed at the CSMS level using OCPP.		
Q08 - Local V2X control for frequency support	To allow an EV to be used for frequency control, depending on local frequency readings.	Frequency control is covered	OCPP executes local frequency control, but OCPI does not provide direct support for it.	A. Functionality Exists Covered in the OCPI 3.0 Measured "Frequency"	
Q09 - Local V2X control for load balancing	To allow the EV to be utilized for locally controlled load balancing.	Not covered in OCPI 3.0.	OCPP manages local load balancing without direct OCPI involvement.	B. Functionality Does Not Exist, Outside OCPI Scope	
Q10 - Idle, minimizing energy consumption	To request the EV to not perform any charging or discharging. Preconditioning of the vehicle is allowed.	OCPI Charging Profile Pause & Resume Control	OCPI allows SCSPs to define when a vehicle should pause charging, which OCPP executes at the charge point level.	D. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable	Use case 13.06 needs to be extend to execute on profile pause and resume charge control operations

Q11 - Going offline during V2X operation	The CSMS requests EV to suspend any charging or discharging during one or more scheduled intervals. CSMS requests EV to precondition itself in order to maintain the battery at an optimal temperature for charging or discharging.	Covered by “Unknown” status of an EVSE in OCPI 3.0	OCPP explicitly defines going offline, OCPI does not.	N/A	Functionality is covered and information limited relevant for (SC)SP and EV driver.
Q12 - Resuming a V2X operation after an offline period	To describe the amount of time that V2X operations may continue when the Charging Station is offline.	Covered by “Unknown” status of an EVSE in OCPI 3.0	No specific OCPI messages related to resuming V2X after offline.	N/A	Functionality is covered and information limited relevant for (SC)SP and EV driver.

Table 7: Smart Charging mapping to OCPP

11.5.4.1 OCPI and discharging profiles, some options for OCPI message extension

To support bidirectional power transfer to a greater extent than it does now, OCPI may require extensions to its current messaging. The following are some potential options for extending OCPI messages to handle discharging profiles.

1. Extend **TariffDimensionType** enum (or OpenEnum) with: **"DISCHARGED_ENERGY"**
2. Add **direction** field in **TariffElement** or **TariffDimension** with: **"direction": "IN" | "OUT" |**

"IN" = charging (default for backward compatibility)
"OUT" = discharging

3. Allow negative price values

OCPI 3.0 schema validation supports negative values in **TariffElement.price_components.price**, to allow credit-based compensation for energy returned to the grid.

```
{
  "price_components": [
    {
      "type": "DISCHARGED_ENERGY",
      "price": -0.12,
      "step_size": 1
    }
  ],
  "restrictions": {
    "start_time": "18:00",
    "end_time": "21:00"
  },
  "direction": "OUT"
}
```

11.5.5 Gap analysis

While OCPP 2.1 provides extensive support for managing charging profiles and data transfer, it's crucial to understand its role in the broader smart charging ecosystem and its relationship with OCPI. Several key observations:

1. OCPP primarily focuses on the internal operations of the charge point and its communication with the CSMS. This includes setting charging profiles, retrieving meter values, and managing transactions. This focus is complementary to OCPI, which handles communication between business entities like CPOs and EMSPs. Therefore, any gap analysis should consider both OCPP and OCPI to ensure a comprehensive solution for smart charging and V2X services.
2. OCPP 2.1's support for charging profiles (e.g., **`SetChargingProfile`**, **`ClearChargingProfile`**) indicates its capability to handle real-time control of charging behavior. This is essential for implementing dynamic charging strategies based on grid conditions, user preferences, or other factors. However, the delegation of charging profile management between

EMSPs and SCSPs via OCPI, as discussed earlier, needs to be clearly defined and aligned with OCPP's functionalities.

3. While OCPP 2.1 includes messages that can be used for V2G-related functionalities (e.g., **`SetChargingProfile`**, **`TransactionEvent`**), the level of detail and standardization for V2G might vary. There might be a need for further specifications or extensions to OCPP to fully support advanced V2G use cases, such as grid support services and bidirectional energy flow. This also needs to be aligned with how OCPI 3.0 handles V2G parameters.
4. Ensuring interoperability and future alignment between OCPI and OCPP is crucial. While they serve different purposes, seamless data exchange and coordination between the two protocols are necessary for a fully functional smart charging ecosystem. Any gaps or discrepancies between OCPI and OCPP could hinder the implementation of smart charging strategies and V2X services.

