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Importance of Interoperability for a seamless EV Charging Experience

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Executive Summary

Interoperability is a key enabler to promote the market penetration and public acceptance of electric mobility solutions. With the product and service landscape in the field of EV Charging and Smart Energy growing at pace, smart charging towards vehicle-grid integration, smart billing & payment and smart maintenance are among the new use cases that add further complexity to the overall ecosystem. To ensure a seamless EV charging experience in a highly complex and dynamic environment, interoperability must cope with the on-going complexity and diversity of new market solutions. P3 will provide an overview of the current status, potential drivers and drawbacks as well as best practices for operators to improve the overall EV charging experience.

Keywords: Interoperability, reliability, ICT (information and communication technology), smart charging, standardization.

1 Status Quo

Electric vehicles (EVs) are becoming more and more popular as an eco-friendly and sustainable mode of transportation. The growth of EVs has led to the development of the EV charging ecosystem, which has evolved through three distinct phases. With the evolution of the ecosystem, new players, diverse charging solutions, and complex IT landscapes have emerged, leading to an increased demand for end-to-end interoperability worldwide. The lack of interoperability is a significant challenge that affects the customer experience and the reliability of EV charging networks.

1.1 Evolution of the EV Charging Ecosystem in Europe

The evolution of the EV Charging ecosystem in Europe is marked by distinct phases that have led to the current state of the market. In the first phase, EV owners could only charge their vehicles with utilities acting as local "Charge Point Operators" (CPO) at public sites, requiring local contracts with CPOs. This approach had limitations as it was not scalable and did not address the needs of cross-country travel.

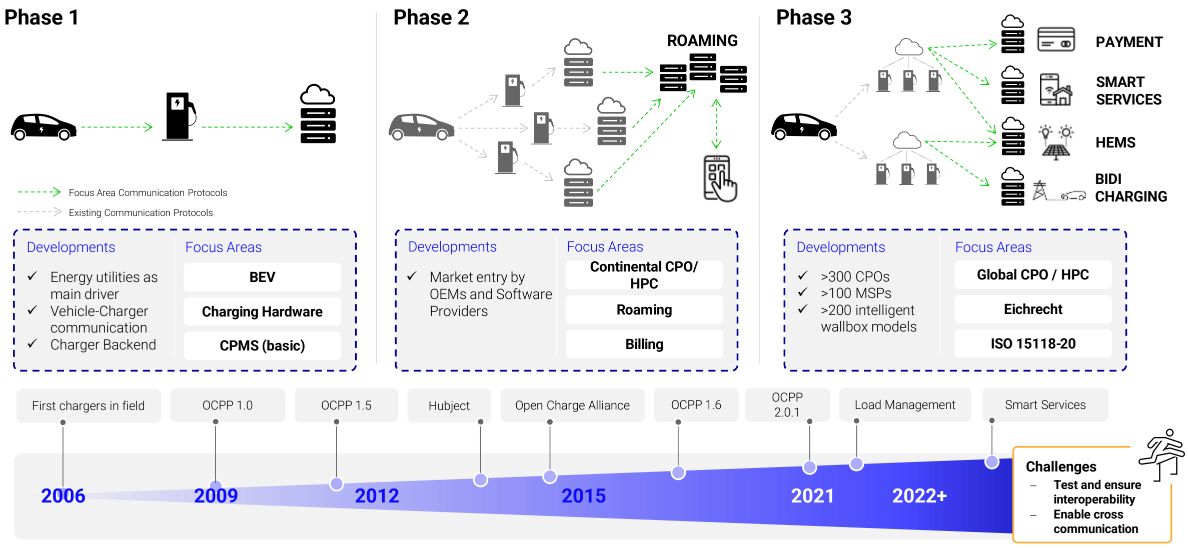

Figure 1: Evolution of the EV Charging Ecosystem in Europe

The second phase was focused on the expansion of public EV charging by establishing cross-country roaming and the first continental High-Power-Charging networks in Europe. In addition to CPOs, Mobility Service Providers (MSP) and Aggregators entered the ecosystem to ensure hassle-free EV charging on a cross-country scale. This marked a significant change as the ecosystem grew beyond EV owners and CPOs.

