Hyper-**N**etwork for **e**lectro**Mo**bility

# NeMo D1.5 Second Updated report on latest technological and market developments in electromobility

| | |
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# List of abbreviations and acronyms

| Abbreviation | Meaning |
|---|---|
| B2B | Business to Business |
| BAEM | Business Alliance for Electromobility |
| BEV | Battery Electric Vehicle |
| B-OBC | Bidirectional On-Board Charger |
| CAFE | Corporate Average Fuel Economy |
| C-ITS | Cooperative Intelligent Transport Systems |
| CP | Charge Point |
| CPO | Charge Point Operator |
| DSO | Distribution System Operator |
| EAFO | European Alternative Fuel Observatory |
| eMIP | eMobility Protocol Inter-Operation |
| EMSP | Electromobility service Provider |
| EV | Electric Vehicle |
| EVSE | Electric Vehicle Supply Equipment |
| GDC | General Data Centre |
| ICE | Internal Combustion Engine |
| ICT | Information and Communication technologies |
| IoT | Internet of Things |
| IVR | Interactive Voice Response |
| LEZ | Low Emission Zone |

| Abbreviation | Meaning |
|---|---|
| NEV | New Energy Vehicles |
| OBD | On-Board Diagnostics |
| OCPI | Open Charge Point Interface |
| OCPP | Open Charge Point Protocol |
| OEM | Original Equipment Manufacturer, refers to the Vehicle Manufacturer |
| PHEV | Plug-in Hybrid Electric Vehicle |
| POD | Point Of Delivery |
| QC | Quick Charge |
| RMI | Repair and Maintenance Information |
| SoC | State of Charge |
| TCO | Total Cost of Ownership |
| TCU | TeleCommunication Unit |
| TSO | Transmission System Operator |
| VIN | Vehicle Identification Number |

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# Executive Summary

With the increase of the electric vehicles sales worldwide, the ecosystem stakeholders have to monitor the evolution of the market, anticipate the coming trends and evaluate the impact of this new mobility on our environment. This is the goal of this deliverable.

This document is the second update of the previous deliverable submitted in 2017, the D1.2 “Report on latest technological and market developments in electromobility”, and includes the latest figures available regarding EV sales and EVSEs installed. A first updated report to D1.2, the D1.4 “First updated report on the technological and market developments in electromobility” was submitted one year later in 2018 to report upon the updated developments for the year 2018.

The EV market follows an impressive progression and specifically from H2 2018, an inflexion point seems to appear. In H1 2019, the global BEV sales skyrocket with a growth of 74% in average with 800,000 EVs sold. Other factors, such as new car models expected to enter the market, the increase in their autonomy, battery cost evolution, urban restrictions, new $CO_2$ standards, and country announcements show that the EV market has just started.

In 2018, several new EV designs accept a charging power of 50kW and more. The landscape of EVSEs should change for a more balanced share between the low power (up to or equal to 22KW) and high power (>22kW) charging points. To support this evolution, the involved actors must develop and install the needed new charging infrastructure. In 2019, Europe counts almost 160,000 public charging infrastructures installed.

Based on this impressive growth, this document shows that the NeMo project makes lots of sense by facilitating the development of new services and gathering all the involved actors of the electromobility ecosystem. The facilitation to make business together and develop common standards and methodologies will support the large evolution of the market. The foundation of the Business Alliance for ElectroMobility, a not-for-profit association to exploit the results of the project and manage the Hyper-Network is necessary to allow further innovation and progress as fast as the electromobility market.

Additionally, the products, cars and charging stations, will evolve in parallel to the upcoming technologies. One can quote for instance the car connectivity, which permits the car manufacturers to propose new kinds of services to their customers. In order to keep a coherence within this market, standardization is deemed important. Moreover, the V2X technology is being developed, bringing new dimensions to the EV ecosystem. With lots of use cases, the development of this technology will allow reductions to the TCO of the car and will participate to the growth of the EV market. This document emphasizes the complexity of communication protocols and standards that must be tackled before a general adoption, and where NeMo greatly contributes.

# 1. Introduction

This Deliverable is the outcome of Task 1.2 of NeMo project which aims to continuously monitor the latest developments in the electric vehicles (EVs) market, trends and new technologies adoption, aiming to derive requirements and specifications for the NeMo project developments.

The European Union has issued the Alternative fuel Directive in September 2014 to push the roll out of charging infrastructure and ensure its interoperability and has requested Member States to provide accurate information about the current public charging infrastructure network. The European Union has also set up an Alternative Fuel Observatory to gather information regarding the roll out of the Directive.

Through this deliverable, the role of NeMo Hyper-Network and its developments is pointed out and the basis for the planning of its operation and further development after the project end is provided.

The methodology followed in this deliverable to capture the current status of the available charging infrastructure, since no official accurate repository exists, was based on stakeholders' interviews, including experts from:

- Vehicle manufacturers
- eRoaming platforms
- Major charge points operators
- E-mobility associations

In order to overview the global ecosystem of electromobility, this document is split into sections: the second chapter focuses on current and expected sales of EVs and on the Electric Vehicle Supply Equipment (EVSE) roll out. The third chapter investigates the vehicle technologies which permit the EVs to be part of the ecosystem, being adaptable and connected, as well as the EVSE features. The next chapters include a quick overview on grid intelligence and smart meters, and the deliverable concludes by reporting on EV standards and eRoaming platforms.

# 2. Market overview

## 2.1 BEV and Plug-in vehicles Market

### 2.1.1 Global Plug-in vehicles sales overview

Global plug-in vehicle deliveries reached 2.1 million units for 2018, 64 % higher than those for 2017. These include all BEV and PHEV passenger cars sales, light trucks in USA/Canada and light commercial vehicles in Europe and China, and EFTA countries, passenger cars and light commercial vehicles.

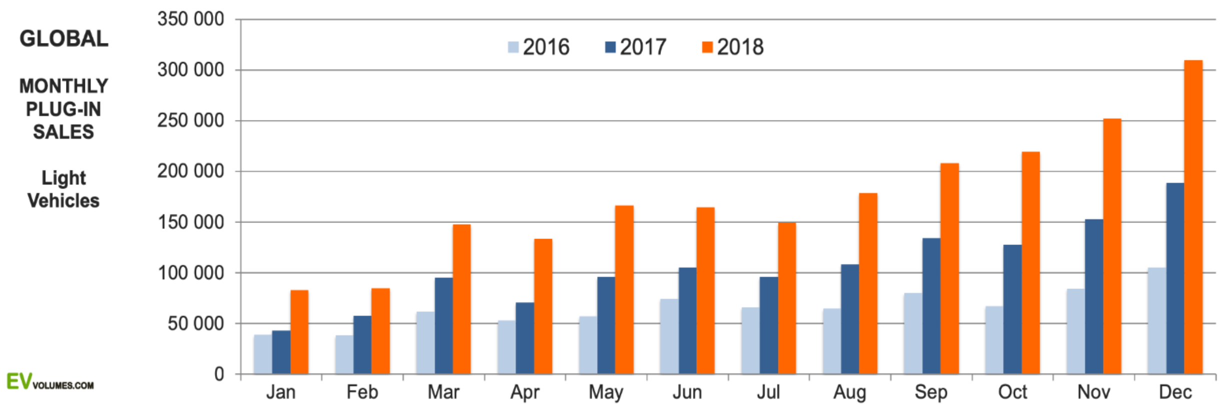



**Figure 1: Global EV sales from 2016 to 2018**

China has further advanced its position in the market as the growth motor of the EV industry. 520.000, or 78 % more NEVs were sold in 2018.

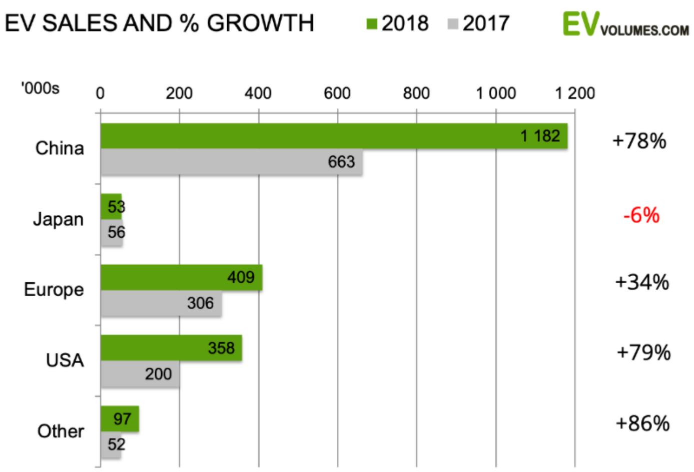



**Figure 2: EV sales and % growth**

In contrast to booming NEV sales, the overall car market saw a severe downturn in the second half of 2018. Y-o-y declines accelerated in Q4 and reached as much as -20 % for January 2019. This raises concerns as to whether the ICE crisis has started.

Japan losses are solely related to the Toyota Prius Plug-in, which has been in steep decline since the arrival of the 2nd generation Leaf in Q4 of 2017. Excluding the Prius, Japan's plug-in sales increased by 38 %, with Leaf and Outlander gaining the most. The USA result was all about the Tesla Model-3, which stood for 138k of the 158k increase last year. 80 % of the Model-3 volume was delivered during the 2nd half of 2018. Others include Canada (42 700 sales, +124 %), South Korea (31 700 sales, +134 %) and many fast growing, smaller EV markets around the world.

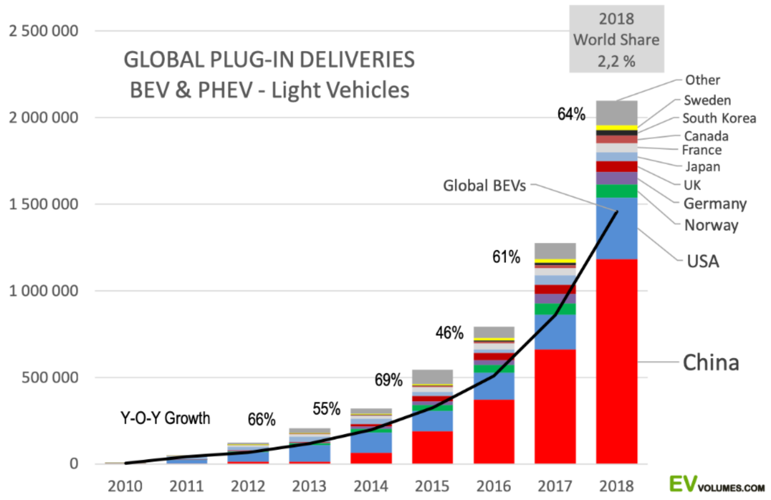



**Figure 3: Global Plug in deliveries BEV & PHEV**

This shows the top-10 markets for plug-in vehicles, underlining the significance of China in the development of the sector. 4.3 % NEV **share in the world's largest car market of 27.5 million light vehicles generated 1.2 million of volume.** Business is kept local: Few units (2,500 according to our records) were exported from China and NEV imports accounted for just 24,000 units. Imported plug-ins are burdened by the usual import duties and do not receive NEV subsidies. The only way to sell at equal terms is to produce EVs (incl. their batteries) in China and all OEMs are rushing to do so. In 2018, still only 58,000 plug-in vehicles were made and sold in China by western brands, half of this volume by BMW.

**The global share for the complete year is 2.2% which is over the expectation of 1.95%.**

## 2.1.2 Global BEV market

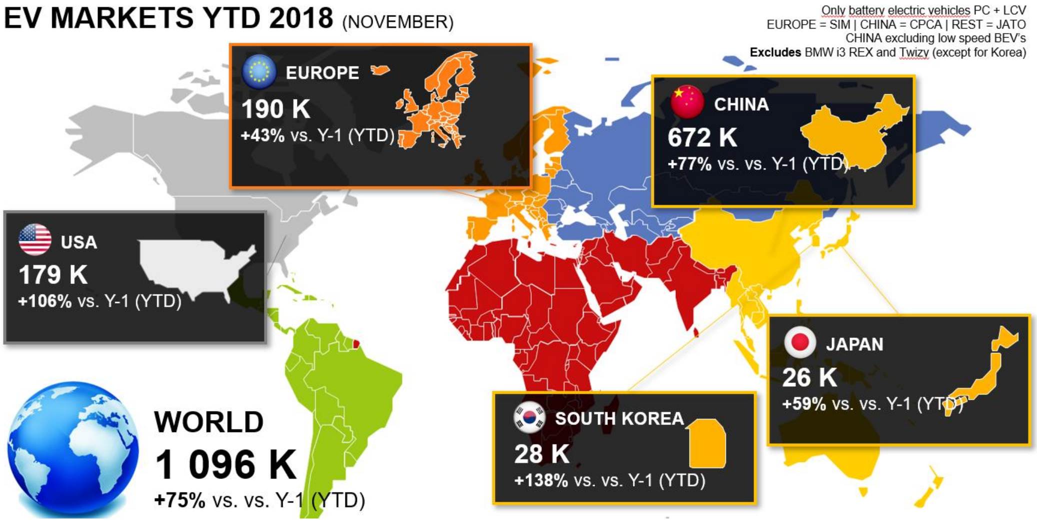



**Figure 4: Global EV sales in 2018**

If we have a look on the 1st semester of 2019, **the BEV sales skyrocket with a growth of 74% in average** despite a down of 24% in Japan.

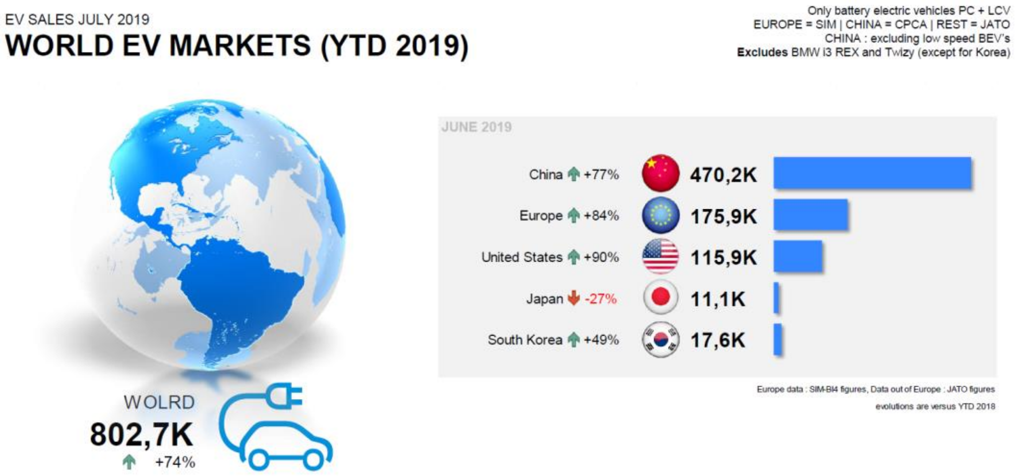



**Figure 5: World EV market H1 2019**

### 2.1.3 Plug-in vehicles European Market Overview

**Plug-in vehicle sales in Europe reached 259,000 units in the first half of 2019, 34 % higher than for 2018 H1.** These include all Battery Electric Vehicles (BEV) and Plug-in Hybrids (PHEV) in EU and EFTA countries, passenger cars and light commercial vehicles.

