EV Related Protocols

ICT aspects of EV charging

Elaadnl

Contents

Terms & abbreviations

Term / abbreviation	Meaning
Customer	The private and business customer of EV and associated energy systems.
EV	The electric vehicle.
OEM EV	The automotive industry.
EVSE	Electric Vehicle Supply Equipment. In this document: the charge point (hard ware & software)
eMSP	E-mobility service provider.
CH	Clearing House.
CPO	Charge Point Operator.
Utilities:	
DSO	Distribution System Operator.
BRP	Balance Responsible Party.
TSO	Transmission System Operator.

1. Introduction

This report is an introduction to some of the ICT aspects of Electric Vehicle (EV) charging and specifically an introduction to the topic of EV related communication protocols. Although EVs are relatively new, the ICT aspects can easily be compared to mobile phones. If you have a subscription from KPN, the Dutch telecom operator, we all think it is normal that your phone still works when you are on holidays, as long as the "roaming" option on your phone is turned "on". You can keep using your phone, despite the fact that KPN only has GSM antennas in the Netherlands. When you get home from your holidays, you also expect that the (one) bill at the end of the month is correct. In short: we expect that it "just works".

When looking at EVs, it does not yet always "just work". We cannot yet charge everywhere in the EU (or the world) with 1 subscription and just one bill at the end of the month. The main difficulty is the fact that the EV market is still "moving" and many aspects relations and business models are not "final" yet.

As the mobile phone comparison already implied, some form of communication between parties in different areas is necessary to handle billing of phone calls. Looking at the amount of countries and mobile phone operators, this concerns a lot of different parties. The communication of course has to be correct: you expect that if you have called 5 minutes from outside the EU, you get billed for 5 minutes, not for 5 hours, so the information should be unambiguous.

The same example can be applied to EV charging by replacing "GSM antennas" by "charging stations" and replacing "calling" by "charging". To provide similar functionalities from the mobile phone market in the EV market, standards are needed.

2. Home EV charging

The simplest form of EV charging is charging an EV at home as illustrated in Figure 1: for this you need an EV manufacturer, the OEM, the EV itself and a charging station, also referred to as an EVSE.

The charging between an EV and a charging station should be standardized to be able to choose any home charging station. Currently, the IEC 61851-1 protocol is mostly used for this. The ISO/IEC 15118 protocol is being developed to do more advanced charging, such as de-charging the battery, i.e. giving back energy to the grid.

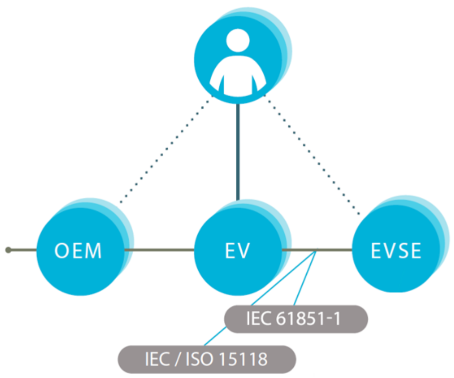

Figure 1: Simple home charging

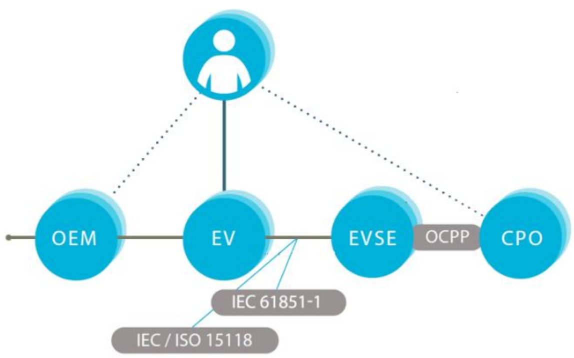

Figure 2: Home charging controlled by a CPO

Perhaps this looks simple, but to enable this scenario in practice, the charging station should have the option to be remotely "controlled" by an operator. This is necessary for the following (non-exhaustive) list of functionalities:

- metering for tax advantages, when charging is being paid by someone's company ("company car")
- Monitoring for errors.
- Firmware updates for fixing bugs or adding functionalities (e.g. connecting to energy computers like "Toon")
- Registering a charging station at a back office when it starts, to prevent fraudulent devices.
- Remote troubleshooting

Adding the Charge Point Operator, CPO, is illustrated in Figure 2. A worldwide standard, the Open Charge Point Protocol, OCPP, has been developed in the Netherlands to standardize communication from this operator to a charging station. The OCPP standard enables executing the aforementioned functionality *and* enables a free choice of charging station for both operators as well as customers.

