Short read
Stakeholder analysis Smart Charging ecosystem

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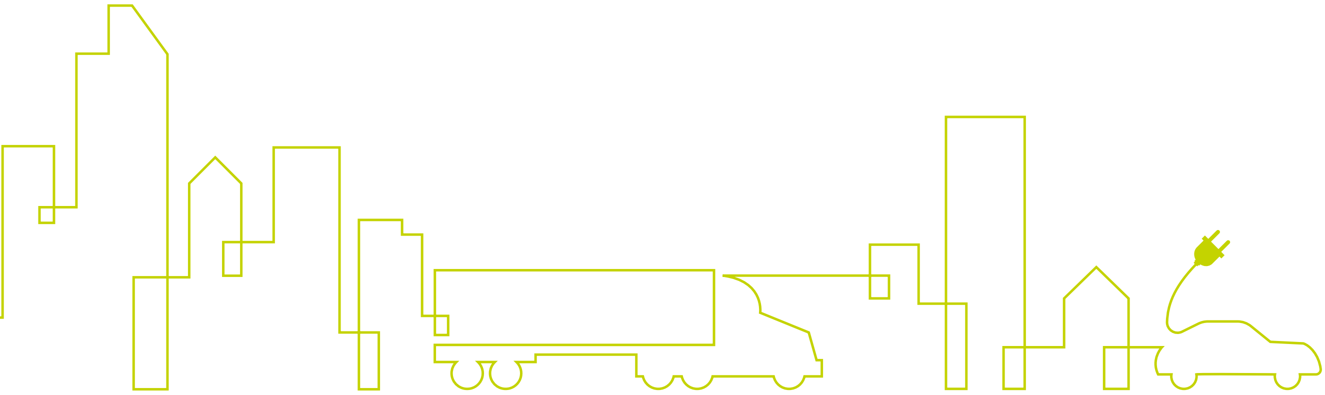

Introduction

The ambition of the European Union to achieve climate neutrality by 2050 have led to a notable increase in the number of decentralised renewable energy resources and an accelerated electrification of industrial sectors such as infrastructure and mobility. New challenges related to grid reliability arose due to the intermittent nature of decentralised electricity production and a steady increase in electricity consumption. Electric vehicle (EV) charging can prove to be part of the solution to these challenges through the use of smart charging and bidirectional charging (also known as Vehicle-to-Anything or V2X), the essence of which is to change the time, speed and/or direction of the charging process. End users, system operators, and participants in EV-related markets can all benefit from charging EVs in a flexible way.

This whitepaper summarises the main findings of the Stakeholder Analysis Report of the SCALE project. By taking into account diverging levels of market maturity and differences in national policy frameworks, this report focuses explicitly on finding a balance between establishing free and fair market principles in emerging EV-related markets on the one hand, while simultaneously ensuring consumer protection and societal interests on the other hand. Both existing and new market models are incorporated in four different industry value chains. The thorough examination of these industry value chains highlights both interactions between EV-related markets and challenges within specific markets. Fundamentally, the incorporation of flexibility models – such as non-firm capacity contracts and congestion management – in energy markets and the development of the planning process in the charging infrastructure market are identified as crucial challenges towards a large scale adoption of smart mobility solutions. As such, our research shows that there are still some major steps that need to be taken, especially with regard to bidirectional charging.

This report identifies the most important stakeholders in the smart charging ecosystem and investigates their main drivers and objectives in existing and future EV markets. This way, we bolster support for core EU principles such as a free and fair market based on consumer protection. The analysis shows that stakeholders face a multitude of barriers ranging from economic, to societal, to political. For EV drivers, the most crucial objective is to grant end customers ownership of EV data, in order to allow them to freely participate in flexibility markets. On the manufacturer's end, we show that the lack of a common regulatory framework inhibits the cross-national penetration of EV-related markets. In general, uncertainties in technological advancements, the lack of clear regulatory to deal with flexibility propositions, and delays in market maturation due to a lack of inter-stakeholder dialogues are considered as additional crucial barriers towards the large-scale deployment of smart charging services. In order to tackle these barriers, specific attention should be given to interoperability, data accessibility, and fostering collaboration between stakeholders across the entire smart charging ecosystem.

The contents of this paper are divided into four section. The first section aims to illustrate the overall system architecture of smart charging services, by formulating different roles and business perspectives within different EV related markets. The second section is dedicated to the requirements for the scale-up of smart charging for a number of involved stakeholders by assessing their needs, value cases, and barriers. The third section formulates a preliminary outline of integral requirements on interoperability, communication, and cybersecurity, which will serve as the foundation for data requirements in the SCALE framework. This paper concludes with policy recommendations based on our findings.