**The trend, so far, indicates an increase of 33 % for the entire 2019, to around 540,000 units.**

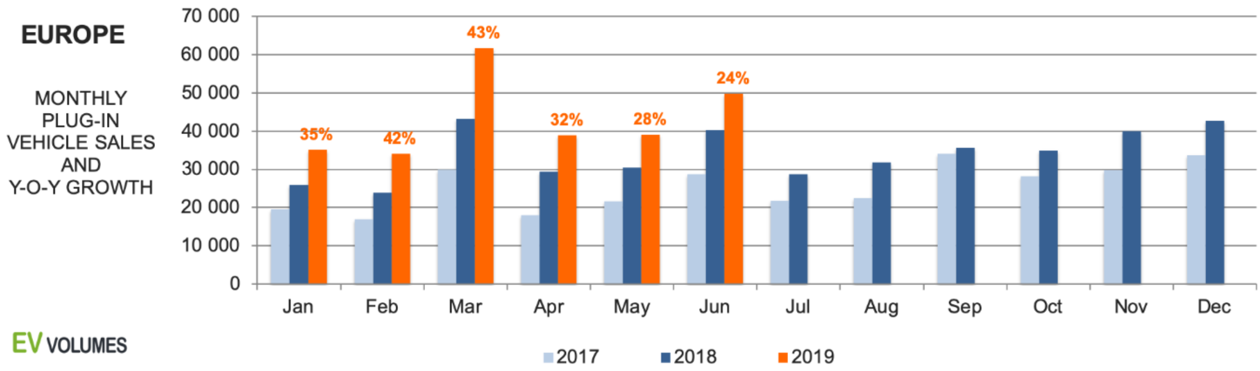



**Figure 6: Monthly plug in vehicle sales and % growth**

The OEM ranking changed a lot, too, with Tesla becoming #1 by 38,000 Model-3 deliveries in H1. The Model-3 was the best seller in the sector posting 12,500 units more than the previous #1, the Renault Zoe. BMW, Volkswagen and Daimler suffered from pending upgrades of popular PHEV models, with deliveries starting in Q3 and Q4 this year. Winners were Hyundai-Kia, Renault, Mitsubishi and Jaguar-Land Rover.

Germany and the Netherlands were the strongest growth contributors, in terms of volumes. Germany has become the largest market for plug-ins in Europe, displacing Norway to the #2 position for the first time.

Norway is still the word leader in EV uptake, with a share of 47 % in this year's light vehicle sales, up 10 %-points from 2018 H1.

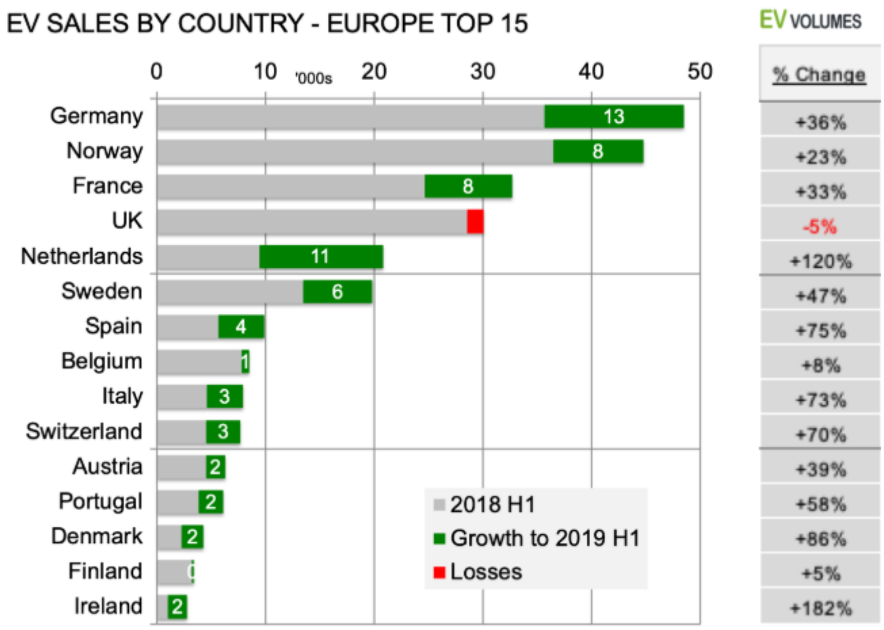



**Figure 7: Plug in Vehicle sales in Europe - Top 15**

**Among the top-15 markets, UK is the only one in reverse in year 2019. PHEVs lost their subsidies and BEV get 1000 GBP less than last year.** The UK plans to set the BIK (Benefit In Kind) for company car taxation to zero for BEVs, starting in April 2020. This will postpone many BEV purchases to next year in the UK. Meanwhile, neighbour Ireland has become the fastest growing plug-in market in Europe.

**In total, Europe plug-in vehicles sales grew by 34 %, compared to 2018-H1. Q1 increased 40%, Q2 by 28%.**

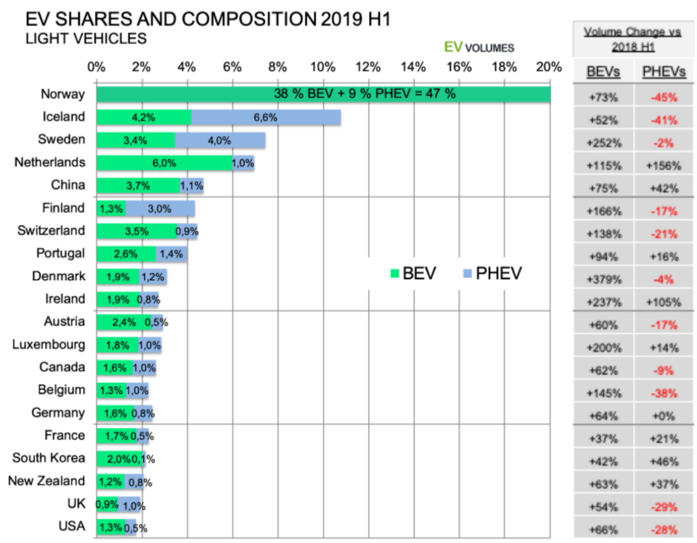



**Figure 8: EV shares and composition H1 2019**

Figure 8 in the previous page shows the share of Plug-in vehicles among all light vehicles sold in a country and the composition of BEVs and PHEVs in the overall share. The %-columns to the right show the gains and losses for BEVs and PHEVs compared to last year in terms of volume. Figure 9 below provides an overview of the number of PHEV and BEV in Europe. The curve looks like an exponential.

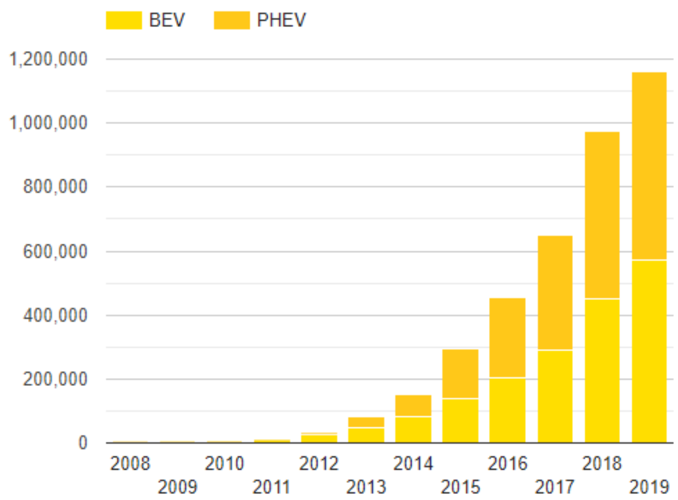



**Figure 9: Plug in vehicles in Europe**

### 2.1.4 BEV market in Europe (without considering PHEV)

If we only consider BEV market, Norway still keeps the first place with Germany and France following, while the Netherlands show the highest increase by 113,2% as shown in the table below.

| JULY 2019 (YTD) | | TOTAL EV MARKET | | % EV vs. T.I.V. | |
|---|---|---|---|---|---|
| | | YTD 2019 | Δ vs. Y-1 | YTD 2019 | 2018 |
| 1 | Norvege | 40 444 | +74,1% | 36,6% | 25,6% |
| 2 | Allemagne | 38 820 | +77,3% | 1,6% | 1,0% |
| 3 | France | 29 134 | +42,4% | 1,8% | 1,5% |
| 4 | Pays Bas | 20 088 | +113,2% | 6,5% | 4,8% |
| 5 | Royaume Uni | 15 720 | +77,7% | 1,0% | 0,6% |

**Figure 10: Europe BEV top 5 market H1 2019**

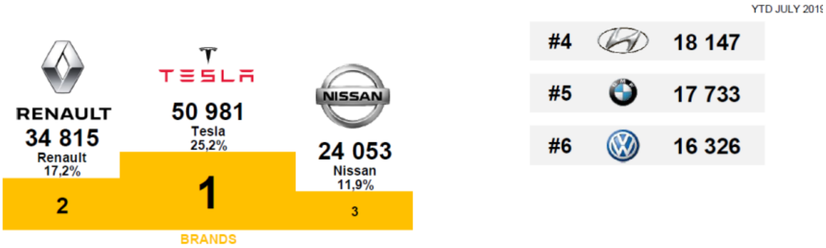



**Figure 11: Global BEV Sales ranking - H1 2019 (Without PHEV)**

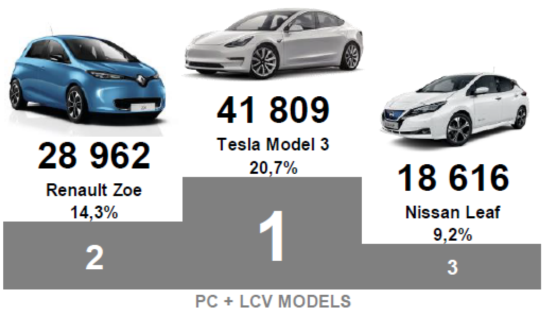



**Figure 12: Global BEV model sales H12019 (Without PHEV)**

As described before, Renault with ZOE lost its leading position regarding the vehicle sales. For sure, the Alliance stays on the first step.

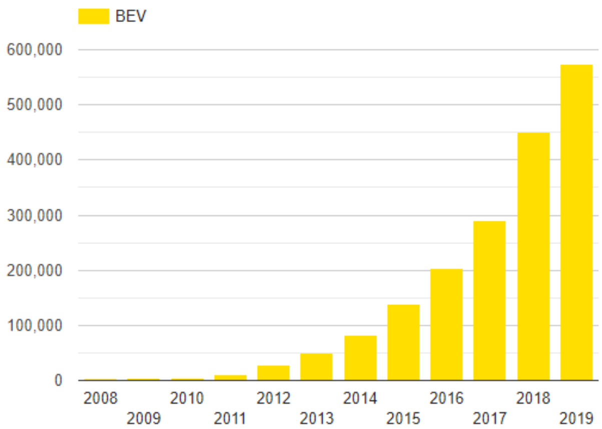



**Figure 13: BEV vehicles sales**

According to the website of EAFO, the number of BEVs reached 573,216 in Europe in 2019.

Renault as a pioneer on this market keeps its leading place, considering the full history of EVs sales, as depicted in the following figure.

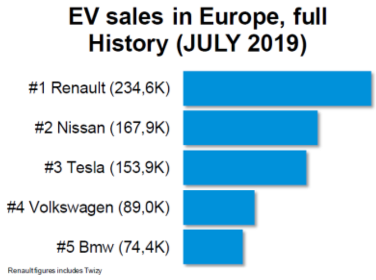



**Figure 14: EV sales full history in Europe**

Figure 15 presents an overview of the evolution of the EV market in Europe from 2015. We could see an increase of EV sales since H2 2018.

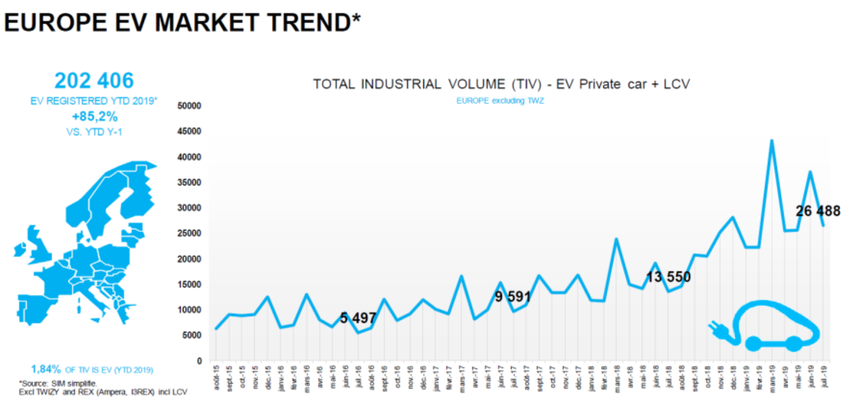



**Figure 15: Europe EV market trend from 2015**

To sum up, the EV market is increasing. Even if the percentage of EV penetration is still weak compared to ICE cars, we can notice that there are more and more EV sales. This trend is expected to stay dynamic thanks to some factors that are further explained in section 2.3, but principally due to the development of the infrastructure network. To support this argument, here are some quotes from some OEM's and consulting firms about the EV evolution:

- "We are targeting 2m to 3m EV sales per year by 2025": *Volkswagen AG*
- "BEV to reach TCO parity by 2021": *UBS estimates*
- "BEV market share of more than 20% by 2025": *UBS Evidence Lab*
- "Global EV sales from 2.5m in 2021 to 9.7m in 2025": *J.P Morgan*

## 2.2 Overview on EVSEs in Europe

The number of EVSEs still keeps increasing in 2019, reaching the number of 158,000 EVSE based on the EAFO figures.

