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# EV Integration in Smart Grids Through Interoperability Solutions

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## Abstract

The high total cost of ownership and the uncertainties surrounding battery reliability are still the main barriers for electric vehicle (EV) market take off in Europe. Storage evolution, leading to both price reduction and performance improvement, is a huge technical challenge in the medium-long term. In the meantime, new business models and market niche developments might play a facilitator role for EV deployment by tackling the economic gap between conventional ICE and electromobility (e-mobility) solutions.

Based on the analysis of the state of the art, this paper considers new business model aspects, but with an especial focus on smart grid integration and interoperability. Available solutions for electro-mobility are sketched out and presented according to the Smart Grid Architecture Model (SGAM), giving hints on regulation, business, services, components and communication and information.

The smart grid integration of EVs is highly dependent on the interoperability of e-mobility solutions with electric network management procedures. In addition, it is expected that the interoperability between different e-mobility developments results in lower prices and extended services availability for final users. This makes this subject to be of great importance at international level.

To achieve this, it is necessary to be able to assess interoperability, not only at the level of physical systems but at all domains, including stakeholder interactions in the frame of a broad diversity of services, business models and regulatory schemes. COTEVOS project aim is to help tackle this challenge.

*Keywords: Electro-mobility, Smart Grid, Business Models, Interoperability*

## 1 Introduction

On the one side, the smart grid integration of electric vehicles (EVs) is highly dependent on the interoperability of e-mobility solutions with electric network management procedures. On the other, the interoperability between different e-mobility developments is expected to result in lower prices and extended services availability for final users. For this reason, these two sides of interoperability within the EV field are of great importance for the European Commission (EC) [1].

EVs emerge as a great challenge for the grid infrastructure, but also as an opportunity under the smart grid umbrella. If we are lucky and clever enough to allow a fast EV deployment, this could be one of the main drivers for developing a real smart grid.

The high total cost of ownership and the uncertainties surrounding battery reliability are still the main barriers for EV market takeoff in Europe. Storage evolution, leading to both price reduction and performance improvement, is a huge technical challenge in the medium-long term. In the meantime, new business models and market niche developments might play facilitator roles for EV deployment by tackling the economic gap between conventional internal combustion engine (ICE) and electric mobility solutions.

This paper considers new business models aspects, but with an especial focus on smart grid integration and interoperability. The work performed in Europe by the Smart Grid Coordination Group on standardization status and gap definition [2] permitted to identify the existing alternatives for actor and system involvement in end-to-end communications. In addition, an analysis of EV related demonstration projects gave as a result a hint of future market alternatives and trends [3]. Both information sources provided enough data to sketch out existing and expected electro-mobility solutions [4].

In the following sections, a summary of these results is presented with the *Smart Grid Architecture Model* (SGAM) layers in mind [5], covering issues related to regulation, business, services, systems (components), and communication and information protocols.

# 2 Regulation

Regulation sets the highest level framework for the development of activities within a region. It has a direct influence on regulated businesses, as those related to the distribution and transmission of energy, but it also builds a framework for private business development.

Regulation should not hinder EV penetration but promote business models and permit their profitability under global sustainability concepts. Both strict rules and the lack of regulatory definition might become a barrier for the development of healthy businesses.

The electricity sector regulation has a direct impact on all businesses developed in this field and, therefore, on those related to EVs. Below are presented some of aspects that may affect the latter as distributed energy resources (DER):

- **Network operation procedures**: they define the involvement of small DER, the implementation of mechanisms for the deployment of demand flexibility services, etc.
- **Low voltage and building codes**: the low voltage (LV) code defines the basic requirements that infrastructure assets and installations should meet when connected to the low voltage network. In the case of EVs, this affects charging infrastructure projects, both technically and economically. Building codes may also impose some requirements on infrastructure in residential and industrial buildings.
- **Electricity tariff definition**: it has influence on final users' behaviour with respect to the use of electricity, basically, on how much and when it is demanded. Flat or time of use tariffs, critical peak pricing and real time pricing will cause, presumably, different consumption patterns. Currently, energy supply tariffs are not regulated anymore, however, in some countries they are still an option for smaller customers. Network tariffs remain regulated and they could be used for demand response shaping.
- **Compensation of regulated activity**: system operators' incomes are based on the eligible costs defined by regulation. Among these, the following are quite common: investments, operation and management, marketing, metering activities… This fact has direct influence on the strategies that system operators accomplish.
- **New actors' definition**: the involvement of small DER in system operation requires the definition of the aggregator role (for demand, generation or both). These actors should be legally defined and entitled to participate in electricity markets and operation mechanisms. The requirements requested to them should not hinder the feasibility of their business model.
- **Security and environmental aspects**: homologation, electromagnetic compatibility (EMC) or emissions requirements have an impact on EV and infrastructure characteristics and on their commercialisation.
- **Market requirements**: market requirements, from the electricity wholesale market to balancing or ancillary services markets, may prevent the participation of small capacity DER, demand, etc. due to cost, technical or administrative issues and, therefore, they might hinder the involvement of some actors in potential business models. On the other hand, new market structures might become a good way to increase competition.

