Theoretical studies on e-mobility services tailored for residents

(SPARCS Action L16-2)

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1. Introduction

Due to the efforts for climate neutrality and the change towards electric mobility, several new business models and players have established themselves in the field of "electric mobility" in recent years. The operation of charging infrastructure and charging station management and billing systems has become a lucrative business field and many different players have focused on this area and driven innovation in this sector. For example, the operation of charging infrastructure and the billing of charging processes are now part of the extended business field of many municipal utilities.

The activities of the companies in the e-mobility ecosystem and the services to the customers currently mainly comprise the provision of charging energy and the billing of charging processes. Other services to customers and the integration of payment processes into other processes currently play only a minor role, but could increase the user experience and customer satisfaction in the future. The extent to which an integration of further services is possible and what corresponding services as well as business models could look like was analysed within action L16-2 of the SPARCS project. According to the proposal, the focus therefore was set on the reservation of charging spaces, the selection of charging tariffs and priority setting. The results of the examinations are presented in the following. This document is relevant for stakeholders who would like to develop or implement services in the context of "charging" (e.g. flexible tariffs) in the future and would like to receive an overview of the corresponding framework conditions and challenges.

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2. Roles, actors and standards in the context of e-mobility

As basis for the exploration of business models and services the relevant roles and actors that exist in the context of e-mobility need to be shown. These are necessary to understand the payment processes of charging processes and to show the possibilities in the design of prices.

Standardised protocols are used for communication between the different actors and backend systems. As these offer different possibilities for pricing and provide a framework for billing, a standard and its pricing possibilities are presented in 2.3.

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2.1 Actors and Roles

The two essential roles in the ecosystem of electric mobility are the Charge Point Operator (CPO) and the E-Mobility Provider (EMP). Their main tasks and functions are described below:

- **Charge Point Operator (CPO):** A CPO is a company that operates various charging stations. CPOs are often also responsible for installation and maintenance of charging stations and mostly own the operated charging infrastructure. CPOs provide the relevant systems to operate the charging points and manage the corresponding processes. For this purpose, CPO backend systems are used. As shown in Figure 1, charging stations are connected to the CPO backend, which ensures the relevant exchange of data to operate and bill the charging processes.

- **E-Mobility Provider (EMP):** An e-mobility provider (EMP) is a company that offers charging services to its customers and enables electric vehicle users (EV users) access to charging points. In general, EMPs provide a visual map of their supported charging stations and enable charging via app or authentication token. Local energy utilities, vehicle manufacturers or other companies often operate as an EMP and operate the corresponding systems and processes. The contract between the EMP and its end customer (EV user) defines one or more tariffs, usually containing a kWh-based tariff and an optional time component. The relationship between the EMP and its customers as well as the connection to the CPO is shown in Figure 1.

To start a charging process the EMP system needs to communicate with the CPO system in order to authorize a charging process and bill its customers according to its own tariffs. The user can only start a charging process at a specific charge point if his EMP has a contract with the respective CPO. An example for the contract situation is displayed in Figure 1. On the left hand there is a single charging station which is operated by CPO A. CPO A has a contract with EMP 1. Thereby user 1 (green) can charge at the charging station with his RFID card provided by EMP 1.

The example also shows a second EMP, that has no contract with CPO A. Since EMP 2 does not have a contract with CPO A, user 2 (red) can’t charge at the charging point with his RFID card, provided by EMP 2.

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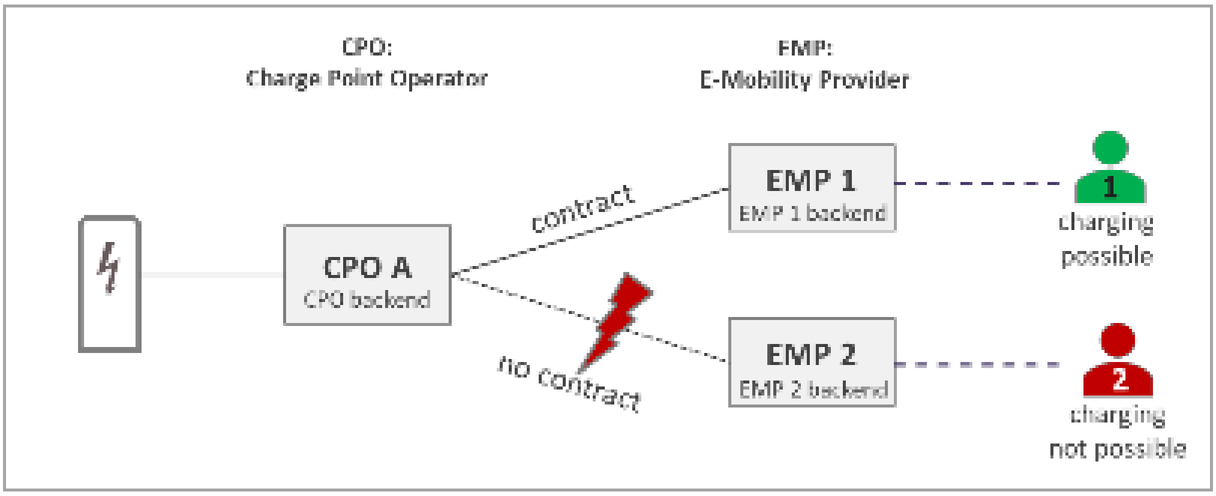

Figure 1: Introduction CPO (charge point operator) and EMP (e-mobility provider)

Two alternatives are currently practiced for communication between CPOs and EMPs:

1. The systems are connected one to another via a direct interface. Thereby, the data is exchanged directly between the CPO and EMP. One possibility to implement that way of communication is the Open Charge Point Interface (OCPI). This is described in more detail in section 2.3.