3. Public EV charging

When not using a charging station at home, but a *public* charging station (e.g. in a parking garage), this adds more complexity. Public charging stations are owned by various operators. To get one bill at the end of the month, EV users need a unique id, currently usually a charging card (RFID card), to identify themselves at charging stations. This id is provided by a party that is referred to as the E-Mobility Service Provider, the EMSP. To be able to use a charging card at any charging station of any operator, some form of communication between the EMSP and the CSO is necessary. This communication is needed for authorization purposes and includes the handover of billing data from any CSO to the EMSP to be able to provide one bill to the EV user. This is the EV charging variant of "roaming": charging at a charging station that is not owned by "your own operator".

For EV roaming, different protocols can be used. In the picture below you see a number of protocols that have been developed in Europe: OCPI, OCHP, OICP and eMIP. Some of these roaming protocols are (partially) peer-to-peer, some use a central hub, also called a Clearing House, to prevent many communication channels between different parties.

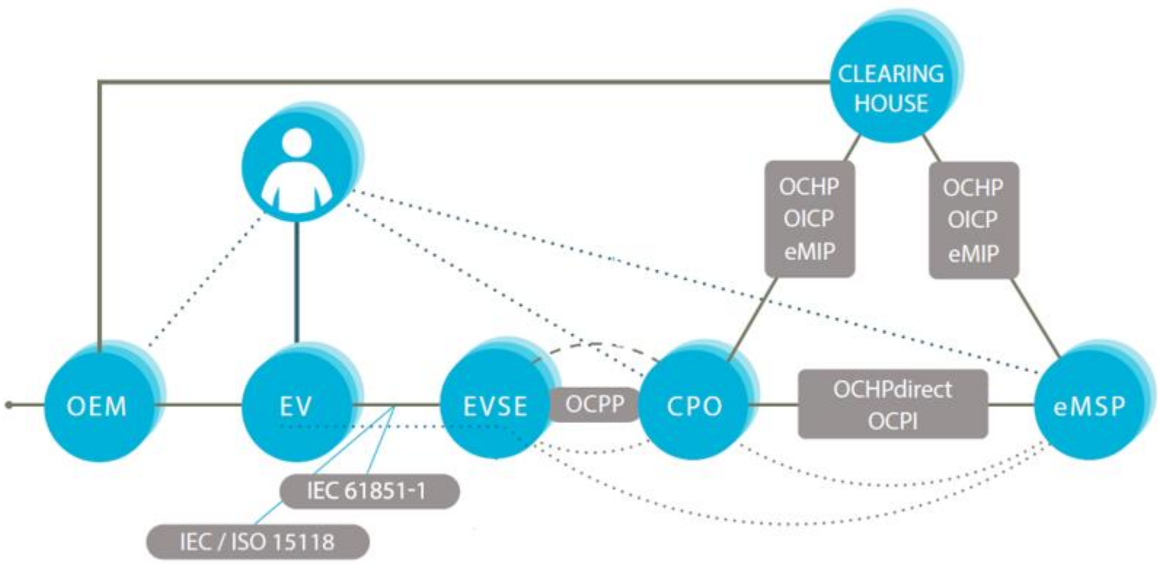

Figure 3: Public EV charging

A comparison of these roaming protocols has been in the EV related protocol study by ElaadNL [1] and is summarized in the picture below.