Other more general aspects of regulation, on top of these mentioned above, have also a great influence on the development of business options:

- **Competition protection**: it is of great importance allowing new stakeholders to access established markets.
- **Administrative requirements and taxes**: they might represent a burden, especially for start-up businesses.
- **Support schemes or other benefits for final users**: they might be necessary at the beginning in order to help develop a new market.

An essential characteristic of regulation is its **area of applicability**. At European Union (EU) level, EC directives are common for all countries and they should be transposed to national legislation. Nevertheless, other rules and requirements exist at national, regional and municipal level. In general, neighboring countries and regions should observe carefully interoperability and, in the best scenario, this would lead to a worldwide integration.

Normally, local electricity market particularities will have an impact on:

- **Functionality/service availability**: more evolved markets or regulation allow, in general, a greater variety of services and, as consequence, of potential business models.
- **Profitability of business models**: regulation should not represent a barrier to business model profitability. This may happen either globally or only for certain business types.
- **Different actors**: some actors are not defined by certain regulation and, therefore, some business models could be hindered. Actors may also play different roles in different countries.

In each market model, actors will offer/demand products and/or services. Many **stakeholders** can be defined and, still, the most relevant aspect is probably the role they play, since market actors might not either have the same functions or share the same names in all regulatory frameworks.

For example, in Spain the roles of the e-mobility service provider (EMSP) and infrastructure operator (EVSEO) are assumed by the same actor, which is entitled to resell electricity. Italy and Portugal have temporary regulations addressed to the first phases of EV market development. While in Italy it is considered that the distribution system operator (DSO) may play the roles of EMSP and EVSEO, in Portugal the EMSP and EVSEO roles are assumed by a regulated party which manages a national infrastructure for the charge of EVs, however private EVSEOs are also permitted.

Summing up, even if harmonisation is being pursued at EU level, structural differences exist between countries resulting in diverse market conditions, which are characterised by players' roles, electricity system operation procedures, small consumers' participation in energy markets, low voltage codes, etc. This poses risks for interoperability.

# 3 Business

The importance of the regulatory framework for the development of business models and, in particular, of innovative businesses has been already mentioned in the previous section. Even if some areas provide better environments than others for e-mobility business development, current and future market options should be considered.

Consumers’ tendency to value losses higher than gains has already triggered the search of innovative businesses able to surface EVs’ positive aspects. In this context, service sale (compared to product sale) and solutions based on information and communication technologies (ICT) seem to stand out. Some examples are the following [6]:

- **Alternatives to vehicle purchase**: the high price of batteries and, in general, the total cost of ownership (TCO) of EVs, make leasing (of the complete vehicle or only batteries), vehicle sharing and rental especially suitable services.
- **Infrastructure**: charging is the main service linked to EVs. The charging point location area, private, public or semi-public, leads to different costs, smartness opportunities and competition level options.
- **Interoperability**: roaming is expected to bring a demand increase for service providers, higher comfort for the final user (more available charging points) and a lower level of overall costs in the sector (duplication is avoided). Another interoperability option is the deployment of mobile smart meters (meter inside the vehicle or in the charging cable), which may require lower infrastructure costs but the use of ICT interoperability platforms (data hub) for socket and EV user identification.
- **Sustainable transportation**: EV is part of a global sustainable approach and, therefore, solutions offering new mobility concepts are starting to appear (combined use of private and

public transport, vehicle share, smart logistic…).

Business models rely on product and/or service sale and those related to e-mobility will have to take into account ICT requirements. Even if the setups and information requirements should be defined on a case by case basis, similarities may also exist when we stick to the exchange of information between systems and actors.

In the following sections some examples will be analyzed according to the location of the charge point.

## 3.1 Public and semi-public charging

Public and semi-public charging present the highest range of solutions and of complexity, because more roles might be involved in the business model, including e-mobility service provider (EMSP), charging infrastructure operator (EVSEO), ICT interoperability (IOP) platform manager, etc. This has a direct impact on end-to-end communication complexity.

The use of ICT interoperability platforms (marketplace, roaming...) is mostly under demonstration phase but some commercial applications already exist in the market. The next figure represents a general scheme showing possible business (orange) and communication (black) relationships between actors/roles.