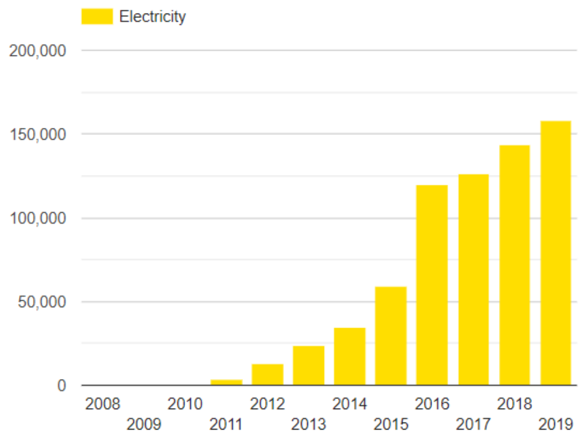
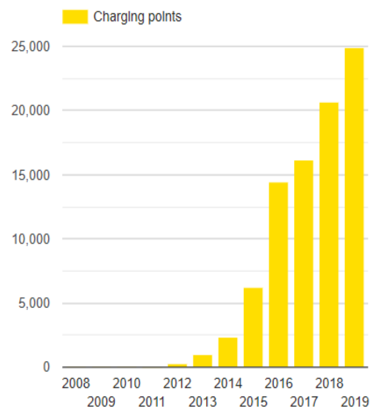



**Figure 16: Total number of EVSE in Europe**

In Figure 17 below, the details for each country and for different charging power levels are presented. The source of this information is an eRoaming platform and the figures are slightly different.

| Country | EVSE - Total | P <= 10 | 10 < P <= 30 | 30 < P <= 60 | P > 60 |
|---|---|---|---|---|---|
| AT | 3413 | 499 | 2355 | 491 | 68 |
| BE | 3880 | 266 | 3362 | 224 | 28 |
| CH | 2289 | 1045 | 1026 | 182 | 36 |
| CZ | 4 | 0 | 4 | 0 | 0 |
| DE | 15764 | 733 | 12287 | 2493 | 251 |
| DK | 3474 | 0 | 3055 | 397 | 22 |
| ES | 470 | 93 | 156 | 221 | 0 |
| FI | 727 | 231 | 410 | 83 | 3 |
| FR | 29098 | 7228 | 19483 | 1731 | 656 |
| GB | 10133 | 5179 | 1617 | 3306 | 31 |
| HU | 38 | 2 | 28 | 0 | 8 |
| IE | 812 | 0 | 612 | 192 | 8 |
| IT | 701 | 128 | 520 | 48 | 5 |
| LI | 9 | 5 | 4 | 0 | 0 |
| LU | 586 | 0 | 586 | 0 | 0 |
| LV | 216 | 0 | 0 | 216 | 0 |
| NL | 23242 | 1442 | 21373 | 397 | 30 |
| NO | 11554 | 6392 | 2101 | 2374 | 687 |
| PL | 51 | 0 | 35 | 16 | 0 |
| RO | 1 | 0 | 1 | 0 | 0 |
| SE | 8926 | 2434 | 5089 | 1097 | 306 |
| SI | 116 | 4 | 24 | 84 | 4 |
| SK | 11 | 0 | 3 | 8 | 0 |

**Figure 17: EVSEs in Europe - Details**



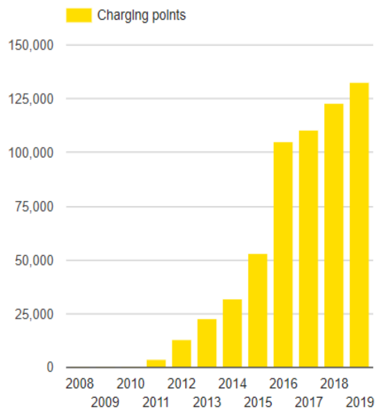




**Figure 18: Charging points in Europe <= 22KW and >22kW**

The figures above show the repartition of EVSEs in Europe based on information coming from eRoaming platforms and EAFO data. Note that the normal EVSE (between 7 and 22 kW) represent the majority (83%) of existing EVSE compared to fast charge ones (43 kW). But this number is decreasing (95% 1 year before) and should keep decreasing with the increasing sales of car accepting quicker charge (New Zoe, Tesla…).

Looking to the figures provided by eRoaming platforms, the EVSEs number reached around 115,000, meaning there are **4,9 BEVs for 1 EVSE.** However, the information from the EAFO (European Alternative Fuels Observatory) is a bit different: In 2017, Europe counts 158,000 EVSEs, so appointing **3,6 EVs for 1 public EVSE**.

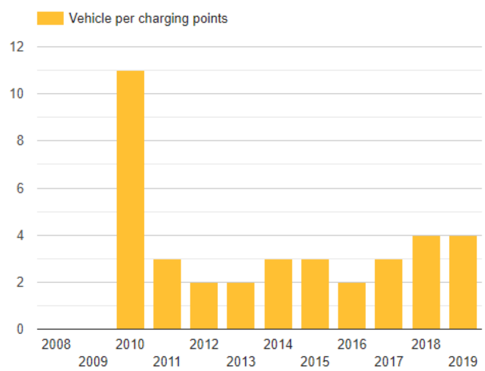



**Figure 19: BEV's per public charging point**

The difference between the EAFO and the eRoaming platform data is due to different factors:

- EAFO is counting the EVSE for all Europe (EU + EFTA + Turkey) while eRoaming platform doesn't include Iceland or Turkey.
- eRoaming data include only public EVSEs and mostly the connected ones, while EAFO data include EVSE installed in private parking areas of companies or parking operators which are not connected.

**In order to reach the ratio of 0.6 - which is considered as the optimal ratio - the number of EVSE should be equal to 343,000.**

To conclude, if the EV market remains this successful and continue its rise, the number of EVSEs must follow its development and keep an acceptable ratio[1] in order to allow each EV driver to charge easily, without being in trouble with unavailable EVSE due to not enough charging points. The technology relevant to EVSEs will be described later in this document.

## 2.3 Factors accelerating EV market

The following 4 factors are identified to have a positive impact on the EV sales and help to further boost the EV market.

### 2.3.1 Line Up

Within 2022, 30 new electric car models will enter the EV market, which equals an increase of 150% of the models available compared to 2017. As the offer of EV models will increase, the sales will go up too. It is actually predicted that in 10 years the 92 million dollars will be invested in EVs by global automakers, with leading German, Chinese and US manufacturers.

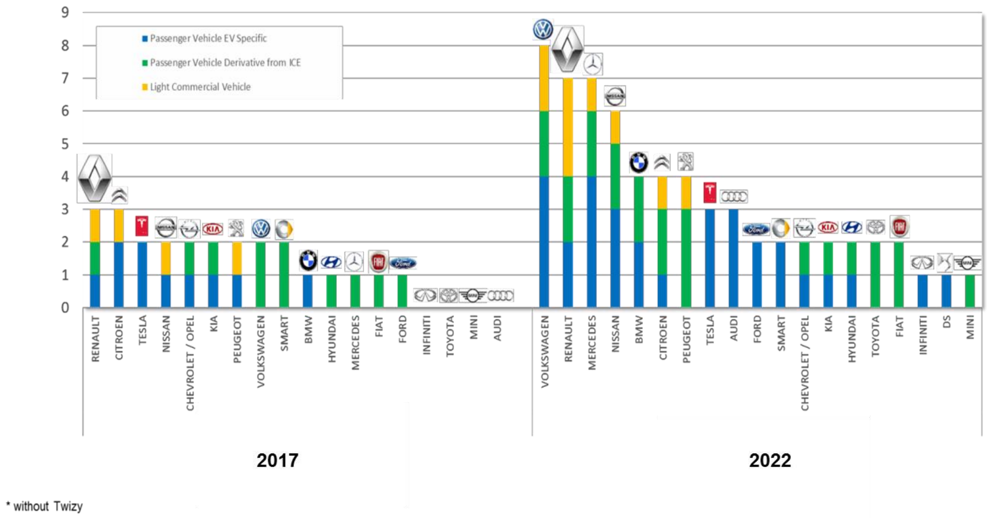



**Figure 20: EV models' availability in 2022**

Daimler told, it will spend at least $11.7 billion to introduce 10 pure electric and 40 hybrid models, and that it intends to electrify its full range of vehicles, from minicompact commuters to heavy-duty trucks.

[1] This acceptable ratio is defined by the European Commission as 1 charging point for 10 EVs.

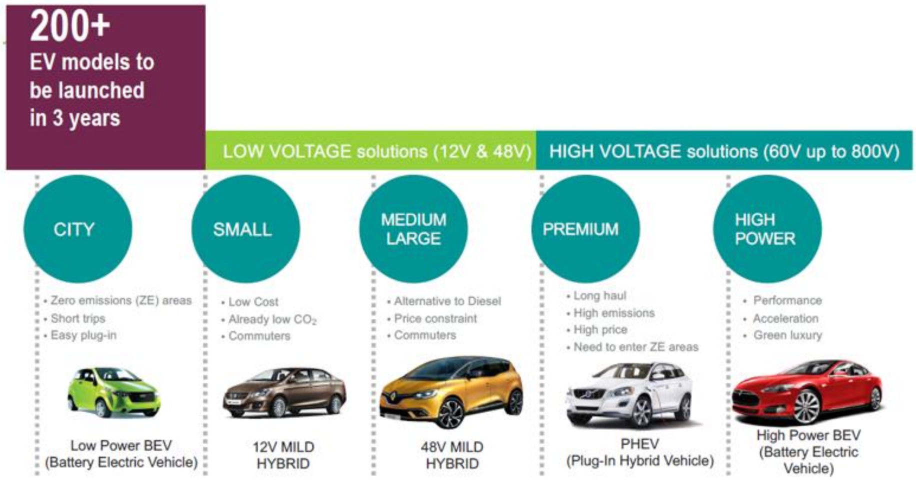



**Figure 21: Different types of electrified cars**

### 2.3.2 Autonomy

Currently, the maximum autonomy is offered by Tesla with 550km. However, in 2022, Audi and Renault have planned to go beyond this, with a battery offering 650km autonomy. Moreover, in 2016, the average autonomy available on the EV market was 270km. In 2022, the average autonomy planned will be 377km.

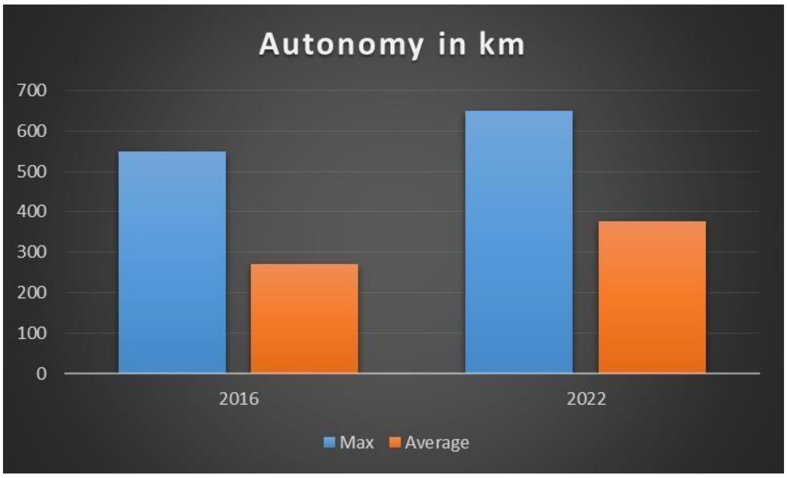



**Figure 22: EV current and planned autonomy**

As seen in the figure, the autonomy is going to increase, as well as the number of different models will increase. Each manufacturer is going to launch its own EV model because of the high demand. Therefore, the offer to the consumers will be larger and their needs in supply will be better satisfied.

Battery cost divided by 5 in 6 years...

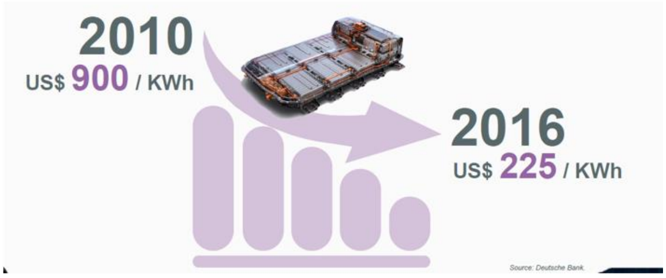



**Figure 23: Evolution of the battery cost from 2010 to 2016**

The cost of the battery and its energetic density will have a real impact on the development of EVs. Moreover, concerning Renault, the new Zoe with the LR (Long Range) battery competes a lot with Renault Clio. Indeed, their price positioning is the same, while the cost of electricity is much cheaper than the oil cost. Moreover, Zoe and Clio are used in the same way by the consumers, they are small vehicles destined for an urban environment and daily trips such as home-work trips. The cannibalization effect has already started between Zoe and Clio and will get wider.

### 2.3.3 Urban restrictions

In Europe, several cities have already taken measures restraining the usage for ICE cars and this trend will further rise in order to provide a better air quality to the urban population. The map below gives an overview of all cities which have enforced some restrictions, like LEZ (Low Emission Zone) or a fee to reach the city centre.

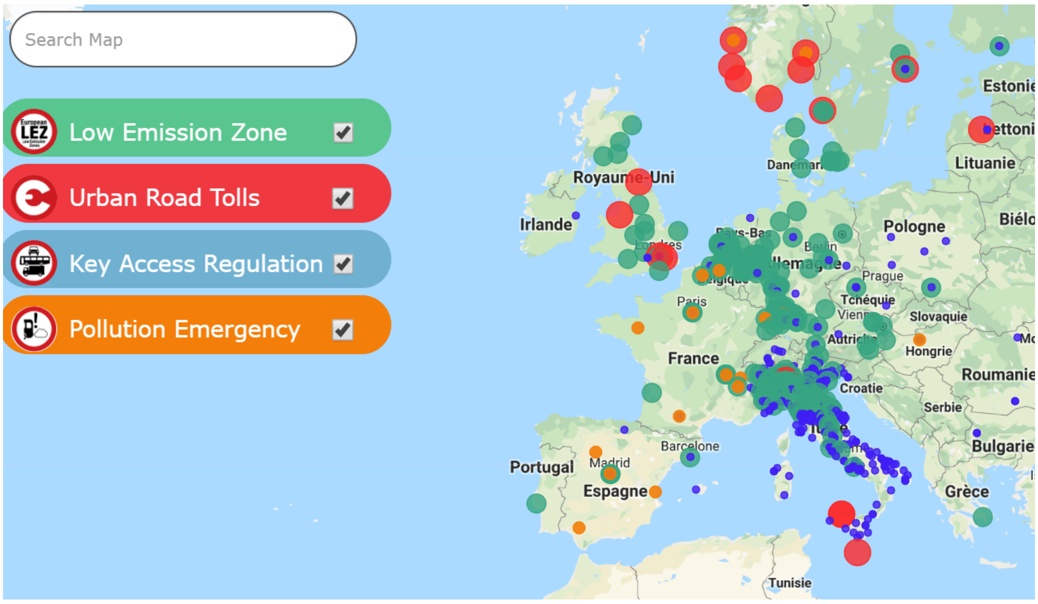



**Figure 24: European cities with restrictions for cars**

**An urban road toll** is where entry to an area is subject to payment. This is usually done to reduce traffic congestion or traffic jams in the city, but can also improve other issues, such as air quality and noise. In most cities the money raised from these schemes is usually spent improving transport in and around the city.

**Low Emission Zones (LEZs)** are areas where the most polluting vehicles are regulated. Usually this means that vehicles with higher emissions cannot enter the area. In some LEZs the more polluting vehicles have to pay more if they enter the low emission zone.

Some cities and towns have **regulations or restrictions for vehicles** going into any area of their vicinity or part of their area to improve issues such as air quality, congestion or how people experience the city. For example:

- charging for access to road space (urban road tolls);
- not allowing polluting vehicles to go into the city (low emission zones);
- or by other entry restrictions or access regulations.

These other types of regulation are called other entry restrictions, or key Access Regulation Schemes (key-ARS) and are one of the different types of urban access regulation schemes.

**Key Access Regulation Schemes (Key-ARS)** are schemes where access to the urban area is regulated by other methods than payment or emissions. It might be that a permit is required to drive into an area, such as:

- access is only allowed at certain times of the day
- only certain vehicles or trips are allowed
- increased restrictions for non-electric vehicles

In most cases, EVs are not included in such restrictive measures. This is another method supporting the switch from ICE to electric vehicles.

