USEF
POSITION PAPER
ELECTRIC MOBILITY

Version : 1.2
Date : October 2015
Author : Marten van der Laan

A solid foundation for smart energy futures

Table of Content

1.	Introduction	3
2.	E-mobility market organization	4
2.1.	Introduction	4
2.2.	The charging environment	4
2.3.	Roles	4
2.4.	Market models	6
2.5.	Interaction for smart charging	7
2.6.	Communication standards and protocols	8
3.	Connection to USEF	9
3.1.	The E-mobility customer is the energy customer	9
3.2.	The CSO is the energy customer	11
3.3.	The EmSP is the energy customer	13
3.4.	Hybrid model	14
4.	Conclusion	16
Appendix: The EV charging environment		17

This USEF position paper is intended to streamline discussions about further development of the USEF framework.

1. Introduction

Electric mobility is one of the game-changing developments in today's energy market. Around the world, charging infrastructure is being rolled out and market models for smart charging are emerging, toward the large-scale deployment of e-mobility. Current market models focus on roaming functionality to ensure interoperability and only briefly explore ways to monetize the flexibility that smart charging offers the energy market—even though multiple stakeholders have interest in this flexibility. USEF provides a level playing field that enables all these stakeholders to compete for access to this flexibility, maximizing its value in the energy market.

The USEF smart energy framework provides the means to unleash demand-side load flexibility and maximize its value in the energy market. This position paper summarizes the major e-mobility market structure developments in Europe and identifies how these market models and their underlying protocols can be aligned with USEF.

An essential cornerstone of both e-mobility market models and USEF is how tasks, roles, and responsibilities are divided among the actors involved in the charging process. We propose a way to align the e-mobility market structure with the USEF framework such that flexibility can be controlled by USEF's Aggregator[1] role and the rest of the charging process handled within the e-mobility domain. Based on this analysis, we identify the necessary requirements for e-mobility standards to ensure proper coupling with USEF.

1. In this paper, capitalized terms indicate roles, phases, and regimes as defined by USEF or by EURELECTRIC, and lowercased versions indicate broader, general energy-market concepts.

2. E-mobility market organization

Especially in public charging situations, there is a need for a market organization with specific e-mobility roles and business models. The development of these roles and models is still at an early stage; different models are being used in parallel and are still evolving. The challenge is to deliver a well-functioning market with easy access for all parties and transparent services. Interoperability and roaming require special provisions.

2.1. Introduction

USEF defines the concept of Active Demand & Supply (ADS), which represents all the energy-consuming or producing appliances in a system that have the ability to shift, increase, or decrease their energy consumption or production. ADS thus serves as the source of load flexibility. USEF considers electric vehicles (EVs) to be a special type of ADS, because demand response based on smart EV charging and decharging has unique characteristics, such as end users' mobility requirements, devices (vehicles) that may charge at different locations (private, semi-public, and public), and different market models.

In the Prosumer's private environment, an EV is treated as an ADS asset behind a connection, controlled by the Aggregator. In semi-public and public situations, however, other domain-specific roles and conditions apply, complicating smart-charging interactions. USEF2014:I.II identifies e-mobility roles and market models, but because the EV domain was at an early stage in its development at that time, we concluded that it was too soon to define a final mapping to USEF roles and interactions. E-mobility has since sufficiently matured that we now feel such a mapping can be made. This paper proposes a way to include smart EV charging[2] in the USEF framework.

This section describes the current situation in the e-mobility domain and serves as background information for our proposal in section 3.

2.2. The charging environment

As can be seen in the appendix, EV charging can take place at multiple locations. Table 1 summarizes the different environments and the primary use of smart charging at present.

Environment	Location	Smart charging used to:
Private	At home, residential building	Local grid capacity reduction, self-consumption
Semi-public	Offices, parking facilities, etc.	Local grid capacity reduction
Public	Public areas	n/a (only field trials to date)
Fast charging	Highways, etc.	Load curtailment (US)

Table 1: The EV charging environment.

2.3. Roles

A large variety of stakeholders are involved in e-mobility, and the e-mobility market is tightly linked to the energy market. EURELECTRIC [1] presents an e-mobility roles model, which is aligned with the ENTSO-E harmonized electricity market roles model [2]. For this position paper, we will use EURELECTRIC's role definitions. Table 2 describes the relevant roles and maps them to their USEF role symbols.

2. In this paper, we concentrate on smart charging. But USEF is also capable of unleashing the flexibility resulting from smart decharging of vehicles (vehicle to grid).

USEF symbol	EURELECTRIC role	EURELECTRIC description
Charging Station Operator	Charging Station Operator (CSO)	A party that operates the charging infrastructure from an operational-technical point of view, that is, who handles access control, management, data collections, repair, and so on. There may be further differentiation between the technical operator and the commercial operator, who uses the charging infrastructure to offer services to the electric vehicle driver. Charging Station Operators engaged in commercial activities may buy electricity on the supply market and include it in the services they sell, or they may sell charging services that do not include the supply of electricity.
E-mobility customer	E-mobility customer	A party that consumes e-mobility services using an electric vehicle, including electricity and charging services.
E-mobility Service Provider	E-mobility Service Provider (EmSP)	A party that sells e-mobility services to E-mobility customers. For example, an EmSP might provide flexible and complimentary access to charging stations run by different Charging Station Operators. EmSP services may be bundled with other services (EV location, parking, and so forth) and may include the supply of electricity.
Aggregator	Flexibility Operator	A party that aggregates load flexibility from different users of low-voltage and medium-voltage grids and trades it with the transmission system operator and/or the distribution system operator in order to provide ancillary services (adjustment mechanism). It may address EV charging through Charging Station Operators and may trade its service to the distribution system operator or to the transmission system operator.
Meter Data Company	Secondary Metering Data Operator	A party that may be requested to measure electricity consumption per EV charged, and process the data in accordance with the organization of electricity purchase. It may provide an extension of the metering point operator's service. This role is relevant in a market model in which the distribution system operator is not involved in the charging service operation.

Table 2. A subset of the EURELECTRIC roles model for e-mobility; only roles relevant to this discussion are listed.