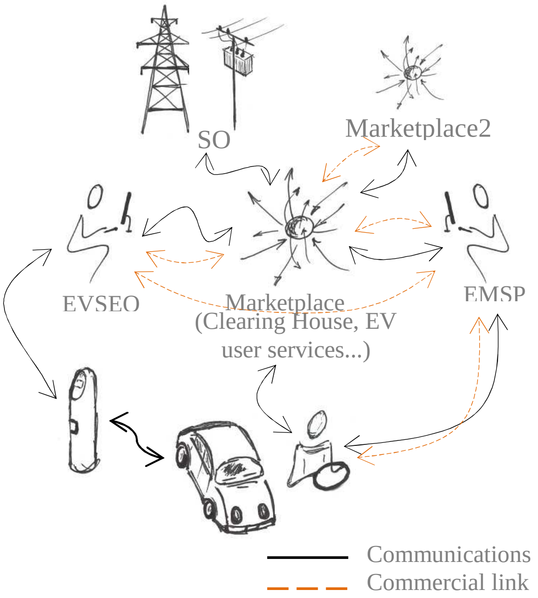


Figure 1: General market model for public charging [3]

Within this scheme, several are the suitable business models and they will depend on applicable regulations in each region and on market approaches of stakeholders. The number of actors and their roles might also differ; normally, it will be lower than in the figure above, at least in the first steps of market development, where complexity might be a cause for high investment.

## 3.2 Private domain

The EV charge in the private domain is similar to that in public and semi-public areas when EMSP and/or EV supply equipment (EVSE) operators are involved. However, many EV users might charge their vehicles under conventional residential energy contracts and infrastructure. In this case, the final user would assume the role of EVSEO and electricity retailers EMSP tasks. DSOs might perform load management in the frame of residential demand response strategies, using the infrastructure and protocols deployed for that purpose, including Home Energy Management Systems (HEMS), Advanced Metering Infrastructure (AMI), etc. (figure 2). The last approach is common in USA and Japan while, in Europe, the focus seems to be set on more complex schemes, as that of figure 1.

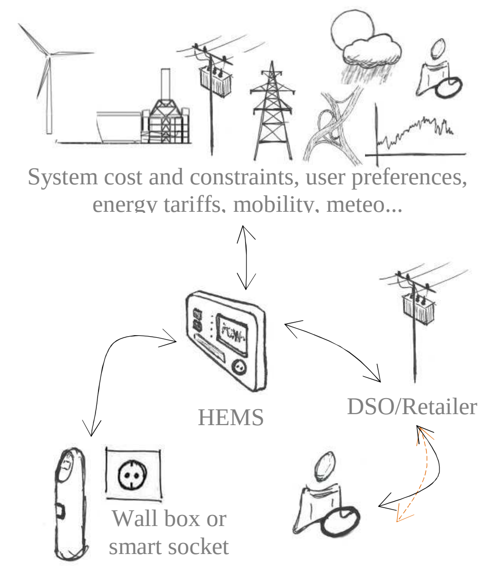


Figure 2: General market model for private charging [3]

## 3.3 Other

**Mobile metering** is a special case related to both public and private domains. This business approach proposes to use smart domestic or industrial sockets for EV charging, instead of the more expensive dedicated EVSEs.

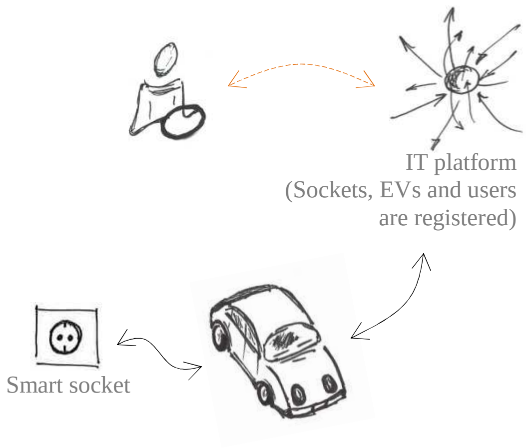


Figure 3: Mobile metering model example [3]

**Fleet management** requires normally some specific services, such as EV monitoring, that other activities may not need. It is suitable for public transport and new businesses, such as the e-vehicle sharing or flexibility aggregation.

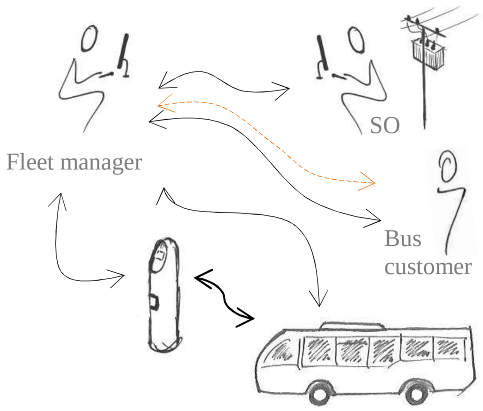


Figure 4: Fleet management model example [3]

# 4 Services

They are the basis of business models. They can be described through use cases, at high level or in a more detailed way going down to, for example, data exchange definition. Services definition permits to know the required interactions between components (stakeholders or systems) and the functions that will have to be covered.

Many services are being or have been tested in demo projects but their feasibility needs to be validated both in real markets and regulatory frameworks since, in many cases, they were developed under research and pilot project environments.