### 2.3.4 CO2 standard (CAFE) linked to global warming

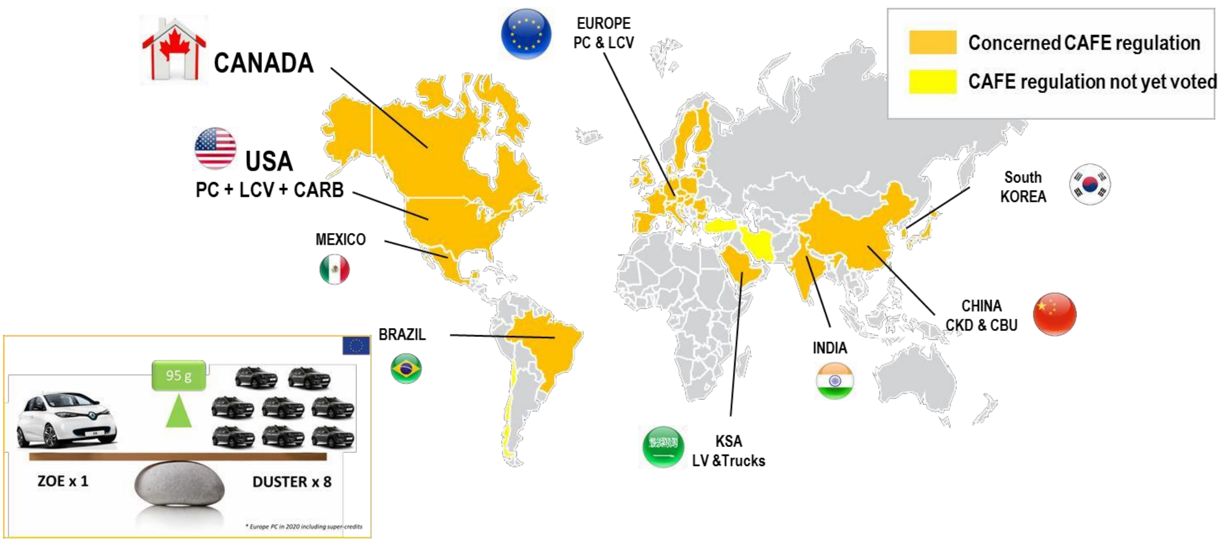



**Figure 25: CAFE standard in the world**

In order to tackle the global warming, strict measures have been taken in order to reduce CO2 emissions, in particularly for the automotive sector, which contributes to 14% of the total CO2 emissions worldwide. It is in this perspective that the European Parliament has voted in 2014 new standards for OEM's, like CAFE (Corporate Average Fuel Economy). The objective is to have an average of 95g $CO_2$/km for the global range of car manufacturers for 2020.

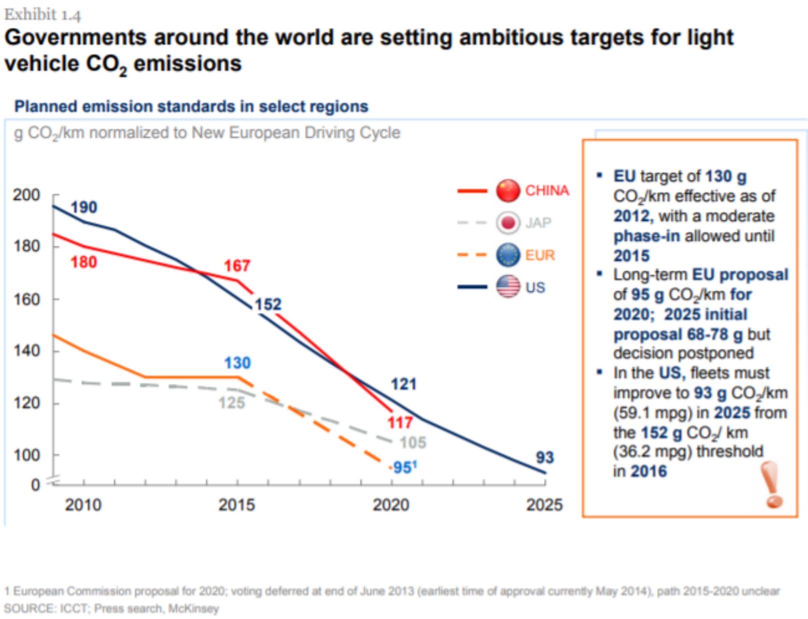



**Figure 26: CAFE regulation targets**

To reach this goal, the OEM's are obliged to develop low emission vehicles. Electric cars, being zero emission cars, are the best candidate to contribute to lowering the CO2 average. This will permit car manufacturers to still sell ICE cars which are above the limit of 95g CO2/km for several years before developing new technologies (very low consumption engines, hydrogen etc...).

Based on that, some countries have already made relevant announcements that will positively impact the EV market.


*ICE = Intern combustion engine

**Figure 27: Country announcements encouraging the EV market development**

## 2.4 Market and Competitors Analysis for the BAEM

It is important for NeMo in its continuation in the form of a Business Alliance for Electromobility (BAEM), to anticipate the market needs and develop quickly new services and technologies. The NeMo Hyper-Network allows for data and information exchange among all actors of electromobility, in a secured and common way, by providing a common open protocol as well as tools and processes to create composite innovative services, register them in a single marketplace and consume services of others by making business with any relevant party. Thus, it is essential to plan for setting up the Business Alliance for Electro-Mobility as a not-for-profit organization that will take over the management of the Hyper-Network but mainly help to develop the EV ecosystem as fast as the market.

A competitor analysis was necessary in order to identify the place of NeMo (or BAEM) in the market. The extended analysis is presented in D7.2 "Business model and regulatory gaps" for ensuring sustainability in the network, while here an overview is presented. In NeMo's case, as there is no competitor or pre-defined market that could be examined, the most reliable path was to examine NeMo as an ecosystem where wide range of electromobility services will be provided. Within this context, our analysis focused on identifying a set of similar solutions, which namely are:

I. **eRoaming platforms**: NeMo Hyper-Network is not an eRoaming platform. Instead it offers a Pan-European eRoaming framework which is supporting the inter-connection of the platforms and their exposure to one single marketplace, thus acts over these solutions as an interoperability enabler.

II. **Open Cloud Marketplace:** Currently there is no such marketplace provided by any actor in the electromobility ecosystem. There are marketplaces like Otonomo, Xevo, Caruso in the field of mobility, automotive and connected car but none is addressing the electromobility ecosystem.

III. **Electromobility ICT services**: There are existing solutions in electromobility ICT services. An analysis of similar services to the ones provided in NeMo was presented in D7.1. However, this fact does not create any obstacle for NeMo's exploitation plan, since the Hyper-Network is not a service provider, instead it is facilitating the overall connections among the various data sources and actors.

In conclusion, currently there are no market competitors to NeMo. It should be mentioned that the commercialization of NeMo will create a whole new market and all available currently existing solutions will be viewed as niche ones. In other words, it will act as enabler for new and existing products and services, empowering them with increased connectivity and interoperability and will also provide a set of horizontal ICT electromobility services and secured connections even for sharing in-vehicle data to service providers.

# 3. Picture of technologies

## 3.1 EV features

### 3.1.1 Connectivity

Today, navigation systems are turning into global HMI (Human Machine Interface), with navigation being just one feature of it. Indeed, navigation is standard on new vehicles, except on delivery cars where the take up rate is below 5%. Below the connectivity status per brand is presented:

| Brand | RENAULT | KIA | Volkswagen | NISSAN | BMW | Tesla Motors |
|---|---|---|---|---|---|---|
| **Connected application name** | ZE Services | UVO EV Services | Car-net | NissanConnect EV | BMW Remote / iRemote | Tesla Motors / Tesla Model S & Model X |
| **Availability** | Zoé, Kangoo and Fluence | Kia Soul EV, Kia Optima Hybrid and Kia Niro | BEV : e-up et e-Golf<br>PHEV : Golf GTE, New Passat GTE | LEAF, E-NV200 EVALIA , NISSAN E-NV200 FOURGON | BMW i3, BMW i8 | Model S, Model X, Model 3 |
| **Pricing** | 3 years free | Free | 3 years free | Free | 3 years free | Free |

**Figure 28: Connectivity status per vehicle brand**

### 3.1.2 In-vehicle smartphone integration

The use of smartphones and their integration in the vehicle is also offered by many vehicle manufacturers since many years. Starting first with audio integration for hands-free phone via Bluetooth and media accessing of music using USB connection, it has been recently extended to enable usage of the driver's smartphone as an app-platform for additional features. Such features include navigation, music streaming and other apps that the vehicle owner wishes to use while driving.

Currently there are several smartphone integration technologies which are available in today's vehicles:

1. Google Android Auto (only Android)
2. Apple Carplay (Only iOS devices from Apple)
3. Mirrorlink from Car-Connectivity-Consortium (Android and Windows devices)
4. MySpin (by Bosch for Android and iOS devices)
5. SmartDeviceLink (SDL) (by Ford and Toyota for Android and iOS devices)

In order to use smartphone navigation apps to find and navigate to charge points (CPs), the smartphone integration is a valuable feature as there are some apps which can be safely used while driving to avoid driver distraction. However, currently there is no in-vehicle data access possible using smartphone integration technology provided by vehicle manufacturers. This in-vehicle data access would allow the apps running on the smartphone to use data from the vehicle, such as state of charge (SoC) or remaining distance of the battery capacity while searching for CPs.

### 3.1.3 EU Platform C-ITS and Access to In-Vehicle Data

The need to access in-vehicle data has been recognised by the EU Platform C-ITS, moderated by DG MOVE, in its working group WG6 and was noted in February 2016 in its report of phase 1. From the independent services providers' perspective (for example: insurance companies, repair and maintenance companies and others) the access to in-vehicle data can be provided via:

1. In-Vehicle Interface connector (OBD+)
2. In-Vehicle Application Platform
3. Extended Vehicle (Connected Vehicle Backend Access)

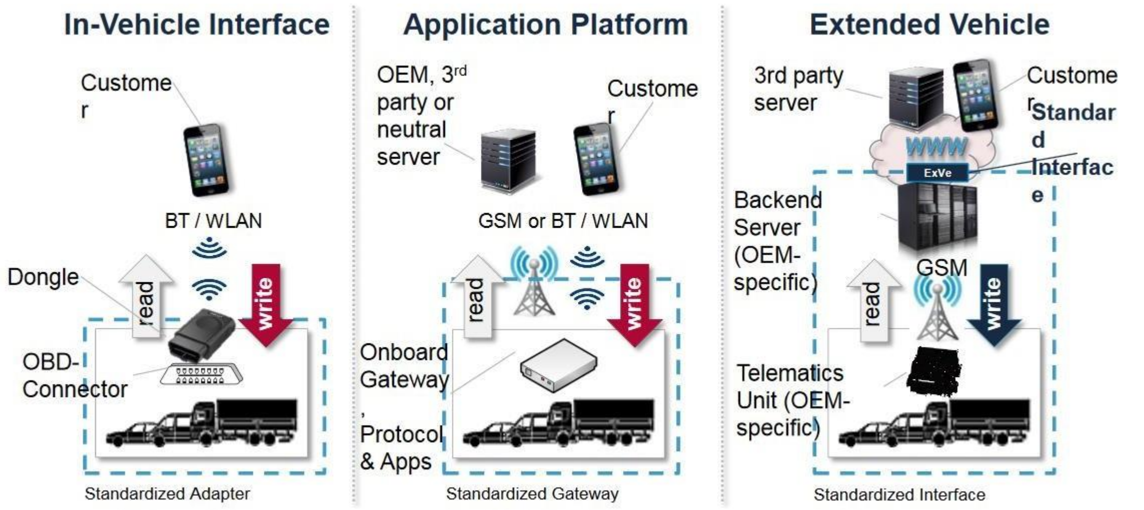



**Figure 29: Access to in-vehicle data (Source: The ExVe ISO 20078 Daimler AG Dr. Christian Scheiblich, Dr. Thomas Raith, November 2014)**

The following sections are describing the three mentioned possibilities in more details.

#### 3.1.3.1 In-Vehicle Interface

Access to a limited set of in-vehicle data can be performed using an OBD adapter connected to the OBD port of today's vehicles. This OBD port allows for example access to vehicle data such as vehicle distance, oil temperature and other data. The EU Platform C-ITS recommended to leverage this interface and to provide other vehicle data requested by independent service providers. A first set of vehicle data has been documented as part of the phase 1 report published in February 2016 which should be part of this new OBD+ standard extension.


**Figure 30: OBD Adaptor**

Using such an OBD adaptor, data from EVs, such as battery State of Charge, can be read by a smartphone. However, it is noticed that this market is currently fragmented and based on proprietary data, as there is no standard data set being defined across all the vehicle manufactures.

#### 3.1.3.2 In-Vehicle Application Platform

Some vehicle manufacturers provide today some way to load and install new "apps" in the in-vehicle application platform of their brands. As this is different for each vehicle manufacturer, each developer needs to develop, test and provide the "app" to the vehicle manufacturer for certification before it can be made available for download by the customer from the vehicle manufacturer "App-Store".

One example for such an in-vehicle application platform and app-store is the one from TOYOTA, that partnered with IBM to provide the T-Connect systems. See figure 31 for more details below.

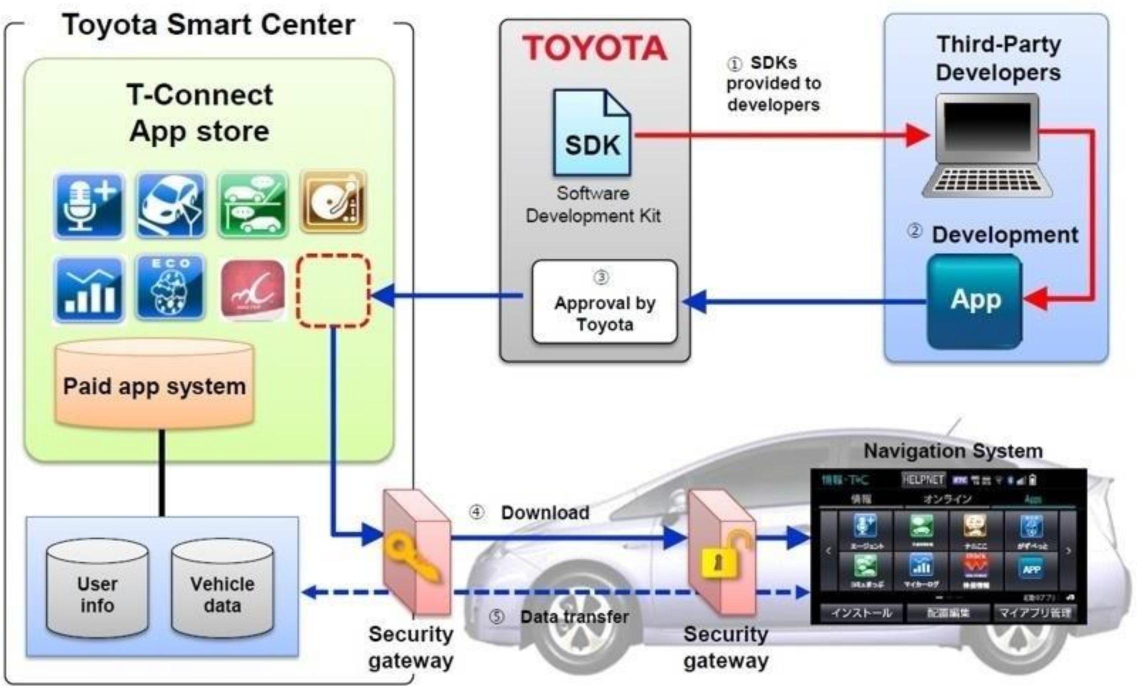



**Figure 31: TOYOTA Open Vehicle Architecture (Quoted from T-Connect Announcement material 2014)**

Most of the members of the EU C-ITS Platform have proposed a standard in-vehicle application platform which would allow 3rd party developers to develop apps for a broader customer base. This would enable innovative apps to be provided by 3rd party developers who would be able to directly access in-vehicle data, where there is a need for low latency of data.

#### 3.1.3.3 Extended Vehicle (Connected Vehicle Backend Connectivity)

The standardization of the Extended Vehicle has started in 2014 in the ISO committees. The main use case is related to Repair and Maintenance Information (RMI), however the IT interface should allow also other vehicle data to be accessed. The relevant ISO standards are ISO 20077 (overall process), 20078 (Web Service Interface) and 20050 (RMI use case). The Extended Vehicle interface is quite advanced from a standardization point of view, while the other means for accessing in-vehicle data, using the in-vehicle interface or application platform, are fragmented across all the vehicle manufactures.

