Aalto University
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D4.2: BILLING AND METERING INFRASTRUCTURE – COMMUNICATION NEEDS

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Executive Summary

This paper comprises a summary of the results of WP4 for EV billing and communication needs. The report discusses first slow and uncontrolled charging, which is expected to be the dominant form of charging in the early steps of electro mobility implementation. Next, the needs of transmission system operator for reserve and balance power are considered and the possibilities of intelligent charging are outlined. In the final part of the report, the communication architecture and the communication volumes are estimated and the barriers for the development are discussed.

Summarizing the communication needs associated with charging services we get the following Table. These figures are estimated per one EV and charging event. If the number of EVs is increased, the communication grows in relation. In addition, there are the messages between charger-network operator-energy seller, which are dependent on the relations of these actors in power market and can't hence be given straightforward estimates. Especially in the case of many EV:s, the volume of these messages is small compared to EV related communication.

Table Summary of EV related communication related to charging services.

Charging case	Number of messages per EV and charging event
Simple / Slow charging	5-6 messages (base case)
Smart charging	5-7 messages in addition

Introduction

This paper comprises a summary of the results of WP4 for EV billing and communication needs. The report discusses first slow and uncontrolled charging, which is expected to be the dominant form of charging in the early steps of electro mobility implementation. Next, the needs of transmission system operator for reserve and balance power are considered and the possibilities of intelligent charging are outlined. In the final part of the report, the communication architecture and the communication volumes are estimated and the barriers for the development are discussed.

Terms

In what follows, the following terms are used:

Customer – the owner or user of the EV who buys the charging service

Charger – the provider of the charging service. The owner or operator of the charging poles

Network operator – the owner of the distribution network where charger is connected

Energy seller – the provider of the energy

Slow / simple charging - uncontrolled charging, which works only direction pole => EV

Intelligent charging – controlled charging. Either on/off controlled (1-phase 16 A) or two-way

Technical architectures in different cases

The basic architecture of the communication and metering information exchange depends on how roles of different above mentioned players are defined in power market situations. The basic cases are as follows:

1. Charging is a monopoly. The customer pays the charging service directly to the charger, who in turn has a contract with network operator and energy seller(s). In this case the customer has no freedom to choose the energy seller and has to pay the price asked by the charger, whatever the price is.
2. Energy selling and network / charging system price are differentiated. The customer may have a contract with some energy seller, or he may choose between offers of different energy sellers. The charger may also suggest some “default” energy seller. In this alternative the network and charging system are only carriers of power and they do not participate in energy trade. There are separate costs for network and charging infra usage. This case is the most likely solution according to the present energy markets legislation.
3. The network operator owns also the charging system. Otherwise similar as case 2.