The main service linked to EVs is charging and the associated business is the energy supply to vehicles. Nevertheless, this service requires different characteristics and information features depending, basically, on its smartness, interoperability level and market model. Some options are shown below as example:

- **Open access**: the EV user charges at an EVSE without the need of having a contract with an EMSP. The EVSEO offers the whole charging service to the EV user and, to do this, it has an agreement with one or more EMSPs. The EV user can be offered the possibility to choose from a list of charging services offered by different EMSPs at the EVSE. The EV user pays at the spot.
- **Without roaming**: The EV users charge at the EVSEs they are allowed to do so. In this case, the EVSEO and the EV user have an agreement with the same EMSP.
- **Roaming**: The EV user can charge at the infrastructure of an EVSEO who has no agreement with his EMSP. Clearance, either financial and/or data, is done through a clearing house. This can happen internationally or within a certain region.
- **With roaming through a market place**: EV customers charge at an EVSE operated by an EVSEO who does not have a roaming agreement with their EMSP, but who has a roaming agreement with a market place operator with whom the EMSP has an agreement too.
- **Private charging**: In the private domain, smart charging is normally foreseen through a HEMS system, able to control the EV load through a dedicated EVSE or a more conventional smart switch, normally allowing for low levels of management (on/off, deferred start...).

Services definition permits to go deeper into the interactions between components (stakeholders or systems) and into the functions that will have to be covered. The information exchange required to perform this charging services depends on the characteristics of each option. The open access will need less information because it involves fewer actors during the charging process (EVSE operator and EV user) and may not require identification beyond established processes (credit card payment, for example). Roaming involves the clearing house, and the market place adds a new actor, but it might simplify operations by centralising exchanges. By adding smartness to the charging process, other actors, like system operators (SO), and services (electricity price information, vehicle information, etc.) are included in the procedure.

Some services and functionalities linked to electro-mobility are presented in the following Table 1 [3].

Table 1: e-mobility services

| **Services** |
|---|
| **EV Charging**:<br>• Public, Semi-public, Private, Others.<br>• Access and payment: customer card holder with or without contract, pre-paid or under subscription; open access. |
| **Marketplace** (B2B platform):<br>• Data routing.<br>• Authorization request.<br>• Customer services offer.<br>• Connection to external ICT platforms. |
| **Roaming/Clearing House (CH)**:<br>• Data and/or economic clearance.<br>• Open access payment. |
| **Load management**:<br>• EVSE control (close loop), EV control (close loop), Open loop.<br>• Capacity availability information and reserve.<br>• Renewable energy integration.<br>• Vehicle to grid, building or home (V2G, V2B, V2H).<br>• EV user requirements consideration. |
| **EVSE related services for EV users (even while roaming)**:<br>• Access: open, restricted.<br>• Status monitoring.<br>• Search.<br>• Reservation.<br>• Identification of optimal EVSE.<br>• Guidance to EVSE.<br>• Service price information.<br>• Retailer selection.<br>• Payment options.<br>• General information: connector type, owner, maximum charging rate, extra facilities, etc. |
| **Other information services for EV users**:<br>• Contract information.<br>• Intermodal mobility: vehicle sharing, public transport, park and ride, etc.<br>• External conditions: traffic, road, weather, etc.<br>• Driving support: trip planning, efficient driving, recharge advisor.<br>• News.<br>• Points of interest in the route.<br>• EV performance information: State of Charge (SOC) of the battery, carbon footprint, driven range, etc.<br>• Driver preferences and patterns. |
| **Customer interface**:<br>• Phone or internet notifications.<br>• Smart phone apps.<br>• Web portal access.<br>• On-board technologies.<br>• EVSE human-machine interface (HMI). |
| **EVSE related services for EVSEO**:<br>• EVSE access: local, remote.<br>• EVSE management.<br>• EVSE monitoring.<br>• EVSE diagnostics.<br>• EVSE maintenance.<br>• Connection to interoperability platforms.<br>• Planning of infrastructure development. |
| **EMSP/EVSEO related services**:<br>• Customer management.<br>• Billing.<br>• Metered data retrieval.<br>• Connection to external systems (DSO, information platforms, energy market, etc.)<br>• Energy price information. |
| **EV related services for fleet managers**:<br>• EV sharing management: reservations...<br>• EV performance monitoring and prediction.<br>• EV location: GPS...<br>• EV remote maintenance.<br>• Customer information.<br>• Charging optimization and scheduling. |
| **Secure and reliable payment** |
| **Testing**:<br>• Interoperability assessment. |

# 5 Components

According to [5], the definition of components includes devices, applications, persons and organizations.

The systems related to the different roles are of great importance when going down in the SGAM layer stack. These systems use communication and information protocols to exchange data with each other and carry out the functionalities required to fulfil services. However, similarities may exist

between the devices or applications of different stakeholders and this helps simplify, up to certain extent, the interoperability problem. For example, front-ends of EMSP, EVSEO, retailer, flexibility manager, etc. for ICT platform connections might share the same communication and information protocols.
The following table shows a selection of those generic smart grid components [2] more directly related to e-mobility, while it proposes a link with several actors/roles [4].

