# INTEROPERABILITY

## FOR ELECTRIC VEHICLE CHARGING

### IN LATIN AMERICA AND THE CARIBBEAN

PRACTICAL GUIDE OF RECOMMENDATIONS

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# Abbreviations

| | |
|---|---|
| **EV** | Electric Vehicle |
| **EVSE** | Electric Vehicle Supply Equipment: charging station |
| **CPO** | Charge Point Operator (also: CSO – Charging Station Operator) |
| **MSP** | Mobility Service Provider |
| **DSO** | Local grid operator (Distribution System Operator) |
| **TSO** | Central grid operator (Transmission System Operator) |
| **OCPP** | Open Charge Point Protocol |
| **OCPI** | Open Charge Point Interface |
| **CCS1, CCS2, ChaDeMo, GB/T** | EV connector standards |
| **LAC region** | Latin-American and Caribbean region |

# Table of Contents

# Executive Summary

Electric vehicles have been embraced as an important solution towards zero-emission transport and cleaner air for urban areas. This promising future relies on a mature ecosystem of electric vehicles, a charging infrastructure and a good integration with the electricity and transport sector, and urban mobility planning.

The aim of this document is to present definitions and concepts around interoperability of EV charging infrastructure. Once such concepts are defined, a common framework is stablished to study interoperability while exploring and assessing the landscape to develop interoperable charging infrastructure in Latin America and the Caribbean. Finally, some recommendations are formulated, and a guideline is given to assess the elements of interoperability in a variety of scenarios and country conditions.

## Interoperability

*The capacity of systems and the underlying business processes to exchange data and to share information and knowledge*, **is a well-established property of mature ecosystems such as the electricity, IT and telecom sectors. It is therefore an important ingredient for a mature and integrated ecosystem of EV charging.**

In addition, the concept of ***layers of interoperability*** is a helpful tool to assess interoperability in all parts of the ecosystem and every aspect of the EV charging value chain. Roaming for electric vehicles is the most visible property of interoperability, and depends on multiple elements in the value chain to be successful:

### The hardware layer

The connectors and plugs of electric vehicles and charging stations need to be interoperable

### The communication layer

All hardware and software systems, that are steering and controlling the hardware, need to communicate seamlessly with each other

### The information layer

The information that is being exchanged between actors and systems needs to be recognized and interpreted to be meaningful

### The service layer

Business processes and services between actors need to be aligned to provide seamless and user-centric services

### The business layer

A clear regulatory and business framework needs to be defined to provide a predictable context for governments, businesses, grid operators, and EV drivers, among other actors, to develop and grow interoperable EV charging services

The study of reference countries and countries in Latin America shows a strong relationship between the energy market configuration and the market design of EV charging services; countries with an open energy market and experience in interoperability are likely to also design an open EV charging market. In contrast, closed or semi-closed markets tend to move to more closed EV charging ecosystems. If they intend to move to a more open configuration, this is often part of a broader sector development towards openness and interoperability.

Each market configuration has its advantages and disadvantages: while closed energy markets may simplify policy and regulatory frameworks and will ease implementation. These are also bound to political willingness from the government and depend heavily on public funding to be developed. On the other hand, more open markets will allow competition and the development of innovative business and market models.

For each market configuration, interoperability can be developed to capture the benefits: Reduced installation and integration costs, efficient scale-up and development of new services, a competitive market environment, preventing technology "lock-ins", transparency in offerings, moving towards user-centric products and services.

For each layer of interoperability, specific recommendations are given, including an assessment of interoperability readiness. The assessment of interoperability readiness is presented in a guideline in the form of a sort of "menu" tool where minimum and optimal elements for interoperability are given for each of the interoperability layers and scale of interoperability. It is expected that depending on context and electric mobility development in each country, the guideline helps to identify such elements that have been developed and those that could be further developed to achieve more mature interoperable EV charging infrastructure in each country. Not necessarily all boxes or conditions must have to be checked, since it depends on country context, but it could be used as a guideline to prepare and plan future developments of charging infrastructure public policy, national roadmaps, and infrastructure plans, among others. The scale of interoperability describes the sub-national, national, and international ambitions towards interoperability, aiming at a vision of an interoperable EV charging infrastructure for the Latin American and Caribbean region.

# Introduction

Electric vehicles have been embraced as an important solution towards zero-emission transport and cleaner air for urban areas. It also provides an opportunity to use the electricity that has been generated from renewable sources (such as hydro, solar or wind) for transport, thereby becoming less dependent on oil and gas production or import. The storage capabilities of electric vehicles have a promising potential to capture the volatile output of renewable sources and provide a storage buffer for the electricity grid.

This promising future relies on a mature ecosystem of electric vehicles, a charging infrastructure and a good integration with the electricity and transport sector, and urban mobility planning. Interoperability, the capacity of systems and the underlying business processes to exchange data and to share information and knowledge, is an important ingredient for such a mature and integrated ecosystem of EV charging.

This report is part of a broader study on interoperability of electric vehicle (EV) charging in Latin America and the Caribbean: it provides recommendations to improve interoperability and thereby the functioning of the whole ecosystem of EV charging.

1. The first part of this report contains **a description of the theoretical framework**, introducing and defining concepts such as openness, interoperability and roaming. It also introduces the market framework of EV charging, its actors, and processes. Finally, it introduces the theory of 'layers of interoperability' as a means of assessing the current and desired level of interoperability.

2. The second part of this report contains an **assessment of countries in the Latin-American region**: their energy market configuration and development of EV charging either as a regulated energy service, or as a separate service. An overview is given of the Latin American and Caribbean countries and their current status regarding EV charging and interoperability.

3. The last part of this report contains an **assessment of the different energy market configurations** and how this impacts the development towards interoperable EV charging. It also contains a number of specific recommendations for governments to work on, in order to support the transition towards electric mobility, and capture the benefits of a sustainable future for transportation.

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# 1. Theoretical framework Definitions and Layers of Interoperability and Electric Vehicle (EV) Roaming

Interoperability, EV charging roaming, and open standards are concepts that must be defined properly before presenting a discussion over how to deploy interoperable EV charging systems. In the following sections such definitions will be presented, and they will provide a structure to define other elements within interoperability such as the layers that compose it and how those interactions between layers result in providing the EV roaming service.

Interoperability is initially presented as a generic concept for systems to exchange information, and this chapter dives deeper on how such information exchange is performed. Interoperability as concept has proven to be successful in sectors such as telecommunications and IT. In both cases, sharing relevant information between service providers allows users to seamlessly benefit from the infrastructure and services of service providers, regardless of the hardware or subscriptions in use.

The following sections will present definitions for interoperability, openness and EV Roaming. Lastly, by borrowing from different frameworks in the IT and the energy sector, the layers of interoperability will be defined and the resulting EV roaming service, linked to the development of interoperable EV charging systems, shall be presented.

## 1.1 Definition of Interoperability

Interoperability is a general concept that refers to the proper "operability" between systems or actors. Some definitions of interoperability can be used to provide a formal description. For reference, some definitions of interoperability are presented below:

### ISO (International Organization for Standardization)

The International Organization for Standardization (ISO) in its standard ISO/IEC 2382-01 (Information Technology Vocabulary, Fundamental Terms) defines interoperability as

***"the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units."***

### IEEE (Institute of Electrical and Electronics Engineers)

The Institute of Electrical and Electronic Engineers (IEEE) provides, from a more technical perspective, a generally accepted definition of interoperability. The IEEE defines interoperability as

***"the ability of two or more systems or components to exchange information and to use the information that has been exchanged."***

These definitions are not unique to electric mobility or EV charging infrastructure, but they are given in a more general sense to define a technical condition where all the elements of certain ecosystem, if such condition is met, shall work together. Specifically, for the context of EV charging infrastructure interoperability, a more practical definition is proposed in the

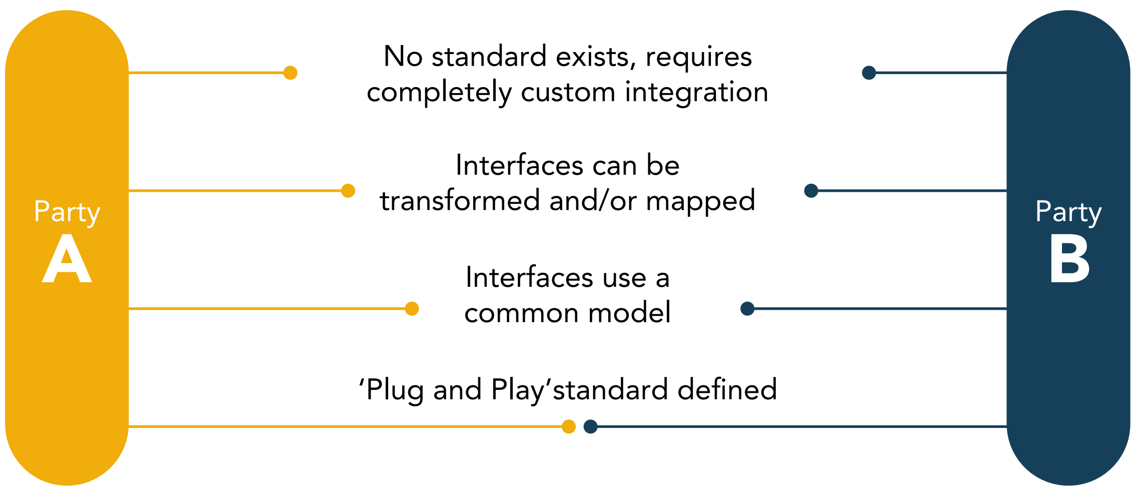
**ITS (Intelligent Transport Systems) Directive of the European Commission:**
***"'interoperability' means the capacity of systems and the underlying business processes to exchange data and to share information and knowledge."***

Interoperability has many benefits that improve the deployment and implementation of EV charging systems and services. Some of the benefits include:

- Primarily, no conversion / translation services / components are required, reducing installation and integration costs.
- Efficient scale-up of services by reusing interoperable components.
- Efficient development of new services with limited reliance on third parties.
- Promotes a competitive market environment, preventing technology "lock-ins". A fair competition leads to better comparisons of offers.
- Price transparency, under the same competitive conditions, levels the playing field shifting competition to price and reliability providing more properly developed offerings.

In the existing literature, such as the Gridwise Architecture Council (GWAC) that was formed by the U.S. Department of Energy (see annex 1), gradations of interoperability have been identified as given in the below figure. From a custom-made interface to a common interface (protocol), to a seamless 'plug and play' standard that directly connects 2 systems: different gradations of interoperability can be developed.

**Figure 1. Gradations of interoperability (GWAC 2008)**



## 1.2 Definition of Openness

Interoperable systems still allow the introduction and use of proprietary tools, standards or protocols. The use of such proprietary tools can lead to additional costs, IP claims or proprietary development processes. Proprietary standards may have the advantage of a more rapid implementation, adoption and use, but on the other hand they might create some restrictions and dependencies that will ultimately inhibit the growth of the market sector. To avoid blocking such market growth, standards and protocols must be open and free to use.

Standard development has several stages where openness can be applied. Openness is a broad concept that can refer to the possibility of having multifarious access to protocol development and implementation, neutral coordination and decisions, manufacturing processes, among others. The Institute of Electrical and Electronics Engineers (IEEE), the Internet Society (ISOC), the World Wide Consortium (W3C), the Internet Engineering Task Force (IETF) and the Internet Architecture Board (IAB), jointly affirmed a set of principles: the “OpenStand Principles”. The OpenStand Principles define open standards and establish the building blocks for innovation in the context of the internet, but they serve also to relate the concept of openness in the context of e-mobility.

**Openness**

**Openness is a broad concept that can refer to the possibility of having multifarious access to protocol development and implementation, neutral coordination and decisions, manufacturing processes, among others.**

Openness is also identified as one of the six principles for the development of international standards, guides, and recommendations by the World Trade Organization’s Committee on Technical Barriers to Trade (WTO TBT). Below the six principles are presented:

### 1. Transparency in communication and information.

“All essential information regarding current work programmes, as well as on proposals for standards, guides and recommendations under consideration and on the final results should be made easily accessible” to all relevant parties.

### 2. Openness in the development of standards.

There should be an open membership on a non-discriminatory basis at every stage of standardization process, and “any interested member of the standardizing body (…) with an interest in a specific standardization activity should be provided with meaningful opportunities to participate at all stages of standard development.”

### 3. Impartiality and consensus in decision making which means no privilege or favoring interests of a particular party.

### 4. Effectiveness and relevance referent to facilitating international trade and preventing unnecessary trade barriers.

"Standards need to be relevant and to effectively respond to regulatory and market needs, as well as scientific and technological developments. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development. In addition, they should not give preference to the characteristics or requirements of specific countries or regions when different needs or interests exist in other countries or regions."

### 5. Coherence avoiding duplication and overlap with other the work of other standardization bodies.

In this respect, cooperation and coordination is essential.

**This set of principles certainly defines open and interoperable EV charging systems, standards and protocols.**

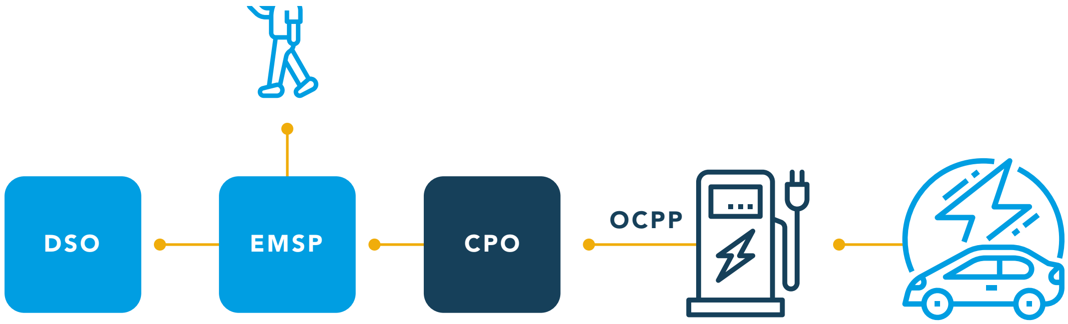
### 6. Inclusion, or a development dimension as stated by the WTO.

This dimension looks for "tangible ways of facilitating developing countries participation in international standards development (..). The impartiality and openness of any international standardization process requires that developing countries are not excluded de facto from the process."