2. The data exchange takes place via a roaming platform. The roaming platform serves as a hub and ensures the flow of information between different systems. The exchange of information via roaming is also illustrated in Figure 2. Well-known roaming platforms are hubject (https://de.hubject.com/) or gireve (https://www.gireve.com/home). In contrast to the Peer-to-peer connection, fewer connections are necessary while using roaming platforms (see Figure 2). By integrating roaming, however, there is an additional actor and an additional value-added stage.

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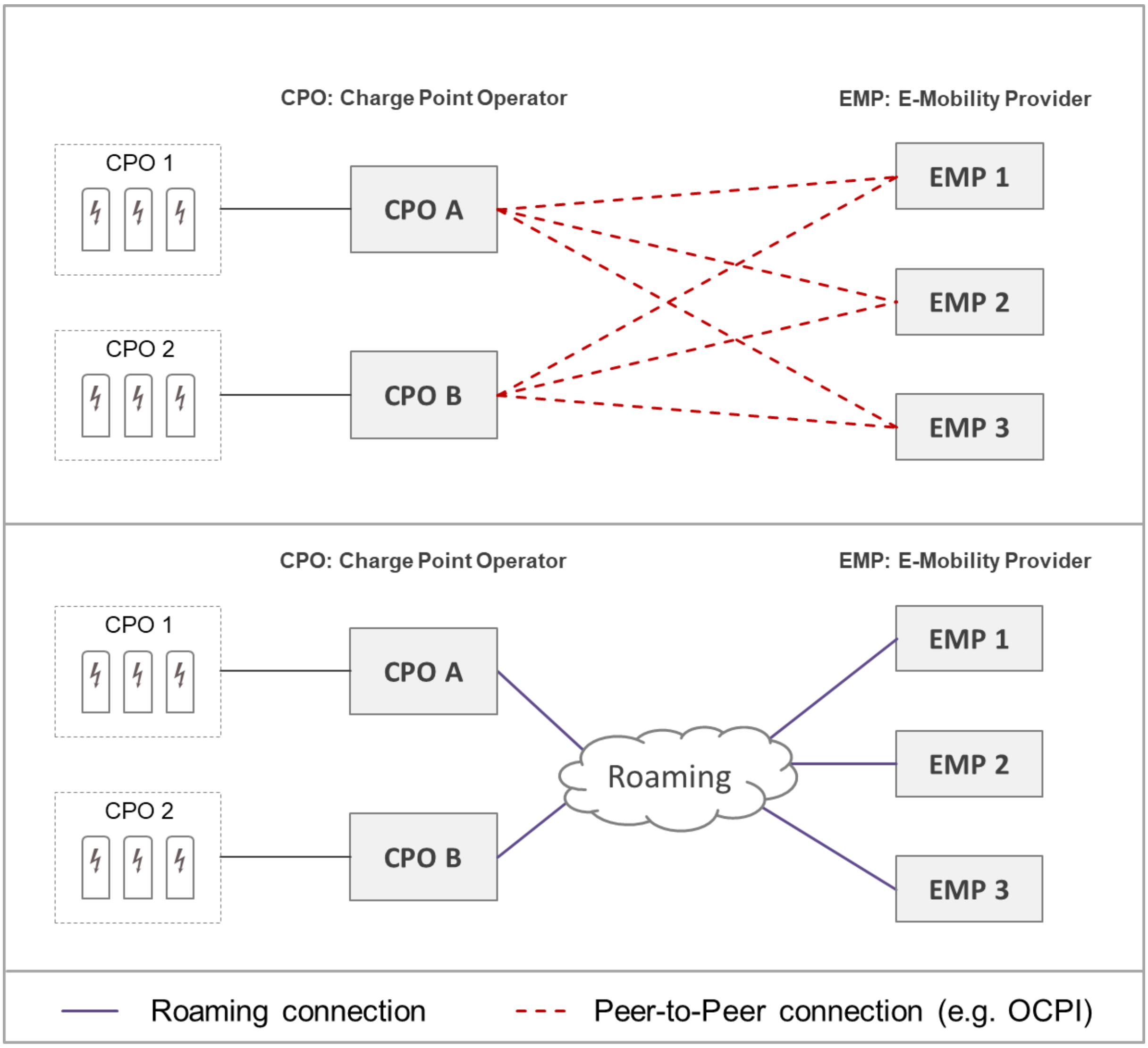

Figure 2: Introduction Peer-to-Peer communication (OCPI) vs roaming hub

In the following sections we assume that both systems, CPO and EMP, are connected via a direct interface. This simplifies the explanations. The roaming use case works similarly since it only adds a third party system which supports the communication between CPO and EMP. However, the basic functionalities and tasks regarding *management of charging stations* (CPO) and billing *e-mobility drivers* (EMP) remain unaffected.

Within the ecosystem of e-mobility, there are also companies that adopt multiple roles. Thereby, there are organizations that act as both charge point operator and e-mobility provider.

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2.2 Payment and billing processes and systems

As described in the previous section, there are several roles and responsibilities in the ecosystem of e-mobility. There are contractual relationships between the players, which regulate payment. This leads to the fact that there are different tariffs in the different stages of the billing process.