EURELECTRIC also refers to an e-mobility clearing house as a combination of data, financial, and commercial clearing processors. This role is not relevant for the USEF mapping, but we refer to it in this paper to help clarify the information flows.

USEF recognizes an additional role that is not present in the EURELECTRIC roles model: the EV manufacturer. EV manufacturers play a key role in determining and accessing an EV's charging requirements (state of charge) and sometimes provide their own back-office systems to control the charging process.

USEF's Aggregator and Meter Data Company are existing roles in the USEF framework that closely resemble the EURELECTRIC definitions for the Flexibility Operator and the Secondary Metering Data Operator, respectively.[3]

3. See the USEF2014:I.II specification for these definitions.

The organization of the different e-mobility actors and their relations is depicted in figure 1. This organization will be the basis for the USEF mapping and only includes those actors that are relevant for this purpose.

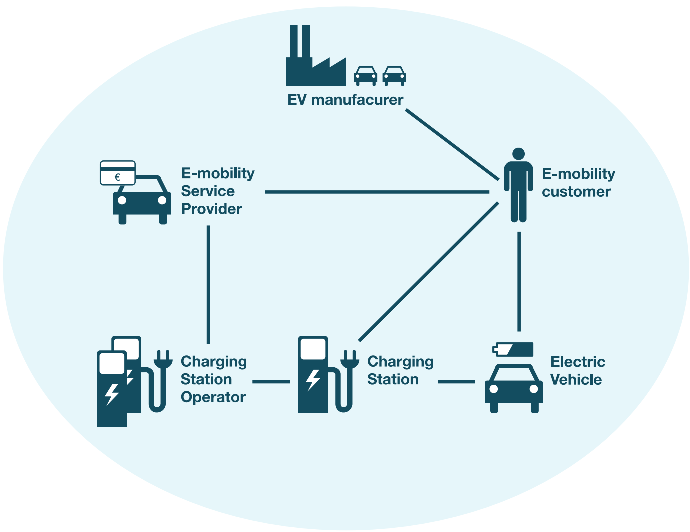

Figure 1. E-mobility roles and relations. Charging station and electric vehicle are not market roles but physical objects. They are included to be able to show all relations.

2.4. Market models

In 2010, EURELECTRIC examined the e-mobility value chain and identified several possible models for e-mobility market organization [3]. Their 2013 study [1] expanded the market organization discussion to include e-mobility service models and the relationships among market actors, with a focus on publicly accessible charging infrastructure.

The 2013 study described two market models in detail:

- **Independent e-mobility model** (EURELECTRIC's "roaming of charging service" scenario). In this model, the electricity contract is between the CSO and the Supplier; in other words, the CSO sells an all-in service (electricity plus charging services).
- **Integrated infrastructure model** (EURELECTRIC's "roaming of electricity and service" scenario). In this model, the electricity contract is between the EmSP and the Supplier. The EmSP sells the electricity to its customers, and the CSO only sells a charging service.

Both models are being used in practice, though with deviations from the original EURELECTRIC descriptions. Experts in the e-mobility domain have made the following observations [4]:

- In most countries, the EmSP and CSO roles are combined in a single market party. This makes the distinction between the two market models irrelevant.
- The division of responsibilities between the CSO and the EmSP differs from one situation to the next. One can observe both "fat" and "slim" EmSPs. Fat EmSPs take responsibility for the charging service; slim EmSPs only handle financial transactions.
- In the integrated infrastructure model, EURELECTRIC assumes that the charging infrastructure is part of a distribution system operator's regulated business. This implies that the infrastructure costs are recouped through the general network fees. This is also known as the DSO model [5]. In practice, we also see a similar model in which independent (unregulated) CSOs offer charging services.
- In the original EURELECTRIC models, the service to the E-mobility customer is independent from the electricity supply. In other words, the E-mobility customer just consumes a charging service and the provider of that service is the consumer of the electricity. In some practical deployments in Germany, the E-mobility customer is also the consumer of the electricity, and is therefore subject to the corresponding regulatory control. This closely resembles private charging, where the E-mobility customer is also the energy customer.
- In some countries, charging stations are equipped with direct payment options (e.g., by credit card or SMS). In this case, there is no relationship between the E-mobility customer and the EmSP.
- The role of a roaming clearing house is foreseen by EURELECTRIC. In practice we see both bilateral contracts between EmSPs and CSOs (e.g., the Central Interoperability Register in the Netherlands) and a variety of clearing-house initiatives: Hubject (DE), MOBI-Europe (PT), Gireve (FR), eMobility ICT Interoperability Innovation group (EU), e-clearing.net (NL/DE/BE), and more.

Note that additional business models might appear in the market in a disruptive way, for example from the EV manufacturer's side, like energy for free with an electric vehicle. The business models and service models might not fit with current proposed market models.

2.5. Interaction for smart charging

EURELECTRIC has defined smart charging as follows [6]: "a controlled charging process that optimizes the use of the grid and the available electrical energy to minimize additional investments in the grid and facilitate the integration of renewable energy sources (RES)."

In response to European Mandate M/490, the Smart Grid Coordination Group's working group on sustainable processes (WGSP) has addressed smart charging and identified various EV-related use cases. The group's report[7] identifies five charging-related areas (charging station services, provisioning, interoperability, payment and billing services, and auxiliary services) and five use-case categories (WGSP-1100, 1200, 1300, 1400, and 1500), as shown in figure 2. Two of these use cases are related to smart charging:

- WGSP-1200, charging with demand response
- WGSP-1300, smart recharging and decharging