### 3.1.4 IT Technology Trends

In a world where the Internet of Things (IoT) and cloud concepts are main stream concepts, the OEMs tend to keep their vehicle under the umbrella of an in-house OEM server and manage data exchange in a cautious way. The main reasons are:

- Privacy regulation making the VIN (Vehicle Identification Number) a private data on the one hand and a key entry point for OEMs on the other;

- Vehicle hardware and software are changing continuously and OEMs don't want to manage updates of software by every backend using car connectivity;
- Access to EVs is a key business enabler.

For this, NeMo has not considered and will not consider EVs as directly accessible by services and connected to IoT, but as always connected to the network through an OEM backend. Indeed, NeMo has developed an example service offering secure access to in-vehicle data following the Extended Vehicle concept.

## 3.2 EVSE features

Renault did an analysis based on 10.000 field tests with EVSE in October 2016, which shows that:

- 100% of connected charge points are equipped with 1 meter per EVSE;
- 90% are equipped with RFID readers;
- 20% have a screen (100% of Quick Charge).

Out of those charge points equipped with screen, slow charge points have basic small 4-line screens while QC (Quick Charge) charge points have bigger screens. Still, these screens aim to support the charging process (under authentication, charging, charge not allowed, etc.) and display the kWh. They are by no means a dynamic display allowing to offer more specific services. In other words, texts are pre-embedded in the hardware and cannot be transmitted via Open Charge Point Protocol (OCPP). Moreover, the number of languages supported is very limited.

Another outcome of the analysis is that less than 2% of the charge points are equipped with credit card device for ad hoc payment. Remote access is more and more spread but almost none exists in the majority of countries, except Germany which seems a bit ahead. The alternative charge point activation means are presented in the Annex.

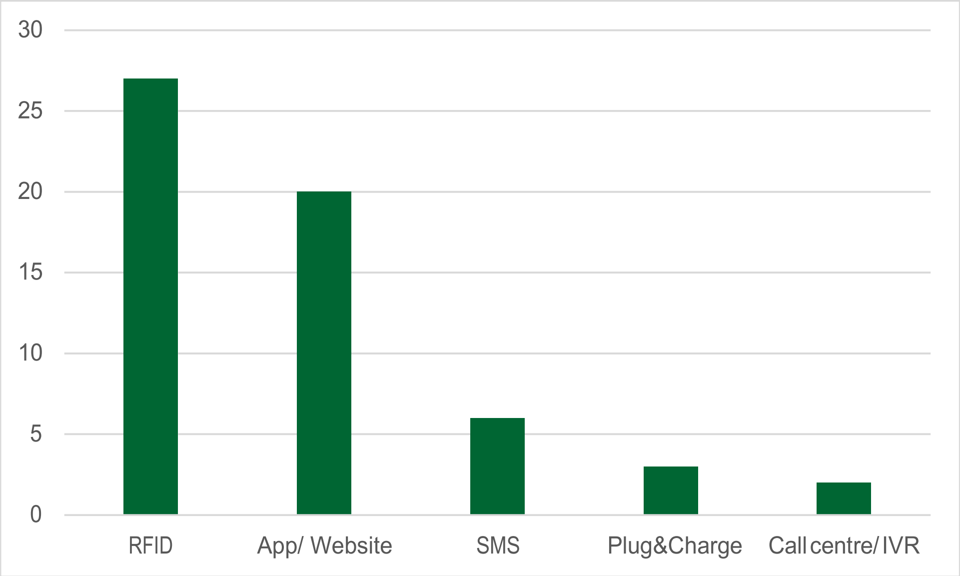



**Figure 32: Number of European Countries commonly using each Authentication Method**

The diversity in the data update can be also pointed out. Indeed, remote monitoring status is between 1 s and 15 min, depending on the operator and connectivity coverage.

Finally, even though a car presence sensor is not so costly, less than 1% of charge points are linked to such a sensor.

## 3.3 V2X technology

Considering the recent booming of Battery Electric Vehicle (BEV) market in Europe and around the world, and the global interest of public and policy makers for eco-friendly technologies, the storage and power capacity represented by the global fleet of BEV could play a significant role in the development of Smart Grids and therefore contribute into reducing electrical distribution network investments and improve its stability.

This is about a BEV equipped with an on-board reversible converter and therefore capable to supply or consume power to and from the electrical network, without the need of an off-board inverter, reducing significantly the cost, hence improving significantly the net benefit to the BEV driver. This is a game changer to reduce the Total Cost of Ownership (TCO) of BEVs and take advantage of the large amount of storage available in the global fleet of BEV.

V2X appears to be a very promising instrument that will align both objectives of electrical industry (keeping grids stable with investments at the right level) and automotive industry (reduce CO2 emissions and sell cars), if economically affordable.

### 3.3.1 System Design

#### 3.3.1.1 Function allocation

Based on previous work (2) in which requirements for generators were analysed in order to define an efficient system architecture, the function allocation concluded is presented here below:

| EV | EVSE / Installation |
|---|---|
| Convert power (bidirectional) using an on-board charger | Store all grid code parameters (local) |
| Ensure active islanding detection | Provide decoupling protection |
| | Measure V/f / Calculate reactive power setpoint |
| Enhanced immunity to voltage / frequency | |

**Figure 33: Function allocation**

Generators are not only delivering active power, they have to fulfil various requirements to help stabilizing the grid. These requirements are set by the grid operator and therefore depend on location. The main requirements include support to voltage (by adjusting the amount of reactive power to the local condition) and support to frequency when over- or under-frequency events occur. Also, generators must have enhanced immunity to disturbances in order to remain connected even in the case of short-circuits on the grid for example. Finally, the most important feature is the decoupling protection, i.e. the capability to detect a non-intentional islanding situation. Passive observation methods and active disturbance methods exist (3). In some areas, it might be forbidden to use an active method as these purposefully disturb the grid by injecting non-sinus current, justifying the introduction of the parameter “GridCodeIslandingDetectionMethod” in ISO 15118-2 ed2.

#### 3.3.1.2. EV

The EV will embed a B-OBC (Bidirectional On-Board Charger) that can work in four-quadrants, i.e., either pure resistive, or pure current source, or with the simulation of an additional reactive load (capacitive or inductive). As mentioned before, it will host also an active anti-islanding function. As this function consists of generating a disturbed sinewave, it can only be done by the power electronics, i.e. the B-OBC. This method has to pass a standardized test known as the resonant circuit. Furthermore, the safety aspects will be enhanced, particularly for the non-connected use cases (V2L) because the B-OBC is responsible for the quality of supply and for responding quickly to a short-circuit for example. As the power electronic is current-limited, it is not capable of providing high short-circuit current (contrary to the grid). The voltage will then drop and this situation will be detected by the charger controller which will then stop generation.

#### 3.3.1.3 EVSE and Installation

The EVSE will host the decoupling protection and the necessary protective devices. Its configuration will depend on the ability to work grid-connected, or islanded, or both. For example, in islanded mode, it will have to generate a new earthing system. The EVSE will also be responsible for storing the local grid code parameters and generating the active and reactive power setpoints requested to the EV, using local Voltage and Frequency measurements.

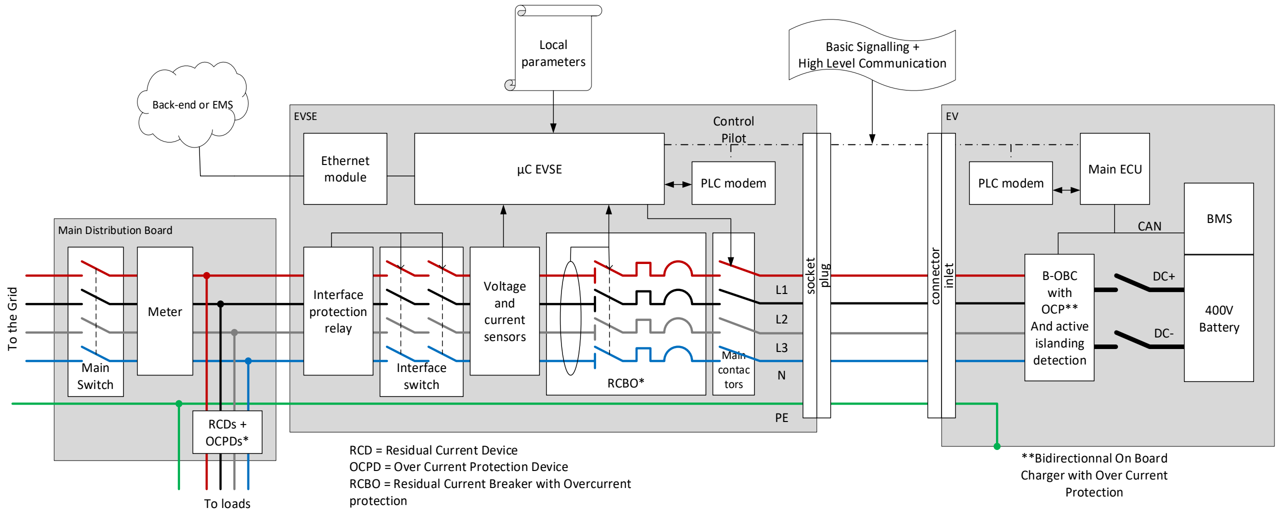



**Figure 34: System design example (Installation, EVSE, EV)**

### 3.3.1.4 Communication protocol

To operate bidirectional energy services, the EV and the EVSE need to exchange information using a suitable communication protocol. The ISO 15118 protocol offers a standardized communication channel based on TCP/IP. The second edition of this international standard brings new control modes and messages that allow bidirectional power transfer services while the first edition of ISO 15118 is limited to charging services. It is based on the following principle:

1. The EVSE communicates to the EV: Maximum power over Time and Energy price level over Time (the energy price levels represent the impact of power consumption on the network)
2. Based on this information, the EV calculates the optimized Charging Profile (Power over Time) respecting the Maximum power allowed and minimizing the impact on the network as much as possible while assuring the driver mobility need (desired level of charge by the time of next departure)
3. The EV then communicates this optimized Charging Profile to the EVSE before starting the energy transfer according to this profile.

To optimize the charging schedule, the EV will use the mobility need: Battery Level target at the next Time of Departure. The EV is therefore in charge of optimizing the Charging Profile while ensuring the mobility need of the driver.

To allow direct control of the EV charging / discharging power from an outside party, as described in (4), a new control mode has been added to the edition 2 of the standard. In this “Dynamic” control mode, the EV communicates its mobility need and the EVSE -or a secondary actor behind it- is in charge of controlling the power transfer. Therefore, the EVSE or a secondary actor controlling the EVSE, is responsible for ensuring the driver mobility need by reaching the desired battery level at the desired departure time.

### 3.3.2 V2X USE CASES

V2X services have been largely described in previous literature (5). To illustrate the full potential of the proposed system architecture, four use cases are described in detail covering a broad range of services: vehicle to grid, vehicle to load, and vehicle to home.

#### 3.3.2.1 Vehicle-to-Grid (V2G)

Use case: Using the EV to provide ancillary services to the electrical network.

Different services are employed by TSOs (Transmission System Operator) or even DSOs (Distribution System Operator) in order to keep the grid stable and operating: frequency reserves, voltage control, demand-response, congestion management, etc. While the need of some services can be forecasted days or hours ahead, others have to react automatically and within seconds. Technical solutions to respond to these services may differ depending on the reaction time required and the ability to predict their need.

#### 3.3.2.2 Vehicle-to-Load (V2L)

Use case: Using the EV to provide power to electrical appliances on a remote site.

In this use case, the remote site powered by the EV is not connected to the distribution network, the power is supplied by the EV only. Two technical solutions are possible:

- either to power a remote site or during a black-out: through an EVSE using ISO 15118 high level communication that would require an embedded battery to start the communication before the EV starts generating power
- or to power electrical appliances directly connected to the EV: using a cable equipped with AC domestic outlets without digital communication needed but only requiring a detection system at the EV side to recognize the special cable.

In both cases, the EV will act as the main voltage and frequency generator within the islanded installation. Therefore, when using an ISO 15118 communication, the EVSE must inform the EV that the installation is disconnected from the grid by offering the VoltageSource generator mode within the service parameter set along with the Schedule control mode. Then the EVSE will communicate to the EV the nominal frequency and nominal voltage of the islanded installation and the EV will automatically regulate these values according to the current consumption of connected appliances. This use case allows only discharge and therefore no tariff table is communicated by the EVSE, the EV is sending a Power profile corresponding to the maximum discharge power it can provide. During the control loop, the EV updates this limit and communicates its remaining energy available (EVMinimumEnergyRequest) before reaching EV minimum SOC.

The system being disconnected from the grid, it lacks also a proper way to address protection against electric shock, which is done generally by the coordination between earthing system and protective devices (or by reinforced insulation). For such small systems, earthing system can be chosen between TN and IT. In TN, there will be a link between one of the power lines and the earth, making it a neutral, whereas in IT, the power lines will be kept floating from the earth. In TN, a default (line to casing for example) will become a short-circuit. The system has to detect it and cut the power (as the short-circuit current will be limited by the power electronic). In IT, default will be seen by an insulation monitoring device.

#### 3.3.2.3 Vehicle-to-Home (V2H)

<u>Use case: the EV is providing storage to a house equipped with solar panel production in order to maximize self-consumption or reduce peak power usage form the grid.</u>

In this use case, the home is connected to the utility distribution network. Due to hard predictable consumption of home appliances and intermittent production of PV, HEMS (Home Energy Management System) might control the charge and discharge of the EV by using the Dynamic control mode.

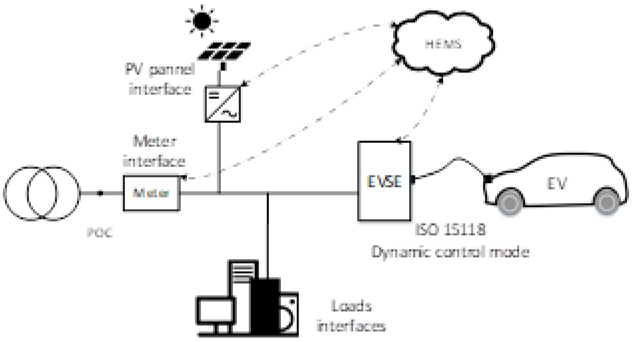



**Figure 35: HEMS dynamically controlling the energy transfer in a house equipped with a solar panel**

Thanks to ISO 15118 high level communication, HEMS is aware of the EV energy requests corresponding to the user mobility need. Those energy requests are instantaneous values calculated, updated and sent by the EV during the entire bidirectional energy transfer loop. They reflect the amount of energy necessary to reach the different State Of Charge levels (minimum SOC and target SOC).

# 4. Grid intelligence: roll out of smart meters

## 4.1 Master Slave

With increasing number of charge points, a master slave structure appears. In such cases, the Master Unit is managing the global connection to the backend and sometimes the global intelligence and protections (Cf Allego's charging plaza). The Master unit is also managing the load by splitting the available power among sockets.

## 4.2 Smart metering

A smart meter is the official meter placed by the Distribution System Operator (DSO). Although every charge point has a meter inside, it is barely a Point of Delivery (POD). Moreover, the meter accuracy and position are not standardized (whether it is considering pole efficiency or not, etc.) and there is no regulation on this.