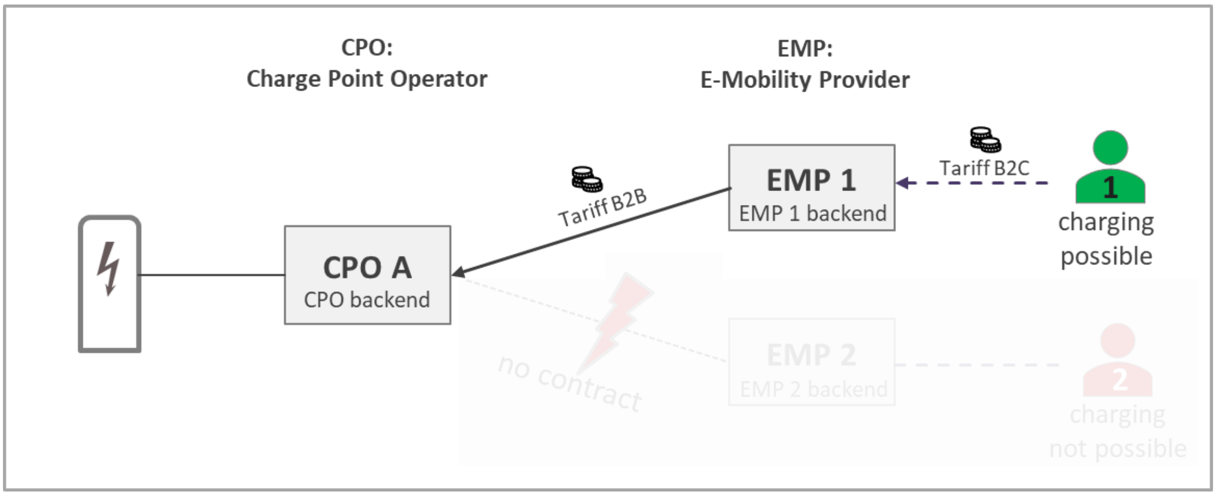

Figure 3: Different tariffs between various actors

Figure 3 shows that there are different tariffs and prices between different actors. These are in turn determined by the contractual relationships and described below:

- CPO and EMP negotiate a tariff for the charging processes within their B2B contract. Figure 3 shows an example of a tariff between *CPO A* and *EMP 1*. This is described as *Tariff B2B* and could be 28 ct/kwh.
- EMP bills the end customer according to their end user tariffs to which the end user agrees. Figure 3 shows an example of a tariff between *EMP 1* and *customer 1* (green). This is described as *Tariff B2C* and could be 39 ct/kwh.

In general, the prices *Tariff B2B* and *Tariff B2C* are unrelated. The described ecosystem shows a drawback for the goals described in the work package. The end user price for a charging process is determined by the EMP (Tariff B2C). The CPO has little to no influence on the end user price since the prices normally are not coupled to the B2B tariffs. Thereby, current roles and processes do not support innovative tariffs or dynamic pricing well.

However, for some users innovative cases and business models are applicable. As already described, there are organizations that act as both *charge point operator* and *e-mobility provider*. One of them is LSW (Leipziger Stadtwerke). LSW operates a lot of charging points in Leipzig and furthermore is responsible for billing charging processes to customers. So, if the contractual framework conditions permit, LSW could provide

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various tariffs to its end customers for its own charging stations. How this could be implemented in the context of SPARCs is described in Figure 4. In that figure, the CPO and EMP functions are aggregated to one system considering CPO and EMP functions.