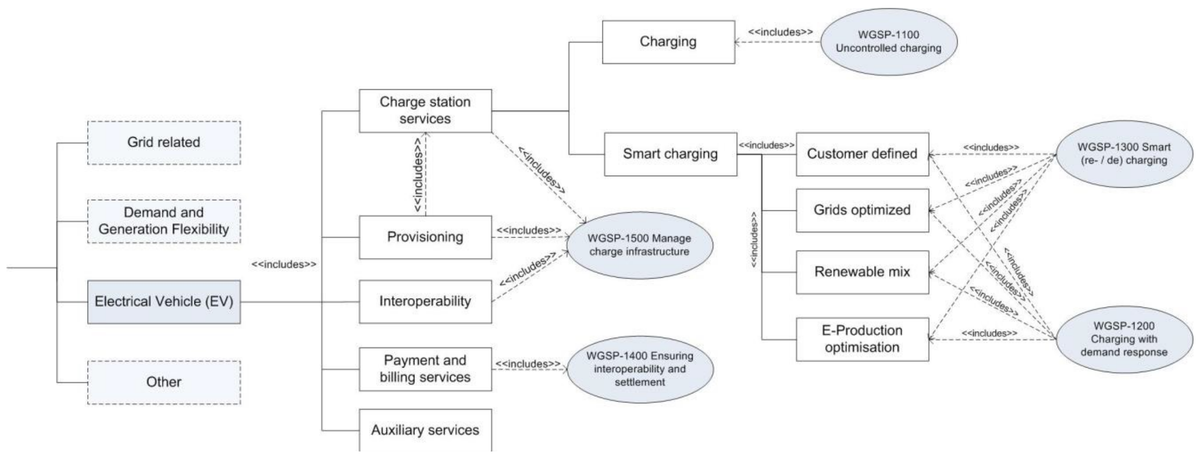

Figure 2. WGSP smart charging overview and relevant use cases. Source: [7]

WGSP-1200 primarily concerns the services an EmSP can offer to an E-mobility customer. WGSP-1300 [8] is closest to USEF's definition of smart charging and describes smart charging based on both energy market needs (e.g., the availability of RES energy) and grid constraints. Dutch distribution system operator Enexis has defined a sub–use case of WGSP-1300, capacity-forecast-based smart charging [9], which is currently being tested in the Netherlands.
In the WGSP-1300 use case, the EmSP is the central party negotiating with the energy B2B market and the distribution system operator. The resulting charging schedule is effectuated via the CSO. A noteworthy detail in this use case is that the DSO directly communicates with both the EmSP4 and the CSO. In the Enexis variant, communication occurs solely between the DSO and the EmSP, and the EmSP communicates the resulting charging schedule to the CSO.

The EU-FP75 project COTEVOS uses the WGSP-1300 use case in its reference architecture [10]. To date, WGSP-1300 is the only use-case description USEF has found that addresses smart EV charging.

4. In the WGSP publications[7] [8] the term Charge Service Provider (CSP) is used instead of EmSP, but with the same meaning.
5. The Seventh Framework Programme for Research and Technological Development, the European Union's primary research funding instrument from 2007–2013. Many FP7-funded projects, including COTEVOS, are still running.

2.6. Communication standards and protocols

2.6.1 Standards for communication between the CSO, the charging station, and the EV

Figure 3 shows common communication protocols used between the CSO, the charging station, and the electric vehicle. ISO 61851 is widely used and enables analog-signal control of the charging current. ISO/IEC 15118 defines digital communication between an EV and electric vehicle supply equipment (EVSE) and has a rich message set for smart charging purposes, including charging needs, price signals, and charging schedules.

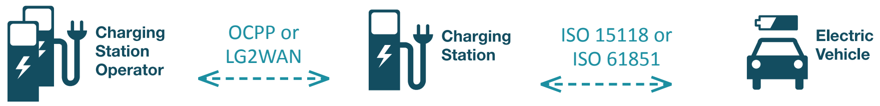

Figure 3. Standards for EV smart-charging communications.

There are several standards for communication between a charging station and the CSO's back office. OCPP is driven by the Open Charge Alliance (OCA), and version 2.0 includes messages for smart charging. German power company RWE is a member of the OCA, but also drives an alternative protocol called LG2WAN for its own charging stations. Both OCPP and LG2WAN claim to be compatible with ISO/IEC 15118. USEF has encountered additional initiatives (such as those of Enel and Siemens), but within Europe OCPP and LG2WAN appear dominant. The eMobility ICT Interoperability Innovation group (eMi3) is also active in this area and aims to define a communication protocol between EVSEs and back-end systems[11].

2.6.2 Standards for communication between the DSO and the CSO or EmSP

The Open Charge Alliance proposes the Open Smart Charging Protocol (OSCP) for capacity management in EV charging [12] [13]. Quoting from the OCA's website:

> The basic function of OSCP is to communicate physical net capacity from the DSO (or site owner) to the back office of the charge spot operator.[6] The protocol can be used to communicate a 24-hour prediction of the local available capacity to the charge spot operator. The service provider will fit the charging profiles of the electric vehicles within the boundaries of the available capacity. [12]

OSCP is currently being used in pilot projects in the Netherlands. USEF has not identified any other protocols at this level.

2.6.3 Standards for communication between the EmSP and the CSO

To facilitate the roaming process, the EmSP and the CSO must exchange data. This information transfer is needed for localization (to find a free charging station), authorization (is this customer allowed to charge at this charging station?), and charge detail record exchanges.

In principle, this communication can be implemented as a direct exchange between the EmSP and the CSO. For example, the Dutch Central Interoperability Register managed by eViolin[14] works this way. But with a broad landscape of EmSPs and CSOs, direct exchanges will result in complex many-to-many communication. Roaming support provided by a clearing house can reduce this complexity from many-to-many bilateral partner connections to a one-to-many connection between the clearing house and the partners.

As mentioned before, there are multiple clearing house initiatives developing different protocols. One of these is particularly interesting: the Open Clearing House Protocol (OCHP) [15]. OCHP's purpose is to connect market actors in the field of electric mobility charging infrastructure. This protocol provides a simple way for parties to communicate between their own back-end systems (such as a CMS) and a clearing house system.

To date, there are no standardized protocols for smart-charging communication at this level.

6. OSCP's charge spot operator is equivalent to USEF's Charging Station Operator. OSCP can also be used between the DSO and the EmSP; the protocol does not include a roles model.

3. Connection to USEF

USEF can create additional value out of the flexibility resulting from EV smart charging. To this end, USEF proposes an Aggregator role that accumulates flexibility from Prosumers and their Active Demand & Supply and offers this flexibility as a service to the BRP, DSO, and TSO.