Three countries are currently considering a charge point as asset of the grid (POD), Luxembourg, Slovenia and Italy. Spain has a similar approach, Gestor de red de carga should have a dedicated POD for the poles.

This leads to different pricing models per country. In countries where charge points are assets, the price is based on kWh consumed. In the other countries submetering is not allowed, so the price is not based on kWh consumed but can only be based on time. Paying with time has disadvantages for both the customer with slow charging vehicles, who will pay much more for the same amount of energy, and for the charge point operator, since slow charging cars need to stay too long connected to quick chargers.

Finally, it needs to be kept in mind that the installation cost for a quick charger is between 40k€ and 80k€ (plus in some countries an annual capacity subscription between 2 and 4k€/y). This means that the charging price on QC cannot be equal to home electricity price.

# 5. Overview of EV standards

## 5.1 Expansion of existing and adoption of new eRoaming platforms

The eRoaming possibility per European country at the end of October 2016 is shown in the figure below.

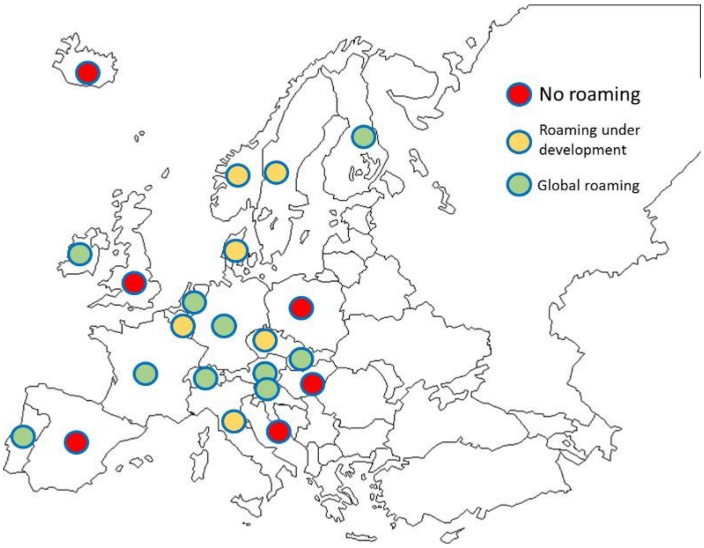



**Figure 36: eRoaming in European countries**

Only few countries have not initiated a “roaming step” yet, among them Spain and UK are the most problematic since the EV market is quite developed. An overview of the Roaming connectivity of charge point operators, as forecasted in early 2017 per country is given in figure 37 below.

| IT | IE | UK | DE | AT | CH | NL | BE | FR | NO | SE | FI | ES | LU | CZ | Baltic | SK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80% | 10% | 5% | 95% | 95% | 80% | 95% | 80% | 60% | 85% | 60% | 95% | 20% | 80% | 10% | 40% | 60% |

**Figure 37: Percentage of eRoaming connected charging points**

It must be noted that public authorities investing in infrastructure are the most reluctant to connect due to several reasons, one of them being that they don’t want to enter into B2B relationships.

There are two possibilities for payment, either direct payment (without a service contract) and subscription-based billing. One issue is that there are different eRoaming standards in Europe for subscription-based billing and communication between charge point operators and service providers in Europe needs to be harmonised.

A unique ID generation Association for EVSE-ID and EMSP-ID across Europe is required to support “eRoaming” across Europe, to identify EVSE connected either via eRoaming “Hub” providers or involved in bilateral contracts between service providers and charge points operators without eRoaming providers.

## 5.2 EV standards

The different communication protocols between electromobility actors are presented below.

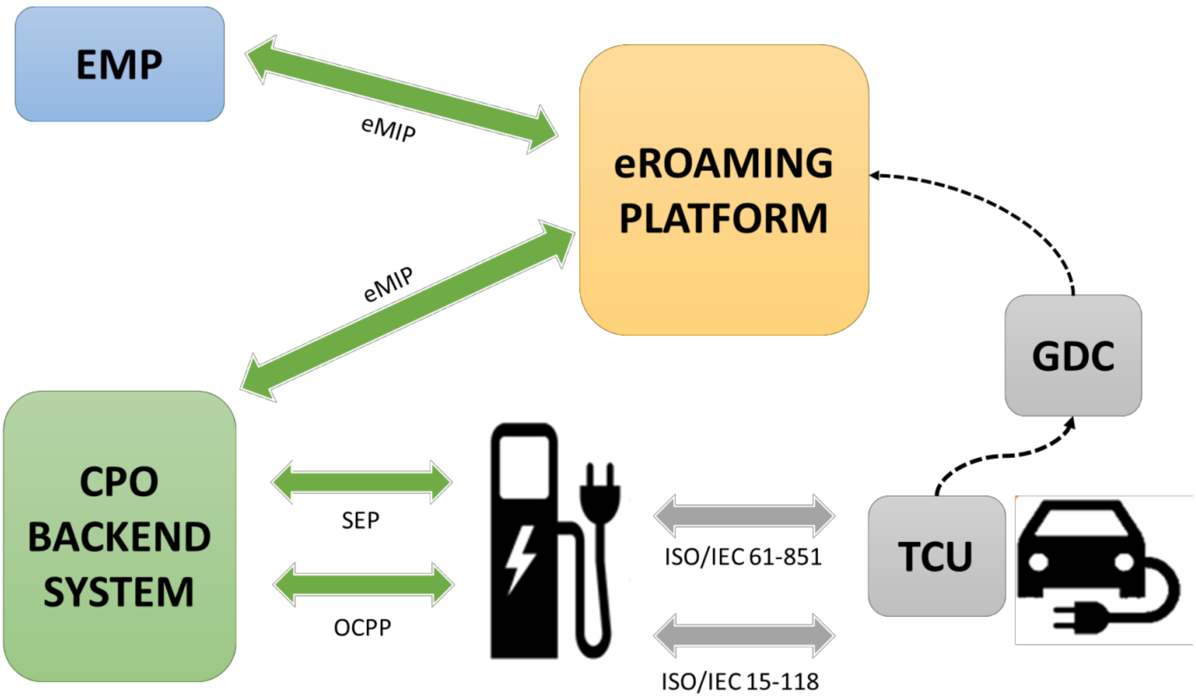



**Figure 38: Communication protocols between electromobility actors**

Since the first version of this document in 2017 the standard and protocols for EVSE has progressed. Lately, the Open Charge Point Interface (OCPI) protocol has found great support in its development by several stakeholders and projects, and seems to be increasingly used among electromobility actors. This protocol allows for a scalable, automated roaming setup between Charge Point Operators, managing the charge stations, and e-Mobility Service Providers, who have as customers the EV drivers. It supports authorisation, charge point information exchange (including transaction events), charge detail record exchange and finally, the exchange of smart-charging commands between parties.

It offers market participants in EV a scalable solution for (international) roaming between networks, avoiding the costs and innovation-limiting complexities involved with today's non-automated solutions or with central roaming hubs.

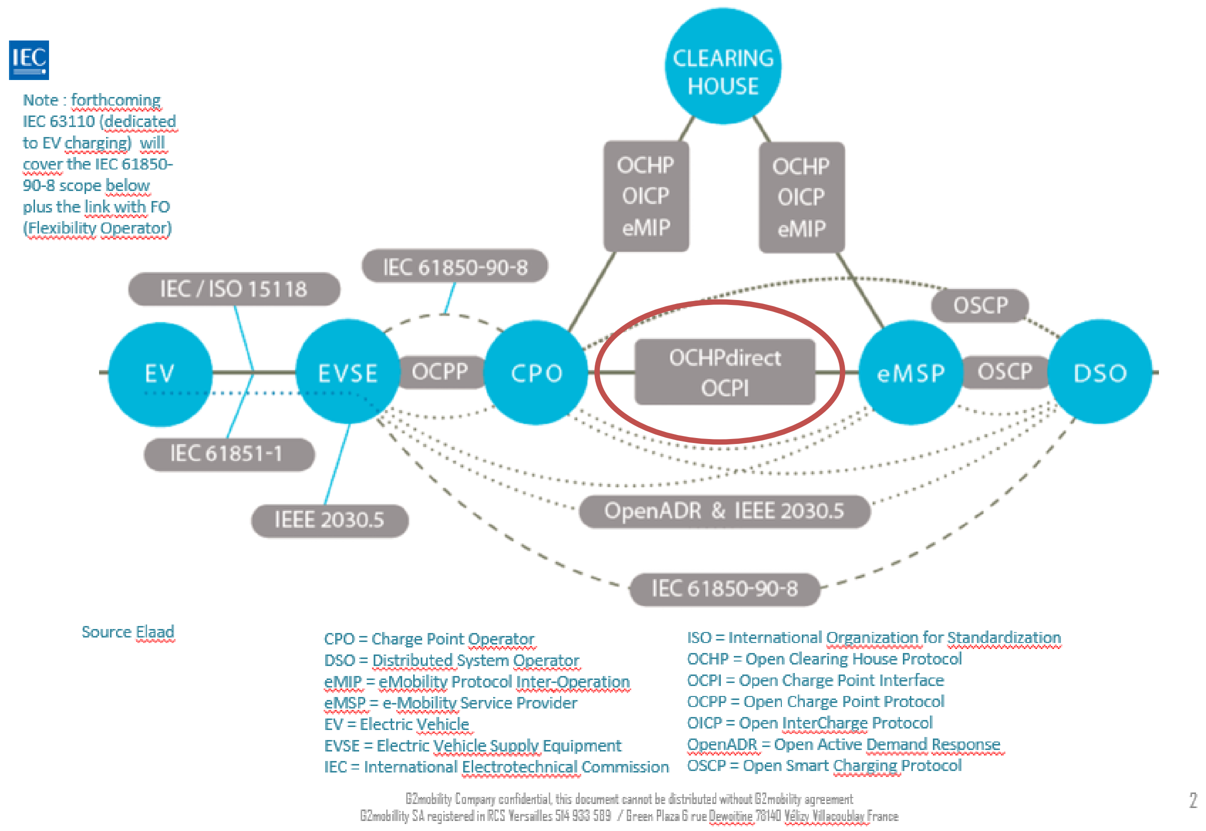



**Figure 39: EVSE protocol Overview with the OCPI**

The main functionalities that OCPI offers:

- A roaming system (for bilateral usage and/or via a hub).
- Real-time information about location, availability and price.
- A uniform way of exchanging data (Notification Data Records and Charge Data Records), before during and after the transaction.
- Remote mobile support to access any charge station without pre-registration.

Many companies already implement OCPI, support it or participate actively in its development. Initiators are EV Box, The New Motion, ElaadNL, BeCharged, Greenflux and Last Mile Solutions. Other participants include Next Charge, Freshmile, Plugsurfing, Charge-partner, Hubject, e-clearing.net, IHomer and Siemens. More include: *Allego, Blue Corner, Blue Current, BMW, Creos, Chargepoint, Easytrip (KiWhi), ELECTRIC 55 CHARGING, E.ON, eMobility Consulting, Eneco, Enervalis, ENIO, eViolin, EVNetNL, FLO, GIREVE, Greenlots, Jedlix, Movenience, Multi Tank Card, Next Charge/Go Electric, Next Green Car, Nuon, Open Charge Map, Open Fast Charge Alliance (Sodetrel, Fastned,* *Smatrics, Gronn Kontakt and Gotthard Fastcharge), Oplaadpalen.nl, Place to plug, Stromnetz Hamburg, Travelcard, XXIMO, and many others.*

OCPI has now been adopted and implemented by several EU energy and smart charging programs, including INVADE. Several other major organizations and roaming platforms are interested in participating. The Netherlands Knowledge Platform for Charging Infrastructure (NKL) facilitates and coordinates this project to guarantee progress and ensure development and results.

An overview of the modules that the protocol includes is provided below (supported by some generic types):

- The **Locations** module: The location objects live in the CPO back-end system. They describe the charging locations of that operator. The Locations module has Locations as base object, Locations have EVSEs, EVSEs have Connectors. The eMSP endpoint is dependent on the Tariffs module.
- The **Sessions** module: The Session object describes one charging session. The Session object is owned by the CPO back-end system, and can retrieved from the CPO system, or pushed by the CPO to another system.
- The **CDRs** module: A Charge Detail Record is the description of a concluded charging session. The CDR is the only billing-relevant object. CDRs are sent from the CPO to the eMSP after the charging session has ended. There is no requirement to send CDRs semi-realtime, it is seen as good practice to send them as soon as possible. But if there is an agreement between parties to send them for example once a month, that is also allowed by OCPI. CDRs are created by the CPO. They probably only will be sent to the eMSP that will be paying the bill of a charging session. Because a CDR is for billing purposes, it cannot be changed/replaced, once sent to the eMSP, changes are not allowed in a CDR.
- The **Tariffs** module: gives eMSPs information about the tariffs used by the CPO.
- The **Tokens** module: The tokens module gives CPOs knowledge of the token information of an eMSP. eMSPs can push Token information to CPOs, CPOs can build a cache of known Tokens. When a request to authorize comes from a Charge Point, the CPO can check against this cache. With this cached information they know to which eMSP they can later send a CDR.
- The **Commands** module: enables remote commands to be sent to a location/EVSE. The following commands are supported: RESERVE_NOW, START_SESSION, STOP_SESSION, UNLOCK_CONNECTOR. This module is dependent on the Locations module and the Sessions module.

OCPI is independent and open protocol (free to use) that offers alternative ways to connect by supporting both connections to the hubs as well as peer-to-peer, thus reducing the need to connect to every hub, essential for meeting the rapid growth of the EV market.

The goal of OCPI is to simplify, standardize and harmonize the communication among the growing number of players, and is thus aligning with the NeMo goals. NeMo addresses the same objectives by providing services to support Pan European eRoaming via the Inter-roaming protocol and the several hubs' roaming features exposure to the Hyper-Network, as well as by creating the Common Information Models, as an extended protocol language that, additionally to the ones of OCPI, includes structures for smart charging functionalities, grid loads management, vehicle preconditioning, wireless authentication processes, vehicle data sharing (Extended Vehicle standard), etc.

Although OCPI is an important support to a seamless charging experience, NeMo Hyper-Network is much more as it enables the quick creation of composite electromobility services, not only limited to charging like OCPI does. The NeMo Common Information Models currently include objects for several use cases apart from charging and can be extended to cover any new use case in the future. NeMo offers the functionality for service providers to create added value composite services, via the service creation domain, and the delivery/registry of those in a common format, via the extended NeMo CIM, and their invocation by all involved stakeholders extending to energy aggregators, grid operators and any third IT provider, upon a secured and distributed environment, and this the NeMo BAEM's focal point. NeMo offers the technical as well as the business framework enabling connections and discovery of services among all actors in the ecosystem.

# 6. Conclusions

Task 1.2 of NeMo project aims to monitor the latest developments in the electric vehicles (EVs) market, trends and new technologies adoption, so as to adequately guide the NeMo developments and operation after the project end. This document is the final deliverable of this task and aims to derive requirements and guidance for the NeMo Business Alliance for Electromobiliy, a non-profit association that will be established to maintain the Hyper-Network after the project end, according to the current market status and trends.

The deliverable presented the market status as regards electric vehicles which is expected to largely grow and the actors' vision to install the appropriate number of EVSE. The market evolution seems to be really favourable to the EV development and its impressive growth request to work together, moving forward in the same direction. Through this deliverable, the role of NeMo Hyper-Network is highlighted, and its relevance has been demonstrated. That supports the partners' willingness to implement the Business Alliance for Electro-Mobility after the project's end, which will be necessary to keep innovating, and to adapt with the large market evolution. No similar marketplace or Hyper-Network has been identified yet, and it could be a big advantage for electromobility actors to be part of it.