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that explores and tests smart charging solutions for electric vehicles. It aims to advance smart charging and bidirectional charging (V2X) ecosystems to shape a new energy system wherein the flexibility of EV batteries' is harnessed. The project will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations in 7 European contexts: Oslo (NO), Rotterdam/Utrecht (NL), Eindhoven (NL), Toulouse (FR), Greater Munich Area (GER), Budapest/Debrecen (HU), and Gothenburg (SE).

SCALE

Industry Value Chains

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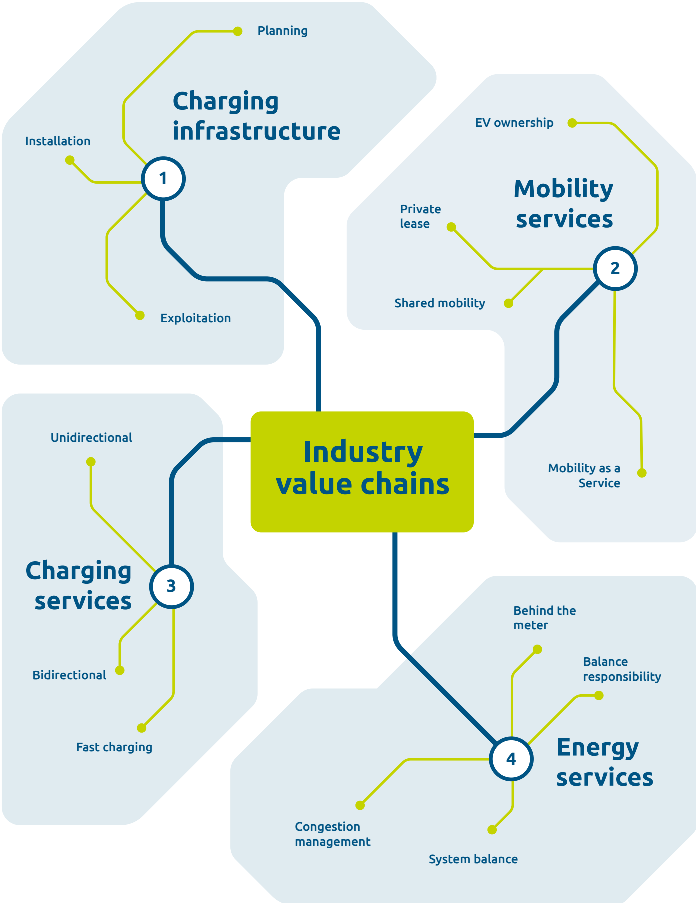


Charging infrastructure

The planning of charging infrastructure is a crucial challenge both in the public and private domain. The adoption of EVs depends on the availability of charging infrastructure, while, simultaneously, the willingness of local governments and businesses to invest in charging infrastructure depends on the current and predicted EV uptake. This chicken-and-egg-dilemma, combined with the total process length and installation costs of new charging infrastructure, complicates the planning process.

Recent European legislation has led to significant advances in proactive planning of new charging infrastructure, making it the dominant approach in most Member States. Major cities in Western Europe are fading out reactive planning in favour of a data-driven approach, in which data on the (expected) number of EVs, the availability of existing charging stations, and local grid capacity is used to determine in advance which locations require more charging stations.

Public charging infrastructure installation requires coordination between site owners, grid operators, and charging station operators. Most public charging stations are installed in two phases. First, a preparatory phase in which the wiring and civil work is finished a few weeks in advance, and, second, the installation phase in which the charger is installed, connected to the grid, and formally registered. Ideally, this process will be simplified and completed by as few parties involved as possible. This demands far-reaching coordination which is still missing in most major European cities and Member States in general. By authorising one party to carry out all three components of the charging station installation, the process can be streamlined and completed within one day.

"Far-reaching coordination needed to simplify the installation process is still missing in most major European cities and Member States in general"

There are a handful of considerations that need to be addressed after the installation of the charging station, including data sharing, safety, smart functionalities, and billing. Transparency of prices and free access to information increase user-friendliness and are therefore a prerequisite for further EV uptake. Ambiguity regarding the costs of the charging session, the charging speed, and the location of the charging station are some key bottlenecks still common for public charging nowadays. To ensure the availability of such dynamic data, the communication between a charging station and a central system needs to be developed and standardised. Standardised communication protocols can also be used to communicate non-charging point related data, such as driver preferences (e.g. minimum state of charge required) in order to make use of smart charging. Similarly, charging station operators can forecast the total EV load, which can be used by system operators to predict peak demand in advance to timely mitigate grid congestion issues.