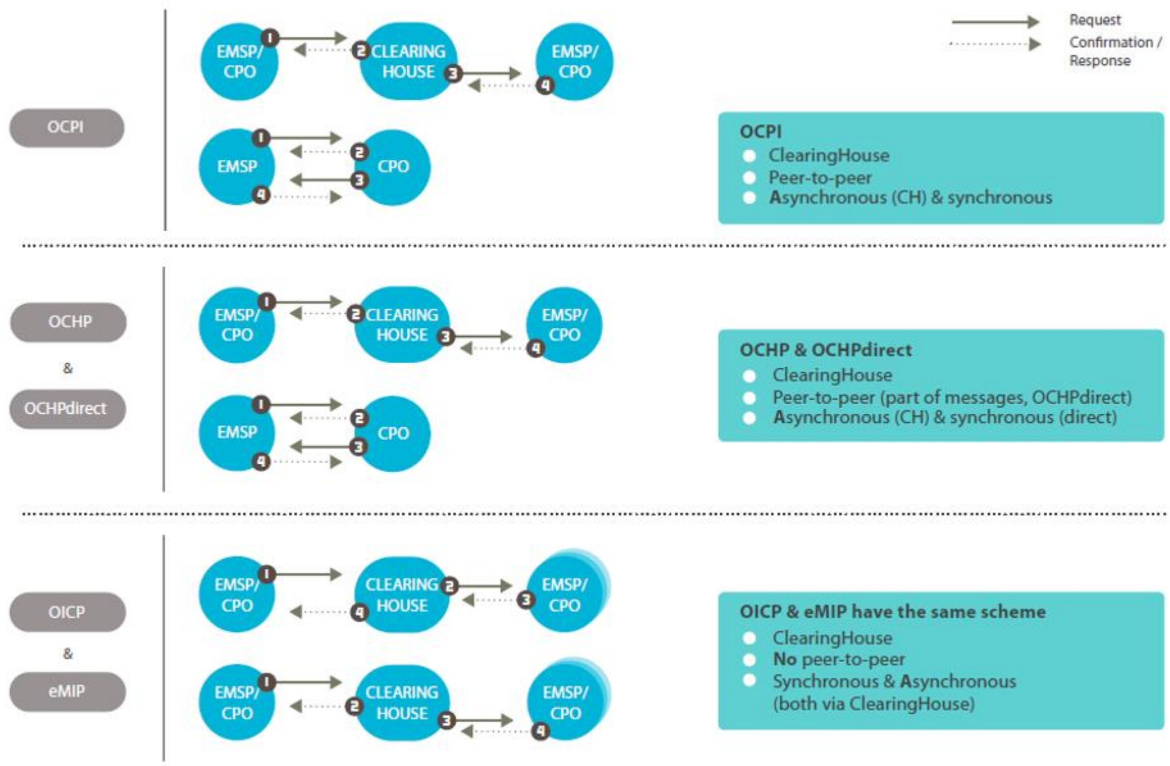

Figure 4: Comparison of EV roaming protocols (updated version of picture from [1])

Please refer to the complete report for more details on this comparison.

In short, the public EV charging scenario is as follows: the EV user swipes his / her charging card at a charging station. The authorization request that is received by the Charging Station Operator is validated at all EMSP's, either in real time or via an offline list of valid id's. When the EMSP has approved the request, the charging session starts. During charging, the charging station measures the amount of energy that is transferred, parking time etc. At the end of the charging session, this information is exchanged with the EMSP again, including the optional fee that the operator requires for using its charging station. In that case, the EMSP has to pay the fee to the Charging Station Operator and passes these costs on to its customer (either directly or, for example, via a monthly subscription fee).

An "add-on" to this public EV charging scenario can be that charging at a specific charging station is planned in advance. To be sure that the charging station is available and is not occupied by someone else, reservation functionality is sometimes available. This means that someone with a different card than yours will not be able to charge at a charging station. To enable this, information about charging stations has to be available as well: if websites or apps offer reservation functionality, you also have to know some information in advance such as the location of charging stations, what types of connectors does the station have, any specific directions where the charging station can be found, any facilities (e.g. restaurant) at the location etc. Again: this information is only known to the operator of a charging station, so to have 1 overview of all charging stations in an app, information is to be exchanged via standard protocols. Currently, this kind of information can be exchanged by the roaming protocols / platforms described above. Please note that even though reserving a charging station sounds as a very obvious functionality, it is not a widely used functionality yet.