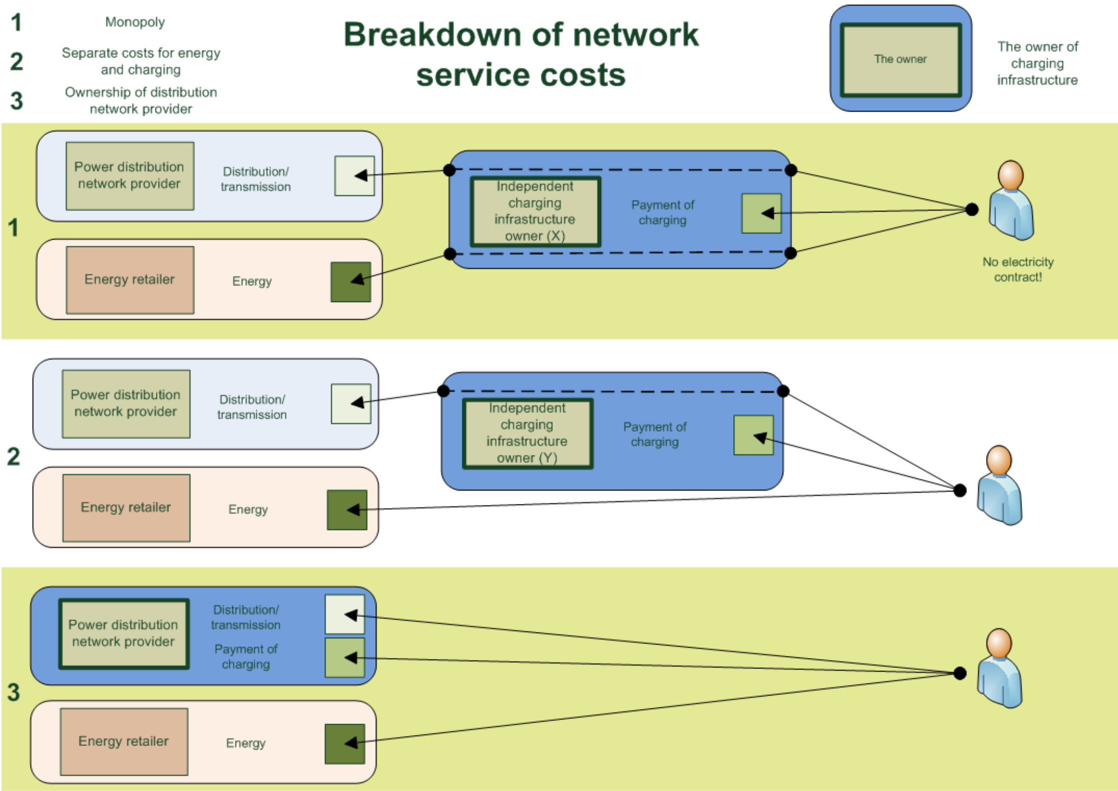

Figure 1. Basic cases of information flows and how they depend on the roles of players.

SIMPLE CHARGING

Communication needs in the monopoly case of simple charging are summarized in Table 1. Main communication is between Customer and Charger. The communication is related to the charging event itself (3 messages per charging event and vehicle) and possibly to the reservation of the charging place (2 messages per event and vehicle). In this case the data communication between charger and network operator is only once a day, comprising the total hourly powers classified by energy sellers. This data is needed for two purposes, the network usage tariff and the power balance calculation for which the network operator is responsible.

The reporting to the energy seller depends on the power purchase of the monopoly charger. For this there are several options: the charger may have only one energy provider, or he is buying from several energy sellers according to the bids. One important possibility also is that the charger has an own company that takes care of power purchase and production. In this case the charger only reports energy use to this one company, who in turn may have rather complicated structure of power market operations. In the well developed market situation it is likely, if independent charging service providers, that relatively large chains of chargers exist with their own power purchase departments.

Table 1. Communication needs in Monopoly case of simple charging.

Communication / single charge	*Communication / N charges*
Customer-charger: - Beginning of charging - End of charging - Metered energy / hourly power consumption - Reservation of charging point - Acknowledgement of reservation	**Customer-charger:** - N x Beginning of charging - N x End of charging - N x Metered energy / hourly power consumption - N x Reservation of charging point - N x Acknowledgement of reservation
Charger-network operator: - Hourly metering per day	**Charger-network operator:** - 1 x Hourly metering per day
Charger-energy seller: - Hourly power consumption per energy seller o Hourly metering per day o Own energy acquisition unit → metering in real- o time	**Charger-energy seller:** - 1 x Hourly power consumption per energy seller o Hourly metering per day o Own energy acquisition unit → metering in real-time

The communication needs in second case, separation of energy selling and charging service, are summarized in Table 2. The main difference with previous case is that now the Customer is free to select the energy seller. Customer might have a fixed contract with some energy seller, who provides the energy to his EV regardless the location of charging. In this case the Customer pays separate bills to the energy seller and to the charger. The latter also settles the network tariff with the local network operator.

In this case there may also be several competing energy sellers who can make offers to the EV owners based on the price of the day. It is also likely, that in order to provide a full service, the Charger also may suggest some power contract. However, the power seller is also in this case probably a different company as the Charger. In this case the Charger is not allowed to discriminate between energy sellers, and it is likely that the relation between Charger and energy seller is regulated and too close business relation is not allowed.