Table 2: Components

| **Components** |
|---|
| **EV User**: HMI platforms, EVSE, computer, smart phone, charging control, customer energy management system, energy management gateway, load controller, meter, smart plug, Plug-in EV, etc. |
| **EVSE operator**: Asset management system, demand response management system, building/customer management system, energy management gateway, GIS, HES, EVSE, meter data concentrator, SCADA, charging/load control, billing, etc. |
| **EMSP**: Customer information system, customer portal, billing, demand response management system, energy trading application, enterprise resource planning, front-end processor, GIS, meter data management system, asset management, load controller, etc. |
| **Market place operator**: SW platform permitting access and operations, energy market management, registration application, settlement, etc. |
| **Clearing house operator**: SW platform permitting clearing house services, energy market management, registration application, settlement, etc. |
| **Network operator**: SCADA, EVSE, DER control, demand response management system, front-end processor, GIS, HES, energy market management (ancillary services), etc. |
| **Energy retailer**: Customer information system, customer portal, energy trading application, enterprise resource planning, billing, etc. |
| **Metering operator**: AMI Head End, meter data concentrator, meter data management system, etc. |

# 6 Communication and information

The interaction between components requires the use of communication and information protocols. This is a fundamental aspect to achieve interoperability. A state of art analysis permitted to identify candidates for the communication between stakeholders [3][4], considering not just the e-mobility but other related domains, such as the smart grid, ITS and home automation. The next figures 5 and 6 show this outcome.
Most of the protocols presented here were not designed to provide interoperability, which means that meeting the standard does not guarantee it. For example RFID systems can follow ISO/IEC 14443, ISO/IEC 15693 or ISO/IEC 18000 standards. In this case, once the technology is selected, the codification should also be made under interoperability requirements: which information fields are defined, with which length, where is the information stored in the card, how users IDs are defined in order for all EVSEs to be able to identify them and the vehicle, etc.
Defining the minimum required information is also an important aspect to fulfil interoperability. For example, in an identification and authentication process even if many fields could be exchanged according to different protocol data structures, some of them should be obligatory. Still, a high number of requisites may cause the impossibility to charge for some users.
It should be noted that business models are based on service trading and that companies use these services to differentiate their product from that of other competitors. Sometimes, communication protocols are not able to address all the services that companies want to provide and this makes some communication protocols to be adapted to allow for new data structures permitting new services. This is a barrier for interoperability but something common today, especially in some interfaces, such as the EVSE-EVSEO link.