These insights highlight the importance of considering both OCPI and OCPP in the context of smart charging and V2X services. While OCPP 2.1 provides a strong foundation for charge point management, OCPI is essential for enabling communication and coordination between business entities. Ensuring alignment and addressing potential gaps between the two protocols is crucial for the successful implementation of the SCALE project's goals.

11.6 Architecture

This analysis examines the thesis: "To what extent can OCPI play a role in V2X services?" It aims to identify the specific use cases where OCPI can provide functional support, ensuring seamless transmission of V2X-related data between stakeholders in the V2X ecosystem, as illustrated below.

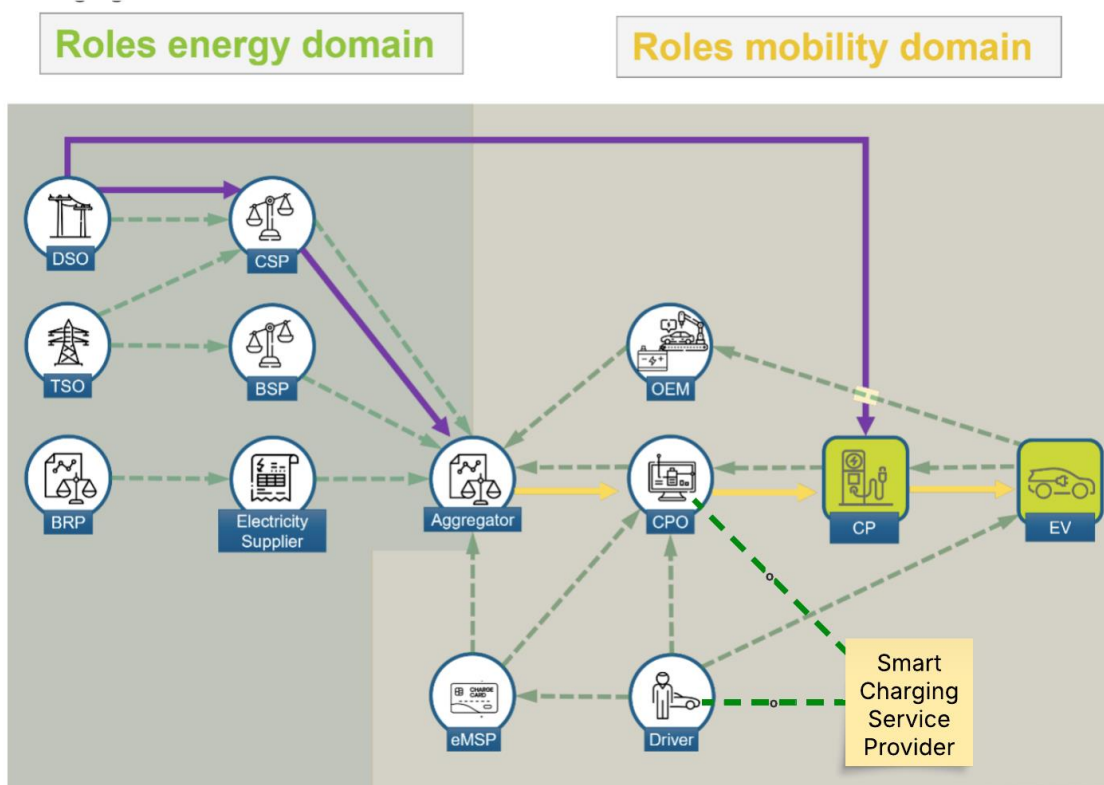


Figure 2: Roles in the V2X ecosystem

In the architecture picture from Project Deliverable D1.4⁷ the new role of “Smart Charging Service Provider” has been added. Using existing technology in OCPI 3.0, Smart Charging Service Providers (SCSPs) optimize EV charging by dynamically adjusting session parameters via CPOs, leveraging real-time data to balance user needs with grid stability, congestion management, and energy market participation, including Vehicle-to-Grid (V2G) integration.