One very important question in this basic case is that who is the balance responsible party. Today it is the network operator, and it is likely that anyway the charger has to report to the network operator all the hourly demands, classified according to the eventual energy supplier. Reporting to the energy seller is in basic case only hourly based demands announced by the next day by noon. However, when volumes of charging energy start to be reasonably, more real-time measurement data with a higher resolution comes necessary. Since the network operator or the charger do not have obligation for this kind of metering data, it is a subject of negotiations between different parties – possibly an extra service from charger to energy seller.

Table 2. Communication needs in case of separation of energy selling and charging service.

<table>
<tr><td>Communication / single charge
Customer - charger:
- Beginning of charging
- End of charging
- Metered energy / hourly power consumption
- Reservation of charging point
- Acknowledgement of reservation
- Information about customer's energy seller
Charger - network operator:
- Hourly metering per day
Charger - energy seller:
- Hourly power consumption per energy seller and customer
o Hourly metering per day
o Large amounts of energy → more frequent metering cycle as an additional service</td>
<td>Communication / N charges
Customer - charger:
- N x Beginning of charging
- N x End of charging
- N x Metered energy / hourly power consumption
- N x Reservation of charging point
- N x Acknowledgement of reservation
- N x Information about customer's energy seller
Charger - network operator:
- 1 x Hourly metering per day
Charger - energy seller:
- N x Hourly power consumption per energy seller and customer
o Hourly metering per day
o Large amounts of energy → more frequent metering cycle as an additional service</td></tr>
</table>

Table 3. Communication needs in case of network operator as charging provider.

<table>
<tr><td>Communication / single charge
Customer - charger:
- Beginning of charging
- End of charging
- Metered energy / hourly power consumption
- Reservation of charging point
- Acknowledgement of reservation
- Information about customer's energy seller
Network operator-energy seller:
- Hourly power consumption per energy seller and customer
o Hourly metering per day
o Large amounts of energy → more frequent metering cycle as an additional service</td>
<td>Communication / N charges
Customer - charger:
- N x Beginning of charging
- N x End of charging
- N x Metered energy / hourly power consumption
- N x Reservation of charging point
- N x Acknowledgement of reservation
- N x Information about customer's energy seller
Network operator - energy seller:
- N x Hourly power consumption per energy seller and customer
o Hourly metering per day
o Large amounts of energy → more frequent metering cycle as an additional service</td></tr>
</table>

The third case, network operator as charging provider, is summarized in Table 3. This case is very similar to case 2, with the difference that there is no communication between charger and network owner. The role of the charger is clear in this case, since it must follow the rules of regulation as imposed on network operators in power market environment, the most important rules being 1) no electricity trade by network owner, and 2) no discrimination of energy sellers.

What will be the most dominant factor with regard of the success of the above cases depends on the development of the power market legislation. At the present, the roles, duties and rights of the EV owner and Charger are not defined in the legislation. This situation is a hindrance to the charging business development since as long as the legal roles of the actors are unknown there is a risk for the investors in charging infrastructure business.

In more detail, the open legislative questions are as follows:

- Is electricity trade allowed to the charging infrastructure owner. If not, the charger is only a carrier of power as the distribution network operator is today.
- Is monopoly allowed to the charging infrastructure owner, or must he be indiscriminative with regard to (other) power sellers.
- Must the infrastructure costs and energy costs be separated in billing, book keeping and financial reporting of the charging business.
- May the network operator be the owner or operator of the charging infrastructure and under which terms. Should there be separation in book keeping.
- Should charger be a balance responsible party. What are the relations of charger and distribution network operator in balance management.

SMART CHARGING

Smart charging will add a lot of new functionality into the communication architecture and billing and metering infrastructure. The demand of smart properties mostly is due to the transmission system operator's needs. These are depicted in Table 4. In normal operation, EV:s could be used for frequency control. This could be implemented within the charging hour by temporary on/off connection of slow charging, or in the case of three phase intelligent charging even so that the power flow is V2G. This kind of frequency control is more or less continuous activity, whereas the other two cases, disturbance reserves, are only needed occasionally when there is unexpected lack of production capacity in the bulk power system. Hence, these reserves are seldom needed, but their existence must be monitored to be sure that the reserve capacity is available if needed.