Mobility services

Mobility is commonly associated with privately owning a car, but this paradigm is changing in favour of alternatives such as car sharing. The main benefit of private ownership is complete control of and access to the vehicle. However, the need for sufficient mobility infrastructure and the high initial investment, which is even more notable for EVs, push customers towards alternative ownership models more and more often. Company or private lease is an alternative to private ownership that still provides the benefit of accessibility. It alleviates the burden of associated with maintenance, repairs, and insurance, albeit at a higher monthly cost. Additionally, the prevalence of car sharing has grown in recent years. As the majority of cars are parked approximately 95% of the time and travel no more than 40 kilometres per day on average, new value propositions for mobility services and car sharing can increase the utilisation of cars while also being financially beneficial and reducing parking congestion. Shared fleets and company fleets are electrifying faster than privately owner cars because they drive more kilometres per year and thus have a stronger business case. A larger EV fleet provides more charging flexibility as well as more opportunities for smart charging and V2X integrations. While meeting the customers' need for mobility, the value of EV fleets can expand into offering flexibility on electricity markets.

Charging services

The rapid uptake of EV usage and the subsequent increase in EV charging causes severe issues with regard to electricity demand predictability and grid congestion. EVs can also prove to be part of the solution by modifying when and at what speed an EV is charged, also known as smart charging. Smart charging can be triggered to charge when there is a high share of renewable electricity in the energy mix, to shave demand peaks and avoid grid congestion, or to charge when the electricity prices are at their lowest. Data availability is a prerequisite to get the most value out of smart charging, as the optimal charging profile is decided by smart technology and algorithms. The EV drivers needs to communicate the expected parking time, the desired minimum state of charge, and the preferred application of smart charging (i.e. as cheaply as possible, using as much renewable energy as possible, etc.). Furthermore, the current state of charge of the EV battery and the maximum supported charging speed by both the EV and the charging station need to be shared to ensure optimisation.

"Data availability is a prerequisite to get the most value out of smart charging"

The prospect of smart charging is becoming more interesting every day. The necessity to charge smartly is growing as grid constraints and demand and supply fluctuations are becoming increasingly problematic. Different business models are currently evolving to use the flexibility of the EV charging process to charge cheaper, greener, and with less problematic impact on the electricity grid. Despite the developments, normal charging is still the default. Awareness of smart charging is still scarce in most Member States. Introducing smart charging models to new EV drivers as soon as possible is valuable for the acceptance of large scale smart charging.

EVs can also make good use of bidirectional charging due to the ability to store a lot of energy within the battery. The essence of bidirectional charging, also known as Vehicle-to-Anything (V2X), is to use the storage capacity of the EV for non-mobility related purposes. Discharging an EV battery can be used to better control energy in a home (V2H), a business (V2B), a depot (V2D), or even feed electricity back into the grid (V2G). Although the first EV models capable of delivering V2X (via CHAdeMO plug) were already introduced in 2011 by Nissan and Mitsubishi, the market has not yet developed to a good size population. Market evolution for bidirectional charging is in its infancy, with few EVs being commercially available and the required communication protocol to enable bidirectional charging for the CCS plug (ISO 15118-20) having been released only early 2022.

Fast charging (≥ 50 kW) is likely to become less prevalent in the near future due to increasing EV driving ranges and a growing number of slower public and semi-private charging stations. In the context of smart charging, instant fast charging is mainly of interest for heavy-duty vehicles. Most heavy-duty vehicles such as trucks and busses have deviant driving and parking patterns, require a full state of charge, and can only be charged at night, usually at a depot. The need for fast charging speeds during daytime due to the size of heavy-duty vehicle batteries and inefficient consumption patterns (0.3 kWh per kilometre for busses; 0.9 to 1.8 kWh per kilometre for trucks) might coincide with other electricity consumption peaks, which may prompt the need for smart charging to avoid grid congestion.

Energy services

Smart charging and V2X can be employed on a handful of flexibility markets. This section describes the potential of EV flexibility in the contexts of behind-the-meter optimisation, wholesale energy markets, balancing markets, and congestion management.