4. Smart Charging

Now that some different ways of charging an EV are discussed, the next topic is to charge in a "smart" way. This is called smart charging or "controlled" charging. The definition of smart charging according to CEN-CENELEC-ETSI [3] and Eurelectric [2] is when charging an EV can be externally controlled (i.e. "*altered by external events*"), "*allowing for adaptive charging habits, providing the EV with the ability to integrate into the whole power system in a grid- and user-friendly way. Smart charging must facilitate the security (reliability) of supply while meeting the mobility constraints and requirements of the user.*"

Before going into the details of the protocols, lets first have a look at the reason why smart charging is done and why it is relevant. In the Eurelectric report from 2015 [2], three stakeholders for smart charging are identified: the customer, the power system and society (sustainability). Of course, the EV user ("customer") is an important stakeholder, since his / her charging sessions are being "controlled". Influencing this stakeholder can be done, for example, by giving price incentives.

In the development to a more sustainable energy network, distributed energy resources (DER) like solar and wind are used more and more. If we do not take action, this will, combined with more and more EV's, lead to an electricity network with a lot of peaks, both positive and negative. This in turn will lead to extending / enlarging the electricity network only for peak moments. To prevent this from happening, the demand for energy has to be aligned with the offer of energy. Where the offer of energy from solar and wind is not controllable, the demand for energy for charging EVs can be controlled (to some extent). This makes the power system one of the stakeholders for smart charging. To align the demand with the offer of energy, the energy network has to become more "smart", this is also referred to as smart grids. From an EV charging perspective, this could be the addition of smart ICT to insert some intelligence into the electricity network, to make optimal use of the flexibility that is available on the demand side. On average, EVs are only used for less than an hour per day, so charging can take place during the other 23 hours. This leaves a lot of room for flexible charging behaviour, to charge EVs at times during the day when the electricity network is not "busy" and charging will not lead to overloading the network.

To create a balance between these stakeholders, standards are necessary to exchange information about their status, wishes and limitations. The figure below adds the Distribution System Operator (DSO) to the picture, as one of the stakeholders representing the power system.