#### 1.2.1 The Open Charge Point Protocol (OCPP) As An Example of Openness

One tangible and explicit demonstration of openness and interoperability within EV charging systems is the Open Charge Point Protocol (OCPP). The OCPP is an application protocol for communication between EVs, the charging stations and a central management system. The OCPP enables switching the management system from one charging station operator to another without going through the hassle of replacing or changing any hardware. The central management system typically determines aspects such as access, pricing, load profiles, and many more that allow for operating an EV charging station. The OCPP allows any operator's management system to work with any charging station allowing open market dynamics; OCPP is truly an interoperable protocol. OCPP has been developed exactly for the purpose of enabling openness and interoperability within EV charging infrastructure and services. Following the principle of openness, the OCPP does not favor a particular or a specific market model. The principles presented in the previous section drive the openness of the OCPP because everyone has the possibility to contribute to the development of the protocol, decision making, and management remains impartial and is consensus driven at any stage of development and based on transparency over the information and communication. The Open Charge Alliance (OCA) is the global consortium responsible of managing the OCPP. Currently, the ISO standard ISO63110 is being developed in parallel to the market standard OCPP, to create a formal standard for this interface. The expectation is that it will take some years before this formal standard will be published. Given the current high market penetration of OCPP, it would be most efficient if ISO63110 would follow this design.

**Figure 2. Architecture and generic implementation of Open Charge Point Protocol**




Some of the main advantages of the OCPP are:

- Enables charge point/station owners to easily change charge point operators at any moment without the need of replacing or abandoning any charge station assets.
- Enables cost-effective network services (such as demand response) using common communication between charging stations and power network operators.
- Encourages customers to own an electric vehicle by providing integrated access to charging stations, roaming and billing services.

## 1.3 Definition of EV Roaming

Roaming is a concept that was initially used in the telecommunications sector. ISO 26927 defines roaming as "*service that enables users/terminals to use access networks and mobility services of a network operator which is different from the operator of the user's home domain*". In the context of electric mobility, the term EV roaming has been coined and it refers to allowing an EV user to have a subscription with operator/service provider A and charge the electric vehicle at a charging station operated by operator B, with whom the EV driver does not directly have a contract. To allow EV roaming, operator A must have a contractual agreement of collaboration with operator B, allowing their EV users to seamlessly use either operator's charging infrastructure without the necessity of having subscriptions or contracts with both operators. The minimum elements necessary to allow EV Roaming are hereby presented:

- **A contractual agreement between the parties involved.** Such agreement can be either direct (bilateral) or indirect (via a roaming platform or similar aggregators).
- **An internet connection at the charging point** allowing direct authentication and charging information exchange.
- Any function for **remote authentication and activation** like and RFID card reader, a token or any other similar.
- Interoperable hardware, software systems, and communication protocols, like the OCPP, to facilitate the authentication mentioned above and activation functionalities.

As mentioned in the previous section, ISO is currently developing standard ISO63119 to describe EV roaming. The final standard will most likely follow the market best practices. The definition of roaming as proposed by the ISO63119 standard is:

## Roaming

**Information exchanges and related provisions between e-Mobility Service Providers (MSPs), which allow EV users to use a single credential and contract to access services on multiple e-mobility networks and contract to access the charging services provided by multiple MSPs or CPOs through roaming endpoints”**[1]

To fully understand such definition, the concept of e-Mobility Service Provider (MSP) is explained. An MSP is a company where EV users have contracts for services related to EV charging. MSP’s do not necessarily own or operate EV charging infrastructure, but still have several responsibilities in the value chain of EV charging services, such as providing authentication means for EV users (RFID cards or apps), providing information platforms (to display the location and navigation indications to find charging points), roaming network management, customer management, billing, and handling charging processes to EV users.

In section 1.3.1, examples are given to illustrate better the case of EV roaming in more detail.

Like the OCPP presented in the previous section, there are multiple interoperable protocols in the market available to facilitate roaming, in varying degrees of openness. For example, the Open Charge Point Interface (OCPI) protocol OCPI that “*supports connections between eMobility Service Providers who have EV drivers as customers, and Charge Point Operators who manage charge stations*”. (EV Roaming Foundation, 2021). A more thorough explanation of such protocols will be given in section 1.3.2.

1. The abbreviations have been changed to fit the definitions used in this document

### 1.3.1 EV Roaming Examples

#### 1.3.1.1 Case 1: No Roaming

A simple ecosystem without roaming, often only involves a single transaction between the EV user and the Charge Point Operator (CPO):

1. The EV user connects the EV to the charging station.
2. The EV user authenticates himself and gets approval from the CPO. (via RFID, app, or any other means offered by the CPO)
3. The charging session takes place.
4. The EV user pays the CPO, by any means made available by the CPO.

#### 1.3.1.2 Case 2: Roaming Between Operators

This case applies when a customer of a particular charge point operator wants to use the charging station network of another CPO. The roaming process will follow these steps:

1. 1 The EV user has a subscription with CPO-1.
2. 5 The EV user connects the EV to a charging station from CPO-2.
3. 1 The EV user authenticates himself at the charging station of CPO-2. (via RFID, app, or any other means offered by CPO-2)
4. 2 CPO-2 checks the authentication with CPO-1 under the following parameters:
    - Is there a contractual agreement between CPO-1 and CPO-2?
    - Is the user known at CPO-1 and allowed to charge at CPO-2's charging station?
    - If positive, the EV user receives approval from CPO-2 to charge.
5. 3 The charging session takes place,
6. 4 The EV user pays the retail price to CPO-1 via post-payment (monthly invoice)
7. 5 CPO-1 pays CPO-2 the wholesale price according to the conditions agreed in the contract between the CPO's.

### 1.3.1.3 Case 3: Roaming Between Operator and Service Provider

If an e-mobility service provider (MSP) wants their customers to use the charging station network of a certain CPO, EV roaming follows the process described below:

1. The EV user has a subscription with the MSP, that does not own or operate charging stations but has agreements with several CPO's.
2. The EV user connects the EV to the charging station from a CPO.
3. The EV user authenticates himself at the charging station of the CPO (via RFID, app, or any other means offered by the CPO at the charging station)
4. CPO checks the authentication with MSP under the following parameters:
   - Is there a contractual agreement between the CPO and the MSP?
   - Is the user known at the MSP and allowed to charge at the CPO's charging stations?
   - If positive, the EV user gets approval from the CPO to charge.
5. The charging session takes place,
6. The EV user pays the retail price to the MSP via post-payment (monthly invoice)
7. The MSP pays the CPO the wholesale price according to the conditions agreed in the contract between them.

### 1.3.1.4 Roaming Via a Hub or Via Multiple Connections

The above cases describe a direct relationship between CPO and CPO, or CPO and MSP. In a mature market there can be many relationships between market actors to enable roaming. Roaming platforms can play a valuable role in connecting all market players. Also, large CPO's or so-called aggregators fulfill a similar role for smaller players, offering back-end services to connect them to the other market actors.


## 1.3.2 Interoperable Protocols in the Market

As discussed above, when multiple connections occur between market players in an open market, these protocols must be interoperable and open. Market models are still developing, so it is also valuable that prescribed protocols are agnostic to a specific market configuration.

### 1.3.2.1 OCPP

The de-facto standard information protocol between the charging station and the operator's management system is the Open Charge Point Protocol (OCPP), managed by the Open Charge Alliance. All leading charging stations manufacturers support OCPP. Operates as described in section 1.2.1.

### 1.3.2.2 OCPI and Other Roaming Protocols

The Open Charge Point Interface (OCPI) protocol is used to exchange information between the charging point operator (CPO) and the mobility service provider (MSP), but also with other market operators who require EV information. The OCPI protocol is used to set up a direct connection between two parties (a peer-to-peer connection) or to communicate with several roaming service providers such as Gireve, eClearing and Hubject.

The OCPI protocol supports the exchange of information on locations, tariffs, authorizations and charging transactions. It also supports the information exchange for smart charging. Internationally, it is increasingly becoming the 'de facto' standard for exchanging information between parties in the EV market.

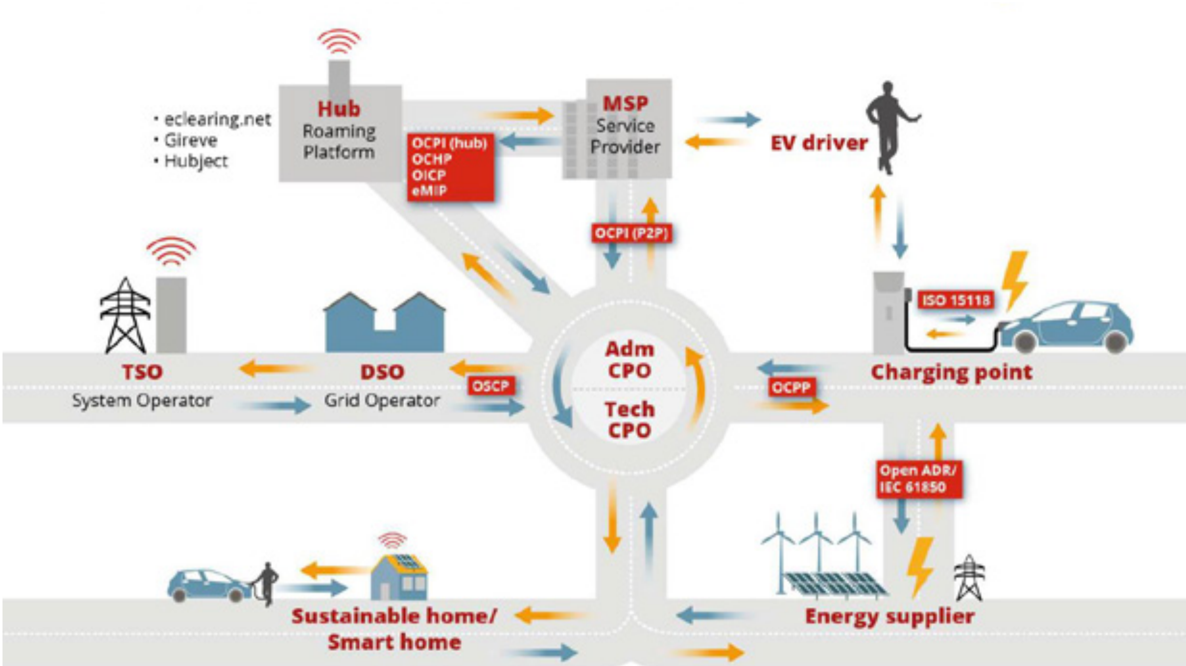
The roaming service providers, or roaming platforms, each provide their own roaming protocol to be used with their platform. These protocols are however limited to the specific platforms.

## 1.3.3 The charging infrastructure ecosystem

The electric vehicle charging infrastructure sector has developed to a level of standardization in roles and functions that have been adequately described for people new to the topic.

The following figure illustrates the ecosystem graphically, describing roles, relationships and protocols used for information exchange:

**Figure 3. The charging infrastructure ecosystem (EVRoaming Foundation)**

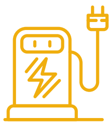



In the figure, the following objects/actors can be identified:

- The electric vehicle with a specific plug
- The charging station:
    - One charging station can have multiple charging points or EVSE (Electric Vehicle Supply Equipment).
    - One charging point has one or more connectors (but only one of these can be active simultaneously).
- The EV driver.
- The operator of a charging point (CPO or Charging Point Operator).
- The provider of user services such as a subscription or other information services. (MSP or Mobility Service Provider)
- The Hub, or roaming platform, delivering roaming services.
- The grid operator (DSO or Distribution System Operator).
- The central grid operators (TSO or transmission system operator).
- The Energy supplier for the charging stations.
- A sustainable home, or other object with an energy management system, with which a charging station can be connected.

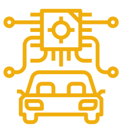
## 1.4 Roaming and interoperability layers

Roaming for electric vehicles depends on multiple elements in the value chain in order to be successful:



### The hardware layer

The connectors and plugs of electric vehicles and charging stations need to be interoperable

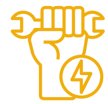


### The communication layer

All hardware and software systems, that are steering and controlling the hardware, need to communicate seamlessly with each other

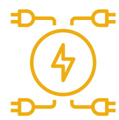
### The information layer

The information that is being exchanged between actors and systems needs to be recognized and interpreted to be meaningful



### The service layer

Business processes and services between actors need to be aligned to provide seamless and user-centric services



### The business layer

A clear regulatory and business framework needs to be defined to provide a predictable context for governments, businesses, grid operators, and EV drivers, among other actors, to develop and grow interoperable EV charging services

The table below gives an overview of these layers of interoperability for EV charging. This layered approach is mainly inspired by previous work done on the Smart Grid Architecture Model as developed by the European standardization organization CEN-CENELEC.

Together, the layers of interoperability define interoperability of the EV charging ecosystem: connecting business processes and systems to exchange information and provide a seamless EV charging service such as roaming. This overview is helpful when assessing interoperability for EV charging infrastructure at sub-national, national, and international levels.

It provides public governments and businesses who are working on improving electric mobility and EV charging infrastructure with a framework for adequate regulation, contracting procedures and the development of systems, standards, and protocols to assure the interoperability and thereby the emergence of a mature market with broad accessibility for all stakeholders.

**Table 1. Interoperability Layers**

| EV interoperability layer | Interpretation | Description |
|---|---|---|
| **Business layer (Market and government)** | The market configuration, policy and regulatory framework. | The business model (processes and requirements, market roles and responsibilities, financial agreements, liability, etc.) is designed to facilitate contract models and collaboration models (e.g., tenders, permits) business-to-business and business-to-government.<br><br>EV Roaming and other services around EV Charging are being facilitated/required by a policy framework, such that businesses and customers can rely on these services |
| **Service layer (EV Roaming)** | EV charging services, functions, and their relationships are described in use cases. | Service-driven use cases are being described, such as EV Roaming, Pricing, Payment, Metering, Smart Charging, and other information services. |
| **Information layer** | Information objects, underlying data models and protocols that are being used for information exchange | A common data model and semantics are in place to exchange information and to deliver aggregated, insights and overviews to end-users<br><br>Systems exchange meaningful messages between each other in an open fashion, regardless of specific hardware or software, using open communication protocols such as OCPP, OCPI |
| **Communications layer** | Connections between hardware and software systems, via ethernet, wireless or via charging cable | All systems can exchange information, regardless of hardware and software involved, making use of standard information protocols such as TCP/IP, 3G or the J1772 protocol |
| **Hardware layer** | Hardware of the ecosystem | Charging stations, connectors and plugs and other hardware elements are designed such that every EV can connect and electricity can be provided, regardless of the type of vehicle or charging station |

# 2. Cases of Interoperability

## 2.1 Current status of e-Mobility Development in the Region

Countries across Latin America are starting to adopt different measures to reduce their greenhouse gas (GHG) emissions and reach their Paris Agreement goals. Electric mobility is one of such measures that go along with the penetration of renewable energy into each country's energy mix. The advancement of e-mobility can clearly be reflected in the development of charging infrastructure, EV sales, and existing regulation to incentivize the EV market and development of new infrastructure and services around e-mobility. The following tables show some figures that reflect how EV penetration, and the development of charging infrastructure are advancing in LAC.