Because flexibility products are closely coupled to the energy supply, USEF requires the Prosumer to be clearly identified. The framework prescribes a tight relationship between the Prosumer, Supplier, Aggregator, and BRP (see USEF 2014:I.II).

The energy supply relationship differs among the market models observed: the Supplier can close an energy supply contract with either the E-mobility customer, the CSO, or the EmSP. This is depicted in figure 4, where the three options give three different mappings to USEF's Prosumer role.

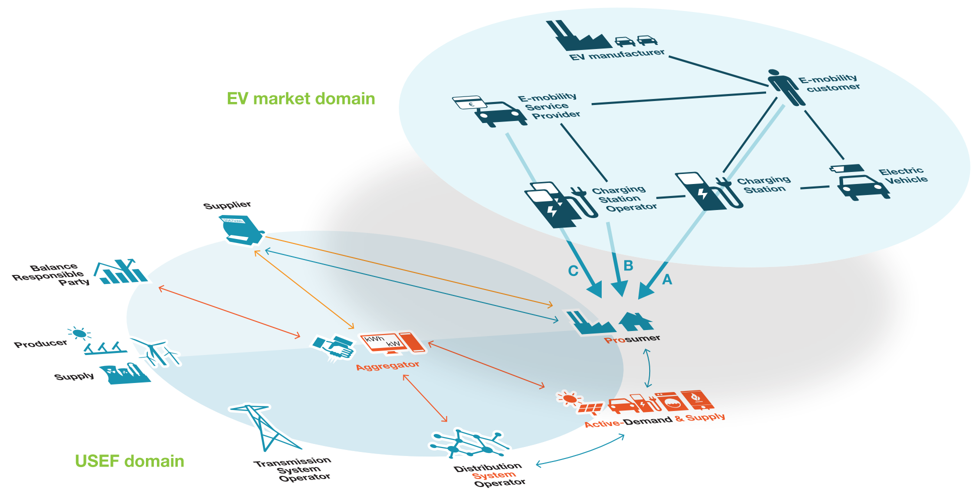

Figure 4. Different options for the energy supply relation and the resulting mapping to USEF's Prosumer role. 1) E-mobility customer is energy customer (mapping A), 2) CSO is energy customer (mapping B), and 3) EmSP is energy customer (mapping C)

In the following sections, we describe the connection to USEF for each of these three situations. For each situation we show the mapping to USEF roles, the interactions needed to participate in USEF's interaction model and, finally, our observations with respect to the handling of flexibility in relation to USEF.

3.1 The E-mobility customer is the energy customer

This situation is the default in private charging, but may also occur in public charging situations where the E-mobility customer uses his existing electricity contract for EV charging.

In private charging situations, the E-mobility customer holds the electricity contract with the Supplier and therefore takes on the Prosumer role. If there is an Aggregator active at the connection on behalf of the Prosumer, the Aggregator could control the EV charging process just as it controls the Prosumer's other Active Demand & Supply. The E-mobility customer, in its role of Prosumer, controls the user settings for the charging process.

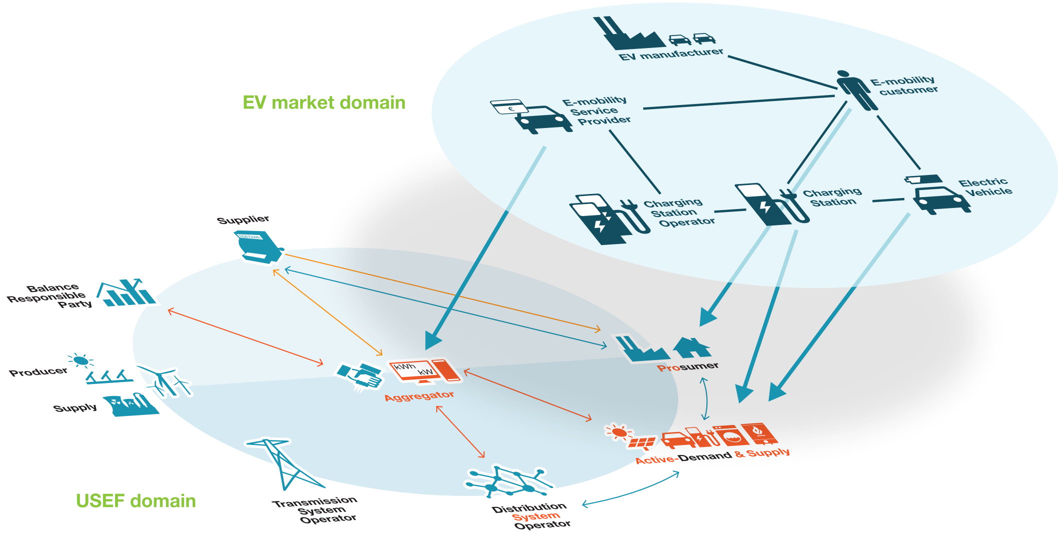

Figure 5. Mapping A: E-mobility customer maps to the Prosumer. In private charging situations, the Prosumer's existing Aggregator also controls the EV charging. When the CS has its own separate connection and in public situations, the EmSP can take on the Aggregator role.

USEF enables the Aggregator to unlock the flexibility resulting from EV charging. This form of smart charging can complement existing smart-charging schemes, in which an in-home control system manages the charging process in order to respect local connection capacity limits.

If the private charging station is open to others, third-party charging sessions take place under the existing energy contract. The Prosumer is compensated for third-party energy consumption by the EmSP. Flexibility stays with the Prosumer, hence under the Aggregator's control.

The charging station may use a separate connection[7]. In this case EV charging is decoupled from domestic energy consumption and production. Several market models are possible. The supply contract for this second connection can be assigned to the E-mobility Customer, who can contract another (independent) Aggregator to exploit the flexibility. In this case it is logically that an EmSP offers the Aggregator services. Alternatively, the charging station can be completely managed by an EmSP or CSO, but then then the contract includes electricity supply, which means that the E-mobility customer is no longer the energy customer.