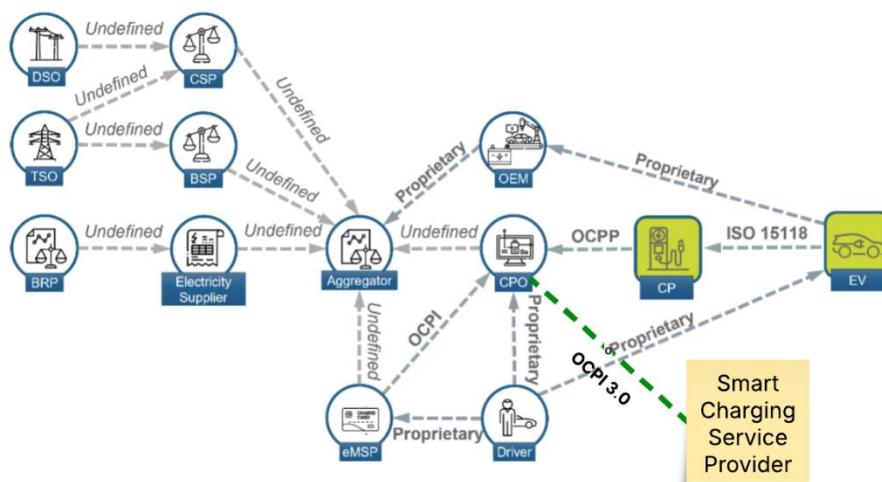


Figure 7.2 Overview of the data exchange protocols

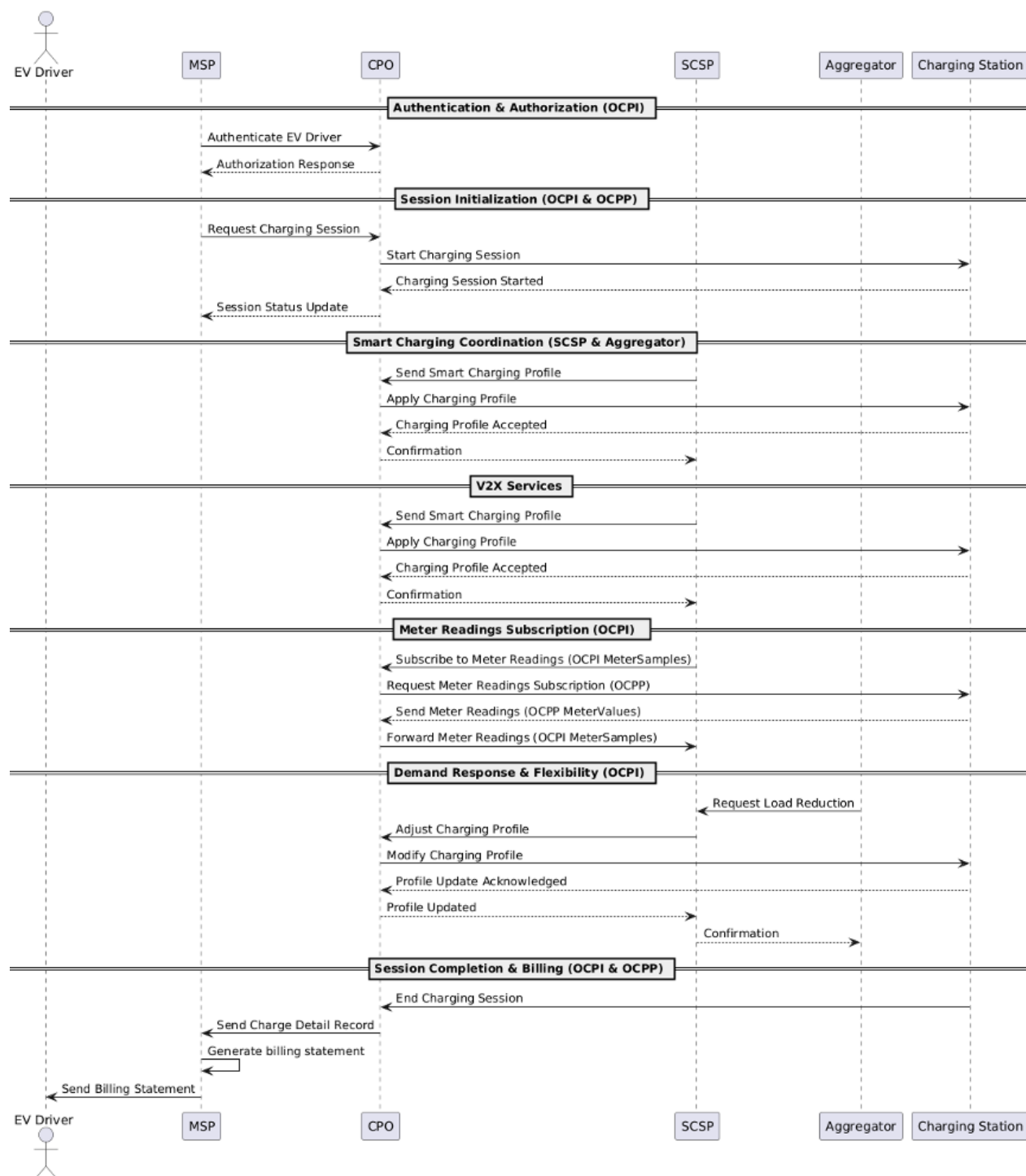
Figure 3. Overview of the data exchange protocols ⁸

11.6.1 Sequence Diagram

The below diagram shows an example sequence of how OCPI can play a role in sending Charging profiles between a SCSP and CPO to control the charging session.