**Table 2. General EV Market Information per Country**

| Country | Country Population | Total # of passenger cars | BEV | PHEV | Total EV cars | EV as % of total # cars | EV per 100k inhabitants |
|---|---|---|---|---|---|---|---|
| **Chile** | 19,116,209 | 3,661,236[2] | 1,238 | 593 | 1,831[3] | 0.05% | 9.5 |
| **Colombia** | 51,049,498 | 6,701,970[4] | 4,542 | 2,984 | 7,526[5] | 0.11% | 14.7 |
| **Costa Rica** | 5,047,561 | 834,245 | 2,651 | 80 | 2731[6] | 0.20% | 30 |
| **Dominican Republic** | 10,500,000 | 1,511,213[7] | 1,577 | 229 | 1,806[8] | 0.12% | 17.2 |
| **Ecuador** | 17,706,066 | 1,549,299 | 462[9] | | 462 | 0.03% | 2.6 |
| **Guatemala** | 14,901,286 | 832,169 | 17[10] | | 17 | 0.03% | 0.11 |
| **Mexico** | 126,014,024 | 34,281,913 | 4,546 | 6,469 | 11,015[11] | 0.03% | 8.7 |
| **Nicaragua** | 6,518,478 | 403,099 | 6 | 0 | 6 | 0.00% | 0.09 |
| **Panama** | 4,278,500 | 953,261 | 67 | 1,963[12] | 2,030 | 0.21% | 47.4 |
| **Paraguay** | 7,133,000 | 1,655,269 | 98 | 296 | 394[13] | 0.03% | 6 |
| **Uruguay** | 3,500,000 | 584,094 | 127 | 1930 | 2057[14] | 0.02% | 4 |
| **El Salvador** | 6,453,553 | 1,259,038 | 37[15] | | 37 | 0.003% | 1 |

2. Data from December 2020. Latest Published by the National Statistics Institute of Chile. (INE) (INE, 2020)
3. Data from December 2021. Asociación Nacional Automotriz de Chile. (ANAC, 2021)
4. This includes buses, vans, trucks, among others. Not motorcycles. Updated on June 30, 2021. (RUNT, 2021)
5. Data from December 2021. (ANDEMOS, 2021)
6. Data of BEVs up to December 2021. PHEVs data from customs agency by September 2021. (MINAE, 2022) (Ministerio de Hacienda Costa Rica, 2021)
7. Data from December 2020 including only automobiles and jeeps. (DGII, 2021)
8. Data from December 2021. (Vehículos Eléctricos RD, 2022)
9. No data discriminating BEVs and PHEVs was reported. Data from December 2020. (AEADE, 2021)
10. No data discriminating BEVs and PHEVs was reported.
11. BEV data includes 3,000 Tesla from non-official sources because Tesla does not report to the AMIA. Data from June 2021. (AMIA, 2021)
12. Data for hybrids doesn't clearly identify PHEV's. Data from Panama from 2021. (SEN, 2021)
13. Data from October 2021. (DNA, 2021)
14. BEVs includes taxis. PHEV data includes HEVs. Data from December 2020. (MIEM, 2021)
15. No data discriminating BEVs and PHEVs was reported.

**Table 3. Public EV Charging Infrastructure per Country**[16]

| Country | # of normal public chargers (<=22kW) | # of fast public chargers (>22kW) |
|---|---|---|
| Chile | 261 | 37 |
| Colombia | 140 | 62 |
| Costa Rica | 30 | 34 |
| Dominican Republic | 186 | 88 |
| Ecuador | 32 | 2 |
| Guatemala | 48 | 0 |
| Mexico | 2100[17] | |
| Nicaragua | 0 | 0 |
| Panama | 37 | 13 |
| Paraguay | 13 | 5 |
| Uruguay | 77 | 59 |
| El Salvador | 2 | 0 |

In general, in Latin American countries, as shown above, EVs requiring charging infrastructure are just a tiny fraction of the whole passenger car fleet of the country. Also, it shows that the development of charging infrastructure is in its early stages in the region. Amid such early stages of development for e-mobility in the region, this hasn't stopped governments from making efforts to develop regulation to incentivize the growth of the EV market, the development of charging infrastructure and the appearance of new services and business models.

Such government efforts and their political commitments towards climate change have created a series of drivers to bolster e-mobility in each country. Those changes have drivers such as supporting a solid automaker industry in Mexico, relieving gas subsidies in Ecuador, and mostly achieving a successful energy transition in a region with a good potential for including renewables into their energy mix and achieving their NDCs and climate goals.

For instance, Chile, setting the year 2007 as the baseline, aims to reduce by 30% its $CO_2$ emissions. This means that 100% of the public transport buses should be electric by 2040, and 40% of their total passenger vehicle fleet should be EVs by 2050. Colombia seeks to have 600,000 EVs in its streets by 2030, and in general their new NDC goals aim to reduce 51% of $CO_2$ emissions. Dominican Republic aims to reduce 25% of their $CO_2$ emissions by 2030, taking 2010 as the base year, and electric mobility is seen as a favorable measure to achieve such goals. Uruguay's NDC mentions the following actions regarding e-mobility: a) introduction of electric vehicles in public transport, 15 buses and 150 taxis by 2025 (these were achieved in 2020 by 100% for buses and 45% for taxis). b) Introduction of light commercial electric vehicles, 150 units by 2025, achieved in 2019, and c) Installation of the first electrical route of Latin America (installing charging systems for electric vehicles in the national routes that connect Colonia-Montevideo-Chuy, which was achieved in 2018).

16. Sources and comments for the data in this table are included in the Bibliography and Literature section.
17. Data from the Federal Commission of Electricity with no discrimination between slow and fast charging.

**Having governments with clear goals moving forward with clear actions to deploy e-mobility in the region is a perfect prelude for interoperability. However, the configuration of the energy market in each country and their perspectives over EV charging services also play a fundamental role in how countries set up a conducive environment for having interoperable EV charging ecosystems.**

## 2.2 EV Charging Services Market in Latin America

To characterize the different EV charging Services in the region, it is essential to understand how the electric energy sector is configurated and how EV charging services are conceived under such electric energy sector.

### 2.2.1 Electric Energy Sector Topologies

The different configurations of the electricity sectors across the region vary in the plurality of actors performing the various activities of the value chain of the electric energy service (generation, transport, distribution, and retail)[18]. Also, the dominance of single actors at a national level or in defined regions establish different setups for the electric energy sector. Such different topologies of the energy sector in each country directly impact the complexity of establishing sectorial agreements or regulation regarding interoperability because of the number of actors involved and affected.

Photo: ASOMOVE

Three different topologies or arrangements of the electric energy sector are given below that will help to characterize the analyzed countries in the region. The variety of actors involved in each of the value chain activities and their national or regional dominance will define or characterize each specific topology.

18. In some countries, the retail activity is included in distribution.

#### 2.2.1.1 National and Vertically Integrated

This topology of the electricity sector arrangement is commonly found in countries with relatively small areas. In this setup, a single electricity company or utility controls the electricity value chain nationwide, i.e., generation, transmission, distribution, and retail. In several cases, such companies are public or state-owned. Additional stakeholders may also be part of the electricity value chain (especially in generation, distribution and/or retail). However, the vertically integrated utility is predominant in the national electricity market.

#### 2.2.1.2 Sub-national and Closed

This topology is similar to the national and vertically integrated utility. The main difference is that the scope of control is at a sub-national level instead of a national level. This means that multiple electricity companies may operate within a single country. Although a variety of actors are found along the value chain, the main characteristic is the strong dominance at a sub-national level, especially in the distribution and retail activities given in concession or are regulated in such way that it impedes the appearance of new actors.

#### 2.2.1.3 Open Market

In what this document calls an open market, regulation leaves the electric energy sector as an open market in which either public or private actors may perform any of the different activities of the value chain across the different regions of the country. This means that a company may be specialized in the generation activity and not have any assets to transport or distribute energy and still participate in the value chain. Also, companies can be set up to only perform retail of energy without being involved in generation, transport, and distribution by owning and operating such assets. Even though this kind of topology complicates having sectorial agreements and setting up regulation, it is beneficial as it welcomes new actors that may bring innovative business models and ideas regarding EV charging services which is beneficial for the deployment of EV interoperability.

Photo: ASOMOVE

**Table 4. Characterization of countries by the energy market topology**

| Country | National & Vertical | Sub-National & Closed | Open Market |
|---|---|---|---|
| Argentina | | | ■ |
| Chile | | | ■ |
| Colombia | | | ■ |
| Costa Rica | ■ | ■ | |
| Dominican Republic | | ■ | |
| Ecuador | | ■ | |
| El Salvador | | | ■ |
| Guatemala | | | ■ |
| Honduras | ■ | | |
| Mexico | ■ | | |
| Nicaragua | | ■ | |
| Panama | | ■ | |
| Paraguay[19] | ■ | ■ | |
| Uruguay | ■ | | |

These topologies help us to classify the country's electricity markets, but it doesn't mean it helps to define precisely how they are configurated. The following table helps to understand better how the markets in each country are configurated and why they are classified in each of the topologies above.

19. Just in distribution and retail two different companies were created and established before current regulation was put in place.

**Table 5.Characterization of electricity markets in selected Latin American and Caribbean countries**

Single company (blue) | Multiple companies (yellow)

| Country | Generation | Transmission | Distribution | Retail | Description |
|---|---|---|---|---|---|
| **Argentina** | Multiple companies | Multiple companies | Multiple companies | Multiple companies | Public and private companies participate in the generation, transmission, and distribution. Distribution and retail are geographically allocated with the participation of public (provincial) and private companies. |
| **Bolivia** | Multiple companies | Multiple companies | Multiple companies | Multiple companies | Generation is performed by private and nationalized companies. Meanwhile, transmission, distribution and retail are geographically allocated to private and nationalized companies. |
| **Chile** | Multiple companies | Multiple companies | Multiple companies | Multiple companies | The electricity system was privatized in 1980 and it is unbundled. There are several private companies along the electricity value chain. |
| **Colombia** | Multiple companies | Multiple companies | Multiple companies | Multiple companies | Private power producers own most of the generation assets. Transmission is served by seven public companies, some of which participate in other segments of the national electricity value chain. Distribution and retail are unbundled. |
| **Costa Rica** | Multiple companies | Single company | Multiple companies | Multiple companies | A state-owned electric utility predominates in generation and complete control of the transmission. Private power producers and electricity distribution companies also participate in power generation. Distribution and retail are geographically allocated between eight companies, including the national state-owned utility. |
| **Dominican Republic** | Multiple companies | Single company | Multiple companies | Multiple companies | Private power producers own most of the generation assets. A state-owned company is in charge of transmission. Distribution and retail are done by three private companies managed by the government that are geographically allocated. |
| **Ecuador** | Multiple companies | Single company | Multiple companies | Multiple companies | Public and private companies participate in the generation. A state-owned company is in charge of transmission. Distribution and retail are in concession to various (mostly public) companies. |

| | |
|---|---|
| **El Salvador** | Private power producers own the majority of the generation assets. A state-owned company is in charge of transmission. Although there is no territorial exclusivity, distribution and retail are geographically allocated among five companies[20]. |
| **Guatemala** | The power market in Guatemala is unbundled. The country has several private and state-owned companies along its electricity value chain. |
| **Honduras** | Private power producers own the majority of the generation assets. The national state-owned utility participates in generation and is in charge of transmission. A private company is in charge of distribution and retail. The country also has isolated systems run by independent companies in its islands in the Caribbean. |
| **Mexico** | A National state-owned electric utility predominates on generation and complete control of transmission, distribution and retail. Mexico's energy reform unbundled the generation, and private companies can participate in a wholesale market. |
| **Nicaragua** | The power sector is unbundled and different (public and private) companies participate in generation, distribution and retail. A state-owned company is in charge of transmission. |
| **Panama** | There is a wholesale market in the generation. A state-owned company is in charge of transmission. Distribution and retail are geographically allocated among the two companies. |
| **Paraguay** | A state-owned electric utility controls the national electricity value chain (Law Nº. 966). Participation of private power producers is allowed (Law Nº. 3.009), but none are registered due to complex requirements. |
| **Peru** | Private power producers own most of the generation assets. Several private companies also control transmission. Distribution and retail are also divided among several companies. |
| **Uruguay** | A state-owned electric utility has control over the national electricity value chain. Participation of private power producers is allowed through auctions. |

20. http://www.sc.gob.sv/uploads/est_24_inf.pdf

## 2.2.2 The Conception of EV Charging Services

The definition of how EV charging services are being conceptualized in each country directly affects the possibility to deploy interoperability strategies in each country. When speaking in an electric energy sector context, the main discussion around EV charging services is if it should be considered as a different service from the electric energy supply service. Considering EV charging as a different service than electric energy supply, will determine if there will be enabling conditions for the appearance and participation of new actors specialized in EV charging services which will bring innovative business models, technology and knowledge that helps to deploy interoperability much faster.

Countries may be classified or characterized on three different categories regarding this topic:

### 2.2.2.1 EV Charging Services as Electric Energy Supply

These are countries where the regulation establishes that EV charging services should be treated the same as the electric energy supply service. Therefore, only actors allowed to retail electric energy supply will be allowed to provide EV charging service. In this category we could also place countries in which serious or advanced discussions at a high level have taken place in this direction regarding EV charging services.

### 2.2.2.2 EV Charging Services as a Different Service than Electric Energy Supply

The countries where regulation has established that EV charging services should be considered different and separate from the electric energy supply service, allowing any actor outside of the electric energy sector value chain to participate in the EV charging services market. In this category we could also place countries in which serious or advanced discussions at a high level have taken place in this direction regarding EV charging services.

### 2.2.2.3 Not Existent

Countries where EV charging services integration into the electric energy sector have not been discussed, are placed in this final category. This means that no official stance or serious high-level conversations have taken place, so it is undetermined how EV charging services will be considered in such a country.