The current market has entered phase three, which is characterized by a massive scale-up of the EV charging market on the one hand, and the market-entry of new players such as traditional energy players and payment providers on the other. This has led to the introduction of “Smart Energy Services” like Load Management, Home Energy Management, and Bidirectional Charging towards Vehicle-to-Grid, which are being introduced to the market. As a result, the EV Charging Ecosystem is evolving into a Smart Energy Ecosystem.

However, with each phase, the complexity of the ecosystem and its underlying IT-landscape grows substantially. In addition to the new market entrants, charging solutions from AC wallboxes to High-Power-Chargers are being developed rapidly leading to a massive increase in diversity of market solutions for EV charging.

1.2 Interoperability and the increased complexity of today's EV Charging Ecosystem

Interoperability has become a critical aspect of modern-day business operations, as it enables different systems to communicate and work seamlessly with one another, even if they are developed by different manufacturers or are running on different IT platforms. This is particularly relevant in complex ecosystems such as the EV Charging ecosystem, where there is a multitude of EV models, hardware models, backends, and MSP products that need to communicate with each other.

Customers expect to be able to charge their electric vehicles wherever they go, without having to worry about whether the charging station is compatible with their EV, or whether they need to sign up for a new account with a different service provider. Without interoperability, the customer experience can quickly become frustrating, leading to customer dissatisfaction and a decline in market adoption.

In Germany, the EV charging ecosystem is a prime example of the complexity and diversity of ecosystem elements that interoperability has to manage. With a fast evolving product landscape in Germany over 70 EV models, over 200 charging hardware models, over 30 IT backend systems, and over 100 MSP products (as seen in Figure 2), need to communicate with each other in order to ensure end-to-end interoperability. The challenge lies not only in ensuring that the hardware and software ecosystem elements are compatible with each other, but also in ensuring that the communication between them is seamless and secure

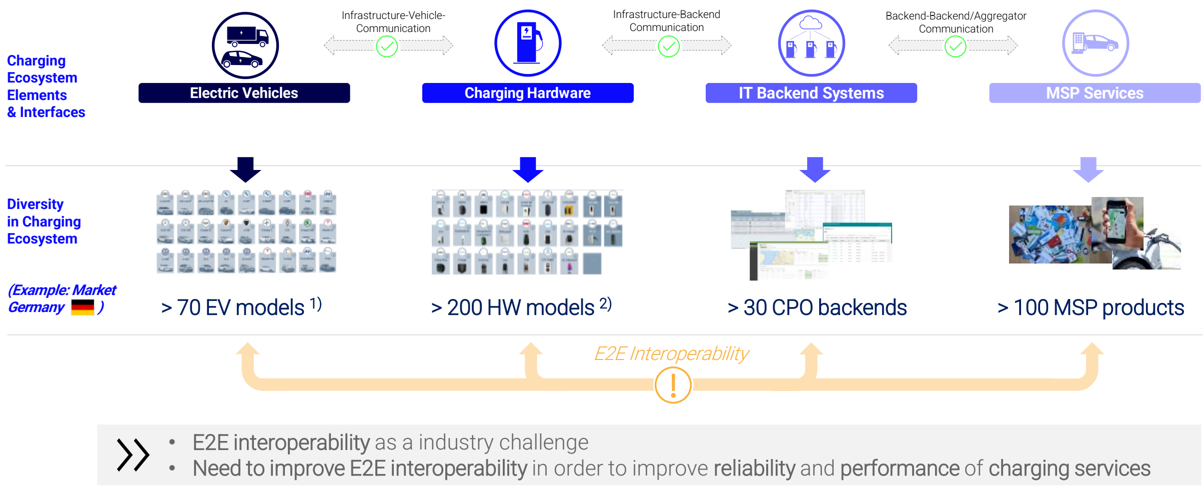

Figure 2: Germany as an example for a highly complex EV charging ecosystem (Source: P3 internal analysis)

Not only European markets show fast evolving and highly diverse EV charging ecosystems. Eligible EV chargers for subsidies in the USA are state dependant. In Minnesota alone, there are 92 models eligible for subsidies [1].