⁷ Source: SCALE, D1.4_Multi-actor-smart-charging-and-V2X-system-architecture-.pdf

⁸ Source: SCALE, D1.4_Multi-actor-smart-charging-and-V2X-system-architecture-.pdf



11.6.2 Gap analysis on protocol level

The gap analysis as discussed Project Deliverable 2.3 revealed a comprehensive coverage of smart charging needs within the existing protocol OCPI 2.2.1. However, the analysis also brings to light some noteworthy gaps that require attention to enhance the protocol's functionality and adaptability:

The analysis also shows the absence of V2X parameters in OCPI 2.2.1. However, this was expected as V2X support is meant to be added to OCPI 3.0.

Feedback on protocol gaps in OCPI 3.0 according to SCALE Project Deliverable 2.3⁹

		Technical Mechanism	OCPI presence
Local frequency to comply with local grid codes	Not explicitly defined in OCPI 3.0 power regulation module. Can potentially be handled via external grid management systems or local EMS integration.	Custom extensions or use of ChargingPreferences class RemoteProcedureCall modules.	<i>C. Functionality Does Not Exist, Potential Addition to OCPI</i>
Local Voltage to comply with local grid codes	Not directly supported; OCPI does not expose real-time voltage values. Info might be needed by an SCSP.	Possible via local EMS integration; not covered in standard use cases or messages.	<i>C. Functionality Does Not Exist, Potential Addition to OCPI</i>

⁹ Source: D2.3 Update-protocol-definition

Feed-in/injection tariff to optimize charging cost	Not <u>explicitly</u> supported; OCPI supports pricing via tariffs that can be changed during a charge session. Changing feed in tariffs during that same session and in between a V1G situation, is not supported.	Suggestion: This functionality requires a different tariff mechanism, as during the session, when also V1G tariffs can be applicable, a feed-in situation might occur with a special feed-in tariff. When this happens is not known before the session. This will impact the traditional way tariffs are shared and communicated. For OCPI, this can impact the “Tariff module” and/or “Tariff Association” module, depending on the source of the updated tariff. Possible option/solution is to add a feed-in tariff as a component of existing tariff format. Also possibility might be to create a potential extension of “Tariff module” or “Tariff Association Module” or integration with external energy market APIs to allow for dynamic pricing, see section 5.4.1 for a suggestion.	<i>D. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable</i>
Capacity Period	Partially supported via ExceptionalPeriod class for availability, not directly for grid capacity.	Use of availability schedule “ ExceptionalPeriod ” and potential extension to model grid constraints.	<i>D. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable</i>
Highest measured peak consumption	Not tracked directly in OCPI 3.0. Sessions may include total energy but not peak power.	Extend Session object or rely on ChargingStation data with external metering.	<i>C. Functionality Does Not Exist, Potential Addition to OCPI</i>
BRP ID to facilitate BSP switching processes	Not currently modeled; no field for BRP ID in Party or Location objects.	Needs extension, possibly as metadata in PartyIssuedObject or Location .	<i>C. Functionality Does Not Exist, Potential Addition to OCPI</i>

EV related Data to optimize the charging session and follow the EV constraints	Partially supported via ChargingPreferences and Session modules.	EV constraints (e.g., max power, battery limits) may be passed through ChargingPreferences / RemoteProcedureCalls .	<i>D. Functionality Missing in Current OCPI, Adjustment of Existing Use Cases/Messages Desirable</i>
--	--	--	--

Table 8: OCPI Protocol gap analysis on smart charging

11.6.3 Gap analysis on architecture level

As smart charging services evolve to support grid-responsive, user-centric, and bidirectional charging use cases, the role of a Smart Charging Service Provider (SCSP) becomes increasingly pivotal. SCALE Deliverable D1.4 outlines a multi-actor architecture in which SCSPs operate between the electricity market and e-mobility actors, facilitating coordination with Distribution System Operators (DSOs), Charge Point Operators (CPOs), and Aggregators.

From the SCSP perspective, OCPI 3.0's Power Regulation Module introduces a robust foundation for smart charging, notably through:

- Charging Profile Control – SCSPs can suggest max power levels based on dynamic constraints.
- MeterSample data replication – enabling near-real-time monitoring.
- Support for asynchronous data flows – suitable for scalable smart charging services.