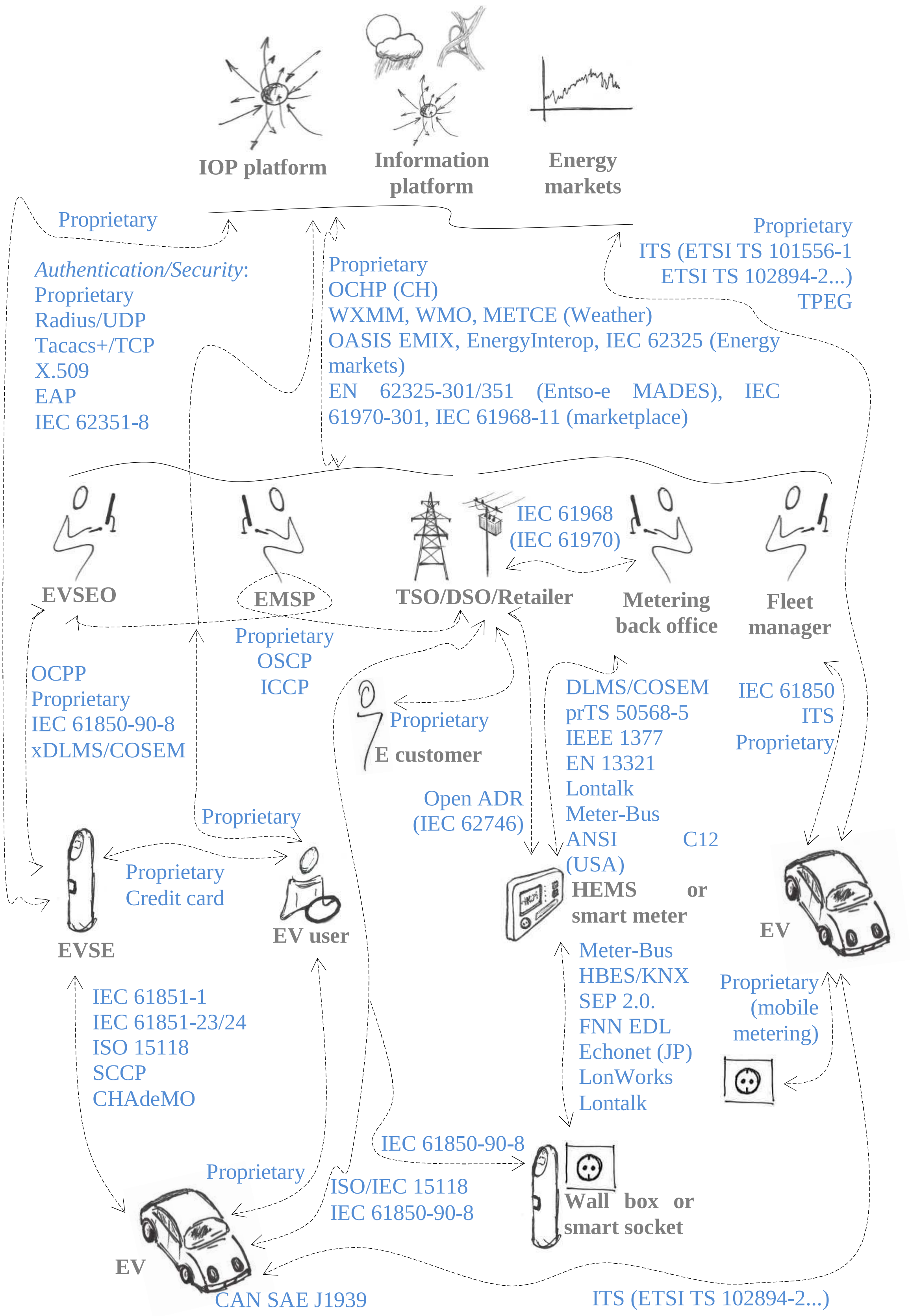


Figure 5: Information protocols summary [4]

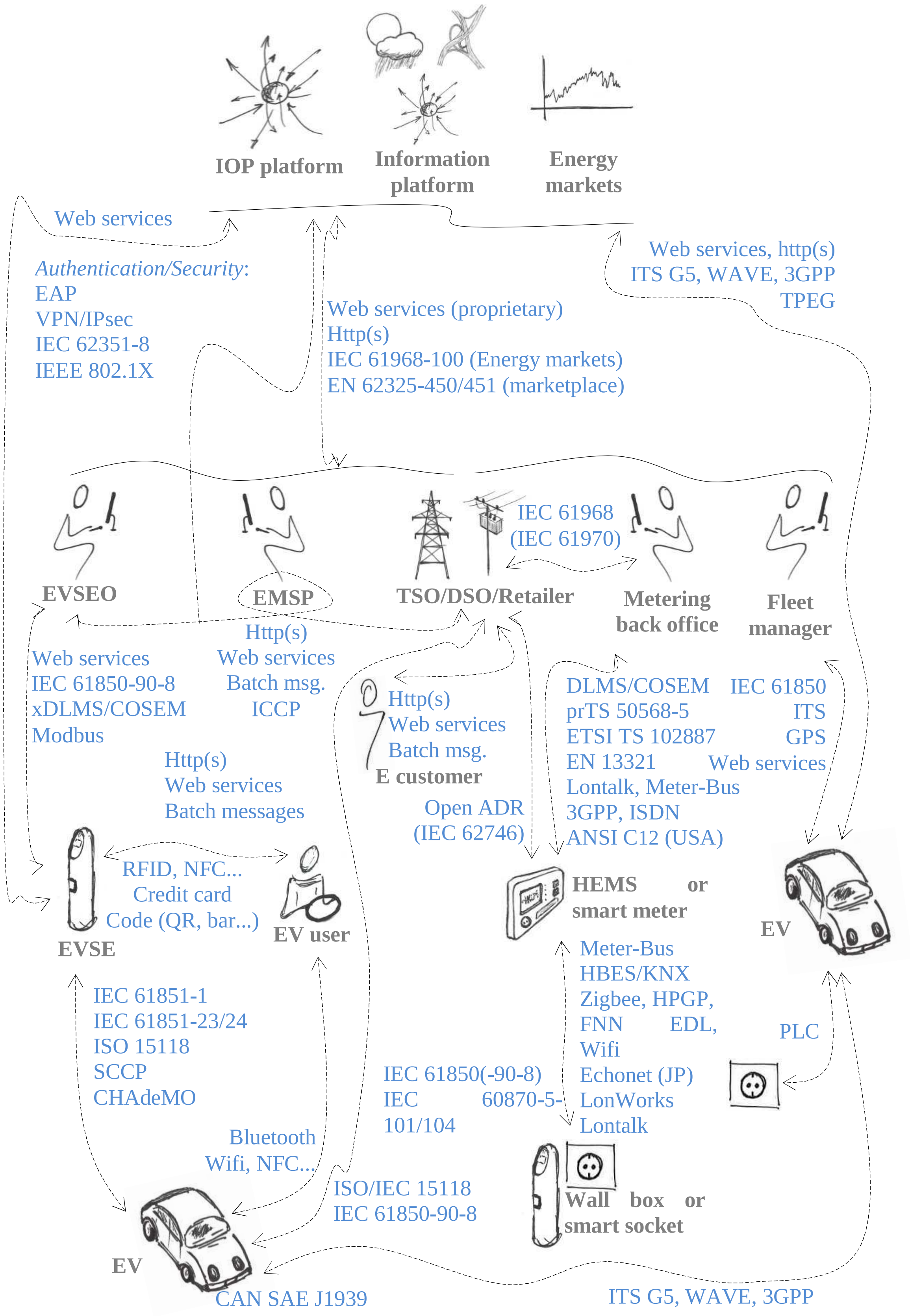


Figure 6: Communications protocols summary [4]