1.3 Lack of maturity in the communication protocol landscape for EV charging

In addition to the fast evolving and highly diverse product landscapes of EV charging solutions, EV charging communication protocols show lack of maturity in Europe.

Table 1. Exemplary overview of relevant communication protocols for EV charging in Europe

Communication protocol	System interface	Short description	Relevance	Maturity
ISO 15118-2/-20	EV - Charging Infrastructure	Road vehicles - Vehicle to grid communication interface - Part 20: 2nd generation network and application protocol requirements	High	Low to Medium

CHAdeMO	EV - Charging Infrastructure	DC charging standard for communication between electric vehicle and charging infrastructure incl. bidirectional charging	Low	High
EEBus	Charging Infrastructure - IT Backend System	IoT protocol suite that aims to coordinate and shift energy between an intelligent power grid and individual components in the households and buildings, e.g. photovoltaic system, battery storage, heating and electric vehicle	High	Low
Modbus-TCP	Charging Infrastructure - IT Backend System	De facto industry standard for automation technology that is used in building energy management systems in industrial plants, hotels and large properties and allows high degree of customization	Medium	Medium
Open Charge Point Protocol (OCPP) 1.6J	Charging Infrastructure - IT Backend System	Open, device-to-cloud communication protocol enabling remote control and monitoring of charging infrastructure operations incl. billing; HW agnostic; established as worldwide “open standard”	High	Medium
Open Charge Point Protocol (OCPP) 2.0.1	Charging Infrastructure - IT Backend System	Open, device-to-cloud communication protocol enabling remote control and monitoring of charging infrastructure operations incl. billing; HW agnostic; established as worldwide “open standard”	High	Low
OpenADR	IT Backend System - Energy Market	Open, cloud-to-cloud communication protocol enabling control signal transmission between grid operators and flexibility aggregators	High	Low
Open Smart Charging Protocol (OSCP)	IT Backend System - Energy Market	Open communication protocol enabling data exchange of physical net capacity from site owner to Energy Market	Medium	Low

While conducting a technical readiness check of the EV communication protocol landscape for EV charging, P3 has identified major differences with focus on relevance (for current & future EV charging use cases) and (technological and market) maturity between the communication protocols along the digital EV Charging value chain [2]. The resulting diversity and competition of EV communication protocols on certain ecosystem levels lead to additional complexity for manufacturers, operators and service providers in order to enable seamless and reliable charging experience.