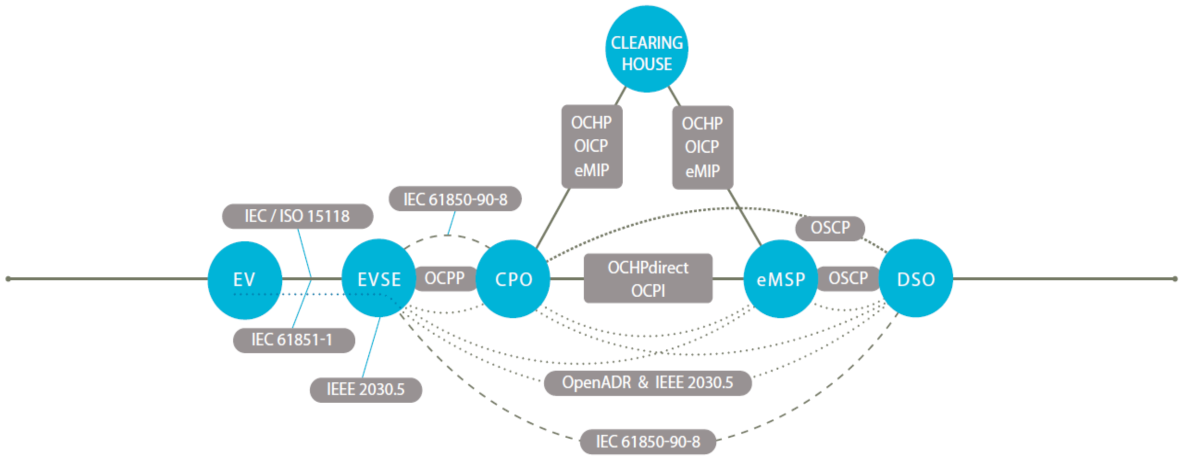

Figure 5: Smart Charging based on input of the DSO

A number of protocols for smart charging already exist, but no de facto standards are available yet. Some protocols that are currently in use for smart charging, are OpenADR, which is a very generic standard aimed at demand-response, OSCP, which is primarily aimed at network availability forecasts and the IEEE 2030.5 standard, primarily aimed at in house smart grid solutions.

Open issues concerning Smart Charging are, for example, the question which party collects all information to charge in the most optimal way. This influences the necessary information flows.

Currently, smart charging is not yet common practice and protocols only have limited support for it. Furthermore, only a few implementations exist where the state of charge of the EV ("how full is its battery") and time of departure ("when should charging be finished") are used as input from the EV or the EV user. These are important variables when creating an optimal charging "schedule" for a smart charging session and can improve the result for all stakeholders.

Another step that is still to be taken, is to add renewable energy aspects to smart charging. These are not yet taken into account in protocols. When looking at the energy transition, it is expected that these aspects will have to be added, for example when more DER are in the electricity network, the weather should be taken into account when calculating energy forecasts, but this information might also be relevant for EV users (e.g. "I only want to charge on solar, not on "grey" energy"). The urgency of this is expected to be partially determined by business models in the EV market and partially by the growth of the amount of energy from distributed energy resources.

5. Overview of protocols and market roles

The different forms of charging as discussed shortly in this report, lead to the overview of the EV landscape below. It looks a bit more complex than the previously presented smart charging figure, since some protocols could be used between multiple roles. For simplicity, this was left out of the previous discussion.

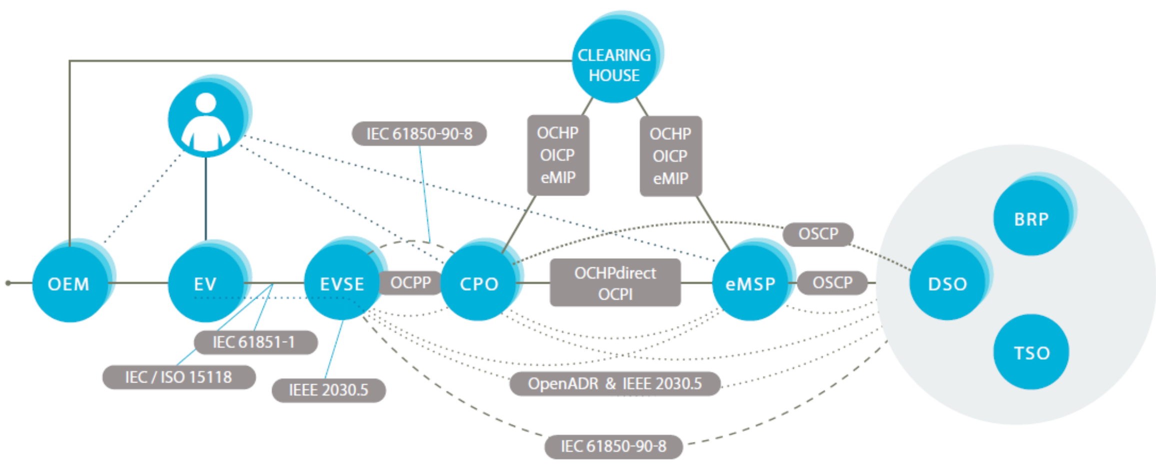

Figure 6: EV landscape including applicable protocols

Another simplification that was used when discussing Smart Charging, was the representation of the power system by the DSO. This is one of the stakeholders of the power system, since it has to prevent local congestion, that might arise due to EV charging. However, other roles are also involved like the Transmission System Operator (TSO), which is responsible for the wide area / nationwide network stability (frequency) and the Balance Responsible Party (BRP) for predicting and trading in energy for net stability and its own portfolio optimization. The different roles (within the power system) might have contradicting needs and wishes. This has to be explored more deeply in the next phase.