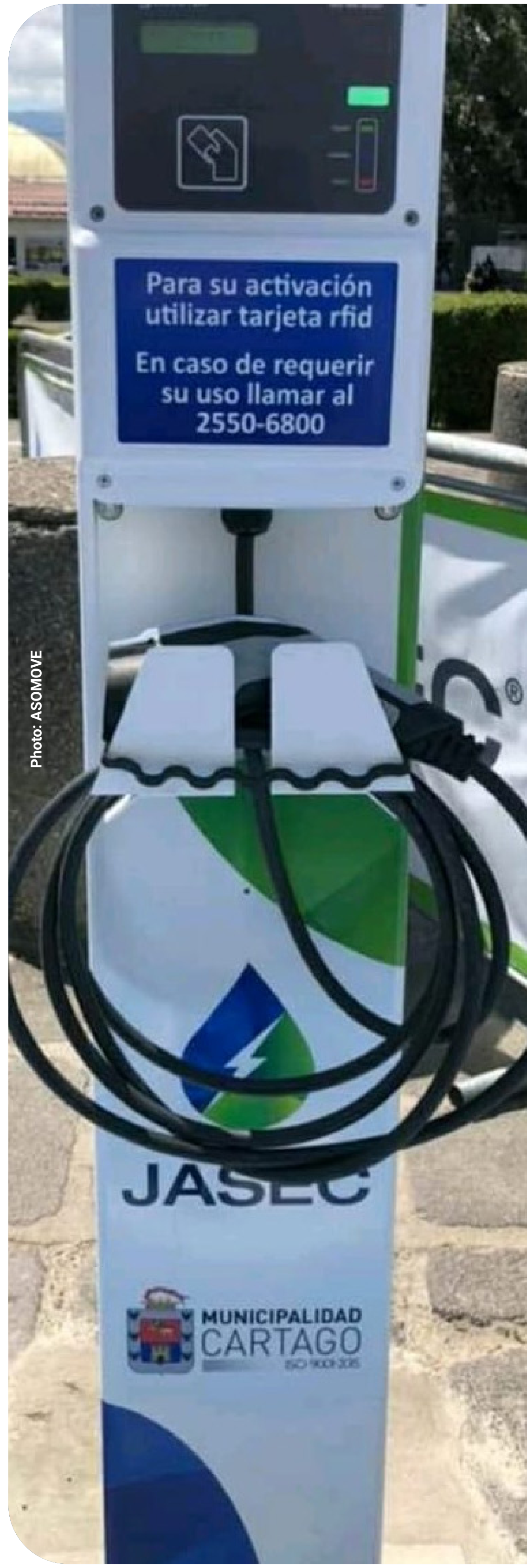


Photo: ASOMOVE

Characterization of countries depending on the conception of EV charging services:

**Table 6. Characterization of LAC Countries Regarding the Concept of EVE Charging Services**

| Country | EV Charging as Electricity Supply | EV Charging different than Electricity Supply | Not Existent |
|---|---|---|---|
| **Argentina** | | | ● |
| **Chile** | | ● | |
| **Colombia** | | ● [21] | |
| **Costa Rica** | ● [22] | | |
| **Dominican Republic** | ● [23] | ● [24] | |
| **Ecuador** | | ● [25] | |
| **El Salvador** | ● [26] | | |
| **Guatemala** | | | ● |
| **Honduras** | ● | | |
| **Mexico** | | | ● |
| **Nicaragua** | | | ● |
| **Panama** | ● | ● [27] | |
| **Paraguay** | ● [28] | | |
| **Uruguay** | ● [29] | | |

21. Article 3. Ministry of Mines and Energy Resolution 40223 of 2021
22. All EV Charging stations are owned by the ICE which is the nationwide network operator
23. Also, current regulation doesn't allow actors outside distributors provide EV charging services, conversations are taking place to allow new actors to enter the EV charging services market.
24. Players like Evergo and other privates are installing charging points all around the country and providing EV charging services in the middle of a lack of regulation to establish who can or cannot deploy EV charging stations and provide EV Charging Services.
25. The Energy Efficiency Organic Law of 2019 in its first reformatory disposition modifies article 43 of the Electric Energy Public Service Organic Law establishing that EV charging services are an exception to energy distribution and retail. https://www.regulacionelectrica.gob.ec/wp-content/uploads/downloads/2020/03/0719_19-2020_02_18-Reg-Contrato-Comercializaci%C3%B3n.pdf
26. Article 13 of the Electric Mobility Law of El Salvador
27. Although current regulation doesn't allow other actors besides energy distribution companies to retail energy or provide EV Charging Services, the Interinstitutional Electric Mobility Commission has voted on favor on a Proposal over Regulation and Standards for EV Charging Infrastructure where the idea of having new actors allowed to provide EV Charging Services is being considered.
28. ANDE is the current energy distributor and the actor allowed to provide any energy retail services.
29. All EV Charging stations are owned by the UTE which is the nationwide network operator

## 2.3 EV Interoperability and Energy Market Configurations

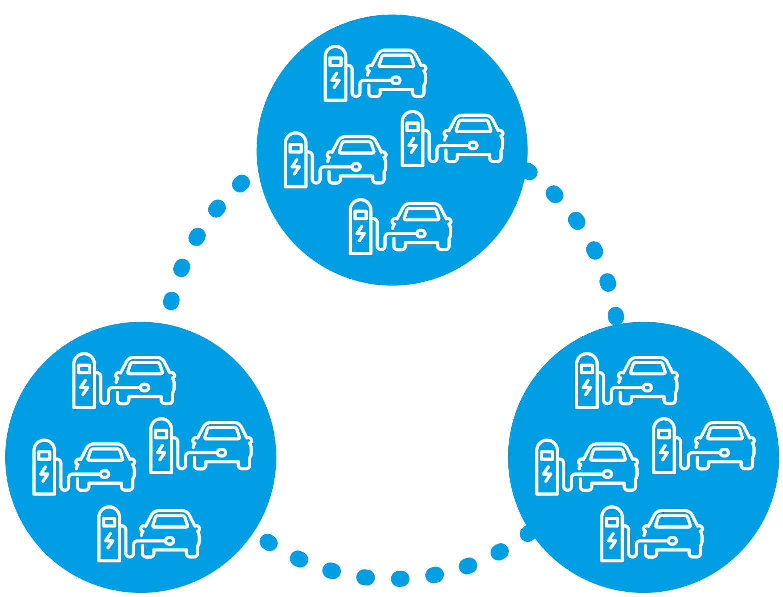
We have seen that different energy market configurations have a different impact on setting up EV charging services. When observing interoperability for EV charging, there is a relationship between the energy market configuration and the level and type of interoperability. In the below sections, three typical cases with different configurations are being discussed and their current level of interoperability. The descriptions and examples are based on an analysis of reference countries and desk research. The specific interoperability properties will be explained using the layers of interoperability approach.

## 2.4 Case 1: Closed Energy Market Configuration

Case 1 consists of a closed energy market configuration with typically one national utility company. This utility acts as an energy supplier and grid operator, directly or indirectly controlled by the government. There is little to no room for commercial players, nor a significant differentiation within the country. Examples of countries that could represent such case are Portugal and Luxembourg.

This model is present in some countries like Uruguay in the Latin-American region. A government authority (utility or otherwise) has responsibility over the grid and the connection of assets. EV charging services are under a single responsibility: both the role of CPO and MSP are being performed by the single utility. Several charging networks exist, and they can even be tendered and operated by different operators, but they all are managed similarly and coordination from a central management system assures access to charging stations. A visual sketch is given below:

**Figure 4. Different charging networks controlled by a single entity**



The level of interoperability for this case can be described using the 'layers of interoperability' approach:

### Hardware and communication layer

Hardware and communication are often standardized as a single entity controls it. As hardware is an international market, international (interoperable) standards usually apply.

### Information layer

Protocols may be standardized as it is an efficient approach for charging network management but are not necessarily interoperable.

### Services layer

Services are regulated, giving EV drivers in the country a standard and predictable customer experience. International EV drivers may not be serviced as they are not recognized by the national utility company. Because of the rapid evolvement of EV charging infrastructure services and no market pressure and business case to offset the cost, there is little incentive to improve the customer experience and develop new services.

Roaming is not relevant as all charging stations are already connected. Pricing and tariffs can be easily standardized.

### Business layer

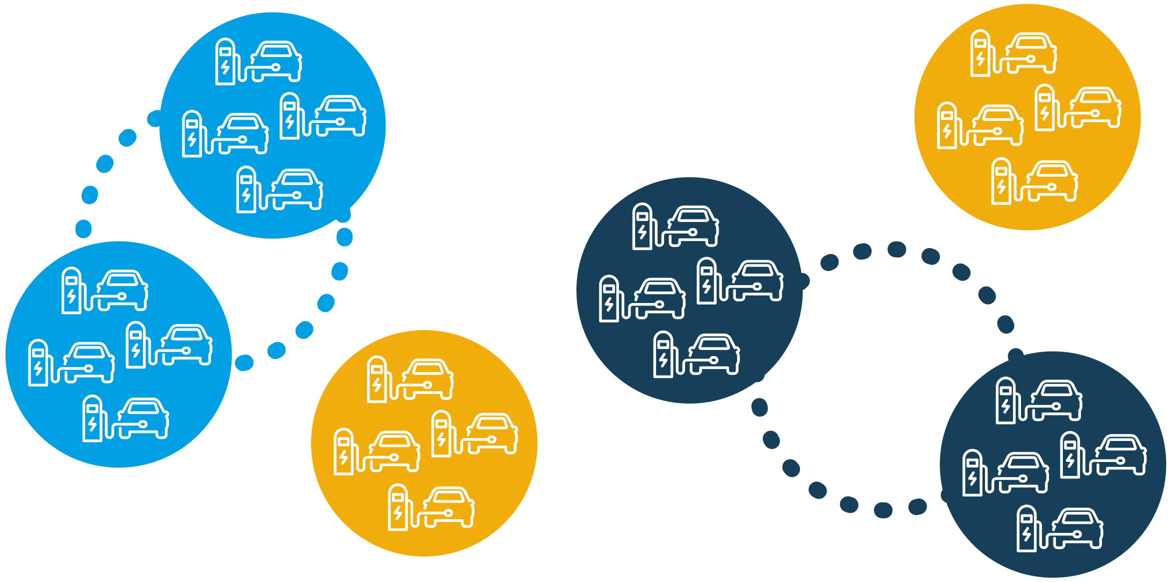
there is a clear and uniform regulatory framework being executed by a government entity. No contractual or market framework is needed. The government, as owner of most parts of the value chain, takes the cost for development and operation.

## 2.5 Case 2: Semi-open Energy Market Configuration

Case 2 consists of a semi-open energy market configuration where there are typically a few government utilities covering a province/state/department or city, as well as some commercial players on local and national level. The public utility is acting both as a grid operator and as an energy supplier providing EV charging services, thereby competing with the commercial players. Local and regional markets are leading within the country. Examples of countries for this case are Germany and France.

This case could be the most common found in the LAC region. In a semi-open energy market configuration, EV charging services are being supplied by commercial players and government-controlled entities. Often the market actors play both the role of the CPO and MSP primarily for their own charging networks and customers. Because of market developments on a local level, different solutions exist that are not necessarily compatible. It takes an effort to connect the various charging networks and develop a standardized EV charging experience for users. A visual presentation is given below:

**Figure 5 Different charging networks controlled by several regional utilities, as well as commercial players.**



The level of interoperability for this case can be described using the 'layers of interoperability' approach as follows:

## Hardware and communication layer

Hardware and communication are often standardized per regional utility. An explicit standardization effort needs to be made by a government to assure interoperability of connectors, smart meters, road signage, and usage instructions. As hardware is an international market, international (interoperable) standards are available.

## Information layer

Protocols are standardized per charging network, but often different solutions exist in parallel. No standardized data model or database is in use. The focus is on its own customer base, with little drive (and investment willingness) to assure roaming across other charging networks. Additional efforts need to be made such as roaming hubs or central datahubs to connect the wide variety of solutions and converge developments towards an interoperable marketplace

## Services layer

Services vary widely per service provider, both in function and quality, making it difficult for customers to cross regions to charge everywhere and have a predictable experience. Because of the diverse evolution of EV charging infrastructure and services at each market actor, it takes an effort for them to cross proprietary and historically grown systems and processes and develop a uniform customer experience in navigation, pricing, charging, etc.

Roaming is extremely relevant to connect the different regions and market players to realize an interoperable charging network, but it is hampered by the variety of market players involved.

**Business layer:** In a semi-open market, both commercial and government-funded actors are developing charging networks and (starting to) compete for the customers. This situation often leads to a non-transparent marketplace with little incentive to collaborate. All actors have an impulse to grow and extend the charging network based on market drivers but are primarily focused on their own (regional) customer base. A robust government framework is needed to assure collaboration and interoperability on a national scale, and to assure a fair and transparent marketplace between the wide variety of market actors.

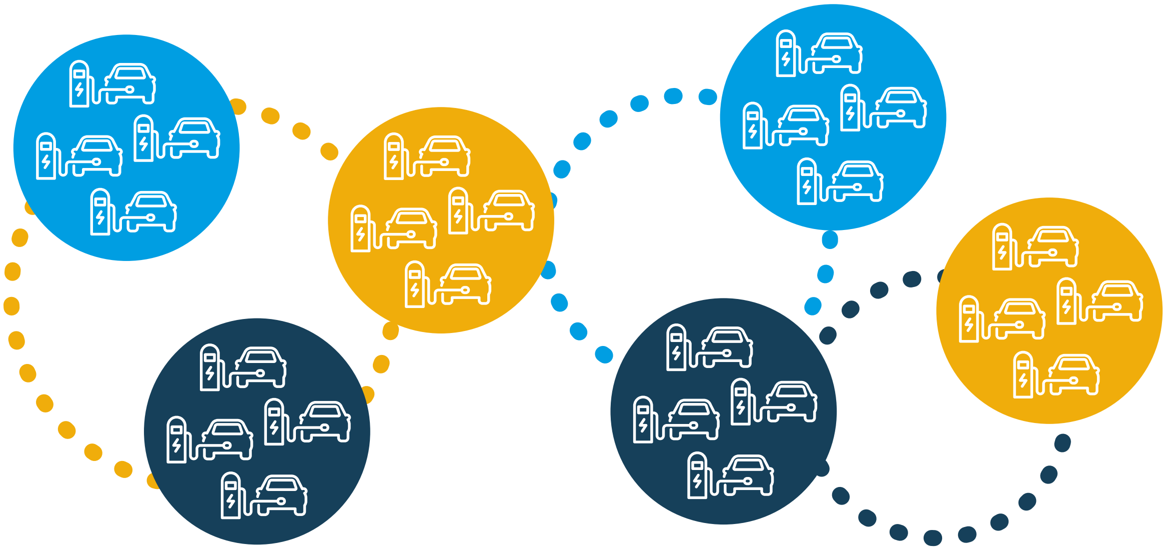
## 2.6 Case 3: Open Energy Market Configuration

Case 3 consists of an open energy market configuration where commercial players drive the market. A clear distinction is made between the commercial actors and the non-commercial (government, network) domain. There is no direct dependency on a specific city or region; therefore, the market will quickly develop to a national scale.