These features provide alignment with several SCALE use cases such as portfolio optimization, congestion management, and balancing services

11.6.3.1 Identified Gaps and Limitations

Despite its strengths, OCPI 3.0 still presents limitations when applied in the context of the SCALE architecture:

Bidirectional Energy Support (V2X)

- OCPI 3.0 currently supports maximum limit profiles but lacks standardized messages for discharging profiles or energy feedback, critical for V2G, V2H, and V2B use cases.
- No native support exists for bidirectional tariff metadata or discharging tariff types, which are essential for economic optimization of V2X flows.

Real-time Grid Signals and Constraints

- OCPI does not yet support ingestion of grid signals from DSOs or TSOs (e.g., load curtailment requests or frequency-based control).
- This limits the SCSP's ability to respond to short-term congestion management or balancing markets, which are key use cases in Chapter 4 of D1.4

Vehicle-Specific Constraints and Battery Data Access

- Battery SoC, health, or driver preferences are not yet consistently accessible via OCPI due to lack of OEM integration or consent-based sharing standards.
- Interim solutions (e.g., bilateral data sharing agreements or OEM APIs) are needed but hinder interoperability and scalability.
- Interoperability with OCPP and Energy Protocols

The division between business-level OCPI and device-level OCPP can lead to misalignment, especially in bidirectional charging where real-time responsiveness is essential.

11.6.4 Conclusions

The analysis reveals that OCPI 3.0 currently lacks native support for several requirements of smart charging and V2X services as envisioned by SCALE, as well with the newly introduced power regulation module. Elements like local grid compliance (frequency, voltage), dynamic feed-in tariffs, and BRP identification for energy market participation are either unsupported or require significant extensions. This is also fine, as the protocol was not specifically designed with those use cases and needs in mind,

While OCPI 3.0 introduces more flexibility (e.g., through ChargingPreferences and Party Issued Objects), it falls short in enabling real-time grid interaction and vehicle-specific constraints essential for advanced smart charging and V2G/V2X use cases. This highlights a need for protocol extensions or complementary systems to bridge the gap between mobility and energy domains in future protocol versions.

11.7 Data mapping

Table 7.1 from SCALE deliverable 1.4. maps out the different data needed for smart charging use cases and who owns the respective data. Hence, this chapter explains to what extent this data can be supported by existing messages from OCPI.

#	Data	Description	Covered by OCPI?	Comment	Which element	
1	Location	Location refers to the EAN code which is used by the TSOs and DSOs to identify the connection on the electricity grid.	Yes		Module: locations	
2	Grid capacity	Grid capacity refers to the available transport capacity on the grid connection.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>	As OCPI describes behaviour of individual chargers and not a group or site level.		
3	CP capacity	CP capacity refers to the maximum charging power available at the charging point.	Yes		Class: TariffRestrictions	
4	Charge preference	Charging preferences refers to the preference of the EV driver. For example, the EV driver could indicate the desire to opt-out of smart charging services.	Yes		Class: ChargingPreferences	
5	Electricity price	Electricity price refers to the electricity price. Depending on the contract with an electricity supplier the price could vary. For example, wholesale prices or a fixed price.	Yes		Module: tariffs	

6	Imbalance prices	Imbalance prices refers to the prices as a result of the different balancing services. This price depends on mismatch in demand and supply volumes in a large geographical (TSO-)area.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>	Describes more a B2B price data point, as such not relevant to communicate between SCSP and CPO.	Module: tariffs	
7	Congestion price	Congestion price refers to the price at which flexible capacity available for demand management will be used by the TSO/DSO. Of: refers to the price that TSOs/DSOs are willing to pay for a reduction in power consumption (in order to prevent grid congestion)	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>	Describes more a B2B price data point, as such not relevant for communication between SCSP and CPO.	Module: tariffs	
8	Charging profile	Charging profile refers to the charging rate over time. The charging profile includes possible changes made as result of smart charging and is based on the current charging session.	Yes		Class: charging profile	
9	State of charge	State of charge refers to the remaining capacity available in the battery at a given time, expressed as a percentage.	Yes		Class: Meter Reading	
10	Battery capacity	Refers to the total energy storage capacity of the EV battery, typically measured in kWh	Yes		Class: Meter Reading	