# 7 Interoperability assessment

European Member States must guarantee by 2020 that the most critical aspects relating to charging infrastructures have been tested according to a set of evolving standards, so that technology and solutions will be ready when electric vehicles arrive. All in all, there is an evident need for precise and clear new procedures and facilities to achieve the conformity and interoperability assessment of electro-mobility systems.

Within this framework, the objective of COTEVOS EU project [7] will be the verification of the functionalities that different systems require to manage EV charging and the associated smart grid infrastructure. Based on the project partners' complementary experience, and an efficient historical collaboration on facilities, standardisation and research infrastructures for DER, COTEVOS addresses key issues such as:

- **Assessment of the interoperability** of systems for the integration of EVs in the grid.
- **Design of procedures and tests** according to relevant use cases.
- **Coherence with the Smart Grid Architecture Model**.
- **Cross-national collaboration** and transparency.

Therefore, COTEVOS aims at establishing the optimal structure and capacities to test the conformance, interoperability and performance of all systems making up the infrastructure for the charging of EVs.

The results achieved in the first half of the project were summarized in [8] and they will be introduced below briefly (the project will end in February 2016).

In order to conveniently settle COTEVOS within the group of stakeholders involved in the integration of the EVs in the smart electricity grid, an exhaustive work to create a **network of contacts** and collaboration has been carried out. Following a first massive e-mail campaign and other later communications, the external contacts of the project were classified in three groups:

- Those willing to participate in round robin tests.
- Those interested in giving opinion about COTEVOS testing procedures and other decisions.

Those that want to be punctually informed of achieved results.

Harmonizing standards to achieve interoperability in the field of electro-mobility is key. With that purpose in mind COTEVOS has targeted the **participation and coherence** with the work carried out by the different international standardization groups or initiatives, among which M/468, e-mobility WG Smart Charging, TC-69, TC-8, eMI3, M/490, etc.

COTEVOS has also collected the different standards presently being used or defined. This led to a first overview of the e-mobility **standardization landscape**, covering about 30 standards, standardisation activities and groups, e.g. IEC 61851, ISO / IEC 15118, IEC 62196, CCS/Combo type 2, DC/CHAdeMO, SAE J1772, ISO/IEC 14443, OCPP, IEC 62056.

Regarding the tests to be implemented, preliminary results have already been achieved, in order to support the gap analysis and priorities of the standardization world.

On the other hand, as a first step towards the COTEVOS' infrastructure, a **reference architecture** was defined, in line with the framework and models considered in the EU Mandates and the international approach. Those partners with laboratories, as well as the project 3$^{rd}$ parties, are implementing each a subset of this interface reference architecture for interoperability testing, leading to a holistic picture (as example, see figure 7 showing a scheme of the developments taking place in TECNALIA).