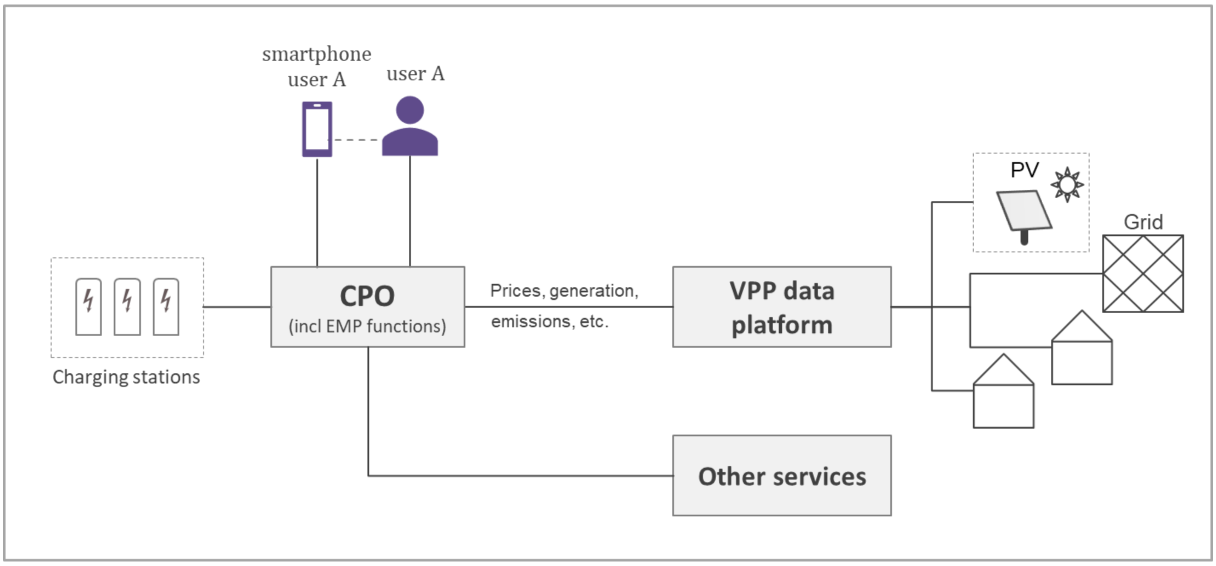

Figure 4: Architecture and systems for various tariffs

In that case the CPO can define a price/tariff the end consumer has to pay. Since the CPO backend includes EMP functionalities, the CPO can determine the end customer price and then in fact offer new tariffs. This provides flexibility in billing charging processes and enables the CPO to offer a specific price/tariff to the customers (e.g. via an app). The CPO's price to the customer can be based on external signals. In Figure 4 the VPP (Virtual Power Plant) data platform backend of LSW provides such signals. The VPP data platform aggregates the data that energy producers, consumers and grid elements provide and provides predictions. In Figure 4 two buildings, one PV module and the power grid are connected to the VPP data platform. As seen in the figure the VPP data platform transmits predictions (e.g. price or emission) to the CPO backend. These serve as input for price and tariff determination. For instance, the VPP data platform predicts a provision of a lot of energy via the PV module. Receiving this information, the CPO backend adapts charging tariffs accordingly by decreasing the prices dynamically in order to increase energy consumption in a time frame of high energy production. These prices and tariffs then can be communicated to the user via app. Moreover, it is possible to integrate other services and systems to offer additional services. Some of them are described in section 3.3.

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2.3 OCPI - Open Charge Point Interface

The Open Charge Point Interface (OCPI) is a protocol that supports communication in the ecosystem of e-mobility. As described in OCPI version 2.2.1 (current version December 2021) *"the Open Charge Point Interface (OCPI) enables a scalable, automated EV roaming setup between Charge Point Operators and e- Mobility Service Providers. … It offers market participants in EV an attractive and scalable solution for (international) roaming between networks, avoiding the costs and innovation-limiting complexities involved with today's non-automated solutions or with central roaming hubs. As such it helps to enable EV drivers to charge everywhere in a fully-informed way, helps the market to develop quickly and helps market players to execute their business models in the best way."* [1]

In addition to the EMP and CPO, OCPI defines further roles in the ecosystem and provides the corresponding communication. The additional roles are described in Table 1.

Table 1: Roles Open Charge Point Interface

Role	**Description**
CPO	Charging Point Operator. Operates a network of Charge Points.
eMSP/EMP	e-Mobility Service Provider. Gives EV drivers access to charging services.
(Roaming) Hub	Can connect one or more CPOs to one or more eMSPs.
NAP	National Access Point. Provides a national database with all (public) charging locations. Information can be sent and retrieved from the NAP. This makes it different from a typical NSP.
NSP	Navigation Service Provider. Provides EV drivers with location information of Charge Points. Usually only interested in Location information.
SCSP	Smart Charging Service Provider. Provides Smart Charging service to other parties. Might use a lot of different inputs to calculate Smart Charging Profiles.

https://evroaming.org/app/uploads/2021/11/OCPI-2.2.1.pdf

The integration of further roles and actors as well as the expansion of functionalities is planned for subsequent versions. For example, the grid operator is included in the use cases of OCPI version 3.0-1 to transmit data regarding charging processes between CPO and grid operator.[2] This may allows to adjust grid operation and integrate e-mobility.

[1] https://evroaming.org/app/uploads/2021/11/OCPI-2.2.1.pdf

[2] https://evroaming.org/app/uploads/2021/11/OCPI_3.0-1_business_use_cases.pdf

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As already described, the Open Charge Point Interface (OCPI) is mainly used for communication between EMPs and CPOs. One component of that communication are tariff options. In principle, four tariff elements can be implemented via OCPI.

These are:

- *Flatrate*, which can be used for example for a flat charge or a basic fee and is billed in €/1,
- *Amount of Energy*, which is billed in €/kWh,
- *(Charging) Time*, which can be used for the charging time for example, but also for a reservation period and which is billed in €/h,
- *Parking time*, which is to be distinguished from the charging time price component and which is also billed in €/h.

Other communication protocols such as OICP (Open InterCharge Protocol) support similar pricing and tariff models.

It is also possible to combine the individual tariff elements for a charging session in case of OCPI. In addition, the listed tariff elements can also be linked to conditions. Examples of conditions can be the charging power, charging current, charging amount, start and end time, days of the week or calendar sections. As a result, high complexities in pricing and tariff structuring can also be implemented through the interface and corresponding complex tariffs can be communicated between the actors.

3. SERVICES AND BUSINESS MODELS

In the following sections, business models and services for residents are presented. According to the proposal, the focus therefore is set on the reservation of charging spaces, the selection of charging tariffs and other services like priority setting.

3.1 Reservation of charging points

Currently, only a few systems allow the reservation of charging stations. A reservation can currently be technically implemented via OCPP (Open Charge Point Protocol)[3]. In the case of a reservation, the charging station is blocked from the time of the reservation until the charging process is activated for the corresponding user. The charging station can also be configured to delete a reservation after a certain time. A reservation for a certain time interval beginning in the future is currently technically not possible via OCPP, because OCPP does not support that function. The corresponding process of a reservation according to OCPP is shown in Figure 5.