USEF role	E-mobility role	Description
Prosumer	E-mobility customer	Is the energy customer for charging sessions
ADS	CS+EV	Flexibility available only when a vehicle is connected
Aggregator	EmSP (optional)	In private smart charging on the domestic connection, none of the e-mobility roles can take on the role of the Aggregator. When the CS has its own separate connection and in public situations, the EmSP can take on this role, provided that operating conditions for the demand response service are included in the energy supply contract (see USEF2014:I.II)

Table 3. Mapping EURELECTRIC e-mobility roles to USEF roles when the E-mobility customer is the energy customer. CS stands for charging station.

7. Connection can be a true connection, but also a Virtual Transfer Point (VTP) as defined in [16]

3.2 The CSO is the energy customer

This model is similar to the EURELECTRIC independent e-mobility model. The EmSP sells e-mobility services to the E-mobility customer and the CSO manages the charging infrastructure. Pivotal in this model is the electricity contract between the CSO and the Supplier. This model is used in semi-public smart charging and is also the currently dominant model in actual public charging deployments.

In order to exploit the smart-charging flexibility, the party playing USEF's Aggregator role must be identified. The CSO, as the energy customer, either appoints an Aggregator or takes on this role itself. The second option is viable because the CSO will generally have multiple charging stations in its energy contract, and will thus have sufficient flexibility volume in its own portfolio.

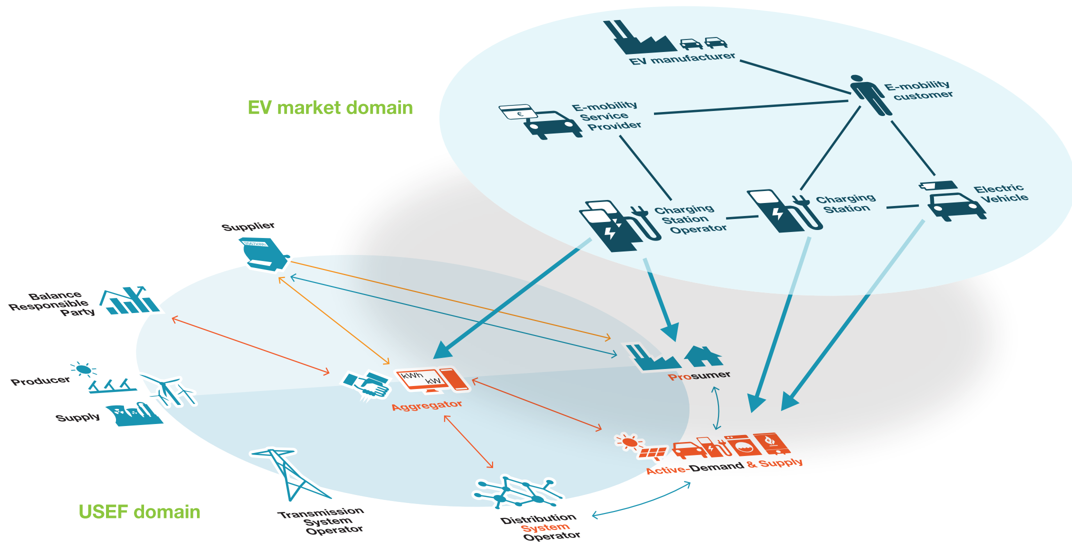

Figure 6. Mapping B: The CSO maps to the Prosumer. The CSO can also take on the Aggregator role or can choose to involve an independent Aggregator.

USEF role	e-mobility role	description
Prosumer	CSO	Is the energy customer for the actual charging
Aggregator	CSO (optional)	The CSO can also choose to involve an third party Aggregator on its behalf
ADS	CS+EV	Flexibility available only when a vehicle is connected
-	E-mobility customer	Is outside the USEF model. However, the E-mobility customer's charging needs must be respected, and must therefore be communicated to the CSO (in its role of Prosumer)

Table 4: Mapping EURELECTRIC e-mobility roles to USEF roles when the CSO is the energy customer. CS stands for charging station.

The CSO manages the charging process, respecting the needs of the EmSP's customers. If an independent Aggregator is appointed, this Aggregator will typically not control the Active Demand & Supply through an own infrastructure, but will use the CSO's management system.

With respect to USEF's interaction model, we note the following:

- The Aggregator participates in USEF's market-based control mechanism (MCM) interactions.
- Control of the ADS by the Aggregator goes through the CSO.
- CSO-ADS interactions at the USEF device interface (UDI) level use an e-mobility-specific protocol (such as the OCPP 2.0 protocol).
- An E-mobility customer must communicate its charging request to the CSO (in its role as Prosumer). There are several alternative paths, depicted in figure 7.
- Direct forecasting from the ADS to the CSO (in its role as Aggregator) is unlikely. Forecast information can be generated by the CSO based on both historic data and known charging needs.

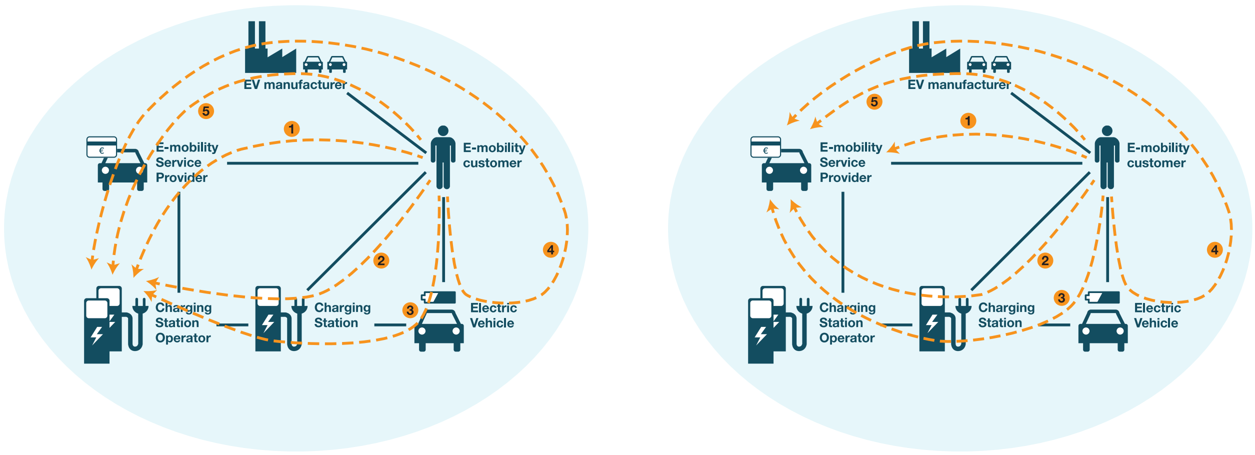

Figure 7. Alternative paths to communicate the charging request from the E-mobility customer to the Prosumer. Left: mapping B where the CSO maps to Prosumer. Right: mapping C where the EmSP maps to Prosumer. Alternative 1 is via the EmSP's back-office, alternative 2 via the user interface at the charging station, alternatives 3 and 4 via the user interface inside the electric vehicle and alternative 5 via the back-office of the EV manufacturer. Note that in all alternatives, the state of charge information must be read from the EV.