Changing the charging process from an uncontrolled to a smart way can provide valuable behind the meter benefits for EV drivers at home and at company sites. Behind the meter optimisation is manifested in a handful of use cases based on price, self-consumption, and emissions. EV drivers can benefit from electricity prices based on time-of-use tariffs and spot market prices by charging at times when electricity prices are low. Similarly, bidirectional charging can be used to feed electricity into a home or other building during periods of high electricity prices. Smart charging can also be employed to charge using more renewable energy. Charging faster when the mix of renewable energy in the grid is high can potentially lower the footprint of all EV drivers, even those not owning solar photovoltaic (PV) themselves. This can be achieved in a more static manner by arranging a charging schedule between sunrise and sunset or in a more dynamic way based on day-ahead prognoses of CO2 levels. Site owners with solar PV have additional possibilities to optimise renewable energy usage by measuring the local production of solar energy at a given time and dynamically adjusting the charging speed of EVs. Charging with your own locally produced solar energy can also provide additional financial benefits, as the feed-in tariff of locally produced electricity is generally much lower than the price for consumed electricity.

Supply and demand of electricity has to be roughly in balance at all times to keep the grid frequency at 50 Hertz. Imbalances can lead to power outages and deterioration of and damage to electronic equipment. To ensure electricity generation and consumption is balanced, the EU employs the concept of balance responsibility. Each market participant is responsible for the imbalances they cause in the electricity system. In practice, small-scale consumers will delegate this responsibility to a balance responsibility party (BRP), which is usually their energy supplier. BRPs shall buy the exact same amount of electricity their consumers will use to keep their portfolio in balance. Based on weather forecasts and predicted consumption patterns, a BRP estimates the surplus electricity which they need to buy or sell on energy markets. BRPs actively try to avoid the imbalances caused by deviations in supply and demand that occur, among other factors, as a result of changing weather or consumption patterns. One way to achieve this is to make use of demand response. For instance, if actual production turns out to be lower than estimated, BRPs may want to incentivise their consumers to also lower their consumption by giving them a financial compensation. The ability to quickly change the intensity of the charging process makes smart charging a viable opportunity to provide demand response.

Despite the efforts of BRPs to maintain balance in their portfolios, system imbalances can still occur in real-time due to forecast inaccuracies and outages of generators. The Transmission System Operator (TSO), responsible for the real-time balancing of the grid, operates on the balancing market to procure and activate balancing reserves. Customers can reach an agreement with a Balancing Service Provider (BSP) to adjust their supply or demand at a given time, for which they will be compensated. The BSP combines the flexibility of a large number of customers and places a bid on the balancing market. An EV user can reach an agreement with a BSP to temporarily diverge from their usual consumption pattern by disclosing the desired time of departure and state of charge to the BSP in advance. The BSP can strategically decide when to adjust the charging process of an entire EV fleet, in order to meet their bid on the balancing market. The holy grail of smart charging in balancing markets is V2G, in which the EV can not only assist in grid balancing via demand response, but is also able to feed electricity back into the grid. As a result, the flexibility range of V2G EVs is twice that of regular EVs. Additionally, whereas regular EVs can no longer provide flexibility when the battery is full, V2G EVs can still aid in frequency balancing by discharging their full battery back into the grid.

“The concept of congestion management is not as well developed within European legislation as balance responsibility and system balancing”

The rapid electrification of the building and mobility sectors, among others, is increasingly leading to grid congestion on the local low voltage level. The high simultaneous demand in power of electronic equipment can put serious constraints on the grid capacity, especially at peak hours. While the electricity grid can generally handle occasional peak loads well above 2 kW per household, a large number of EVs charging simultaneously will lead to grid congestion. Similarly, generation peaks of solar energy on sunny days can lead to supply-side grid congestion. Historically, grid congestion was averted long-term by investing in grid reinforcements. However, such investments are expensive and system operators are currently not able to keep up with the pace of electrification. The alternative to costly investment is congestion management: interventions executed by system operators at the supply or demand side in order to prevent or mitigate grid congestion. The most notable application of congestion management in the context of e-mobility is peak shaving: using smart charging to shrink the total peak demand by temporarily interrupting the charging process of an EV. The concept of congestion management is not as well developed within European legislation as balance responsibility and system balancing. Prior to the Electricity Market Directive of 2019, most Member States did not allow system operators to procure flexibility due to unbundling requirements. Congestion management schemes have therefore not been fleshed out sufficiently in the majority of Member States due to a lack of a European wide framework and the recency of the Electricity Market Directive. Therefore, it is still unclear how congestion management markets will develop, how EV drivers will be compensated, and what market roles need to be developed further to facilitate congestion management.