[3] OCPP (Open Charge Point Protocol) is a protocol for communication between charging stations and CPO backend systems

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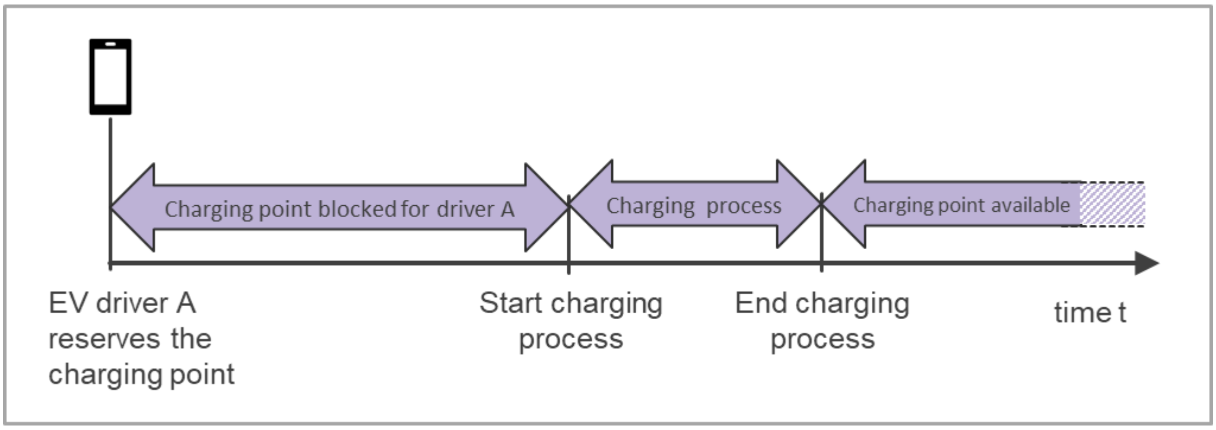

Figure 5: Reservation process supported by OCPP (Open Charge Point Protocol)

A drawback for the current reservation function is that charge points cannot be reserved for a future time interval. The CPO backend can implement this by sending a delayed OCPP reservation request to the charging station. But in this case other EV drivers could still start a charging process in the time between the custom reservation request and the start of the OCPP reservation. The reservation then cannot be fulfilled anymore since the previous charging process might extend into the reservation interval. Similar to the described pricing issue in section 2.2 there are also challenges regarding reservations in the current ecosystem of e-mobility since e-mobility drivers use EMP's apps, but CPOs have to reserve charging stations. According to section 2.2 we assume that both functionalities (CPO and EMP) are integrated within one system and one actor (e.g. LSW) operates the charging points and further more is responsible for billing the customers. This allows users to reserve charging stations and the CPO to block the charging point.

An exemplary reservation process and an app mock for reservations are displayed in Figure 6 and described below. Before being able to issue a reservation the respective charging station (Figure 6 view 1 and 2) and a date for the reservation (Figure 6 view 3) need to be selected. For the depicted example the 23.05.2021 is used. On the last view the user can then see available and already booked time slots. Finally, the user can book his preferred reservation time slot.

For a reservation a fee could be issued with which the CPO then can generate revenue for blocking the charging station. On the one hand, a **fixed fee for the reservation** could be defined. For the fee calculation the location or the utilization of the charging station could be taken into account. Another possibility for a reservation fee is **price based on the duration of the reservation**. If the start of a reservation was half a day in the future the CPO would lose revenue due to lost possible charging processes. Therefore, the CPO could try to prevent long reservation periods by introducing time dependent reservation fees [€/min].

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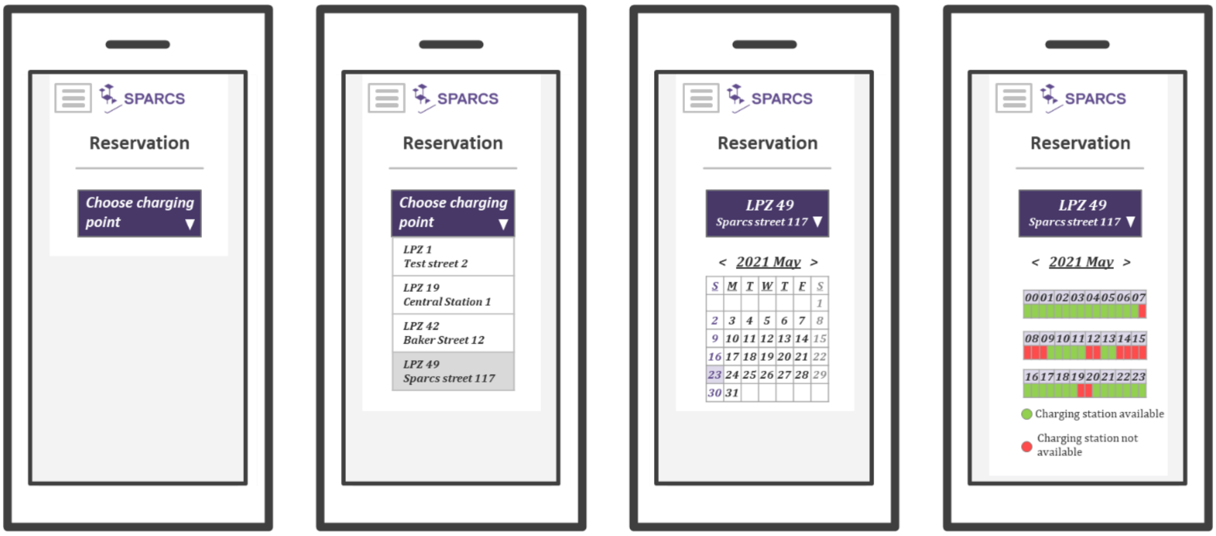

Figure 6: Reservation of a charging point

Additional to the billing of reservation fees other variants can be implemented. For one, the reservation fees can be generally raised. In this case the fee will be billed even when there is no following charging process. Another variant of billing calculation could be to only bill reservation fees for no-shows. When a charging process is started then the reservation fees will be omitted.