Every commercial player adheres to the same rules and regulations, both new actors and incumbent actors coming from a various business domains such as energy utility, automotive, oil and gas, IT etc. Examples of countries with open energy market configurations are The Netherlands, Norway, and the State of California.

Commercial players are performing EV charging services: market players perform either the role of CPO or MSP or both roles. Different charging solutions may exist, but the competitive environment assures a drive towards delivering an optimal charging service. National and regional governments assure a fair and transparent marketplace. A visual representation of such a case is given below:

**Figure 6. The national charging network consists of multiple commercial actors that perform their activities in an open and transparent marketplace.**



The level of interoperability of the open energy market configuration can be described using the 'layers of interoperability' approach:

## Hardware and communication layer

Hardware and communication is not standardized by definition; in a young market with a lot of freedom, CPO's may try to create a lock-in to protect market share. An explicit standardization effort needs to be made by a government to assure interoperability of connectors, smart meters, road signage, and usage instructions. As hardware is an international market, international (interoperable) standards are available.

## Information layer

Due to the great variety of market actors and the interdependency to provide charging services, there is a need for information exchange in the early market development phases. A focus on cost efficiency will result from early investment in efficient solutions such as interoperable protocols and common data models, although different solutions may exist in parallel. Protocols are standardized per charging network, but often different solutions exist in parallel.

## Services layer

Services vary widely per service provider, both in function and quality, but an open energy market often has experience in developing minimum standards and a level of interoperability to establish a customer-centric EV charging value proposition and create a consistent customer experience in terms of navigation, pricing, charging, among others.

Additional efforts need to be made to establish initiatives such as roaming hubs or central datahubs to connect the wide variety of solutions and converge developments towards an interoperable marketplace.

Roaming is extremely relevant to connect the different market stakeholders to create an interoperable charging network. Different roaming solutions may be developed in parallel (peer-to-peer connections, roaming hubs, direct payment solutions, among others).

Pricing, tariffs, information services, and other service elements are differentiating aspects in the multiple business propositions towards customers and are well developed.

## Business layer

In an open market, all actors are familiar with a level of market regulation and expect a transparent business and regulatory framework to assure a fair competitive environment. There is interest from all actors to grow and extend the charging network based on market drivers, and their own customer base. Therefore, there is usually a strong tendency towards interoperability. A robust government public policy framework is needed to assure collaboration and interoperability and prevent market inefficiencies (which often occur in a young sector) from providing wrong incentives.

# 3. Recommendations for the Development of Interoperability in Latin America and the Caribbean

Based on the analysis of reference countries and the desk research performed, this section contains some observations regarding EV charging interoperability in the LAC region. In the next section, specific recommendations will be made with minimum and optimal interoperability requirements per layer of interoperability and the scale of interoperability being applied: sub-national, national, and international.

## 3.1 Observations

### 3.1.1 General

#### Different contexts

Across Latin America and the Caribbean there are various energy market configurations and maturity levels for EV charging, leading to multiple approaches towards EV charging interoperability.

Often, choices for a specific configuration are directly related to the energy market configuration. Sometimes, the structure of other sectors, such as a dominant automotive or oil and gas sector, influences the EV charging market.

The different energy market configurations per country are often firmly embedded in local regulations and standard practices and will not be easily changed. This is an important prerequisite when looking into the possibilities of EV charging interoperability on a regional level: acknowledging the different starting points per country yet striving for interoperability in a way that fits all countries involved.

#### Scale of interoperability

Interoperability can be viewed at different scales: some countries have developed interoperability on a sub-national scale, assuring that EV drivers in a city or province can charge everywhere. Other countries are developing interoperability on a national scale, ensuring that EV drivers can charge at every charging station from border to border. The optimal level would be to make it possible that EV drivers can travel across borders and have the possibility to charge in a neighboring country. This implies work on the different layers of interoperability and ambition and vision to develop a converging charging network as a region.

#### Scope of interoperability

The perspective of interoperability is mainly focused on light passenger vehicles. Some countries also involve light-duty vehicles and buses; little attention is paid to heavy-duty or special purpose vehicles. It is recommended to treat passenger vehicles and light-duty vehicles as a single group to which the same requirements apply. Buses should be treated separately as these have specific requirements, and trucks also have a different scope.

Photo: Ariel Cecilio Lemus

Photo: Janyer Rolando Gutierrez

There can be an interdependency in modalities, for example when designing a DC charging network, such as charging hubs that will accommodate different modalities.


### Regulation of interoperability

It is strongly recommended to embed some aspects of interoperability in regulation: as it is a system improvement that affects all market actors, government plays a vital role in defining the rules and regulations. Not all aspects of interoperability need to be captured in a regulation; sector organizations or concession/permitting contracts based on standard requirements can provide more details and can provide a stronger base for support and compliance in the market.

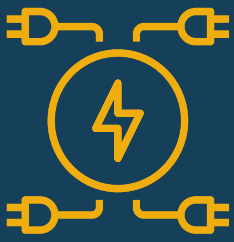
### Interoperability, openness and future-readiness

Interoperability is not by definition the same as openness. It is recommended to use open standards and protocols as much as possible when implementing interoperability. This will ensure a future-proof solution, limit costs and limit the risk of lock-in.

In addition, when looking into interoperable solutions, the recommendation is to use solutions that are not tailored to a specific market configuration. For example, countries that have developed a roaming platform to perform services, may later decide to also allow other roaming solutions, join an international roaming service, or use the current model for other functions such as data aggregation; open protocols will make it easier to do this. The EV charging sector is very innovative and expected to undergo some developments in the coming years, such as new business models, or a move from a semi-open to a fully open market configuration

## 3.1.2 Business Layer

**Countries have either an open, semi-open or closed energy market configuration in the LAC region which may impact each country's roadmap but should not hinder the evolution towards interoperability. Interoperability is also axiomatically an efficiency measure aimed for open, efficient, and future-proof interfaces.**

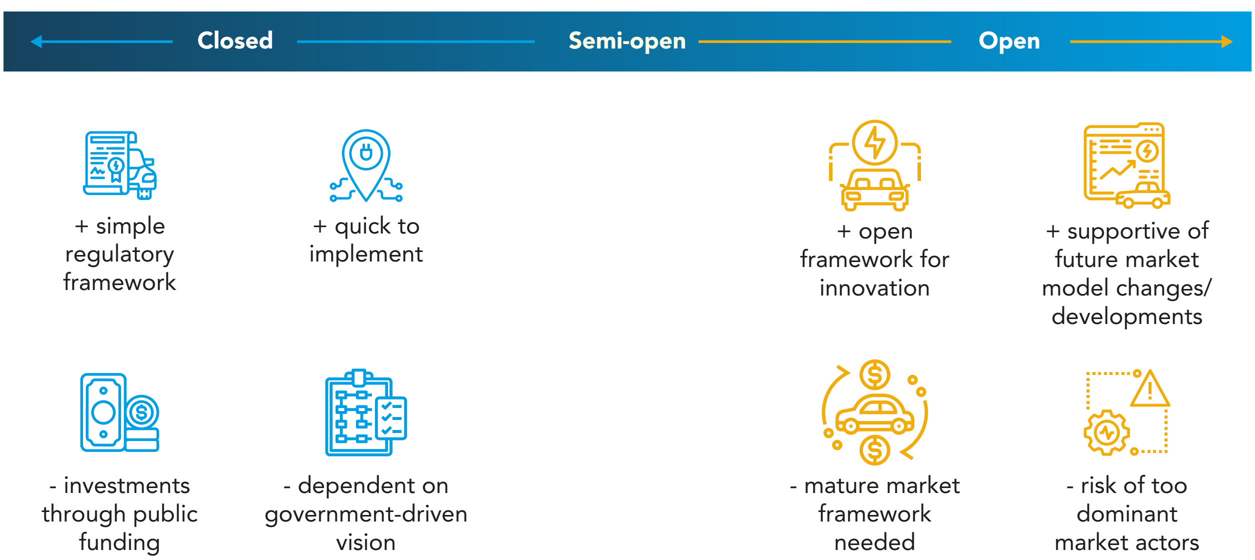


The main difference between countries seems to be the variety in the maturity of e-mobility development, both in the number of EV's and charging infrastructure and, therefore, in providing regulation for interoperable EV charging services. Also, young markets often offer charging services for free, limiting the development of a competitive charging services market. This might be counterproductive since competition drives innovation.

Therefore, it is expected that when the number of EVs increases, charging services will further develop and capital investment in charging infrastructure will increase. When that point is reached, adequate regulation should be in place and a clear description of the roles and responsibilities of the different actors and stakeholders. Current efforts to collaborate across countries to further develop a regulatory framework that is aligned across countries are most helpful. In this conversation, special attention should be given to a regional approach.

Like all other layers of interoperability, the business layer will certainly be influenced in its optimal development by the energy market configuration and policy contexts. Therefore, pretending to give specific or one-size-fits-all recommendations should be avoided. Rather than that, a spectrum or continuum is shown bellow of the different advantages or disadvantages that each energy market configuration could bring when developing the business layer. While closed energy markets may simplify policy and regulatory frameworks and will ease implementation, they are also bound to political willingness from the government and depend heavily on public funding to be developed. On the other hand, more open markets will allow competition and the development of innovative business and market models. The trade-off from allowing such open competition can be the necessity for a robust and heavily regulated framework and the risk of the presence of very dominant actors that may lead to blocking the emergence of the desired innovation.

**Figure 7. Business layer interactions across different market configurations.**



### 3.1.3 Service Layer

**The development of EV charging services seems to be related to the maturity of the energy sector. Currently, and especially in closed or semi-closed energy markets, EV charging services are an extension of the existing portfolio of electric energy services and not a separate market.**

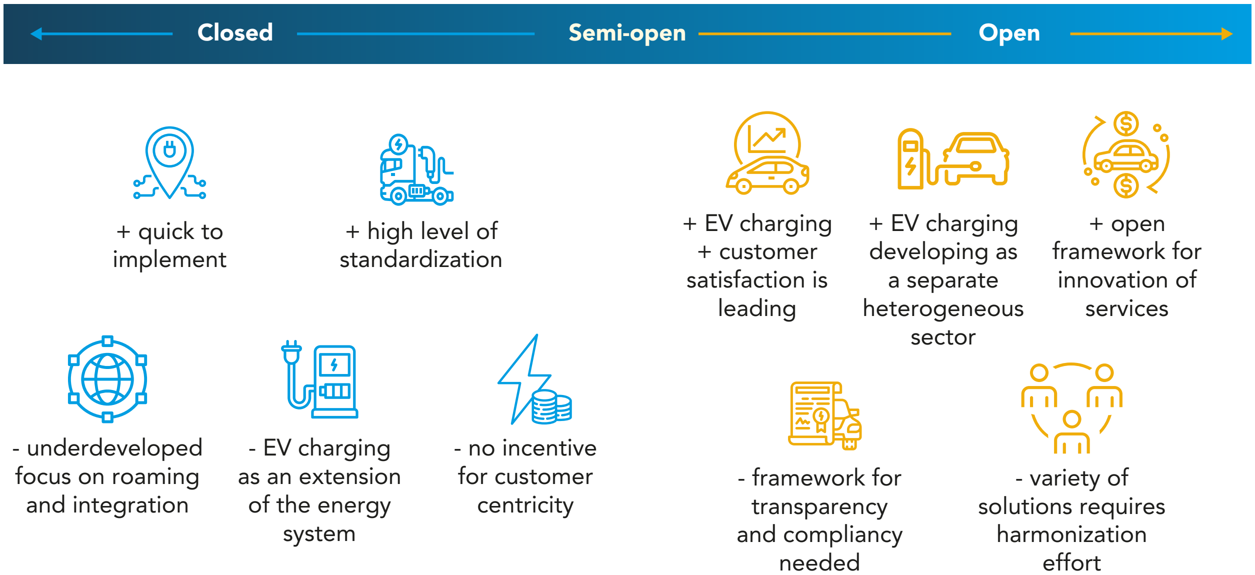
With a larger number of EVs and a better business case for EV charging services in the region, this will develop towards a market that will provide navigation services, transparent prices and tariffs, and the possibility to charge across different charging networks. But, as discussed earlier, this is very much dependent on the country's energy market configuration and its consideration of EV charging as a service separate from the electric energy public service or supply.

On a regional level, it is recommended to promote the development of services, based on a solid basis of interoperable information exchange and storage between countries.

Below, the spectrum for the drivers and barriers that each energy market configuration brings to developing of the service layer is presented. Closed energy markets, as with the business layer, allow for a quicker and easier implementation and deployment. Nonetheless, since the scope of EV charging services is hardly costumer focused but rather an extension of the electric energy service portfolio, it is focusing on the energy supplier's business model rather than focusing on the customers' needs. Also, there is a reduced focus on roaming and integration, making cross-border interoperability in some cases more challenging.

Open energy markets allow developing ecosystems around customer satisfaction through a wide variety of service options and a variety of market actors. Such wide variety of value propositions leads to creating an independent and separate market of EV charging services that energy supplying companies do not necessarily control. Such a variety of solutions comes with challenges for harmonization and robust frameworks to ensure transparency and compliance from the different actors in the market.

**Figure 8. Service layer interactions across different market configurations**




### 3.1.4 Information Layer

**In most countries of the region the information layer is just starting to develop as protocols are being defined between actors and databases are being developed to register charging stations and provide reliable metadata.**

Since the EV charging market is in most cases relatively young, little effort is given to assuring interoperable standards, roaming protocols or a standardized data model.

OCPP is often mentioned as the de-facto standard protocol between charging stations and back office because this is what most hardware manufacturers support.