Stakeholders

Stakeholders

EV Driver

Early EV adopters have been accustomed to simply plugging in their EV when needed to charge at maximum capacity. However, charging patterns are beginning to shift, either as a result of external influence such as regulation and standards, or as a result of intrinsic motivation. Smart charging is becoming the norm. Variations in consumer charging behaviour can be motivated by environmental ideology, economic incentives, or social motivations. A consumer motivated by environmental ideology will want to charge using as much renewable electricity as possible, whether generated by their own solar panels or from external sources such as wind energy. Financially driven consumers want to charge as cheap as possible and respond to fluctuations in energy prices and grid tariffs. Socially motivated consumers respond to incentives based around fair use and avoiding local grid congestion.

“Optimising charging requires data from the EV and the driver, highlighting the importance of giving drivers access to proprietary EV data”

The key for EV drivers to make use of smart charging and V2X is availability of and access to important data. EV drivers want certainty that the EV is sufficiently charged at the end of the charging session. Information about the charging session must thus be transparent and communicated clearly. Optimising charging also requires data from the EV and information from the driver, highlighting the importance of open data standards and giving drivers access, at no costs, to proprietary EV data such as the state of charge. In addition, uncertainty with regard to driving range and the state of health of the EV battery have been named as crucial barriers for EV drivers. Range anxiety is decreasing as EV battery sizes are increasing and the number of publicly available charging stations rapidly grow as well, but is still a major concern when coupled with smart charging and V2X propositions.

Charge Point Operator and e-Mobility Service Provider

The Charge Point Operator (CPO) and e-Mobility Service Provider (EMSP) are two distinct important roles in the exploitation of charging infrastructure. In many instances, the roles of CPO and EMSP are fulfilled by the same company. A CPO installs and maintains charging stations from one or more manufacturers to enable EV charging. They are responsible for standard operation, maintenance, data sharing, and providing additional functionalities such as smart charging. The EMSP is the contracting party and point of contact for EV drivers when charging at publicly available charging stations. EMSPs aim to make EV charging convenient for drivers by providing access to a large network of charging stations via a charging card or an app and by standardising transactions and billing procedures. EMSPs can also play an important role in facilitating smart charging by offering propositions that respond to customer needs, combining charging needs with preferences such as low costs or charging on renewable energy. EMSPs and CPOs can help translating fluctuating market prices into a simple smart charging service, while also providing unique selling points to their customers such as enabling smart charging on local renewable energy.

In order to scale up smart charging and V2X quickly, attention is needed for open standards and protocols for both hardware and software, as well as connectivity with grid data. Standardisation of tender procedures of local governments will provide clarity to CPOs for requirements regarding dynamic pricing schemes, as well as smart charging and V2G operability and/or readiness. A basic set of requirements for (public) charging stations, which includes at least smart charging capabilities, would even out the total costs for installation and create a more level playing field for CPOs and EMSPs. Further access to transparent information when providing smart charging services is needed as well. It must be clear to the customer what options are available and what the associated benefits are. A key barrier still existing in this context is the lack of access to proprietary EV data such as the state of charge. Giving customers control over this data allows them to enter flexible contracts with EMSPs and optimise the added value of EV flexibility across the smart charging ecosystem.

Distribution and Transmission System Operator

The Distribution System Operator (DSO) and Transmission System Operator (DSO) are responsible for operating, ensuring the maintenance of, and developing respectively the electricity distribution system and electricity transmission system. Concretely, the DSO fulfils three roles within the electricity market: connecting distributed energy resources and the vast majority of consumers - including charging stations - to the grid, physically transporting electricity flows across the distribution grid, and facilitating the market by managing registration of grid connections and market participants such as energy suppliers, BRPs, and flexibility providers. The roles and responsibilities of DSOs have not changed significantly over time, but meeting the objectives on system security have become more challenging as a result of the energy transition. With the rapid electrification of the energy system, issues regarding grid congestion and power quality of low-voltage grids are occurring at a higher rate than before. In contrast to the roles and responsibilities, the tools to deal with system security related issues have improved notably in recent years. DSOs were traditionally not allowed to actively participate in the electricity market as they were heavily regulated due to their status as a natural monopoly. Following the EU regulations part of the Clean Energy Package, DSOs are now allowed and incentivised to procure flexible assets in order to maintain system security. EVs capable of smart charging are a potential flexible asset to be deployed by DSO in the near future.