3.2 Selection of charging tariffs

To define other tariff structures different tariff types are defined beyond according to the OCPI interface. OCPI defines four different tariff options: *regular*, *cheap*, *fast* and *green*. These four tariffs could be offered to the user via app using different configuration options.

An exemplary representation is given in Figure 7. In that figure a view is shown in which a user can choose between the four different tariffs. For the tariffs *cheap* and *green* additional options can be selected. In the example this is displayed in the center and right view in Figure 7. For both options the user needs to determine the current SoC (state of charge) and the departure time, at which the EV shall be fully charged. The input data then can be used by the CPO to define the restrictions for the charge control system.

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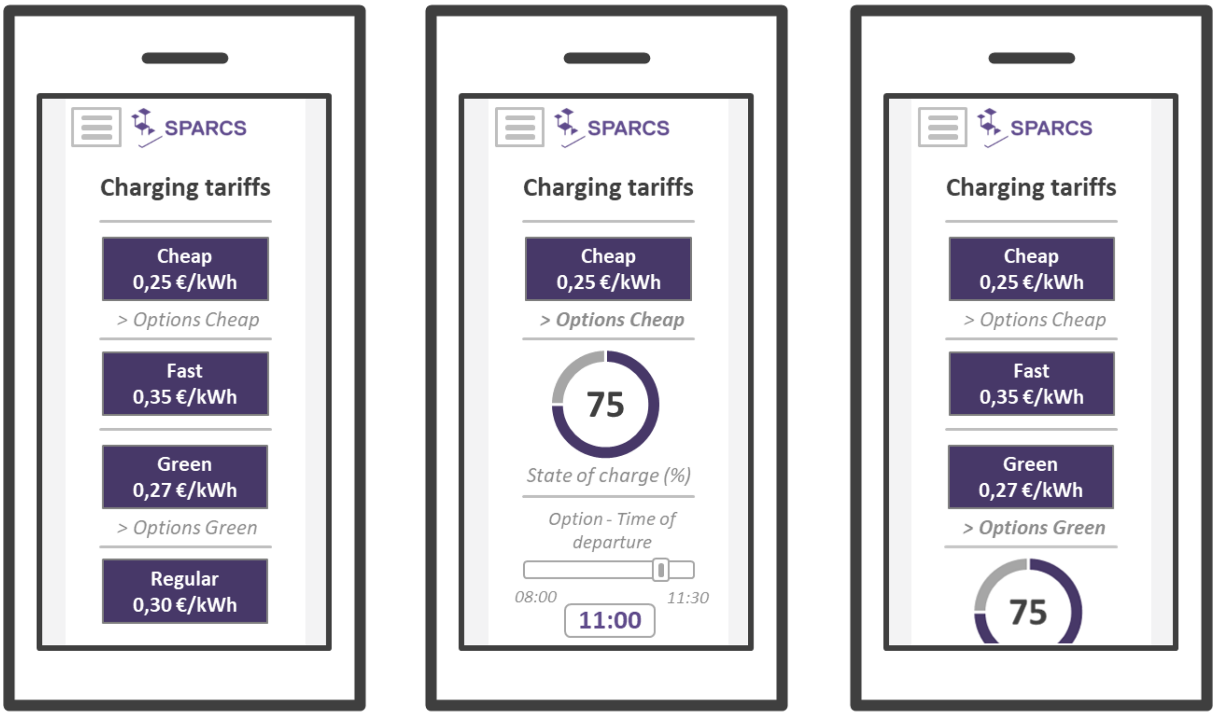

Figure 7: Selection of charging tariffs

In Leipzig LSW (Stadtwerke Leipzig) could offer the various tariffs to their customers at the charging stations LSW operates. A possible implementation of the tariff options is as follows:

Cheap: In case of the *cheap* tariff, the driver wants the cheapest tariff for the charging process. Thereby, the functionality of the VPP data platform could be used. The VPP data platform provides future price signals for various players. If the current SOC, the charging power and the desired departure time of the driver are known, the vehicle can be charged at those times when the VPP data platform predicts the lowest prices, e.g. when there is a low demand for energy in the grid at the time. A corresponding mechanism can be implemented in the CPO backend. In addition to the *cheap* option, a desired departure time at which the vehicle must be charged at the latest and the current SOC can be defined. If the user does not want to specify the options, default values can be assumed and an optional risk factor can be selected. The advantages and disadvantages of the cheap tariff are as follows:

- \+ Cheap tariff
- \+ Flexibility for the CPO and the grid
- \- Possibly longer charging time

