A Framework for Electric Mobility Services for a Car Park

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Abstract.

Electric vehicles (EV) are seen as one promising technology which can provide flexibility to the demand side in the electricity market. One promising application might be a car park where an operator schedules the charging processes of EV.

This paper outlines a conceptual framework to enhance this demand side flexibility of EV customers with incentives through diverse service designs. Thereby, the development of a business model takes both sides into account: the offset between cost and benefits for the operator as well as tariffs with attractive incentives for customers. We focus in the following on a car park and give a comprehensive outline on the design of services for different groups of EV customers.

Keywords: EV fleets, mobility services, car park operator.

1 Introduction and background

Currently, grid stability is primarily provided by the conventional supply side. However, due to an increasing uncertainty and volatility of renewable energy sources (RES) an arising probability of imbalances exists which could be offset through demand side flexibilities. The idea of scheduling the charging of electric vehicles (EV) when RES are available increases both, the environmental advantages of EV and the reliability of the electricity system. There is already a broad literature on this issue [1]. New business model may foster the value for customers and therefore increase the willingness to provide load shifts.

So far, several studies focus on the possible flexibilities of EV in the grid regarding the supply side. Most studies assume that a certain amount of EV will be managed by an aggregator and hence existing flexibilities could be offered at an energy market (which is linked to an independent system operator (ISO)) to e.g. reduce peak load or provide ancillary service

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etc. (e.g. [2]) A car park operator is such an intermediate operator – acting as an aggregator – being the interface between supply and demand (see Figure 1).

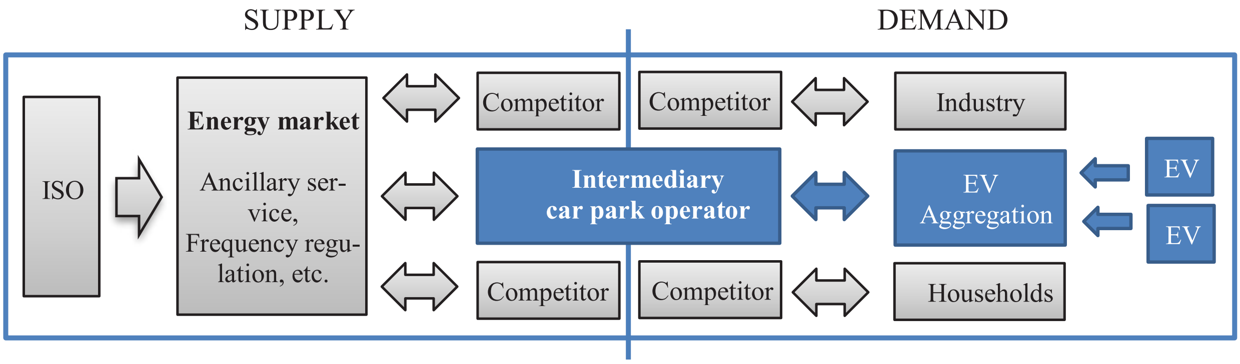

Figure 1: Concept of the market participation of a car park operator based on [3]

The purpose of this paper is to focus on the demand side flexibilities through EV aggregation in the context of a car park. It studies possible service designs which can be offered from a car park operator point of view to their different groups of EV customers to enhance their flexibilities and address incentives. Especially, as reasonable business models are needed to increase the profitability of charging stations.

After a brief overview of relevant related work, Section 3 gives insights of a conceptual framework for electric mobility services in the context of a car park operator. Afterwards, Section 4 ends the paper with a conclusion and an outlook on future work.

2 Related Work

A holistic approach for business models for EV can be found in Kley et al. (2011) [4]. Further development of more specific frameworks exists, e.g. for the design of energy services for customer [5] or for electric mobility services around the usage of EV [6]. These studies use the morphological box as a methodology approach to systematizing the developed business models and the including possible solutions. Another study designed a conceptual framework for various services provided by EV [7].

Methodologies for business models in the context of EV charging infrastructure was analyzed by Madina et al. (2016) [8]. They have a closer look at three different charging locations – at home, highway, semi-public. The latter one can be referred to charging in a car park in which they found out that for profitable reasons a higher usage of the charging stations is relevant. Another finding of their work was that charging at home seems to be the preferred solution with respect to total cost of ownership. Other qualitative business models in the context of EV are e.g. [9], [10].

Salah and Flath (2016) apply a deadline differentiated pricing scheme in the context of a car park to incentivize flexible loads. They identify that price levels are driven by the cost of conventional generation [11]. Brand et al. (2017) investigate a business model in the case of a car park using aggregated EV load to facilitate reserve energy. Their findings with respect to revenues imply that they are very little in comparison to investment costs for IT infrastructure and charging. Hence, associated business models require a closer look to derive robust implications [3].

This paper extends the literature by a detailed look at service design for different groups of EV car park customer to foster their demand side flexibility. This is set into the context of the development of a conceptual business model framework for the demand side perspective in the market for a car park operator that takes the role of an EV aggregator.