11	Battery efficiency	Battery efficiency refers to the loss of energy when charging and discharging a battery.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>	* Might be useful for charging in general to predict (dis)charging moments and charge speed within a certain time. + Might be useful if available through OCPP and thus for future OCPI versions.	<i>n/a, cell intentionally left blank</i>	
12	Congestion areas	Congestion area refers to an area on the electricity network that is predicted to have, or does have, less transport capacity than required.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>	* Might be useful for charging in general to predict (dis)charging moments and charge speed within a certain time. + Might be useful if available through OCPP and thus for future OCPI versions.	<i>n/a, cell intentionally left blank</i>	
13	Connection groups	Connection groups refers to a bundle of EAN codes, therefore containing multiple connections. Bundling connections into a group can increase the effectiveness of smart charging services. More on this in section 6.4.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>		<i>n/a, cell intentionally left blank</i>	

14	Regulation state	Regulation state refers to the current state of imbalance within periods of 15 minutes. The regulation state indicates whether imbalance is caused by a surplus of either demand or supply.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>		<i>n/a, cell intentionally left blank</i>	
15	Connection demand prognosis	Connection demand prognosis refers to the predicted supply or demand for a connection within periods of 15 minutes. This is used as a reference point to measure the effect of a smart charging event.	<i>B. Functionality Does Not Exist, Outside OCPI Scope</i>		<i>n/a, cell intentionally left blank</i>	

Table 8: Message mapping

*= There are a few Data fields/sets that are currently not needed in OCPI to enable Smart Charging and V2X, but might be interesting for future developments and relevant for charge predictions.

Note: While OCPI 2.2.1 remains widely deployed, many V2X use cases evaluated here require OCPI 3.0 due to its enhanced support for power regulation, actor flexibility, and real-time data replication.

- **11. Battery efficiency:** it is becoming more and more important to know before charging how much energy in which period of time can be delivered. E.g. in Logistics where knowing that the HDV get the right and expected amount of energy in the right time slot, is very important. Information about Battery efficiency is important to predict this.
- **12. Congestion areas:** where battery efficiency gives relevant data for prediction from the vehicle side how much energy in which period of time can be delivered, information about the congestion area is important from the charge station side.

OCPI currently supports essential data elements for smart charging, such as location, charging point capacity, driver preferences, electricity prices, charging profiles, state of charge, and battery capacity. However, it lacks support for grid-level data like grid capacity, imbalance prices, and congestion prices, suggesting its primary focus is on individual charger behavior rather than broader grid management, which is also the main purpose and use cases for OCPI.

This limitation implies that OCPI is well-suited for transactional data exchange between CPOs and service providers but might need enhancements to fully integrate with grid-level optimization and flexibility markets in the context of this SCALE project. If these enhancements are needed in OCPI also depends on the users, and if with these enhancements they will use OCPI, or that they use alternative protocols.

Future OCPI development could consider incorporating real-time grid signals, more granular bidirectional energy flow parameters, and enhanced EV data sharing with consent management to better support advanced V2X scenarios.

Additionally, discussions in the SCALE project around the agreement for more frequent heartbeat information and meter value sharing indicate a need for flexibility in data update intervals, can probably be better solved through business agreement, then putting these negotiations in OCPI.

11.7.1 Possible future development in data for smart charging services in OCPI

In the SCALE project, many scenarios are described and in this analysis the match and mapping with OCPI is explained. There are a few discussions and developments that are not part of the SCALE project scenarios, but are worth being mentioned.

- Request from the SCSP to the CPO to get more frequent heartbeat information ¹⁰(can also be agreed via business agreement)
 - To be able to act faster on changing situations, there is a demand from SCSPs to get more frequent heartbeat information instead of the standard 15 minutes period. It is up to the CPO to change this in the CPMS system. For the moment it is decided that it is easier to agree on this via business agreements (e.g. the roaming agreement) then managing the request and following discussion via OCPI.
- Request from the SCSP to the CPO to set the meter value sharing to a different period (can also be agreed via business agreement)
 - Similar to the heartbeat information, there is a demand from SCSPs to more frequently get the meter values from the CPO. In OCPI this is part of session information and normally shared/updated every 15 minutes during charging. Changing this requires in total more data that need to be shared from the CPO to the SCSP, which makes it possible that CPOs are not automatically willing to change this. For the moment it is decided that it is easier to agree on this via business agreements (e.g. the roaming agreement) then managing the request and following discussion via OCPI.
- Possibility to offer real time during a session a different V1G tariff and V2G tariff
 - At this moment a fixed tariff is set for a certain period/moment. During a session this is the same tariff for that moment, without making a difference if during that period a V2G flow starts. In other words: the tariff for buying the energy is now the same as the tariff for delivering back the energy. There will be many scenarios (if not all) where this should be different tariffs, while it is also in most scenarios not clear before the charging session starts when during the session the V2G flows begin and end. This is complex and not yet covered by the OCPI Power Regulation services in v3.0. It will be part of future updates, based on clear use cases.
 - Complexity is in the fact that it requires several tariffs that are valid during the same period, can change during the charging session, and it is not known when it will be applicable/used.
 - At this moment, there's no indication whether a tariff is associated with V1G or V2G power flow, this might leave room for future improvements or enhancements of OCPI and even OCPP.