Since the E-mobility customer is outside the USEF model, USEF does not describe its interactions. However, some arrangements must be made, because the E-mobility customer is affected by smart charging (e.g., the session may take longer than expected). USEF expects smart charging to affect the Contract and Settle phases. It is up to the e-mobility market to find good solutions.

A complicating factor is that the EmSP holds the contract with the E-mobility Customer and must be sure that its customers' needs are satisfied. Since the CSO controls the actual charging, these needs must be included in the roaming agreement between the EmSP and the CSO.

3.3 The EmSP is the energy customer

This model is similar to the EURELECTRIC integrated infrastructure model. The major difference with the previous model is that the EmSP rather than the CSO holds the electricity contract with the Supplier. In order for the EmSP to offer charging services at charging stations belonging to different CSOs, roaming contracts must be in place. As in the previous model, the actual charging process is controlled by the CSO, respecting the needs of the EmSP's clients.

To use USEF with this model, the party playing USEF's Aggregator role must be identified. Here, the EmSP either takes on the Aggregator role itself or contracts another Aggregator. The first option is viable since the EmSP will generally have sufficient flexibility volume in its portfolio.

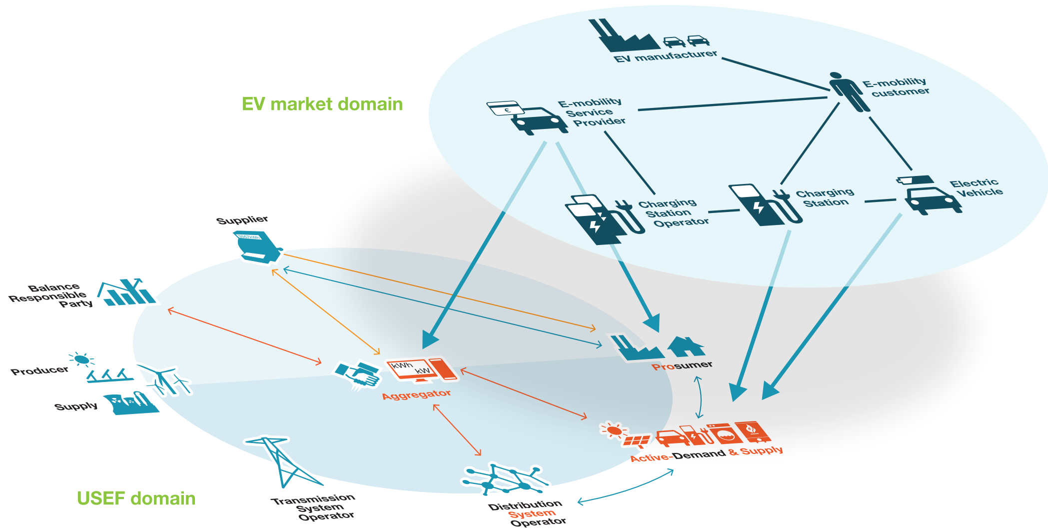

Figure 8. Mapping C: The EmSP maps to the Prosumer. The EmSP can also take on the Aggregator role or can choose to involve an independent Aggregator.

USEF role	e-mobility role	description
Prosumer	EmSP	Is the energy customer for the actual charging
Aggregator	EmSP (optional)	The EmSP can also choose to involve an third party Aggregator on its behalf
ADS	CS+EV	Flexibility available only when a vehicle is connected
-	E-mobility customer	Is outside USEF model. However, the E-mobility customer's charging needs must be respected, and must therefore be communicated to the EmSP (in its role of Prosumer)

Table 5: Mapping EURELECTRIC e-mobility roles to USEF roles when the EmSP is the energy customer. CS stands for charging station.

Note that the CSO is now outside the USEF model, yet needed to control smart charging on behalf of the EmSP (or the Aggregator acting on behalf of the EmSP).

With respect to USEF's interaction model, we note the following:

- The Aggregator participates in MCM interactions.
- EmSP-ADS interactions are indirect through the CSO, or, alternatively, through the EV Manufacturer's back office directly to the EV.
  - The smart-charging protocol used between the EmSP and CSO is to be defined. USEF suggests making the relationship direct. The role of a clearing house as and intermediate party is unlikely because a clearing house is primarily focused on roaming. Note that USEF imposes sub-PTU timing in the Operate phase.
  - CSO-ADS interactions at the UDI level use an e-mobility-specific protocol (such as the OCPP 2.0 protocol).

- The E-mobility customer must communicate its charging request to the EmSP (in its role as Prosumer). There are several alternative paths, depicted in figure 7.
- Direct forecasting from the ADS to the EmSP (in its role as Aggregator) is unlikely. Forecast information can be generated by the EmSP based on both historic data and known charging needs.
- In contrast to the in-home situation, there is more than one electricity contract for a connection; different EmSPs use the charging station in sequence. This complicates commodity and flexibility settlement. This can be resolved within the energy domain through virtual EANs or outside the energy domain through separate recordkeeping.

One complexity in this model is that the EmSP must be sure that its MCM positions can be fulfilled. The presence of another role in the control path to the ADS introduces additional risk (will the CSO execute my orders?). This must be addressed in the roaming agreement between the EmSP and the CSO.
A second complexity is related to capacity management. In contrast to the situation in fixed grid connections, the set of Aggregators (EmSPs) active on the DSO capacity market is not fixed. This set can potentially be very large, and interactions between individual Aggregators and DSOs will be briefer and less frequent. Most importantly, an EmSP can only contribute to a given Congestion Point when one of its customers has planned to charge at a station belonging to the congested area. This complicates the D-prognosis process. Moreover, the administrative burden can be high relative to the value of the flexibility.