3 Business model approach

According to Osterwalder et al. (2005) a business model describes a conceptual tool which contains a set of elements and the respective relationships to represent the business logic of a firm [12]. Bringing this into our context different design possibilities need to be considered when a car park operator evaluates the possible tariffs. The main leverages are provided through flexibility by customers and the corresponding incentives.

Looking at the possible service design in the context of customer flexibility of a car park several aspects need to be considered. Parking is for the most EV customer a necessary process where not too many options should be provided to reduce complexity. However, it should be distinguished between the different types of customer. If one-time appearances or short-term customers (e.g. parking for shopping or leisure time) are considered it's unlikely that they have a lot of flexibility to offer as their idle time is about 1h to 3h in average depending on the car park or do not provide a regularly projectable demand [13]. In contrast, a recurring customer has the advantage that this demand might be better projectable by a car park operator. Additionally, long-time customer who might have a parking duration of up to

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9 h during a day might have more flexibility [13]. Service levels could be dependent on the customer. The more flexibility regarding the load management is offered by an EV customer the more variation exists for the service level which goes together with the complexity of the respective tariffs (see Figure 2).

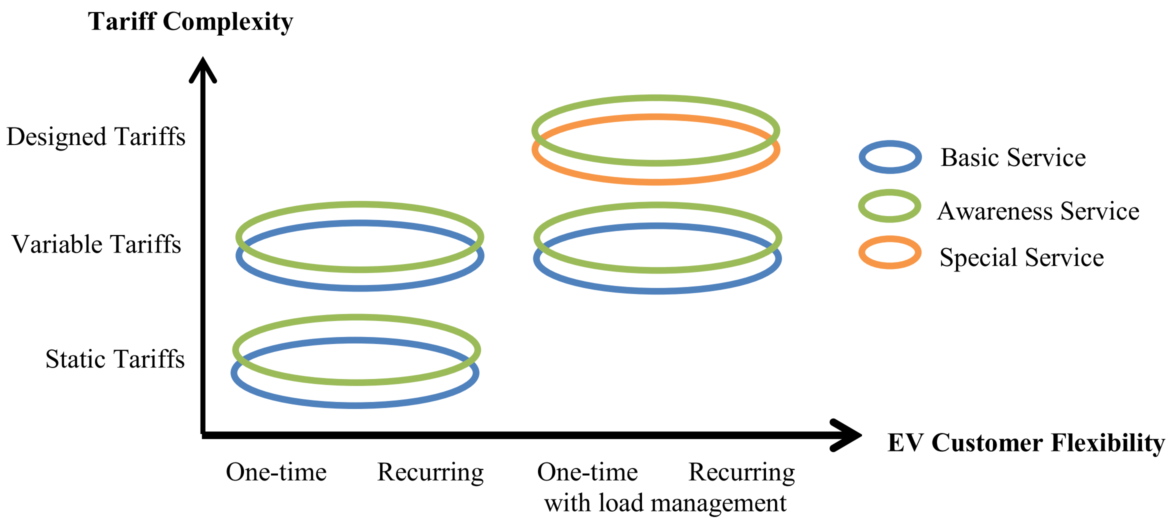

Figure 2: Possible service designs in the context of customer flexibility and tariff complexity for EV car park customers

A static tariff implies fixed rates for charging which could be daily, monthly or per usage. Under variable tariffs, the car park operator could adapt to varying prices as they change over the course of time. Moreover, a linear price concept regarding the energy amount used could be another option in this setting. Additionally, special premium prices for high priority and high demand customer requirements could be included. With load management, a more specific charging is possible, e.g. real-time pricing for the variable tariffs. These concepts are related to different versions of the ‘basic service’ for customers.

The latter concept of ‘designed tariffs’ has the prerequisite, that with load management flexible goals could be achieved for the customers. The ‘special service’ offers an even more selectable version, e.g. customers can give a range for the required energy at the end of a charging process or peak-demand reduction. The customer awareness of aspects like green and RES should be considered for all options. It is possible that customers would change their charging behavior and have a higher cost sensitivity regarding offered price concepts. Therefore, for each service is additionally an ‘awareness service’ introduced. Overall, all the concepts should satisfy the customer needs with reliability guarantees.

4 Conclusion and Outlook

The development of new business model concepts to foster the demand side flexibilities to ensure the stability of the grid seems necessary. This paper presents the first approach to develop a business model for the use case of a car park operator interacting as an intermediary for aggregated EV charging. Moreover, possible service designs which could be offered to different types of EV customers in a car park were presented to enhance the demand side flexibilities through load management and increase the profitability of charging stations which can lead to an improved economic outcome.

One remaining question is whether individual concepts for the customers are beneficial and whether the customers have the willingness to adapt to such new concepts. Consquently we will try to validate numerical use cases in future work in order to have a better understanding of costs and benefits of individual tariff design possibilities. Analysis of the profitability would need to develop a detailed model to consider several elements, like mobility data of the EV and the according to scheduling, flexibilities of the customer, grid, and energy market data, etc.

In the future, even more specified tariffs and products could be offered if vehicle-to-grid charging will be considered for the EVs as the flexibility increases for the operator. That could be one further enhancement of the demand side flexibility.

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