Table 4. TSO needs for frequency control and reserve capacity – possibilities of EV:s

Reserve	**Need**	**Minimum (maximum) unit size**	**Activating time**
Frequency controlled normal operation reserve	139 MW (The Nordic system totals 600 MW)	0.1 MW (5 MW) ~ 30 E-cars with slow charging ~ 5 E-cars with Mode 3; 32 A	3 min
Frequency controlled disturbance reserve	220 – 240 MW (largest Nordic dimensioning fault – in proportion to the countries' individual dimensioning faults)	1 MW (10 MW) ~ 45 E-cars with Mode 3; 32 A	5 sec (0...50 %); 30 sec
Fast disturbance reserve	880 MW (dimensioning fault; Olkiluoto 3 → 1300MW)	10 MW ~ 25 E-cars with Mode 4; 400 A	15 min

Table 5 Communication needs due to intelligent properties of smart charging

Communication / single charge	Communication / N charges
Charger - energy seller:	***Charger - energy seller:***
- *Information about the controllable capacity: Up/down regulation potential, fast and slow reserves* - *Information about the control: volumes in power and energy, control times*	- *N x Information about the controllable capacity: Up/down regulation potential, fast and slow reserves* - *N x Information about the control: volumes in power and energy, control times*
Energy seller - charger:	***Energy seller - charger:***
- *Control needs: real-time information*	- *1 x Control needs: real-time information*

The communication needs due to intelligent charging are presented in Table 5. These properties are the same regardless the technical architectures or power market cases discussed in previous section. Whenever an EV is connected, the following information has to be updated:

- The up/down capacity of the EV in question
- The capacity of frequency controlled reserves
- The capacity of fast (manually controlled) disturbance reserves
- The contract parties (probably the EV owner has a contract with a energy provider who in turn controls the business of controllable loads towards the TSO), and
- A report about control actions performed
    - Frequency control volume activated in normal operation situation
    - Frequency control volume activated in disturbance situation
    - Manually controlled reserves activated in disturbance situation

The communication should hence include at least four messages per charging event, that are delivered to the party in charge of the control capacity. Most likely this party is the company who is in charge of delivering electrical energy either based on the contract between the EV owner and the energy seller, or between the energy seller and the charging infrastructure provider (in monopoly situation – at least). It may be so, for instance, that the charger gives a better price to the EV owner, if intelligent charging is allowed.

A second question is the communication needs in the case of controls. In the case of frequency control the decision of control actions have to be practically made in real-time. This requires that the control is decentralized close to the charging site, i.e. integrated in the charging pole or implemented at a local control level immediately above the charging poles. The manually initiated fast disturbance reserves have to be activated in 15 minutes, which allows for centralized control.

In addition to the above mentioned TSO-related controls, the EV-charging will probably be used as a controlled load in order to optimize the bulk power purchase of the energy provider. This activity will add one more control message into the list of communications. This is the bulk control needs of the energy provider in the charging location in question.

Summary of the communication needs and volumes

The above analysis has been made for the case, where the charging is made as a service by some charging infrastructure provider. This is the case with parking garages, park-and-ride cases and in other similar situations. These are the likely cases in metropolitan areas and in cities, where new infrastructure has to been built in order to make electro mobility a reality. In most suburban cases, the charging will be probably done, at least in the beginning, using slow and uncontrolled sockets of private houses or of the present parking place sockets of housing co-operatives, nowadays used in winter time for cabin and motor pre-heating. It may yet be possible, that when the benefits of intelligent charging come evident, also these sockets are integrated in an intelligent control of future Smart Distribution Grids. In that case, a simple on/off control coordinated by a local control level probably will be satisfactory.

Summarizing the communication needs associated with charging services we get the following Table 6. These figures are estimated per one EV and charging event. If the number of EVs is increased, the communication grows in relation. In addition, there are the messages between charger-network operator-energy seller, which are dependent on the relations of these actors in power market and can't hence be given straightforward estimates. Especially in the case of many EV:s, the volume of these messages is small compared to EV related communication.

Table 6. Summary of EV related communication related to charging services.

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