From a DSO perspective, the set of Aggregators active at a given Congestion Point will vary greatly over time, which complicates the check on whether all D-prognoses have been received. Moreover, there is the possibility of overestimation due to the fact that multiple EmSPs may forecast a charging session at the same charging station at the same time, whereas only one session at a time may take place. If not handled adequately, a DSO might incorrectly conclude that flexibility is needed. USEF suggests that the CSO could play a role in validating and communicating a unified D-prognosis, based on its existing roaming relationships with EmSPs. The optimal process for this is still to be investigated.

In conclusion, the CSO and the EmSP exchange information to control the charging process and to settle accordingly. The elements of this exchange need to be identified, and appropriate privacy and security measures must be applied.

3.4 Hybrid model

As mentioned in section 3.3, the model in which the EmSP is the Prosumer gives rise to complications with respect to capacity management. These could be solved by using an alternative model where capacity management takes place between the CSO and DSO and commodity trading between the BRP and EmSP. This is depicted in Figure 9. Hybrid model. The EmSP maps to the Prosumer. The EmSP takes the Aggregator role and trades flexibility with the BRP. CSO acts as an independent Aggregator and trades flexibility with the DSO.

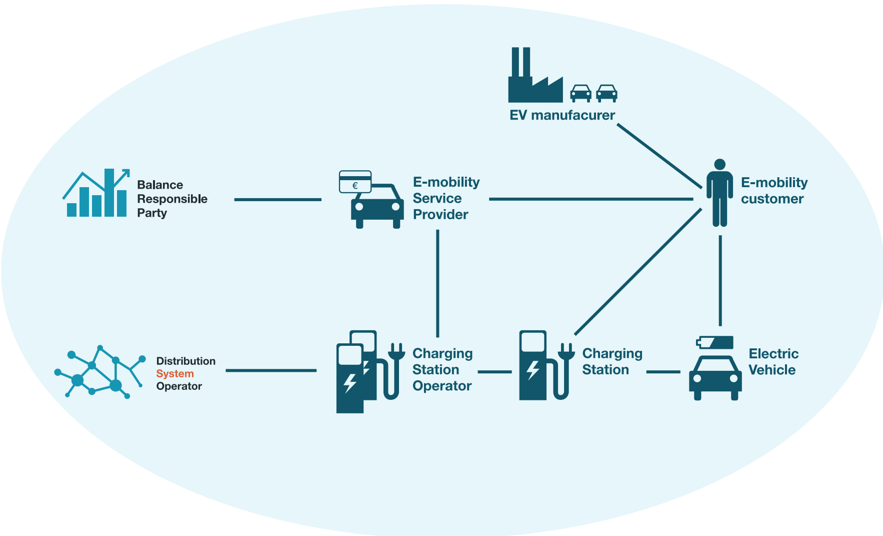

Figure 9. Hybrid model. The EmSP maps to the Prosumer. The EmSP takes the Aggregator role and trades flexibility with the BRP. CSO acts as an independent Aggregator and trades flexibility with the DSO.

Although this might be considered as an obvious model, this is not the case because two parties act on the same source of flexibility. This seriously complicates the flexibility exchange and settlement between the different parties. However, it can be accommodated using the concept of the at the same time'independent aggregator', as defined in a separate position paper [16].

The independent aggregator was originally introduced to treat the flexible part of an energy profile separately from the rest.
In this case it would be applied to separate flexible profile in two parts, which is a similar problem.

The EmSP, as the holder of the electricity contract with the Supplier, maps to the Prosumer and takes the main Aggregator role.
In this role it exchanges flexibility with its BRP. The CSO takes an independent Aggregator role and in this role exchanges flexibility with the DSO. Existing roaming agreements between CSO and EmSP include conditions for invoking flex. During USEF's plan phase an agreement between both parties is needed upon a baseline reference. This must include both parties' intentions to activate flex.
The baseline reference is then be used for settlement. If appropriate, Aggregator-Aggregator flex trading can be used to mutually optimize portfolios and optimal utilization of the available flexibility.

There following issues have to be solved:

- As said, both aggregators operate on the same flexible load. There is no natural distinction beforehand. The distinction can be made when an EV arrives at a charging station and is assigned to either the portfolio of the CSO or the EmSP.
- Both aggregators may control the same load. CSO by controlling the charging station and the EmSP by controlling the EV directly. Both control signals might interfere.

USEF will work out the independent aggregator concept in a future version of the framework. Once completed this hybrid model can be worked out in detail.

An alternative way to incorporate this hybrid model in USEF is to consider the EmSP as main Aggregator who trades flexibility with its BRP. If the DSO needs flexibility for capacity management, it can use USEF's 'orange regime' to regulate the capacity of certain charging stations. Instead of controlling the connections directly, as directed by USEF, it might be more convenient to control indirectly via the CSO's backoffice. Of course this should be agreed upon in the contract between DSO and CSO.
In the Settle phase, the DSO compensates the Prosumers whose connections have been limited in the orange regime during the Operate phase. Also this compensation goes via CSO to the EmSP, who can settle with the e-mobility customer.

4. conclusion

Based on the information presented in this paper, we conclude that USEF fits well with e-mobility. USEF can be used in parallel with existing smart-charging schemes and can be used to unlock flexibility value. In all the e-mobility market models we observed, an Aggregator role can be assigned to enable USEF participation. Existing EV standards can be used to control the charging process.

Private charging is similar to the standard in-home situation described by USEF. In semi-public and public situations, the other e-mobility market roles come into play. USEF identifies three dominant market models for EV, characterized by different energy supply relationships:

1. Model in which the E-mobility customer is the Prosumer
2. Model in which the CSO is the Prosumer
3. Model in which the EmSP is the Prosumer

In all models, the Prosumer is in the position to appoint an Aggregator to optimize its portfolio on the Prosumer's behalf. In the semi-public and public scenarios, it is likely that the CSO and EmSP will take on the Aggregator role themselves.