6. Protocol comparison

Many of the protocols that are discussed in this report are compared in the EV related protocol study by ElaadNL [1]. The protocols are compared based on functionality supported by the different protocols as shown in Figure 7.

PROTOCOL	OSCP	OpenADR	OCPI v0.4	IEEE 2030.5	OCPP	61850-90-8	OCHP	OCPI 2.1	OICP	eMIP	IEC 61851	ISO 15118
	SMART CHARGING				CS <> CP		ROAMING				EV <> CP	
Authorize charging session			•		•		•	•	•	•		•
Billing					•		•	•	•	•		
EV Charging											•	•
Handle registration		•		•				•				
Manage grid	•	•		•	•	•						
Operate Charge Point					•	•						
Provide charge point information			•				•	•	•	•		
Reservation			•		•		•	•	•			•
Roaming			•				•	•	•	•		
Smart Charging	•	•	•	•	•	•	•			•	•	•

Figure 7: Comparison of EV related protocols based on functionality

Furthermore, the protocols are also compared based on the following four aspects:

- Market adoption, based on, among others, the current number of users / companies / countries that use the protocol.
- Maturity, based on: number of releases, time in use, market adoption, certification possibility (at an official test laboratory), availability of a testing tool (dedicated / specific), availability / detail of a (test) specification and the possibility to implement only basic / relevant parts
- Interoperability, both technical interoperability (i.e. syntax and semantics) as well as interoperability on the level of expected / desired behaviour.
- Openness of the protocols: whether the it has been developed by an accredited standards organization, whether it is subject to intellectual property, licensing and/or royalties or other implementation/usage restrictions and whether it is publicly accessible at no / minimal cost.

	Version	Maturity	Interoperability	Market Adoption	Openness	Testing tool (dedicated / specific)	Certification (official testlab)
SMART CHARGING							
OSCP	1.0	Low	High	Low	Medium	No	No
OpenADR 2.0	1.1	High	Medium / High	Medium / High	High	Yes	Yes
OCPI	v0.4	Very low	Very low	Low	Low	No	No
IEEE 2030.5	2.0	High	Medium / High	Low	High	Yes	Yes
CS – CP							
OCPP	1.6	High	High	High	High	Yes	No
IEC 61850(90-8)	-	Medium	Low	Low	High	Unknown	Yes
ROAMING							
OCHP	1.4	High	High	Medium / High	Medium	No	No
OCPI	2.1	Low	High	Low	High	No	No
OICP	2.1	High	High	High	Medium	No	No
eMIP	0.7.4	High	High	Medium	Low / Medium	No	No
EV – CP							
IEC 61851-1	-	High	High	High	High	Unknown	Yes
ISO / IEC 15118	-	Medium	High	Low	High	No	No

Figure 8: Comparison of protocols based on Maturity, Interoperability, Market Adoption and Openness

Please refer to the complete protocol comparison for more details. In the coming period ElaadNL will invest more time in studying the applicability of the different smart charging protocols like OSCP, OpenADR, OCPI, IEEE 2030.5 but also IEC 61850(90-8) which also is foreseen to have smart charging control functionalities.

7. Conclusion

This report has given an overview of some of the ICT aspects that are relevant for EV charging, primarily aimed at the communication between the different market roles. Standard protocols play an important role and can serve as building blocks for a still changing EV market. Although many open protocols are available, the EV market is not yet mature enough to enable (smart) charging in a flawless, user friendly way comparable to mobile phones. However, the market is evolving fast, large steps are expected in the coming years, with new EV models with larger (and relatively cheaper!) batteries.

8. References

No.	Title	Author	Year
1	EV Related Protocol Study	ElaadNL	2017
2	Smart charging: steering the charge, driving the change	Eurelectric	2015
3	Smart Grid Coordination Group - Sustainable Processes	CEN-CENELEC-ETSI	2012

EV RELATED PROTOCOLS
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