New technologies appear as the V2X and will bring new use cases that could change the mindset of people and ease the mass EV adoption. Thanks to NeMo and the future BAEM, these services and technologies can be developed easily and quickly in adequation with the growing needs of the market.

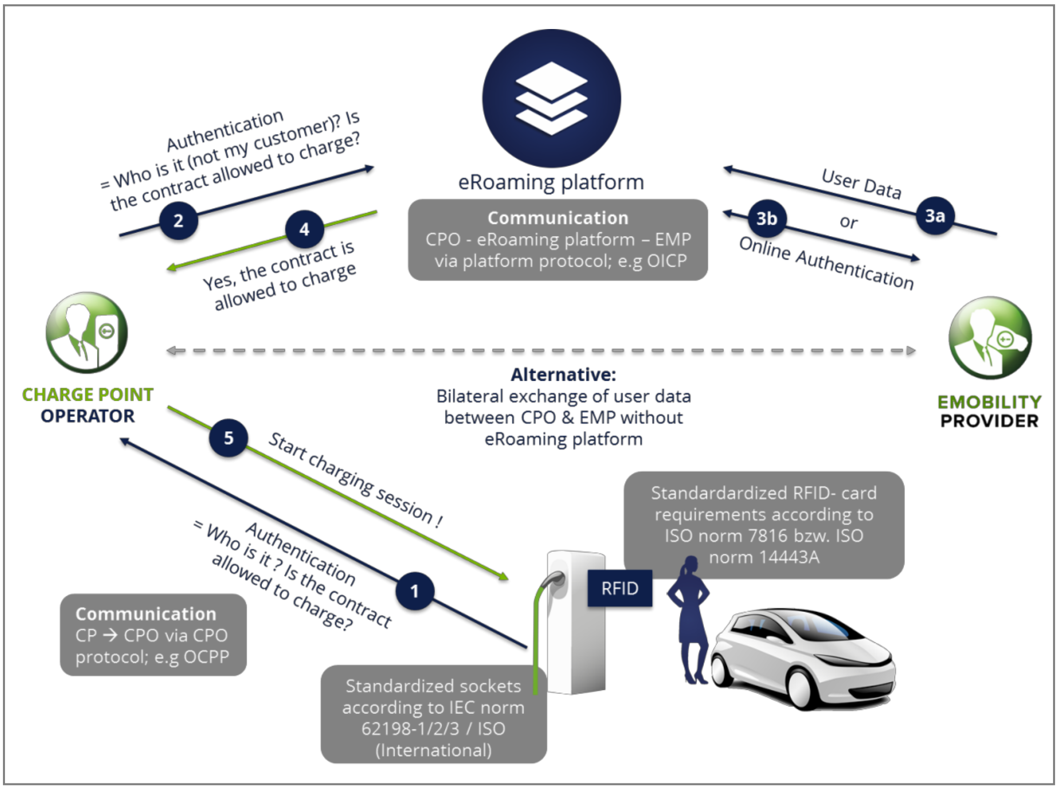
# References

1. ISO 15118-2:2014: Road vehicles -- Vehicle-to-Grid Communication Interface -- Part 2: Network and application protocol requirements
2. Dreumont T, Gouraud S: System architecture for Electric Vehicle used as a distributed energy resource – V2G AC, EVS30 Symposium (2017)
3. Bower W, Ropp M: Evaluation of Islanding Detection Methods for Utility-Interactive Inverters in Photovoltaic Systems, Sandia Report 2002
4. ChandraMouli GR: Implementation of Dynamic Charging and V2G using Chademo and CCS/Combo DC charging standard, IEEE (2016)
5. Kempton W, Tomic J: Vehicle-to-grid power implementation: From stabilizing the grid to supporting large-scale renewable energy, Journal of Power Sources 144 (2005)

## ANNEX: Identification means

Various identification means used for charge point authentication are described below (source STF / SGEMS / Deliverable 1.1 / Hubject).

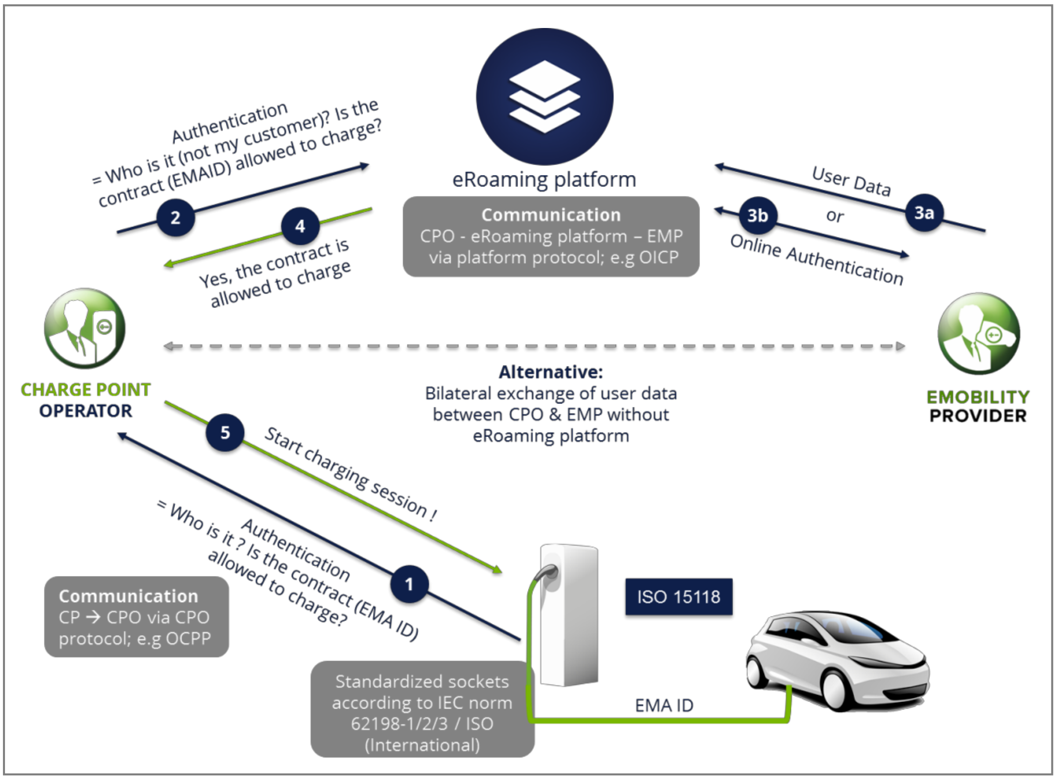
### LOCAL RFID-Card




**Subscription-based authentication (local) via RFID-card**

The driver requests the activation of a charge point with its specific EVSE ID at the CPO by holding a RFID-card in front of the charging station. The CPO requests the verification of the authentication at the eRoaming platform. The authentication data is either provided by the EMP as user data or an online authentication between eRoaming platform and EMP is set up. The CPO gets feedback of the eRoaming platform on whether the contract is allowed to charge at this charge point and the charging session is started. The driver stops the charging session by holding the RFID-card a second time in front of the charging station.

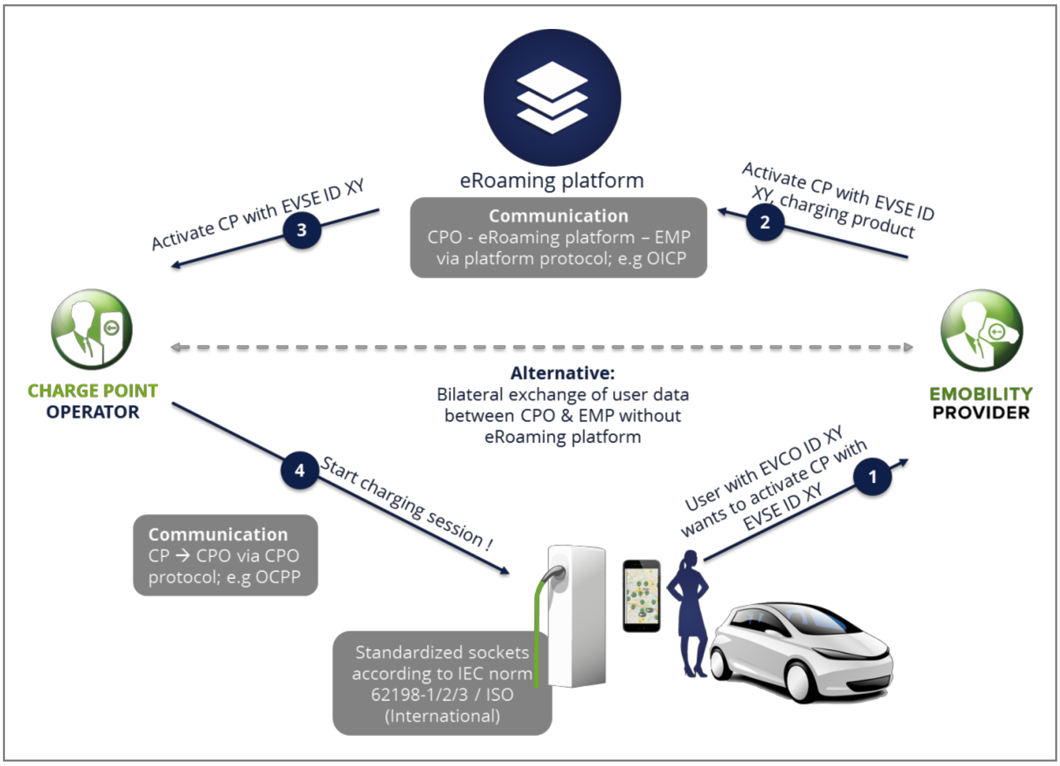
## LOCAL Plug&Charge




**Subscription-based authentication (local) via Plug&Charge**

The activation of a charge point with its specific EVSE ID at the CPO is ensured by a direct communication between the car and the charge point. The CPO requests the verifying of the authentication at the eRoaming platform. The authentication data is either provided by the EMP as user data or an online authentication between eRoaming platform and EMP is set up. The CPO gets feedback of the eRoaming platform on whether the contract is allowed to charge at this charge point and the charging session is started. The driver stops the charging session by disconnecting the charging cable vehicle-sided.

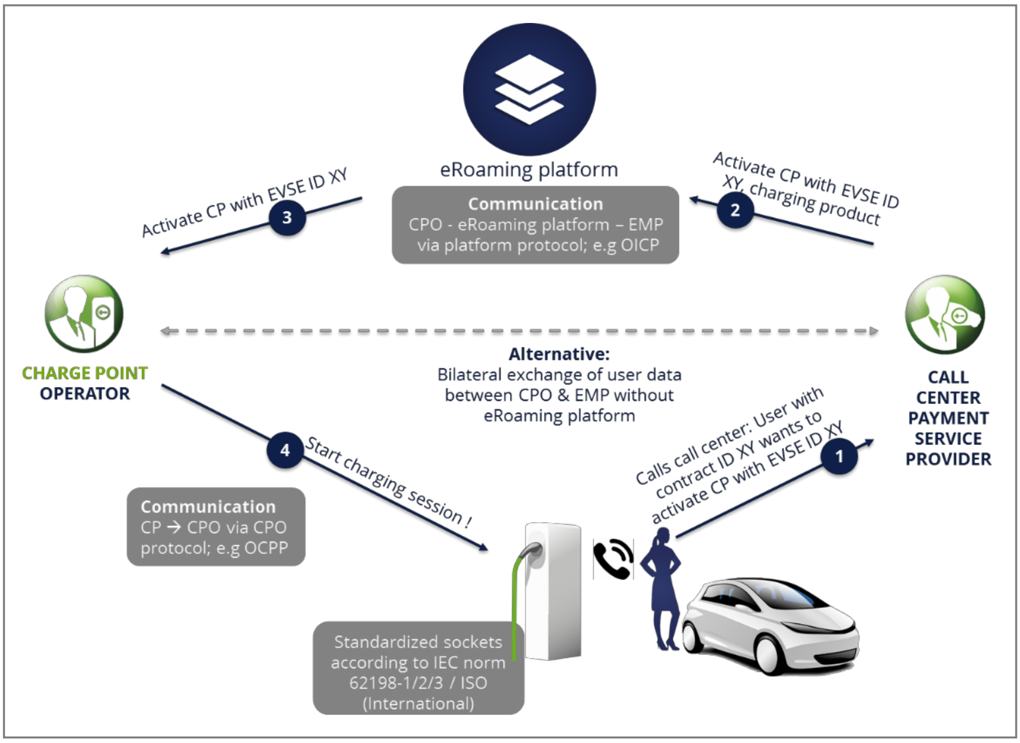
## REMOTE App/ mobile Website




**Subscription-based authentication (remote) via app or mobile website**

The driver requests the activation of a charge point with its specific EVSE ID at his EMP via the mobile website or app either by scanning a QR code at the charge point or by selecting the charge point on the map of the website/app. The EMP then requests the activation of the charge point via an eRoaming platform at the authorized CPO, who then starts the charging session. The driver stops the session using the mobile application or website.

## REMOTE Call Centre

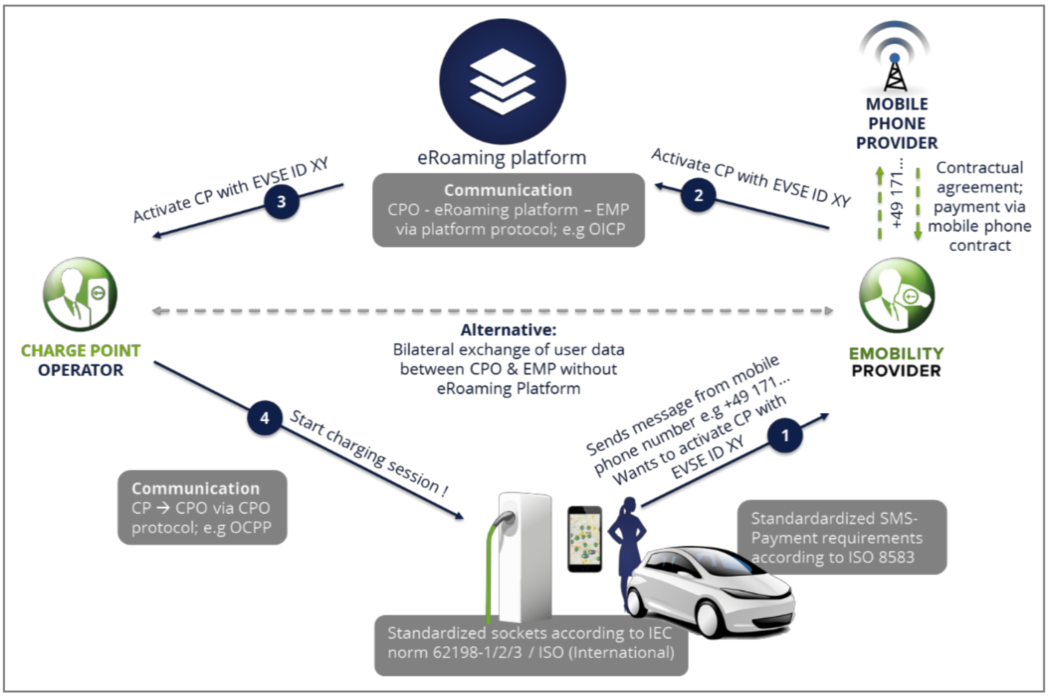



**Subscription-based authentication (remote) via call centre**

The driver requests the activation of a charge point with its specific EVSE ID at a call centre payment service provider by calling a call centre. The payment service provider then requests the activation of the charge point with a specific charging product via an eRoaming platform at the authorized CPO, who then starts the charging process. The driver stops the charging session by disconnecting the charging cable vehicle-sided.