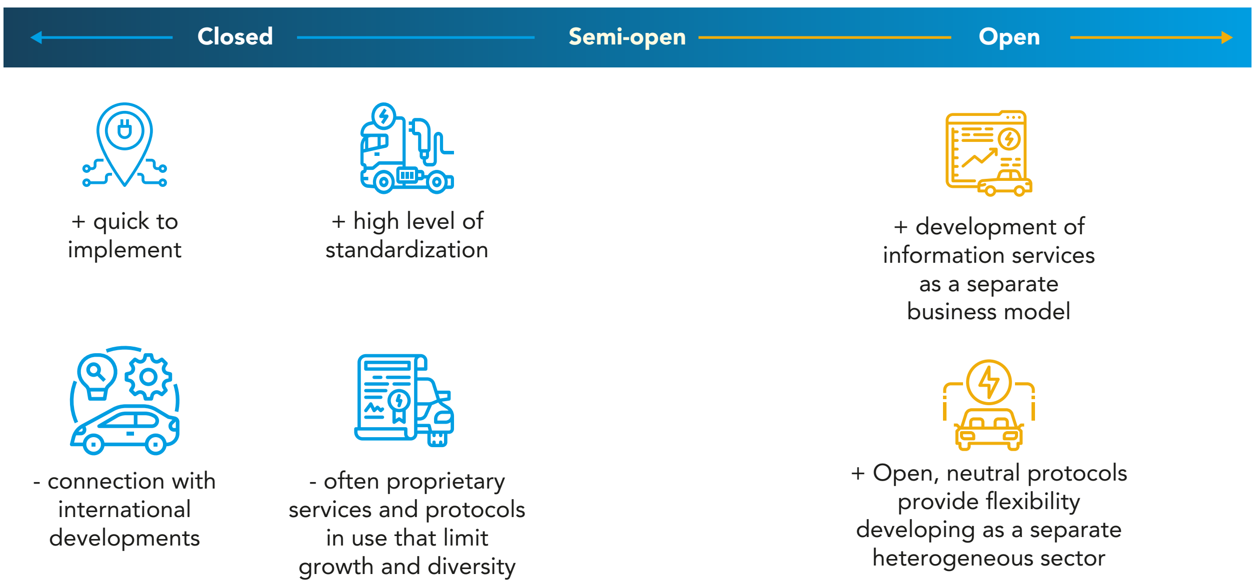
Roaming standards such as OCPI are being considered but become more relevant when the volume and specialization of the market increases; the necessity for its use arises when interface simplification between actors and systems is needed.

Databases for registration of charging stations and operators, and the underlying data models are still developing within countries in the region. Developing such databases and data models with a regional scope would be of great value, ensuring that information services can be used across borders, and the regional market for information services can be further developed.

As expected, closed energy market configurations allow more straightforward and quicker implementation and a higher level of standardization of protocols regarding the information layer. As a drawback, such closed energy market structures may hinder connection with international developments. Also, having proprietary tools and service protocols may not enable diversification and growth of the interoperable EV charging infrastructure.

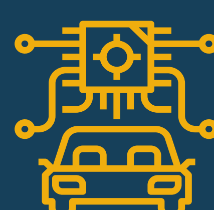
On the other hand, more open energy markets allow the development of information services as separate business models. Also, using open and neutral protocols provide flexibility when developing an independent services sector from the usual electric energy market dominated by utilities. The emergence of actors and business models dedicated to information management, analysis, and the display becomes preeminent and allows for the deployment of e-mobility within the region. A good example is the development of smart charging services: charging more (less) when renewable energy is abundant (scarce), when the electricity price is low (high) or when grid capacity is available (constrained)

**Figure 9. Information layer interactions across different market configurations**



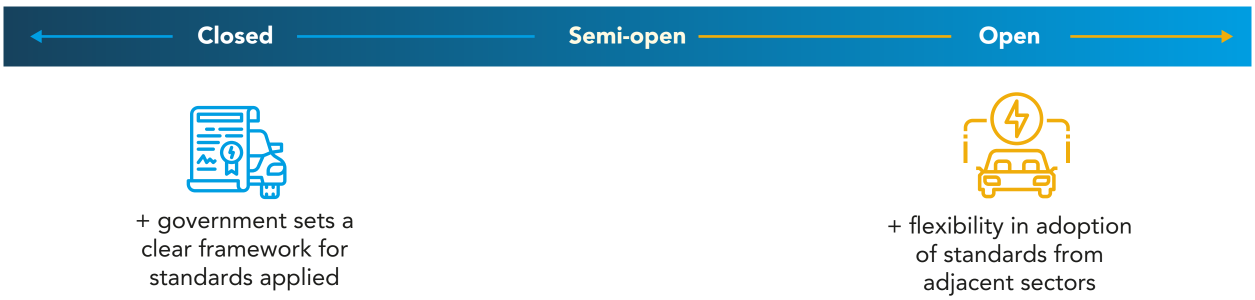

### 3.1.5Communications Layer

**Every charging station should be connected to a back office to ensure proper control and management of the charging stations. Following the recent hardware manufacturing developments, the standards in use follow the international IT/telecom standards.**



Regarding communications: since it follows IT/telecom standards, it doesn't have a wide range of discrepancies between having a closed or open energy market, which have already adapted such standards for communications in the energy sector. Nonetheless, it can appear that closed markets can have governments setting a clear framework of standards to be applied because they control the assets, while in open markets each actor has the freedom or flexibility to adopt standards from adjacent sectors. (Not necessarily the ones already used in the electric energy sector.)

**Figure 10. Communications layer interactions across different market configurations.**




## 3.1.6 Hardware Layer

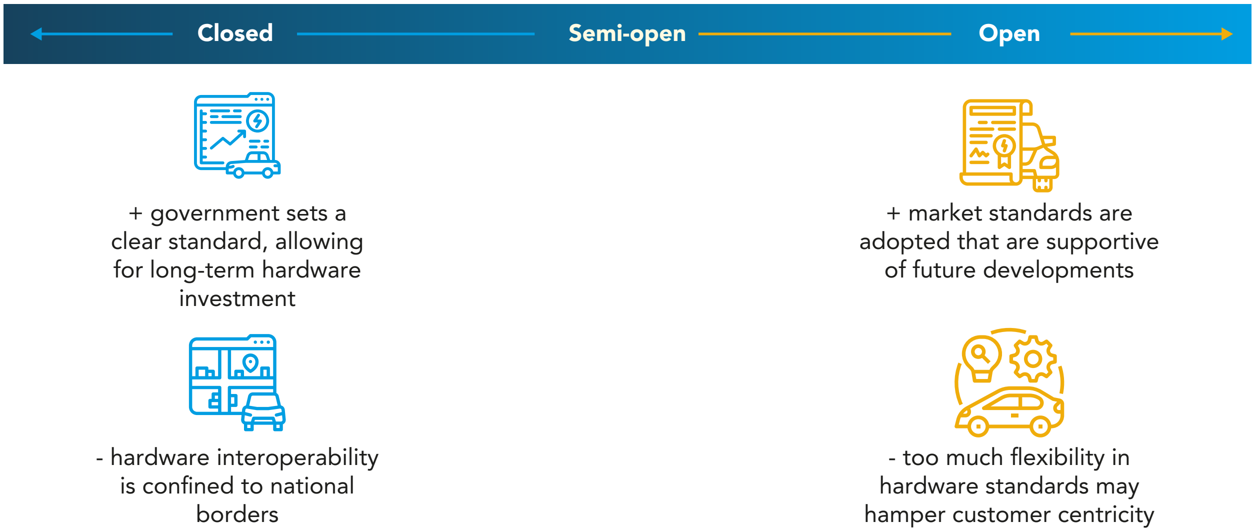
**As hardware manufacturers are already working globally, there is a level of interoperability in the charging stations themselves. Many countries within the region have started to develop regulation to establish an interoperable charging connector for passenger vehicles.**

There is a consolidation in the LAC region towards either CCS1 or CCS2 connectors as the minimum required in charging stations. The Chinese GB/T standard is also being applied, as well as the ChaDeMo standard, but these are less often used than the aforementioned CCS1 and CCS2.

As hardware installations are made for a longer timeframe (between 10 to 15 years) and the financial investment is significant, standardization at this level needs to take place as soon as possible to ideally one or maximum two connector types. Also, corrective measures (e.g. adapters) need to be applied to deal with the lack of hardware interoperability.

Standardizing connectors could be the first step towards interoperability in any country in the region. This standardization process of the hardware layer is also influenced by the market configuration specific for each country, and whether this is strictly and swiftly applied, or flexibility is allowed for. It also depends on the import of electric vehicles, from China, Japan, US and/or Europe, that each promote their own connector type, and whether a country has a standardization strategy for these.

**Figure 11. Hardware layer interactions across different market configurations**




## 3.2 Assessment of Recommendations and Application Methodology

This section describes several interoperability elements recommended to be observed in a country or sub-national region to assess the possibility of adequately developing an interoperable charging network. It is intended that identifying such elements can operate as an assessment tool when analyzing how advanced countries or sub-national regions are in implementing interoperable EV public charging systems.

A distinction has been made in the five layers of interoperability as described in previous sections, as these address different elements and often involve different actors. A sixth perspective has been added as well: the scale of interoperability. It has become clear that interoperability can be organized on a sub-national or national level, depending on the energy market configuration. In addition, a regional level has been identified to support cross-border EV travelling and charging. Recommendations are given for each of these perspectives.

This section intends to guide public governments towards interoperability, rather than provide a list of requirements; local context will influence the direction and priority of the topics to be addressed. For each layer, a minimum set of interoperability requirements is presented and the optimal conditions for advanced interoperability.

### 3.2.1 Business Layer of Interoperability

**Business layer of interoperability: A regulatory and business framework that allows for collaboration and exchange of information: Uniform regulation, Standard business processes, contractual procedures. The minimal and optimal interoperability requirements to assess this layer are presented below.**

#### Minimal interoperability requirements

- Central government has a vision, strategy, and goals for an interoperable charging network.
- A definition of public (accessible) charging (and private charging) is available, defining non-discriminatory access for public charging stations.
- Grid operators have a well-defined pre-competitive role concerning the commercial marketplace.
- The role and responsibilities of Charge Point Operators (CPO's) has been clearly defined and is open to any new or incumbent companies.

#### Optimal interoperability requirements

- A roadmap has been defined capturing the charging infrastructure development five years ahead, focusing on interoperability and adjacent developments in the energy and transport sector.
- The role of a Mobility Service Provider (MSP) has been defined as separate from the operator.
- Authentication and settlement procedures between CPO's, or between CPO's and MSP's have been defined.
- Each business model in charging infrastructure is competitive and has multiple market participants without any monopoly or lock-in.
- A sector organization has been founded to promote efficient operation, act as representative and develop a level of self-regulation within the framework of a competitive marketplace.
- Public-private collaborations support further knowledge development while assuring a competitive marketplace.
- Standardized contracts (concessions, permits) are available for installation and operation of charging stations.

### 3.2.2 Service Layer

**Services layer of interoperability: a uniform definition of standard services or use cases across the sector: navigation, charging, payment, metering, availability, price transparency, quality. The minimal and optimal interoperability requirements to assess this layer are presented below.**

#### Minimal interoperability requirements

- Publicly accessible DC chargers provide direct access for every EV driver to charge and pay.
- An ID Registration Office (IDRO) has been set up to register all business actors, assign ID's and monitor basic requirements.
- A register or repository of charging station metadata has been developed to allow every service provider to develop information services with correct information.
- Smart Metering is implemented in the energy sector for public charging.
- Minimum payment methods have been defined.

#### Optimal interoperability requirements

- Every public charger is accessible for every citizen, either directly or via a subscription model
- Pricing models have been specified, assuring transparent pricing for customers.
- A uniform customer experience is promoted with the identification of a customer journey
- Minimum service requirements have been defined on sector level (uptime, support desk) and are being monitored.
- Price transparency is being monitored.

### 3.2.3 Information Layer

**Information layer of interoperability: uniform, standardized and meaningful information exchange: a uniform data model and information protocols for the interfaces in the value chain. The minimal and optimal interoperability requirements to assess this layer are presented below.**

**Minimal interoperability requirements**

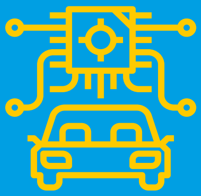
- A uniform data model has been defined to collect charging point meta-information.
- A standard information protocol between the charging station and back office has been defined (OCPP).
- A standard information protocol between Charging Point Operators (CPO) and Mobility Service Providers (MSP) has been defined (OCPI).

**Optimal interoperability requirements:**

- Standard information has been defined to collect meta-information in a repository or 'national access point'.
- A uniform description of data quality has been defined (completeness, correctness, timeliness) including monitoring and compliance criteria.
- ISO15118, a 'plug and play' protocol between vehicle and charging station has been researched in terms of impact for stakeholders.
- Smart charging information protocols have been researched to prepare for an interoperable smart charging business model.
- Calibration of metering devices for charging stations has been defined.
- Open interfaces between commercial tools and applications have been defined to improve quality and efficiency.

### 3.2.4 Communications Layer

**Communication layer of interoperability: the seamless collaboration between system components to exchange data. The minimal and optimal interoperability requirements to assess this layer are presented below.**



#### Minimum interoperability requirements

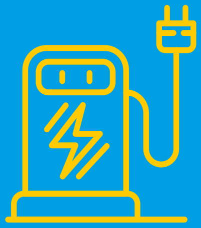
- Every charging station is digitally connected with a CPO management system.
- Every CPO management system can share static and dynamic information.

#### Optimal interoperability requirements

- Every CPO management system can share real-time dynamic information.
- Data protocols have been defined to collect data in a central repository.

### 3.2.5 Hardware Layer

**Hardware layer of interoperability: hardware elements that are needed for a seamless charging service: such as connectors, plugs, signposts, among others. The minimal and optimal interoperability requirements to assess this layer are presented below.**



#### Minimum interoperability requirements

- A minimum connector standard for regular (AC) charging for passenger vehicles and light commercial vehicles has been established.
- A minimum connector standard for rapid (DC) charging for passenger vehicles and light commercial vehicles has been established.
- Uniform user instructions have been defined.
- Uniform signage is regulated (signposts, parking space, etc.).

#### Optimal interoperability requirements

- Uniform guidelines for charging station requirements have been defined (security, safety, location, etc.)
- A minimum connector standard has been defined for trucks.
- A minimum connector standard has been defined for buses.