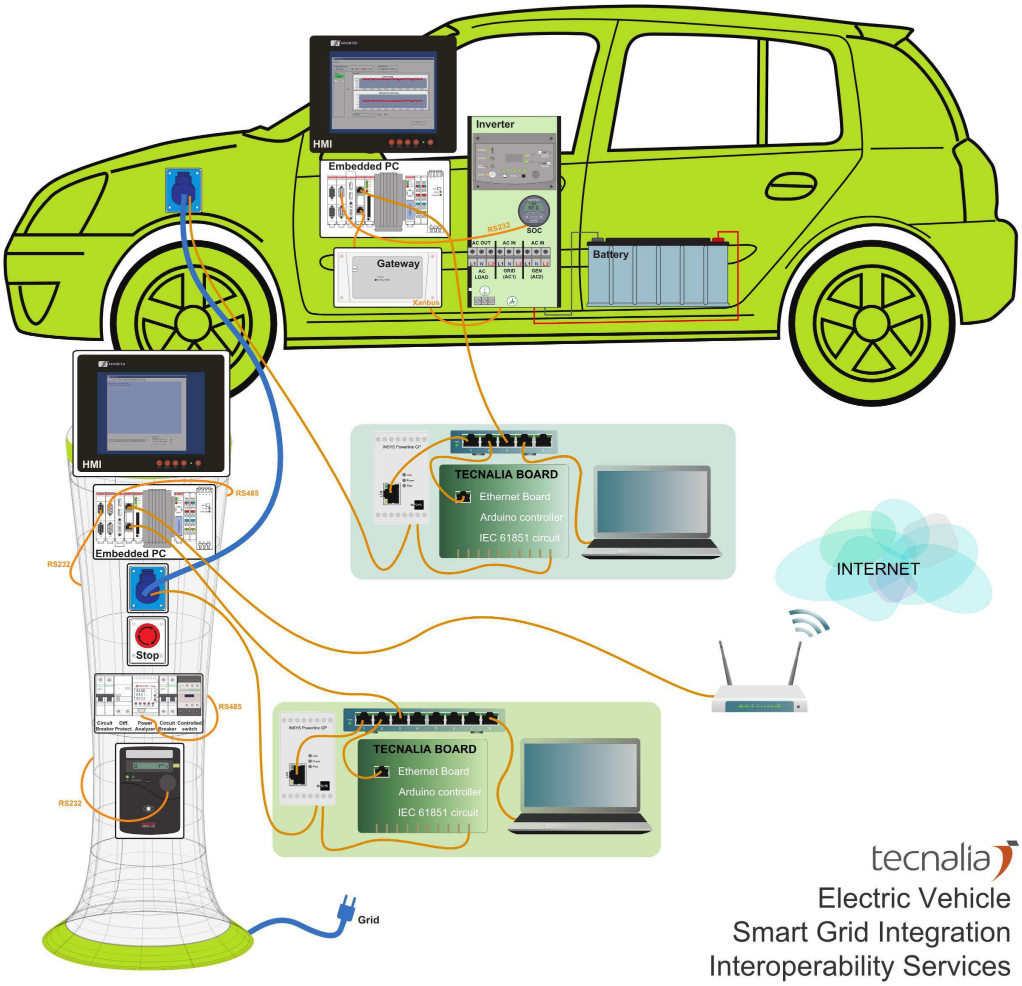


Figure 7: TECNALIA infrastructure

Looking at the needs for answers to questions around interoperability that have been arising in the different related groups and projects, COTEVOS has worked out a set of **test cases**, some of which will be included in the round robin test campaigns.

# 8 Conclusions

In order to reduce some of the existing barriers and to promote the widespread adoption of EVs in Europe, it is imperative a certain level of compatibility between them, the charging points and the rest of the infrastructure providing e-mobility services. This will facilitate that EV users charge at public or semi-public infrastructure and will also support the roll-out of the latter.

To achieve this, it is necessary to be able to assess interoperability, not only at the level of physical systems but at all domains, including stakeholder interactions in the frame of a broad diversity of services, business models and regulatory schemes. COTEVOS project aim is to help tackle this challenge.

The regulations need to evolve to definitions permitting an increased availability of services; an increased profitability of business models; and, in general, higher levels of market participation and competence.

In the meantime, innovative businesses are starting to arise, making the most of EV benefits. Unfortunately, the infrastructure, the market and/or the regulation are not ready yet for some of the services that are being tested in pilot project environments. For this reason, it is difficult to make any economic assessment on added value services trade before validation in real life conditions starts. Here, the high investment required for infrastructure might result a barrier in many cases.

Even if some gaps exist, the number of ICT protocols is very high in the smart grid field. The good news is that the harmonisation work being carried out internationally is clarifying the extensive group of available options. Again, the diversity of approaches and company procedures can endanger interoperability. Therefore, it is necessary to agree on a minimum set of requirements and standards to allow, at least, for the most basic electro-mobility services.

## Acknowledgments

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## References

[1] *M/490 EN Smart Grid Mandate - Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment*, European Commission, Directorate-General for Energy, B.2 – Electricity and Gas, Brussels, 2011-03-01

[2] CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG), *First set of Standards*, 2012 [available: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/xpert_group1_first_set_of_standards.pdf].

[3] R. Rodriguez, et al., *specification, analysis and assessment of situation of interoperability related to EV deployment in EU cities and member states*, COTEVOS EU project, Deliverable 4.1 v1.4, 2014.

[4] R. Rodriguez, C. Madina, E. Zabala, *requirements for infrastructure for interoperability assessment*, COTEVOS EU project, Deliverable 1.3 v2.3, 2014.

[5] CEN-CENELEC-ETSI Smart Grid Coordination Group, *Smart Grid Reference Architecture*, November 2012 [available: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/xpert_group1_reference_architecture.pdf].

[6] R. Rodríguez, N. Vidal, E. Zabala, *Added Value Services for EV Charging Management*, EVS27 paper, Barcelona, 2013.

[7] COTEVOS EU project, http://cotevos.eu/, last accessed on 2015-01-29.

[8] E. Zabala, et al., *first project periodic report*, COTEVOS EU project, Deliverable 7.2, 2015-01.

## Authors

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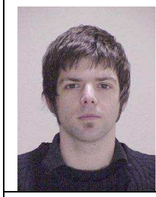
|  | Raúl Rodríguez, M. Sc. in Electrical Engineering (1996) from the School of Engineering of the University of the Basque Country in Bilbao. Since October 2000 to date, at the Energy Unit of LABEIN, now TECNALIA, working as researcher and project leader on socioeconomic and technical aspects of active distribution networks in the electrical system both in the frame of international and national research and consultancy projects. |
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