¹⁰ The “Heartbeat feature” ensures that the Charge Station Management System (CSMS) remains aware that the charging station is still connected. The charging station periodically sends a heartbeat signal at a configurable time interval. Depending on the configuration, the heartbeat can also be used for time synchronization, ensuring that the clocks of the charging station and the CSMS remain correctly aligned.

11.7.2 Ideas for additional OCPI use cases

Data fields related to grid-side signals (e.g., congestion pricing, imbalance tariffs) are currently out of scope for OCPI, which focuses on business-to-business communication between mobility actors. For deep grid integration, additional protocols or business agreements remain essential.

11.7.2.1 Granular Bidirectional Energy Flow Management

- Suggestion: Enhance OCPI to include more detailed parameters for controlling bidirectional energy flow (V2G). Currently, OCPI 3.0 primarily supports "maximum limit" profiles, which are insufficient for nuanced V2G scenarios.
- Example:
 - Introduce specific data fields in the `ChargingProfile` object to define:
 - **DischargeRate**: The rate at which the EV should discharge energy back to the grid (in kW).
 - **DischargeSchedule**: A time-based schedule specifying when and at what rate the EV should discharge.
 - **EnergyExportLimit**: The maximum amount of energy the EV is allowed to export during a specific period.
 - This would allow SCSPs and EMSPs to program sophisticated V2G strategies, such as frequency regulation, peak shaving, and energy arbitrage.
- Benefit: Enables more precise and dynamic control of V2G, supporting grid stability and ancillary services.

11.7.2.2 Real-Time Grid Signal Integration

- Suggestion: Add a mechanism for OCPI to receive and propagate real-time grid signals (e.g., frequency deviations, congestion prices) to relevant stakeholders.
- Example:
 - Create a new module or extend an existing one (e.g., `Tariffs`) to include:
 - **GridSignal**: A data object containing information about the current grid status, such as frequency, voltage, and congestion levels.
 - **SignalSource**: An identifier for the entity providing the grid signal (e.g., DSO, TSO).
 - **SignalImpact**: A field indicating how the grid signal should influence charging behavior (e.g., reduce charging rate, initiate discharge).
 - This would allow SCSPs to adjust charging profiles dynamically in response to real-time grid conditions, ensuring grid stability and optimizing energy use.
- Benefit: Facilitates responsive and adaptive smart charging, enabling EVs to act as flexible grid resources.

11.7.2.3 Enhanced EV Data Sharing with Consent Management

- Suggestion: Expand OCPI to include more detailed EV data sharing capabilities, with a robust consent management mechanism to protect user privacy.
- Example:
 - Introduce new data fields in the `Session` or `EV` object to include:
 - **BatteryHealth**: Detailed information about the EV battery's health and degradation.
 - **DriverPreferences**: Granular charging preferences, such as desired state of charge, departure time, and charging cost sensitivity.

- **Consent:** A mechanism for EV drivers to grant or revoke access to specific data points for different stakeholders (e.g., EMSP, SCSP, CPO).
- This would allow SCSPs to optimize charging strategies based on comprehensive EV data, while ensuring that data sharing is transparent and controlled by the EV driver.
- **Benefit:** Enables more personalized and efficient smart charging, fostering trust and user acceptance of V2X services.

These additions could help bridge the gaps identified in the analysis and enhance OCPI's ability to support complex smart charging and V2X use cases. By providing more granular control, real-time grid integration, and enhanced EV data sharing, OCPI can become a more robust and versatile protocol for the future of electric mobility.

Overall, while OCPI provides limited foundation for smart charging, its smart charging evolution, based on the power regulation module could focus on aligning with broader grid management needs and V2X complexities to remain relevant and effective in the future energy ecosystem, taking into account the role of OCPI in the ecosystem.

11.8 Conclusions

This analysis evaluated the alignment of OCPI 3.0, specifically its Power Regulation Module, with the smart charging and V2X requirements of the SCALE project. While OCPI 3.0 introduces meaningful advancements—such as support for Charging Profiles, MeterSample replication, and third-party profile management—several functionalities (e.g., discharging tariffs, BRP ID handling, real-time grid signals) remain outside its current scope.