Photo: Proyecto MOVÉS

### 3.2.6 Scale of interoperability

**The scale of interoperability describes how interoperability of charging can be defined on different scales (sub-national, national, and international):**

#### Sub-national scale

In some markets, interoperability can only be organized on a sub-national scale (cities, provinces, states). When EV drivers travel outside these borders, this is not optimal. The minimal and optimal interoperability requirements to assess in this layer are presented below.

**Minimum requirements for interoperability on a sub-national scale:**

- Publicly accessible DC chargers should provide direct access and payment for every EV driver to charge and pay.
- Sub-national operators of publicly accessible charging infrastructure organize interoperability according to the above-defined recommendations for the drivers in the specific city/province/state.

**Optimal requirement for interoperability on a sub-national level in this context:**

- Local public governments and grid operators organize themselves on a national level to assure full interoperability between cities and provinces.

#### National scale

- Interoperability requirements as given can be applied on a national scale.
- Market actors can provide their services in every part of the country without additional requirements or investments.
- EV drivers benefit from interoperability requirements on a national level: they have access at every public charging station and a basic level of customer experience is similar at every charging station.

Photo: ASOMOVE

### International scale

**Minimum interoperability requirements have been agreed upon on an international level to allow for a minimum service level for international travel of electric vehicles:**

- Standardization of connectors for person vehicles, both for AC (slow) charging and DC (rapid charging).
- Roaming via direct access and direct payment for EV drivers.

**Optimal interoperability requirements between countries include the following:**

- Agree on similar market access requirements and tax agreements for charging infrastructure companies to provide services across countries.
- Harmonized ID issuing. Unification of operator issued ID's to be unique across countries.
- Harmonized ID registration offices, so that an operator from one country can be easily registered in other countries.
- Harmonized data collection requirements, for companies to easily fulfill data requirements from their back office for multiple countries.
- Roaming via a subscription model, allowing contractual agreements between CPO's and MSPs across countries.

# 4. Final Remarks and Conclusions

As presented in the previous chapters, interoperability is a well-established property of mature ecosystems such as the electricity, IT and telecom sectors. The concept is easily applicable in the context of EV charging and has proven to be of added value. The concept of interoperability layers is a helpful tool to assess interoperability in all parts of the ecosystem and every aspect of the EV charging value chain.

The study of reference countries and countries in Latin America has shown a strong relationship between the energy market configuration and the market design of EV charging services; countries with an open energy market and experience in interoperability are likely to also design an open EV charging market. In contrast, closed or semi-closed markets tend to move to more closed EV charging ecosystems. If they intend to move to a more open configuration, this is often part of a broader sector development towards openness and interoperability.

Each market configuration has its advantages and disadvantages. These have been highlighted, emphasizing openness and interoperability as the key topics of a fast-growing EV Charging sector, and the theme of this report.

The overview of recommendations and the proposed application methodology, described as a ‘menu’, are meant as a guide to assessing a country’s readiness for EV charging interoperability. When working in practice with these recommendations, there is much more context-specific detail underneath to be developed, depending on policies and regulations in the energy, transport and urban development sectors.

Concluding, the transition towards electric mobility is an efficient and effective means to realize the shift towards a more sustainable world: less dependency on oil and gas in the transport system, an efficient means of renewable energy usage and storage, lower CO2-emissions and less air pollution. We hope that this report will contribute its part to this mission.

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# Annex 1:
# Reference models for interoperability of EV charging infrastructure

## Reference: SGAM – Smart Grid Architecture Model

For interoperability between systems or components, the SGAM as defined by the European standardization organization CEN/CENELEC, consists of five layers representing business objectives and processes, functions, information exchange and models, communication protocols and components. These five interoperability layers represent an abstract and condensed version of the interoperability categories introduced by the GridWise Architecture Council (GWAC2008).

**Table 7. Description of SGAM layers**

| Layer | Description |
| --- | --- |
| Business | The business layer represents the business view on the information exchange related to smart grids. SGAM can be used to map regulatory and economic (market) structures (using harmonized roles and responsibilities) and policies, business models and use cases, business portfolios (products & services) of market parties involved. Also business capabilities, use cases and business processes can be represented in this layer. |
| Function | The function layer describes system use cases, functions and services including their relationships from an architectural viewpoint. The functions are represented independent from actors and physical implementations in applications, systems and components. The functions are derived by extracting the use case functionality that is independent from actors. |
| Information | The information layer describes the information that is being used and exchanged between functions, services and components. It contains information objects and the underlying canonical data models. These information objects and canonical data models represent the common semantics for functions and services in order to allow an interoperable information exchange via communication means. |
| Communication | The emphasis of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service and related information objects or data models. |
| Component | The emphasis of the component layer is the physical distribution of all participating components in the smart grid context. This includes system & device actors, power system equipment (typically located at process and field level), protection and tele-control devices, network infrastructure (wired / wireless communication connections, routers, switches, servers) and any kind of computers. |

**Figure 12. Detailed Description of Interoperability Layers in The SGAM Model**

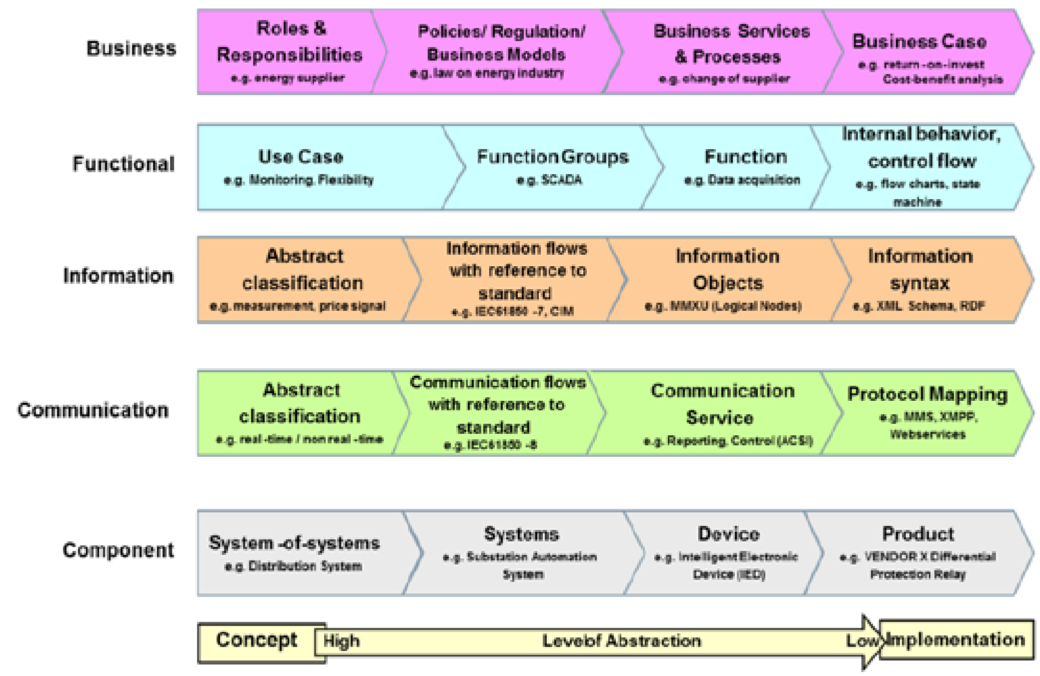
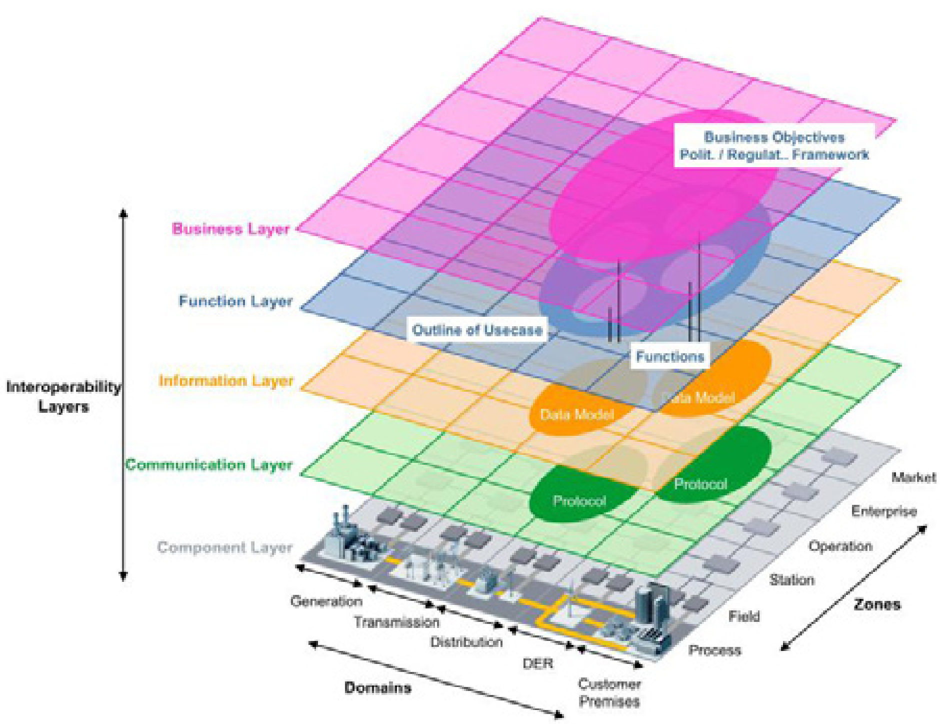



**Figure 13. Relationships between interoperability layers in the SGAM model**



## Reference: GWAC: Gridwise Interoperability Context-Setting Framework (2008)

The Gridwise Architecture Council (GWAC) was formed by the U.S. Department of Energy to promote and enable interoperability among the many entities that interact with the electric power system. The Council provides industry guidance and tools that make it an available resource for Smart Grid implementations. The goal is a concept called interoperability, which incorporates the following characteristics:

- Exchange of meaningful, actionable information between two or more systems across organizational boundaries
- A shared understanding of the exchanged information
- An agreed expectation for the response to the information exchange
- A requisite quality of service: reliability, fidelity, and security.

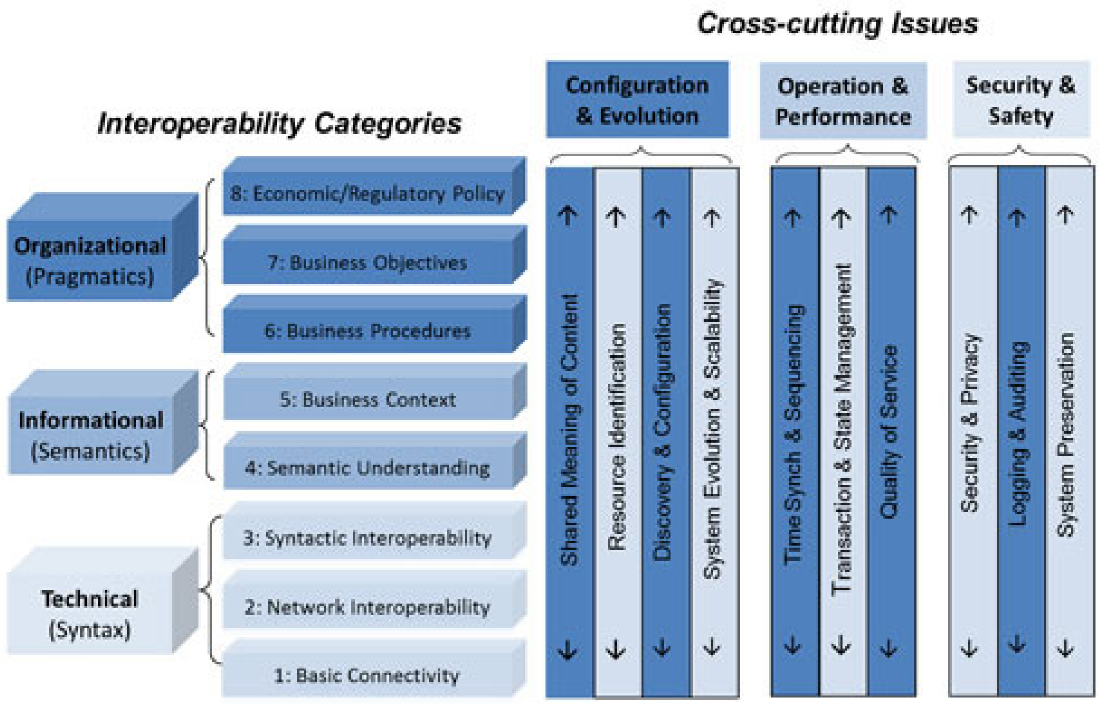
The result of such interaction enables a larger interconnected system capability that transcends the local perspective of each participating subsystem.

The figure below summarizes the layered interoperability categories according to technical, informational, and organizational groups. In addition to these categories of interoperability, the framework proposes a classification of interoperability issues that cut across the layers. The cross-cutting issues represent the areas that must be focused on to start improving interoperability across the web of electricity concerns.

**Figure 14. Overview of interoperability categories according to the GWAC framework**


When looking at an architecture for interoperability, there are overlapping topics that should be aligned between the layers, see below figure.

**Figure 15. Overview of relationships between the interoperability categories of the GWAC framework**




## Reference: OSI model

The OSI model is used as one reference model. The Open Systems Interconnection (OSI) model, has a background in computing and telecommunications, and has been published by ISO (ISO/IEC 7498-1) in 1994 in order to promote the idea of a consistent model of protocol layers.

OSI cannot be directly applied to the EV charging ecosystem, but it does support the development of (protocol) layers that each require interoperability, in order to deliver the required roaming service.

**Table 7. Overview of the OSI protocol (Wikipedia)**

| Layer | | | Protocol data unit (PDU) | Function |
|---|---|---|---|---|
| Host layers | 7 | Application | Data | High-level APIs, including resource sharing, remote file access |
| | 6 | Presentation | | Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption |
| | 5 | Session | | Managing communication sessions, i.e., continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes |
| | 4 | Transport | Segment, Datagram | Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing |
| Media layers | 3 | Network | Packet | Structuring and managing a multi-node network, including addressing, routing and traffic control |
| | 2 | Data link | Frame | Reliable transmission of data frames between two nodes connected by a physical layer |
| | 1 | Physical | Bit, Symbol | Transmission and reception of raw bit streams over a physical medium |

# Annex 2: Data Collection Methodology for the Interoperability Layers in Latin American Countries

To collect the information regarding the different interoperability layers, with the help of the local consultants in each analyzed country, two matrixes were used. Such matrixes were developed by UNEP and Qurato to collect the information regarding the general state of electric mobility in each country and also the state of development of elements associated to each layer of interoperability.