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Fast: In case of the *fast* tariff, the electric vehicle user wants to charge his vehicle as fast as possible. In this case, the CPO backend and the VPP data platform provide the maximum charging power of the vehicle/charging station. The costs, greenhouse gas emissions or other parameters are not taken into account for optimization. Flexibility cannot be provided as a result. The advantages and disadvantages of the tariff *fast* are as follows:

+ Fast Charging
- High load on the grid
- No consideration of emission values
- Expensive tariff

Green: In case of the *green* tariff, the driver prefers the most ecological tariff for charging his vehicle. Therefor the functionality of the VPP data platform can be used. The VPP data platform provides forecasts of the greenhouse gas emissions of the electricity mix for various actors. If the current SOC, the charging power and the desired departure time of the electric vehicle driver are known, the vehicle can be charged at the times when the VPP data platform predicts the lowest greenhouse emissions of the electricity mix - e.g. at times with high feed-in from renewables. A corresponding mechanism can be implemented in the CPO backend. In addition to the green option a desired departure time at which the vehicle must be charged at the latest and the current as well as target SOC could be defined. If the options are not specified, default values can be assumed. The advantages and disadvantages of the green tariff are as follows:

+ Cheap tariff
+ Most ecological tariff and lower CO_2 emissions.
+ Flexibility for CPO and grid
- eventually longer charging time

Regular: The regular tariff is used if the driver's preferences are not specified and the charging periods are not specified. Control of the charging process based on the needs of the users is therefore not possible as they are not explicitly defined. Such framework conditions could, however, already be defined once when the contract between the EMP and the user is concluded. The advantages and disadvantages of the regular tariff would then be:

+ Flexibility possible to a certain extend
- No consideration of emission values

Prospectively, the regular tariff could be changed to support grid-compatible charging in the "regular case" as well and thereby approach the green tariff.

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3.3 Other business models, tariffs and services

Flexibility through bidirectional charging

Bidirectional charging enables using electric vehicles (EV) as accessible battery storages which can be used to feed power back to the grid. Therefore, more flexibility is available to compensate for load peaks within the energy grid. At times with high PV generation the EV batteries can be charged and discharged when immediate energy is required and the renewable energy sources do not provide enough power.

To compensate for the additional usage of the battery incentives are necessary to convince users to participate in the flexibility market. Therefor different kinds of reimbursements could be made:

- Compensation based on the provided power (€/kW)
- Compensation based on the accessed power (€/kW)
- Compensation based on the retrieved effect work (€/kWh)
- Compensation based on time (€/h)
- Combination of previous aspects

Residents can gain profits by providing flexibility to the energy market. The desired scenario for bidirectional charging would be that EV drivers can define their own boundaries. Therefore, a driver could communicate his desired minimal SOC which shall not be undercut. Another use case could be to communicate the target SOC, which shall be reached until a certain point in time.

For the use case "bidirectional charging" the charging station control requires extensive implementations and additional optimization algorithms for the VPP data platform and CPO backend systems. To establish bidirectional charging across the board further adjustments to the legal regulations are necessary. Furthermore, there are many technical challenges involved in the field of bidirectional charging. Currently only few EVs und charging stations exist which support bidirectional charging. For a rollout across the board further technical advances must be made besides the existing legal questions.

Charging with own PV energy

Residents which in addition to their EV own a PV plant could be offered to charge their vehicle with their self-generated energy at public charging infrastructure. For this case the provision of PV energy requires an implementation of mechanisms supported by the VPP data platform and the CPO backend system. One way of implementing the functionality is given as an example in Figure 8.

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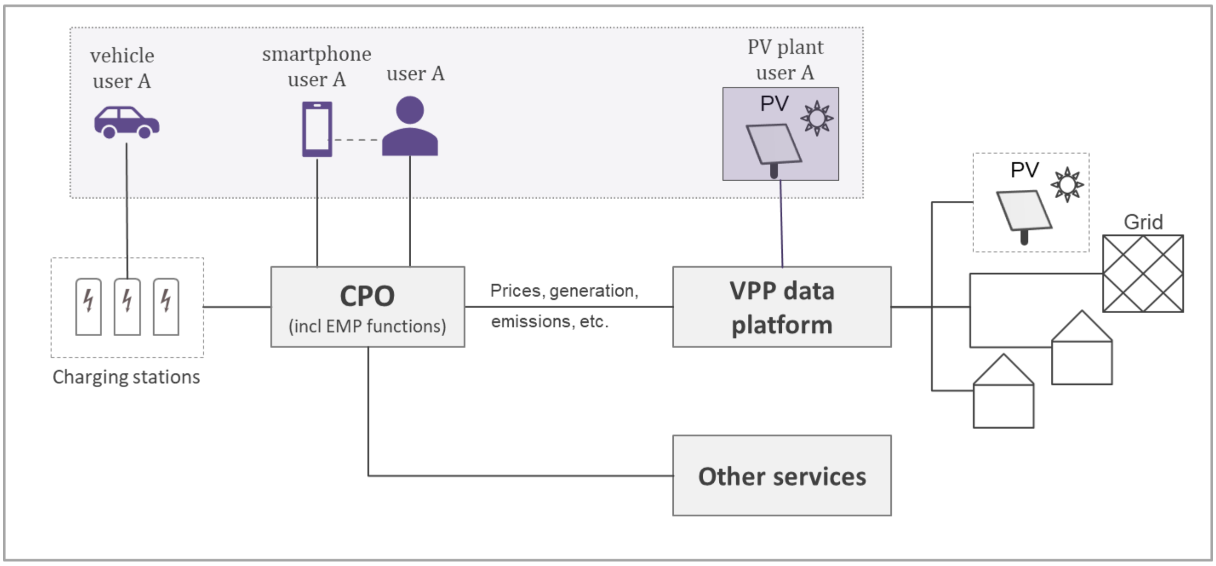