TSOs are responsible for the reliable and safe operation of the electricity transmission grid. Safeguarding electricity supply is dependent on the TSO’s ability to maintain the grid frequency within predefined boundaries and to ensure that the transmission grid is able to transport the total electricity demand. Daily TSO tasks therefore consist of both resolving grid imbalances via the activation of balancing reserves and preventing exceedances of the technical limits of the transmission grid by applying constraint management. Increasing frequency instability resulting from the volatile production patterns of distributed energy resources, such as solar PV, forces TSOs to activate balancing reserves at higher total capacity and on a more regular basis. Historically, large power plants have been used to guarantee frequency stability, but their slower response time and high CO2 emission output have dwindled their effectiveness. This leaves a lucrative market opportunity for smart charging and V2G in particular, as frequency balancing requires both up and down regulation of balancing energy.

It is possible that DSO and TSO activities on respectively the congestion management and balancing markets interfere with one another and can cause inadmissible effects on other system operator’s activities. To prevent that measures taken by the TSO for frequency balancing cause grid congestion in distribution grids and, vice versa, that DSO activities on congestion management complicates the TSO’s ability to maintain grid balance, there is a need for extensive cooperation between system operators. Such cooperation already exists in a number of Member States via market platforms such as Equigy and GOPACS, but legislation on system operation need to be revised to account for these new market platforms.

“Many system operators currently lack the necessary experience to act based on market based principles when compensating consumers for flexibility services”

Another major barrier associated with DSO and TSO flexibility services is the relative immaturity of flexibility markets. Congestion management markets in particular are in a lower stage of development than frequency balancing markets. Many Member States are yet to clarify congestion management schemes for DSOs or lack financial incentives to allow for voluntary congestion management by small-sized distributed energy resources, thereby restricting the DSO to mandatory congestion management by large electricity production units only. Both the TSO and DSO, which have historically been heavily regulated entities, now have to act based on market based principles when compensating consumers for flexibility services. Many system operators lack the necessary experience to do this short term. For instance, prequalification procedures for balancing and congestion management markets need to be developed and standardised further, keeping in mind the specific characteristics of e-mobility. Due to the high total number of EVs and charging stations that can potentially provide grid services to system operators, an automated prequalification procedure should be defined to further advance prequalification efficiency.

Market participants: energy supplier, BRP, and aggregator

E-mobility is an enticing business opportunity both for traditional and emerging energy market participants. Traditional market participants, such as energy suppliers and BRPs, need to redefine their roles. The transition towards e-mobility enables energy suppliers to sell more electricity and consequently generate higher profits. EV charging as a form of flexibility is another interesting prospect for suppliers with the use of dynamic pricing, which has been enabled by European legislation such as the Electricity Market Directive of 2019. Other market participants, such as the BRP, can use smart charging and V2X as a source of flexibility to balance their portfolio and avoid imbalance charges.

New market participants, such as the aggregator and the flexibility service provider, have emerged in European flexibility markets as the result of European legislation. Such market participants are key actors in allowing small size prosumers to participate in flexibility markets by bundling a large number of small assets and offering the aggregated volume on one of the flexibility markets on behalf of their consumers with the end goal of making profit and reducing total energy costs. Offering flexibility via smart charging and V2X requires the use of an aggregator due to the minimum bid sizes enshrined in European and national laws (≤ 0.5 MW on wholesale markets, 1 MW on balancing markets).

Market participants face a wide variety of barriers towards the scale-up of smart charging and V2X. Suppliers and aggregators struggle with determining a fair and competitive price for flexibility services, most notably for electricity fed back into the grid via V2G. Extensive communication between system operators and market participants is needed to validate that the procured flexibility has been delivered and to determine a fair compensation for the flexibility. Market participants are reliant on data accessibility in order to develop market platforms and build sophisticated data models that facilitate the needed inter-stakeholder communication and pricing schemes. Real time EV data is currently proprietary to EV manufacturers and European wide legislation requiring free and non-discriminatory data sharing will likely not be implemented by Member States in the next few years.