Such matrix is composed of two sheets. The first sheet relates to the general information over electric mobility in the country divided in four different sections:

- **General Country Info:** information about the country's population and the number of passenger cars registered in such country.
- **Information regarding Electric Vehicles:** Number of passenger cars that are BEV, HEV or PHEV, relations of percentage of total passenger cars that are EV in the country and EVs per 100.000 inhabitants, and leading EV models in the country.
- **Charging Infrastructure:** Number of Publicly accessible chargers and disaggregated by <=22kW and >22kW (fast chargers). Also, EVs per public charging point installed.
- **Drivers and targets for transport electrification:** This section collected information about main drivers to adopt EVs from an economic perspective and SDG goals, the energy market design of the country, and the EV charging market design.

Below, an example of the layout of such sheet is presented with an example information from the Netherlands to show graphically how the matrix was presented by each local consultant.

**Table 8. General Country Information Sheet Layout**

| Information item | Explanation | example: answers Netherlands |
|---|---|---|
| General country info | | |
| | # of inhabitants | 17,500,000 |
| | # of passenger cars | 8,500,000 |
| EV's | | |
| # of EV passenger cars per 2020 (BEV, PHEV, total) | BEV | 172,524 |
| | PHEV | 100,371 |
| | HEV | |
| | Total EV Passenger cars | 272,895 |
| | | |
| Absolute number, % of total, per 100.000 inhabitants | % of total # cars | 3.2% |
| | EV per 100.000 | 1,559 |
| | | |
| (optional) | Light commercial <3500 kg | |
| | EV | 5,996 |
| | Total | 1,000,000 |
| | % | 0.60% |
| | | |
| (optional) | Heavy Duty >3500kg | |
| | EV | 241 |
| | Total | 172,000 |
| | % | 0.14% |
| | | |
| (optional) | Buses | |
| | EV | 1,218 |
| | Total | 9,628 |
| | % | 12.65% |
| | | |

| | | |
|---|---|---|
| Leading EV models | Leading EV passenger car models: | Tesla Model 3<br>Tesla Model S<br>Hyundai Kona<br>Kia Niro<br>Volkswagen Golf<br>Volkswagen ID.3<br>Renault Zoe<br>Nissan Leaf<br>BWM i3<br>Tesla Model X |
| Charging infrastructure | | |
| Publicly accessible chargers: | | |
| # of normal chargers (<=22kW) | | 64,236 normal chargers (2020) |
| # of EV's per normal chargers | | 4 EV per normal charger |
| # of fast chargers (>22kW) | | 2,429 fast chargers (2020) |
| # of EV's per fast charges | | 112 EV per fast charger |
| Drivers and targets for transport electrification | | |
| Main drivers for adopting EV's: | | |
| Economic | what are the main drivers in each country? E.g. reducing oil import, green tourism, | no own car production. Government policy: As of 2030, all new passenger cars sales are zero-emission. Looking into car batteries for flex grid storage |
| Sustainable development goals (SDG) | which SDG drivers? Climate, social, etc | SDG: 7.3 Mton CO2 reduction per 2030 |
| Energy market design | | |
| Diversity of producers, suppliers | which are the dominant players on the EV charging market? | Energy supply and grid operators are separate legal entities<br>3 large incumbant energy suppliers<br>20+ new players, in the area of charge point operation, subscription providers or data/navigation services (MSP), smart charging solutions, etc |

| | | |
|---|---|---|
| Role of incumbent vs new players | The incumbent players: are they commercial, or combine this with non-commercial roles? what are the possibilities for new market players? Can they start operating charging stations, and in what way do they need to rely on incumbent utilities? | incumbent players have a slight advantage due to their electr expierence and customer base/scaling advantage Otherwise the barriers for entry are low |

| EV charging market design | | |
|---|---|---|
| Value chain for EV charging per transport modality, value drivers | in brief (or with link): how is public charging organized | public charging for normal charging is organized via tenders or via a permitting model, by cities or regions. Price for charging is fixed in tendering model. Income via Elec sales. For fast charging, ministry has auctioned highway charging location s in 2012. other charging stations are placed on private locations (hotels, etc) |
| Leading EV charging players (elec, hardware, software) | what are dominant stakeholders, that are relevant to take along when developing the market for EV charging? | Leading sector association: eViolin<br>leading operators (CPO) in public charging: Vattenfall, total, Engie<br>leading hardware providers: EVBOX, Alfen, ABB, Allego, Tesla<br>leading service providers (MSP): NewMotion, ENECO, Plusurfing,<br>leading backoffice services (on behalf of CPO): Greenflux, LMS |

For all of the information given, the local consultants were requested to provide the source of information and the year of the data.

The second sheet was exclusively created to collect information over specific elements of interoperability in each of the layers. Specific questions were formulated to identify such elements and classify them as part of any of the different interoperability layers. Interoperability is a very new concept in Latin American countries, so if asked properly about interoperability, most would say that it is inexistant or that there no elements or development towards interoperability of EV charging service, but when asked about specific elements that form part of the different interoperability layers, it becomes evident that there have been more developments and advance towards interoperability in the region than initially conceived.

The information collected was collected for the five interoperability layers: business layer, service layer, information layer, communication layer and hardware layer. Each layer had a explanation and interpretation box where a guide was given to each local consultant over the expected information to be collected and the relevant elements that each layer included and that should be considered in the information collected. These columns could be found at the far right of the sheet. In each layer, different parameters were considered, and information collected for such parameter should be classified depending on the source or condition that could back up such shared information. In this case, the consultant should fill in the answer and then choose from five classifications for the source or status of the information given:

- **Sector agreement:** This was selected when there is no formal regulation or documents that establish certain market condition or parameter as something widespread on the country, but it has been developed as the result of an organic process of interaction of the different actors and stakeholders of the EV ecosystem.
- **Norm:** The regulating or normative body of the country has issued a norm that establishes the parameter as something to be followed.
- **Standard:** The regulating or technical normative body has issued a technical standard regarding the parameter evaluated.
- **Regulation:** Regulation has been issued by the government regarding a specific element or parameter of the layer.
- **Non- Existing:** When such parameter is not existing in the analyzed country.

An example of the Interoperability sheet is shown below:

| | EV interoperability layer | | parameter | Description | Answer (NETHERLANDS example) | sector agreement | norm | standard | regulation | Non existing | Additional comment | Interpretation | Explanation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Business layer (Market and government)** | | | | | | | | | | | A generic market, policy and regulatory framework.<br><br>- Non-discriminatory towards incumbent or new market players.<br>- User centric | The market model (processes and requirements, market roles and responsibilities, financial agreements, liability etc) is designed to facilitate contract models and collaboration models (e.g. tenders, permits) business-to-business and business-to-government EVRoaming and other services around EV Charging are being facilitated/required by market regulation or a similar policy framework, such that customers can rely on user-centric interoperable charging services. |
| | | 1.1 | Governance - government | Description of responsibilities at central/regional government wrt interoperability | regional governments and municipalities are the contractors for public charging, for location planning and strategies. Central government provides overall policies focusing on open data, pricing etc, assuring an effective market.<br>The National Charging Agenda is a programme installed to efficiently organize the rollout of public charging and address any obstacles in legislation, planning or operational elements | | | | | | | | |
| | | 1.2 | Governance - sector | Description of entities, responsibilities involved with interoperability | the sector organization eviolin is leading wrt a code of conduct and collaboration between market players, and for promoting harmonization and standardization. Grid operators have an obligation to connect charging stations, and provide predictive models to understand the impact on the grid. | | | | | | | | |
| | | 1.3 | Regulations | Overview of regulation implemented/ intended | EU AFID and ITS directive are leading. Specific NL legislation on sharing information on charging stations | | | | x | | | | |
| | | 1.4 | Standards | Overview of applicable (national/international) standards | ISO15118 (in development)<br>OCPP (in development as ISO63110)<br>OCPI (in development as ISO63119) | | | x | | | | | |
| | | 1.5 | Norms/codes | Overview of norms, codes in use | national grid cod, describing connection requirements, smart metering requirements | | x | | | | | | |
| | | 1.6 | Market/sector agreements | Overview of sector agreements | code of conduct between market players, describing B2B contracting, payment, price transparency etc (pre-competitive)<br>NKL provides guidelines, to be used as input for contracting, location planning, strategy setting etc<br>National Charging Agenda describes the goal (1.8M charging points in 2030, based on 100% EV new car sales per 2030), the roadmap and workplan. | x | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2** | **Service layer (EV roaming)** | | | | | | | | | | | Services and functions around EV charging, as well as their relationships, which can be described in use cases. | Service-driven use cases can be de- scribed, such as EV Roaming, Metering, Smart Charging. These can be further detailed in use cases such as: Finding a charging station, Charging with any car, and any card/app (Authentication, Charging, Payment) |
| | | 2.1 | Definition of public charging | Is there a uniform description of public charging (versus semi-public and private) | there is a definition in EU directive AFID, leading for NL. NL has it further specified | | | | x | | public chargers on private grounds are so-called publicly accessible and thus follow the 'public charging regula- tions' | | |
| | | 2.2 | EV Roaming design | Is there a roaming service available in the country, how is this set up (P2P, via platform, via grid operator etc) | roaming is prescribed via the EU AFID direcrtive, and specific via the sector organization eViolin in NL, prescribing OCPI as the protocol of choice | | x | | | | part of code of conduct | | |
| | | 2.3 | EV roaming scale | cross-border/na- tional/grid operator/ regional/city | national agreement with all CPO's and MSP's active in NL | | x | | | | | | |
| | | 2.4 | Ad hoc charging/ non-subscrip- tion | is this existent, required etc? | this is part of EU directive | | | | x | | the way to implement is not pre- scribed | | |
| | | 2.5 | Payment methods | | not prescribed | x | | | | | a variety of existing payment methods is in use | | |
| | | 2.6 | Information service | Are there require- ments for data that needs to collected, published etc for generic information service | National Access Points for defined data sets have been defined in EU ITS directive. Governments describe their data/ reporting needs in contracts. | | | | x | | | | |
| | | 2.7 | ID register | is there a register of market players, optionally with ID's for organized collab- oration | there is a registry of CPO's and MSP's, this is part of EU ITS | | | | x | | | | |
| | | 2.8 | CP Register | Is there a register or some central over- view of CP/charging stations | there is a registry, also accessible as the National Access Point | | | | x | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3** | **Information layer** | | | | | | | | | | | Information objects, underlying datamodels, semantics and protocols (OCPP, OCPI, ISO15118,...) that are being used for information exchange to realize mentioned use cases. | A common data model and semantics are in place to exchange information and to deliver aggregated, insights and overviews to end users. Systems exchange meaningful messages between each other (information, authentication, CDR, payment, profiles etc) in an open fashion, regardless of a specific charge point, information system, energy provider, app, website etc. using open communication standards and protocols such as OCPP, OCPI |
| | | 3.1 | EV charging data model | is a standard data model defined and applied? | no explicit model defined. SGEMS is loosely followed. OCPI data model used in practice | x | | | | | | | |
| | | 3.2 | standard/protocol EV-CP | is there a standard protocol in place between the vehicle and the charging station? | ad hoc communication at DC chargers (J1772) | | | | | | ISO15118 will be used in future, currently in development | | |
| | | 3.3 | standard/protocol CP-CPMS | is there a standard protocol in place between the charging station and the CPO management system? (often OCPP) | OCPP is used | x | | | | | in development as ISO standard | | |
| | | 3.4 | Roaming standard/protocol CPO-MSP | Is a standard (roaming) protocol in use between the management systems of CPO and MSP? | OCPI is often used. Also hub-protocols are in use such as those from Hubject, eclearing, Gireve (resp OICP, OCHP, eMIP) | x | | | | | OCPI is the sector agreement, and pushed from government | | |
| | | 3.5 | standard/protocol CPMS-Elec supplier | is there a standard protocol in place between the CPO mgt system and the elec supplier? | yes (to be checked) | | | | | | | | |
| | | 3.6 | Payment standards | Which are the payment standards in use | subscription uses invoicing. Non-subscription via credit card | | | | | | ad hoc payment (non subscription) is required, therefore options via credit card, QR code etc have been developed. | | |
| | | 3.7 | Navigation standards | Is there a standard for collecting data for the purpose of information sharing | no standard. European commisions DATEXII as a data standard. Otherwise OCPI is used as the standard by data aggregators. | | | | | | | | |
| **4** | **Communications layer** | | | | | | | | | | | Connections between hardware and software systems, e.g.<br>CP - CPMS (TCP/IP, 3G)<br>EV-CP via cable (J1772 protocol) | All systems are able to exchange information, regardless of the EV, CPO, MSP etc involved, making use of standard information protocols such as TCP/IP, 3G,... |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4.1 | Connection CP-CPO | Which connections are in use between charging station and back office (and how is this regulated) | 3G, TCP/IP | | x | | | | follows smart metering norms | | |
| | | 4.2 | Connections ecosystem | Which connections are in use between systems in the EV charging ecosystem (and how is this regulated) | standard practice to exchanger info between CPO, Elec supplier, MSP. internet-based | x | | | | | | | |
| **5** | **Hardware layer** | | | | | | | | | | | EV (Plug, BMS)<br>Charging station<br>Connector (Mennekes, CCS 1, CCS 2, ChaDemo)<br>Payment terminal<br>Management system (CPO, MSP) | Charging stations, connectors and plugs are designed such that every EV can connect and electricity can flow, regard-less of brand of the vehicle or charging station |
| | | | Connector re-quirements DC (fast charging) | CCS1, CCS2, ChaDe-Mo, GBT | EU directive requires CCS2 (DC) minimum. Chademo is also in use. Adaptors are available at DC stations | | | | x | | | | |
| | | | Connector re-quirements AC | Type 2/Mennekes | EU directive requires Mennekes/ Type 2 (AC) minimum | | | | x | | | | |
| | | | Other hardware requirements | Which other re-quirements have been identified that are involved in EV charging interoper-ability? | NKL has (togehter with market and govt and grid companies) defined the basic requirements for a charging station, defining hardware elements based on practices. Such as form, dimensions. Connection is a regular 'household' connection with 2 meters (1 for grid company, one for CPO). CE quality standard is expected | x | x | | | | | | |

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