In the models where an EmSP or CSO controls the charging process, additional indirections occur with respect to the standard USEF model. The details here still need to be sorted out. USEF proposes to extract requirements for the corresponding e-mobility protocols and standards.

In the model where the EmSP is the Prosumer, capacity management is more complex because the energy supply relationship is not directly coupled to a fixed grid connection; hence the set of Active Demand & Supply devices that contribute to a Congestion Point is constantly changing. This must be resolved in USEF and may result in a USEF update. Again, USEF will extract requirements for the corresponding e-mobility protocols and standards.

A hybrid model, where capacity management takes place between the CSO and DSO and commodity trading between the BRP and EmSP, could solve the complications of the third model, but also introduces new challenges. USEF can be applied either using the independent Aggregator concept or using the orange regime. USEF will study this model in more detail once the independent aggregator concept has been worked out.

With respect to control of the smart-charging process, USEF identifies two suitable standards for communication between the CSO and the charging station: OCPP and LG2WAN. USEF proposes to adopt these standards in future versions of the framework. Standardization activities on other levels are not yet mature enough to decide on adoption. USEF will monitor standardization activities (OSCP, OHCP, and others) and discuss USEF-specific requirements with the respective bodies.

Appendix: The EV charging environment

EV charging may take place in different environments: at home, at work, or at public locations. Smart charging's current and potential use is different in each situation.

Private

In the private environment (households and offices), EVs can be charged using a normal domestic socket, but in most cases a dedicated charging station[8] is used. A charging station typically takes a specific plug type and enables higher charging currents. The charging station is connected to the location's existing electrical installation and grid connection; the latter must be reinforced to provide higher charging currents. Alternatively, the charging station can use a separate connection.

A private charging station may be equipped with an energy meter to monitor charging sessions or facilitate separate billing schemes, and with a card reader to enable other e-mobility customers (guests) to use it.

The flexibility resulting from smart charging can be used to reduce local grid connection capacity, thereby reducing monthly network costs, and to align charging with local production. USEF enables this flexibility to also be used to generate revenue through activities such as commodity optimization and grid congestion management

Semi-public

EV semi-public charging can be found in offices, parking garages, and so forth. The building tenant operates a set of charging stations, to be used by employees and guests. The charging stations may be open to the public, that is, to anyone with an EV charging card or other authorization. In most cases, the set of charging stations are behind a single grid connection.

Smart charging can be applied to reduce connection capacity. In some field trials, a distribution system operator is using smart-charging schemes to manage grid congestion.

Public

In the public scenario, a charging station operator operates a set of charging stations in public spaces; e-mobility customers go through e-mobility service providers to use them. The two roles (operator and service provider) are often combined in a single company. The main challenge is interoperability: roaming contracts are required to ensure that all customers at all service providers can make use of all charging stations. Payment options include pay-as-you-go, monthly subscriptions, and free-of-charge. Charging services might be combined with parking services.

Smart-charging schemes for public charging are currently in the field-trial stage; to date, none have actually been deployed.

Fast charging

Fast charging is typically used to recharge during a trip. Fast-charging infrastructure has now been rolled out throughout Europe at highway locations; Estonia is the first EU country to achieve full nationwide coverage [17]. Fast-charging equipment uses high-power DC charging.

With respect to smart charging, fast-charging sessions provide limited flexibility, because the e-mobility customer generally wants to resume his trip as quickly as possible. Hence EVs are charged in the shortest possible time and most often at peak hours. Nonetheless, fast-charging stations do participate in load curtailment schemes, where charging current is limited during peak hours. Charging infrastructure may be equipped with OpenADR communication for this purpose.[4]

8. Also known as charge point, charging point, charging spot, or electric vehicle supply equipment (EVSE).

References

[1] EURELECTRIC. (2013, July) Eurelectric. [Online]. http://www.eurelectric.org/media/84461/0702_emobility_market_model_final-2013-030-0501-01-e.pdf

[2] ENTSO-E. (2011, Jan.) THE HARMONISED ELECTRICITY MARKET ROLE MODEL. [Online]. https://www.entsoe.eu/fileadmin/user_upload/edi/library/role/role-model-v2011-01.pdf

[3] EURELECTRIC. (2010, September) EURELECTRIC. [Online]. http://www.eurelectric.org/media/45284/2010-09-21_market_model_final_for_membernet-2010-030-0808-01-e.pdf

[4] USEF partners private communication.

[5] European Distribution System Operators for Smart Grids. (2012, Apr.) EDSO for smart grids. [Online]. http://www.edsoforsmartgrids.eu/wp-content/uploads/public/EDSO-on-Electric-Vehicles.pdf

[6] EURELECTRIC. (2011, April) EURELECTRIC. [Online]. http://www.eurelectric.org/media/26100/2011-04-18_final_charging_statement-2011-030-0288-01-e.pdf

[7] CEN-CENELEC-ETSI. (2012, November) CEN-CENELEC-ETSI Smart Grid Coordination Group – Sustainable Processes. [Online]. http://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_sustainable_processes.pdf

[8] CEN CENELEC ETSI. (2012, Aug.) WSGP-1300: Smart (re- / de)charging.

[9] Enexis. (2013, Apr.) Capacity Forecast Based Smart Charging.

[10] COTEVOS. [Online]. http://cotevos.eu/

[11] eMI3. [Online]. http://emi3group.com/

[12] Open Charge Alliance. http://www.openchargealliance.org/?q=node/6.

[13] Enexis. Open Smart Charging Protocol 0.6. (Private communication).

[14] eViolin. eViolin web site. [Online]. http://www.eviolin.nl/

[15] smartlab, bluecorner.be, e-laad.nl. (2014, June) http://www.ochp.eu/. [Online]. http://www.ochp.eu/wp-content/uploads/2013/12/140617_Open-Clearing-House-Protocol_v1.2_0.18.pdf

[16] Hans de Heer, "The Independent Aggregator," Arnhem, 2015.

[17] Wikipedia. Wikipedia. [Online]. http://en.wikipedia.org/wiki/Charging_station