"Suppliers and aggregators struggle with determining a fair and competitive price for flexibility services, most notably for electricity fed back into the grid via V2G"

EVs can most notably be of added value when they are also capable of bidirectional power transfer. The vast majority of currently available EVs are not capable of providing these V2X services and a large scale adoption of V2X in the automotive market is not expected for at least a few years. Deploying EVs on flexibility markets is therefore limited to smart charging for now, which is considerably less flexible and consequently less profitable than V2X due to the smaller bandwidth and the inability to provide flexibility when the EV battery is full.

EV and charging station manufacturers

The EV market has gradually moved away from a business model based on the luxury of EVs towards one based on their economic and environmental characteristics, increasing market penetration in the process. This was motivated by a growth in public knowledge and demand in EVs and by EU policies specifically aimed at decarbonising the mobility sector. From the perspective of the automotive market, the transition towards smart charging and V2X readiness necessitates the adoption of an EU-wide policy framework in favour of EV manufacturers. Manufacturers are hesitant to invest in smart charging and V2X because of the higher investment costs, while not profiting themselves from the unlocked flexibility. The current lack of demand from potential EV buyers for smart charging and V2X functionalities makes it difficult to justify additional investments. A regulatory framework in favour of the automotive sector would at least include measures to increase awareness of smart charging and V2X for end consumers and financial incentives to boost demand, such as tax breaks for 'V2X ready' EVs. This way, manufacturers are encouraged, but not mandated, to add more sophisticated functionalities to their EVs.

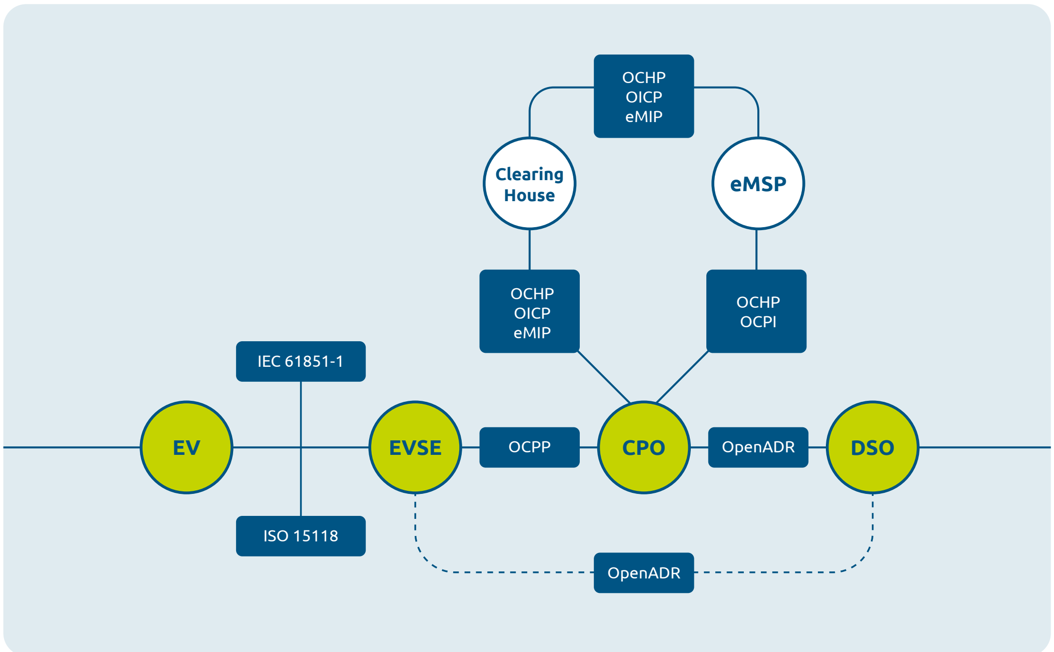
Charge point manufacturers make charging stations and sell them to CPOs or directly to businesses or individual customers. Charge point manufacturers are a crucial link in the smart charging ecosystem because they must provide products capable of smart charging and V2X. Charge point manufacturers might also be reluctant to invest in innovative services such as bidirectional charging as it is currently not clear when a charging station can be deemed 'V2X ready'. A clear definition of what requirements shall be complied with, which communication protocols shall be implemented, et cetera, can help both charge point manufacturers and EV manufacturers create a clear long-term business case.