The analysis highlights the importance of a multi-protocol approach, where OCPI coordinates actors across the mobility domain, while deeper grid integration may require extensions or parallel standards like OCPP and custom APIs. A number of suggested protocol enhancements (e.g., “DISCHARGED_ENERGY” tariff type) could form the basis for future community discussions on OCPI evolution.

From the EVRoaming Foundation’s perspective, these findings will inform both the continued development of OCPI and the creation of a public white paper to foster broader market alignment on V2X data exchange needs.

11.9 References

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11.10 Abstract White paper

Target audience: smart charging service providers, service providers, charge point operators

As smart charging and Vehicle-to-Everything (V2X) technologies gain traction across Europe, ensuring seamless data exchange between mobility service providers, aggregators, and energy actors becomes critical. This paper explores how OCPI 3.0, with its Power Regulation Module, can support scalable and interoperable smart charging use cases. It examines the evolving role of Smart Charging Service Providers (SCSPs), their interaction with eMobility Service Providers (EMSPs) and Charge Point Operators (CPOs), and the alignment of OCPI 3.0 with emerging bidirectional energy flow scenarios.

Through use case mapping, protocol comparison with OCPP 2.1, and gap analysis based on the SCALE project deliverables, this paper identifies strengths, limitations, and opportunities for OCPI protocol evolution. It further outlines hypotheses about required protocol extensions and governance models that could support dynamic tariffs, discharging profiles, and real-time flexibility services. The study aims to provide a roadmap for protocol convergence and encourage collaboration across standardization bodies and industry actors in preparation for mass deployment of V2X technologies in the EU.

Our findings indicate that while OCPI 3.0 introduces significant enhancements in smart charging coordination, critical gaps remain in supporting bidirectional energy flows, frequency regulation, and congestion pricing mechanisms. Additionally, legacy systems using OCPI 2.2.1 require transitional frameworks to ensure compatibility with future extensions (OCPI 2.3+ and 3.1). We propose protocol improvements and policy recommendations for standardization bodies, industry stakeholders, and policymakers to foster a scalable, interoperable, and market-ready smart charging ecosystem across Europe.

The outcomes of this study contribute to the advancement of open protocols for smart charging, promoting a unified European approach to EV-grid integration and energy flexibility markets.

Keywords: Smart Charging, OCPI 3.0, Vehicle-to-Grid (V2G), Vehicle-to-Everything (V2X), Open Charge Point Interface, OCPP 2.1, Power Regulation Module, Energy Flexibility, SCALE Project, Electric Vehicle Charging, Grid Integration.

11.11 White paper outline

1. Introduction (1 Page)

- 1.1. The Electric Vehicle Revolution: Why It Matters, > the growth of EVs and the need for smart charging.
- 1.2. What is Smart Charging? > explanation of smart charging and its benefits (e.g. cost savings, grid stability, renewables integration, grid congestion).

- 1.3. The Role of Vehicle-to-Grid (V2G) > Basic explanation of V2G and its potential to transform energy systems.
- 1.4. Purpose of This White Paper. > Outline what the paper aims to explain

2. The Smart Charging Ecosystem (2 Pages)

- 2.1. Key Players in Smart Charging > Who is involved? (EV drivers, charging station operators, energy providers, smart charging services).
- 2.2. High-Level Use Cases > Examples of how smart charging works in everyday situations:
- 2.3. How It All Connects: A Simple Architecture > A simplified diagram showing how data and energy flow between different players.

3. Using OCPI for Smart Charging (1.5 Pages)

- 3.1. What is OCPI? > To explain OCPI as a way for different companies to talk to each other about EV charging.
- 3.2. The OCPI Power Regulation Module > Explanation of how OCPI helps manage charging rates and energy flow.
- 3.3. How OCPI Supports Smart Charging and V2G > Real-world examples of how OCPI enables smart charging and V2G.

4. Requirements for Mass Deployment (1.5 Pages)

- Guidelines for Stakeholders
- Simple advice for each player (EV drivers, operators, providers) to participate in smart charging using OCPI.
- Emphasis on collaboration and clear communication.
- The Role of Standards and Interoperability
- Why it's important for all systems to work together (like having universal plugs).

5. Conclusion (1 Page)

- 5.1. The Future is Electric and Smart > Recap of the benefits of smart charging and V2G.
- 5.2. The Importance of Ecosystem Collaboration > Emphasis of the need for all stakeholders to work together for V2X.
- 5.3. Next Steps > Briefly mention ongoing efforts and future developments in the field of V2X.