2 The Challenge and Opportunity Ahead

2.1 The EV Charging Ecosystem evolves into a Smart Energy Ecosystem

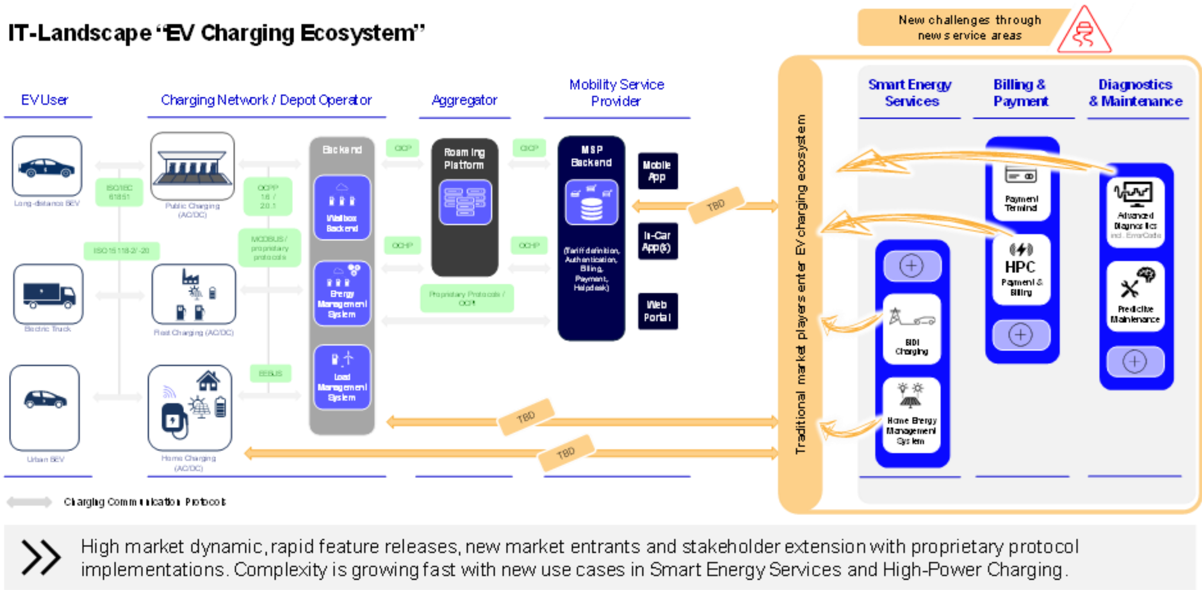

Figure 3: IT-Landscape "EV Charging Ecosystem" evolves into "Smart Energy Ecosystem"

The IT-landscape of the EV Charging Ecosystem is a complex web of diverse communication protocols that connect different ecosystem elements such as the EV, Charging Station, CPO Backend, Aggregator Platform, and MSP Backend. The usage of various IT communication protocols including standards, de-facto standards, and proprietary standards adds to the complexity of the ecosystem. In addition to the traditional EV Charging Ecosystem, new use cases like “Smart Energy Services”, “Smart Billing & Payment”, and “Smart Maintenance” have emerged, bringing new players and their proprietary communication protocols into the Ecosystem. This rapid influx of players and protocols has resulted in a shift in the EV Charging Ecosystem towards a Smart Energy Ecosystem. As the IT-landscape continues to evolve at a rapid pace, the coexistence of multiple communication protocols in different areas of the IT-landscape increases the need for interoperability. This is necessary to ensure that EV owners have a hassle-free and efficient charging experience, as well as to support the new use cases that are emerging.

2.2 Interoperability is key for a seamless EV charging experience

The results of the xEV charging test drives conducted globally in 2022 have highlighted a crucial issue in the current public EV charging ecosystem. The test drives have revealed a lack of interoperability, which is leading to an insufficient EV charging experience for the end-users. The charging success rate was observed to be around 72% at approximately 1000 charging attempts, which is a matter of concern for the stakeholders involved in the EV charging ecosystem.

These results indicate that the EV charging ecosystem needs to address the interoperability issues urgently to provide a better experience to the customers. The lack of interoperability between different EV models, charging stations, CPO backends, MSP backends, and aggregator platforms is one of the primary reasons for the low success rate observed in the test drives. As the number of EV models and charging solutions continues to increase, it is becoming essential to ensure seamless communication and compatibility between them.