"A regulatory framework should be developed that specifies when an EV or charging station can be considered smart charging ready or V2X ready"

EV and charge point manufacturers operating in multiple Member States are especially hindered by different tender procedures and grid code requirements. Building a European wide framework for charging services and charging infrastructure, which might include harmonisation of aforementioned tender and grid code requirements, would significantly improve the business case for EV and charge point manufacturers and mitigate the existing chicken-and-egg dilemma for V2X readiness. For both stakeholders, a major barrier towards large scale smart charging and V2X adoption is the absence of a regulatory framework that specifies when an EV or charging station can be considered smart charging ready or V2X ready. The implementation of such a framework would enable them to officially claim that they are able to provide smart solution, thereby significantly improving their business case.

Data

E-mobility market growth is fundamentally conditional to the degree of user centricity of the provided services. Ideally, charging an EV should be as convenient as refuelling a fossil-fuel vehicle. This requires an open charging infrastructure in which all market participants can participate on a non-discriminatory basis and the various systems within the e-mobility market can work together. Ensuring that assets and system from different manufacturers can work together, also known as interoperability, will accelerate the adoption of EVs and reduce total costs. Two types of interoperability can be distinguished. Hardware interoperability is aimed at standardising the connectors and sockets used in EVs and charging stations (in this context also referred to as the Electric Vehicle Supply Equipment, or EVSE) respectively to allow EVs to charge at any (public) charging hub. The goal of software interoperability is to ensure that all different system aspects within the e-mobility market – from EV to charging station and from energy supplier to EMSP – speak the same language. Software interoperability can be improved by adopting widely accepted open standards and communication protocols. The figure below shows an overview of the most common standards and protocols:



Overview of the most dominant standards and protocols related to EV charging

ISO 15118-20, the most recent version of ISO 15118, provides the basis for bidirectional charging. Market adoption of ISO 15118-20 is still relatively low as the protocol has only been released recently. There are currently no mass produced EV models that support ISO 15118-20 and charging stations supporting earlier versions of the protocol have mainly been used in pilot projects. ISO 15118 is currently included in the recommendations for public tenders for charging infrastructure by the Sustainable Transport Forum and is expected to be mandated as a European standard as part of the Alternative Fuels Infrastructure Regulation. Mass market adoption of the standard can thus be expected in the next few years. Another crucial communication protocol for bidirectional charging is the Open Charge Point Protocol (OCPP). OCPP has been designed and developed to standardise the communication between a charging station and a central management system, which is used for operating and managing charging station. OCPP is currently the de facto standard in both the European Union and the rest of the world for such back-end communication. The necessary update to add V2X information exchange to OCPP is currently under development and is expected to be released in 2023.

"Market adoption of ISO 15118-20 is still relatively low as the protocol has only been released recently"

Significant attention should also be given to cyber security. All charging stations together form a smart network to optimally deploy the use of renewable energy and grid capacity. To make this possible, all the different elements have to communicate with each other and are connected to various ICT systems and back offices. Charging infrastructure should be open and accessible to everyone: for all kinds of vehicles, software systems, charging protocols, and apps, while at the same time being protected against cyberattacks. Cybersecurity in the smart charging chain can be improved by including technical security measures in tender requirements for (public) charging infrastructure and by making cybersecurity an integral part of communication protocols.

Conclusions and recommendations

Conclusions and recommendations

The stakeholder analysis indicates that a large number of stakeholders play a crucial role in successfully unlocking the flexibility of EV charging and a growing number of stakeholders across the ecosystem have a clear interest in accelerating the adoption of large-scale smart charging and V2X. Each of these stakeholders face significant barriers that need to be addressed to fully unlock the potential of flexible mobility services. In general the analysis shows the need for cross-sectoral collaboration and knowledge exchange. Building an alliance with interested stakeholders from different value chains will foster synergies and improve collaboration across the entire ecosystem, thereby mitigating uncertainties related to technological advancements and potential value streams. Specific attention should be paid to the following barriers:

- To fully unlock the potential of EVs in flexibility markets, barriers to enter flexibility markets for EV drivers should be removed. Most notably, prequalification procedures for small-size distributed energy resources should be simplified and EV drivers should be given access, at no costs, to proprietary EV data.
- Uncertainty of market developments should be mitigated by defining when an EV or charging station can be considered 'smart charging ready' or 'V2X ready'. Tender procedures for (public) charging infrastructure should include a basic set of requirements for smart charging readiness.
- Many market participants face difficulties justifying a business case for smart charging and V2X, which leads to a chicken-and-egg problem. A regulatory framework aimed at increasing awareness of smart charging and V2X can encourage manufacturers to implement smart functionalities.
- The further development and implementation of widely accepted standards and protocols such as ISO 15118-20 and OCPP should be promoted by European legislation.

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