Figure 8: Charging with own PV energy

Figure 8 shows possible steps to implement the described functionality. In purple a user (user A) and his vehicle, his smartphone and his PV system are shown. To implement the functionality, the feed-in data of the PV system must be collected. Not only the amount of fed-in energy is relevant, but a high-resolution time series must also be collected and assigned to the customer (user A). In addition, the time series of user A's charging process have to be gained. By calculating the difference between the time series, one can determine the amount of self-consumption and the amount of energy provided by the grid.

Theoretically the implementation of the approach is possible, but for the implementation many regulatory topics need to be clarified. Examples are:

- Development of a process to charge with self-generated PV energy
- Determination of grid fees
- Definition of tax handling and apportionments

Due to the regulatory framework, the practical implementation of the service "charging with own PV energy" is not possible easily. However, if the regulatory and legal issues are clarified, such a service could be offered by Stadtwerke Leipzig. In this case, a service could look like this: customers obtain their home and charging electricity from the Stadtwerke Leipzig. Stadtwerke Leipzig and associated companies such as Netz Leipzig provide a concept and metering service so that customer's PV electricity is correctly allocated to a charging process executed at a LSW charging station.

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Priority Setting

In section 3.2 different tariffs regarding charging EVs were presented. Equivalently, one can define different priority groups. In this case vehicles with higher priority are charged before vehicles with a lower priority. In case of an energy bottleneck the first charging processes which are reduced to lower charging rates will be vehicles in the lower priority group.

An exemplary selection of priority is shown in Figure 9. In Figure 9 three priority groups are selectable. To start a charging process a priority with a certain price needs to be selected. Charging processes with the highest priority group also cost the most (45ct/kWh) and receive the maximum charging rate. The charging rate of the priority group 2 can be reduced during a bottleneck with a guaranteed minimum charging rate of for example of 7kW. Here a price of 35 ct/kWh is set. Charging processes of priority 3 are the ones to be reduced first when a bottleneck occurs. The users therefore have a reduced price as incentive to use the lower priority groups. For priority group 3 it might also improve customer satisfaction if a minimum charging rate of 3,6 kW is introduced. Since such a pricing model provides flexibility for operators and favorable prices for customers, such an approach could be interesting for both operators and end customers.

Figure 9: Priority setting

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There are a number of possible variations for the example listed. The adaptation of the following parameters is conceivable:

- Number of priorities
- Minimum charging rates (kW)
- Prices (€/kWh)
- Additional price components (e.g. costs per time)

Operation of charging stations by housing associations

As a wholly owned subsidiary of Leipziger Wohnungs- und Baugesellschaft mbH (LWB), WSL (WSL Wohnen & Service Leipzig GmbH) provides housing-related services for property managers and property owners such as heating cost billing, water billing, equipment rental.[4] As an additional service for the citizens WSL (WSL Wohnen & Service Leipzig GmbH) could operate charging stations and offer the service “charging electric vehicles”.

There are two main operator models to operate charging stations as a housing association:

- **Own service:** The housing association operates as a full-service provider of the charging infrastructure and operates a charging station backend. The housing association bills the citizens and performs all necessary steps for operation.
- **External service:** Typically, the operation of charging infrastructure is not the core competence of housing associations. Therefore, the service may be subcontracted to a subcontractor. The subcontractor's billings can then be integrated into the housing associate's billings.

Free charging while shopping

In addition to the players mentioned so far, other partners could also be integrated into the system and provide services. For example, shopping centers, supermarkets or malls with charging infrastructure could offer discounted rates or free charging while their customers are shopping. In this case, shopping centers and supermarkets could provide an incentive to visit their own location and attract additional customers. Vehicle users who do not shop at the mall pay full price for charging accordingly, allowing supermarkets additional revenue opportunities. In turn, the integration of systems is necessary for the implementation of the use case. External systems, such as those of shopping centers, may need to be connected. This would be a use case for the connection of further systems in Figure 4.

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[4] https://www.wsl-leipzig.de/

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4. Conclusion

In this document, business models and services for residents regarding reservation of charging spaces, selection of charging tariffs and priority setting were presented. For this purpose, the e-mobility ecosystem was first introduced and the relevant roles, actors and systems that exist in the context of e-mobility were shown. Limits of the current ecosystem and the problem of integrating additional services due to task allocation were presented. Thereby the current billing processes and technical communication protocols such as OCPI (Open Charge Point Interface) were taken into account.

Afterwards the business models and services for residents regarding reservation of charging spaces, selection of charging tariffs and priority setting were shown. The individual advantages, disadvantages and needs for action (e.g. in the regulatory framework) were also highlighted.

To foster climate neutrality and the energy transition innovative services and pricing models in the context of electromobility could create incentives. However, this requires a reduction in the complexity of the ecosystem and the adjustment of the legal framework. In addition, processes must be defined and systems integrated that can bundle the relevant information, manage energy, create the incentives and implement relevant actions. The described services for customers and the business models currently play only a minor role in reality, but could increase the user experience and customer satisfaction in the future and thereby contribute to sustainable future mobility.

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