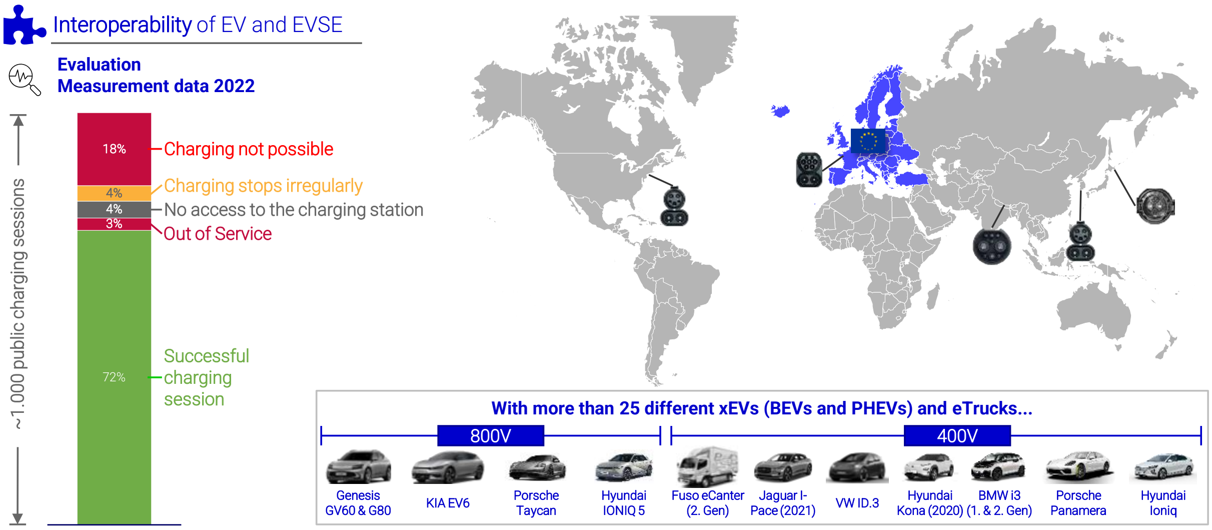

Figure 4: Overview of xEV test drive results in Europe in 2022 by P3 (Source: P3 internal analysis)

The results of the test drives also highlight the need for the EV charging ecosystem to evolve and become more standardized to ensure a better experience for the end-users. The rapid growth of the EV charging market has led to the entry of new players and diverse solutions, leading to a more complex ecosystem. It is crucial to maintain a standard and consistent approach to ensure interoperability and provide a hassle-free charging experience to the end-users.

In comparison to P3's xEV test drive results in Europe, similar experiences have been reported in the US and Germany. A study conducted in the Bay Area, California, in 2022 showed that only 72.5% of 657 open public EVSE were functional. Reasons for non-functional EVSE were unresponsive or payment system failure, charge initiation failure, connection failure, unavailable screens or a broken connector. Interoperability is required for the first four reasons. Furthermore, the study showed that the statewide target of 97% accessibility of EVSE or "uptime" is not being met. Uptime refers to the percentage of time during which the system is fully operational and delivers power at the intended level. This highlights the need for CPOs to invest in the maintenance and upkeep of their charging infrastructure to ensure maximum uptime for EV drivers [3].

Moreover, a german study presents an analysis of charging events in an electric vehicle project based on data collected from RFID and remote authentication messages and CDRs in Europe. A total of 42,573 individual charging events were analyzed, with 87% of RFID authentication events rated as flawless compared to 79% for remote authentication. However, 74% of potentially faulty remote events had no error message assigned. Further analysis revealed that more errors occurred between the charging station and the CPO back-end in remote events, while more errors related directly to the charging station in RFID events [4].

In conclusion, the insights gained from P3's xEV test drives and studies in the US and Germany demonstrate the need for improvement in the interoperability and reliability of the charging infrastructure for EVs.

3 Time is now to establish a seamless EV charging experience

P3 has faced the industry challenge of interoperability in multiple projects. In the following, best practices are shown for operators and service providers in order to tackle the complexity in interoperability and ensure a seamless EV charging experience for end customers.