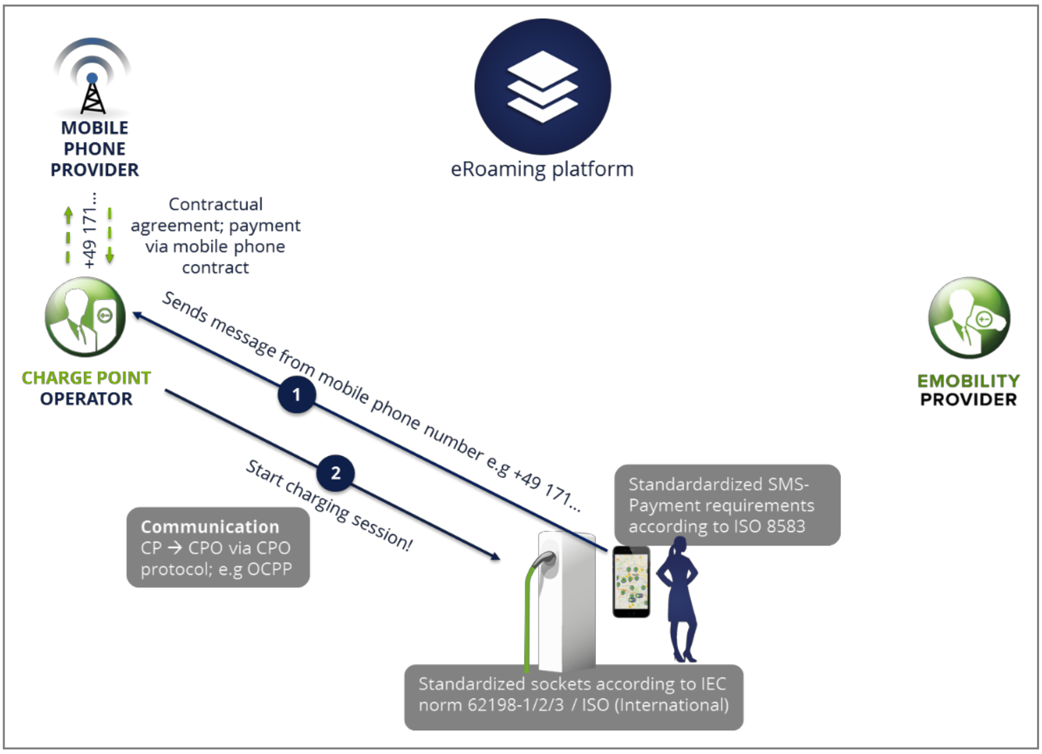
## REMOTE via SMS

Ad-hoc charging becomes possible through mobile phone authentication by means of an SMS payment.




**Ad-hoc authentication (remote) via SMS variant 1**

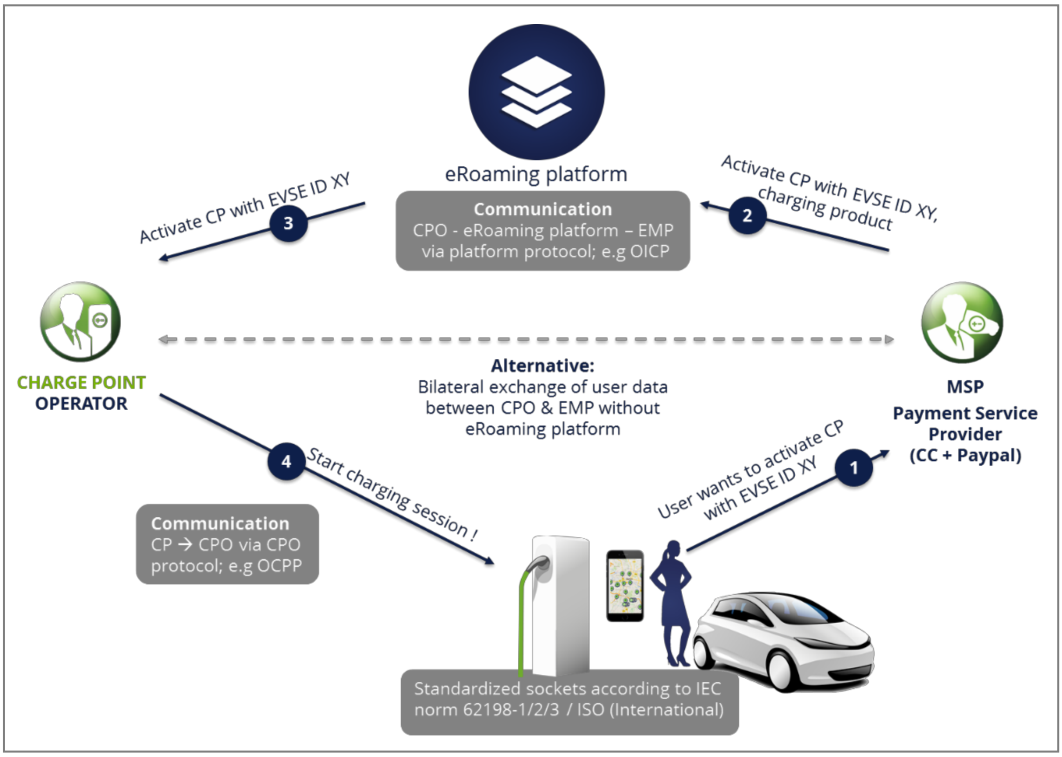
In the first variant of SMS payment is the driver able to choose the mobile phone provider. The driver requests the activation of a specific charge point with EVSE ID and sends a message from his mobile phone number to the EMP. The payment will be made via the mobile phone contract. The EMP then requests the activation of the charge point via the eRoaming platform at the authorized CPO, who then starts the charging process. The driver stops the charging session by disconnecting the charging cable vehicle-sided.




**Ad-hoc authentication (remote) via SMS variant 2**

In the second variant of SMS payment inherits the CPO at the same time the role of the EMP and chooses the mobile phone provider. The driver requests the activation of a specific charge point with EVSE ID and sends a message from his mobile phone number to the CPO. The payment will be made via the mobile phone contract. The authorized CPO starts the charging process. The driver stops the charging session by disconnecting the charging cable vehicle-sided.

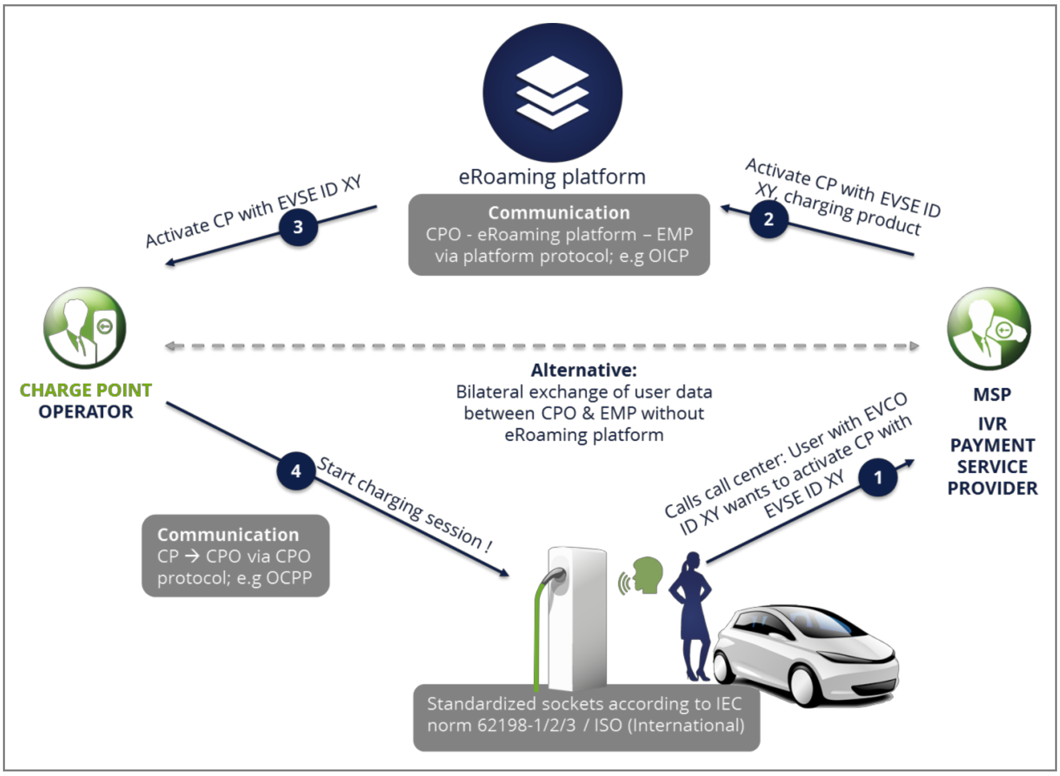
## REMOTE Mobile Website




**Ad-hoc authentication (remote) via mobile website**

The driver requests the activation of a charge point with its specific EVSE ID at a payment service provider via the mobile website either by scanning a QR code at the charge point or by selecting the charge point on the map of the website. The payment is made either by Paypal or credit card. The payment service provider then requests the activation of the charge point via an eRoaming platform at the authorized CPO, who then starts the charging. The driver stops the session using the mobile website.

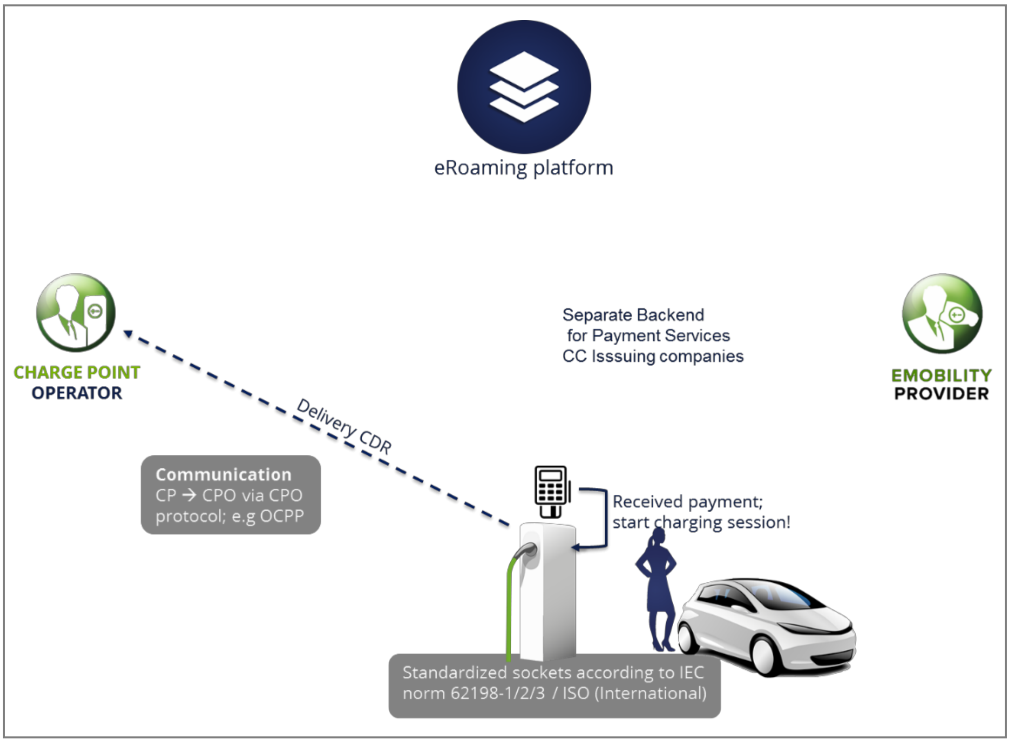
## REMOTE via IVR




**Ad-hoc authentication (remote) via IVR**

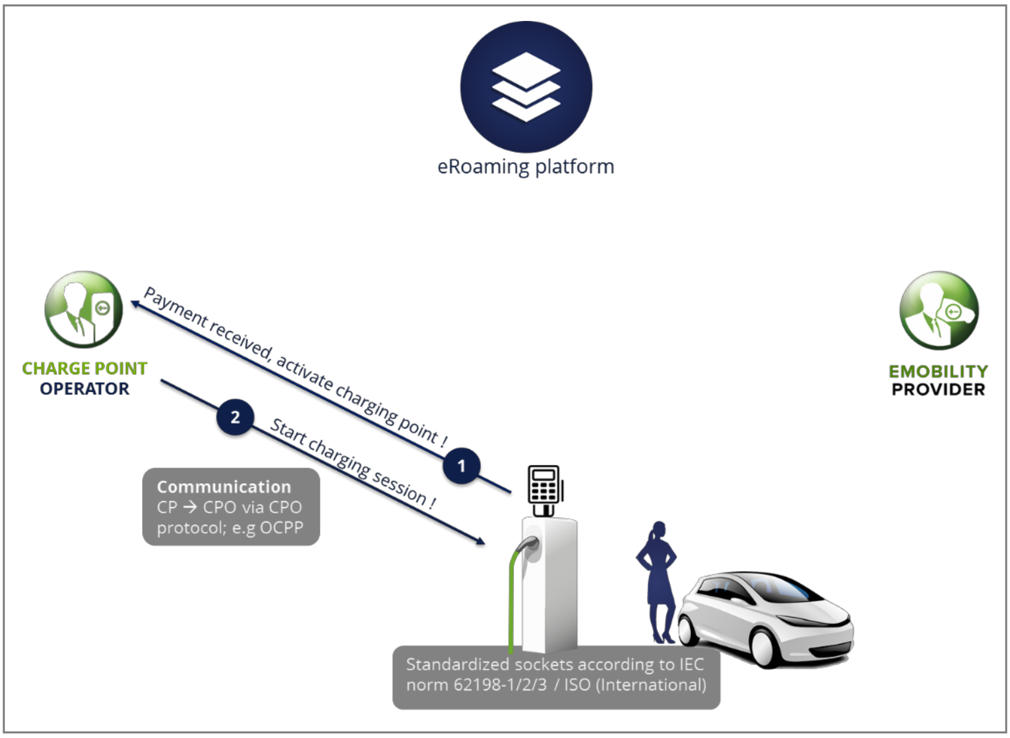
The driver requests the activation of a charge point with its specific EVSE ID at an IVR payment service provider by calling an IVR system. The payment service provider then requests the activation of the charge point via an eRoaming platform at the authorized CPO, who then starts the charging. The driver stops the charging session by disconnecting the charging cable vehicle-sided.

## LOCAL CC Reader




**Ad-hoc authentication (local) via CC reader variant 1**

The driver starts the activation by paying with his credit card at the CC reader of the charging station for a specific charging time period. When the CC reader receives the payment, the charging session is started. The CDR of this session is sent to the CPO, who functions in this case as the EMP. A separate backend for payment services CC issuing companies is needed. As soon as the preselected time period run off, the charging process is stopped automatically.




**Ad-hoc authentication (local) via CC reader variant 2**

The driver starts the activation by paying with his credit card at the CC reader of the charging station for a specific charging time period. The CPO here also inherits the role of the EMP. When the CPO receives the payment, the charge point is activated and the session is started. As soon as the preselected time period run off, the charging process is stopped automatically.

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