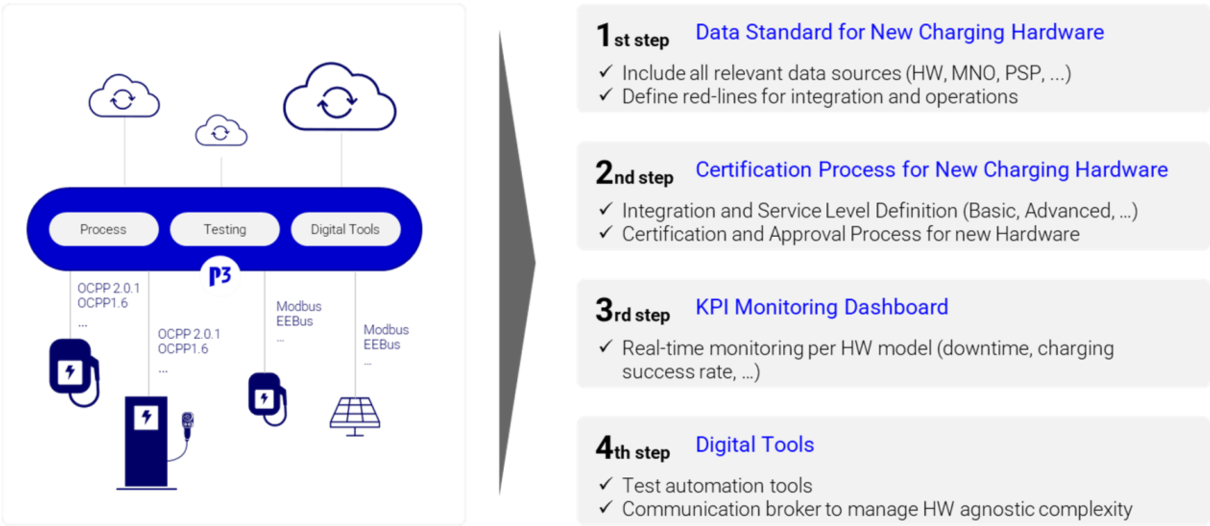

Figure 5: Overview of best practices to improve interoperability

Firstly, developing a data standard for the integration of new charging hardware models is essential. This standard includes all relevant data sources (incl. hardware data, mobile network operator data, payment terminal or service data, …) and defines red-lines for integration. By establishing a clear and consistent data standard, integration of new chargers follows a “plug & play” approach and operators can ensure high reliability and performance within their EV charging network.

Secondly, it is important to establish a certification process for new charging hardware models. This process defines integration and service level specifications (i.e basic, advanced, and premium levels). According to the customer needs, the certification, testing and approval process for new charging hardware models need to be clearly defined.

Thirdly, introducing a HW-agnostic Key Performance Indicator (KPI) monitoring dashboard is recommended. This involves monitoring KPIs for each hardware model group, such as uptime/downtime and customer charging success rates. Additionally, charging hardware model performance and reliability benchmarks can help to improve time-to-fix as well as the overall EV charging experience.

Finally, leveraging digital tools to improve interoperability is crucial. Digital tools, such as a HW agnostic communication broker or a test automation script, can be used in order to manage the varity of different firmware versions/ charging hardware models/ manufacturers, harmonize different protocol implementations and establish secure connections. In addition, digital tools offer flexibility and speed when scaling the EV charging network while ensuring a seamless EV charging experience.

4 Conclusion & Outlook

Interoperability is a industry challenge for operators and service providers in EV charging. Since complexity and diversity in the EV charging ecosystem will not decrease (continuous growth in product landscape, new upcoming use cases such as V2H or V2G, competing protocols in EV communication landscape), operators and service providers need to establish operational excellence programs in order to cope with changing interoperability requirements.

Operational excellence programs need to focus on HW-agnostic data standards, robust processes in supplier selection, charging hardware certification, testing and operations as well as the introduction of digital tools. A professional and consistent implementation of such programs has the potential to significantly improve reliability and performance of EV charging networks which leads to a seamless EV charging experience for end customers.

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Presenter Biography

Lukas Schriewer leads the Charging Technology & Network Operations team at P3 Group. For more than 8 years he has gained in-depth expertise in the areas of product development for charging hardware and software solutions, interoperability testing of charging infrastructure (EV – EVSE – Backend) and operational excellence for network operators. During this period he worked with automotive OEMs, HW manufacturers, CPOs, MSPs and utility companies. His daily work also focuses on the design of technology roadmaps, the development of smart maintenance models and the strategic supplier evaluation for charging infrastructure products and services. Before joining P3, he has studied industrial engineering at RWTH Aachen University (Germany) and Polytechnic University of Turin (Italy).

Jozsef Farkas leads the software development department in the field of energy & e-mobility within the P3 group. For more than 10 years he has been able to gather in-depth knowledge in the areas of connected charging infrastructure, standardization and digitization in the field of e-mobility. During this period he was responsible as a product manager at a major energy supplier and rolled out one of the largest IT platforms for the management of charging infrastructure. In his current role, he accompanies and supports his customers in the development and operation of customer-specific software solutions, from the backend to the frontend. This has resulted in some valuable and innovative products for the e-mobility and energy market. He developed his passion while studying electrical & industrial engineering at the RWTH Aachen University.