Pathways to Electromobility

Upgraded Charging Infrastructure Through Renewable Energies

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***Abstract*—Within the context of the state-supported, cooperative project "low-carbon city", Aalen University researches solutions to increase the utilization rate of charging stations and to improve the use of renewable energies for power supply. The project is state subsidized by the German Federal Ministry of Education and Research (BMBF) from August 1, 2016, to December 31, 2018, under the references 02K12A150 and 02K12A151. In this research project, business models are developed that generate added value for the stakeholders such as electric vehicle users, grid operators, energy suppliers, and other companies. This paper particularly focuses on the advancement of semi-public charging infrastructure.**

Keywords-electric vehicles; charging infrastructure; grid integration of large-scale electromobility solutions; innovative business models; market design; power system integration and operation; stakeholders of the renewable energy industry

I. Introduction

Charging infrastructure of electric vehicles can be divided into three kinds:

- Private charging infrastructure: private usage only and no public access
- Semi-public charging infrastructure: private usage and access for a defined user group
- Public charging infrastructure: usage by and access to everybody

II. Research Background on Charging Infrastrure

The construction and expansion of different kinds of charging infrastructure is currently undertaken. However, the status of advancement of these infrastructures differs as governmental funding applies only to certain kinds of charging infrastructures and also the costs of the diverse systems vary.

The costs for a simple private charging infrastructure are comparatively low to a public charging infrastructure because they do not require billing mechanisms and special protection measures (e.g., against vandalism, moisture etc.).

Especially the semi-public infrastructure lacks business models incentivizing the operation of charging stations. Only business models of low profitability or unviable ones exist so far in this area. Thus, semi-public infrastructure is attractiveness of companies for employees and the attractiveness of shops for customers, potentially resulting in a longer duration of stay in the shop, for example. The provision of charging stations may not directly deliver a monetary value, yet, it can indirectly lead to a rise in revenue due to non-monetary advantages resulting in other financial benefits and provide a competitive advantage.

The photovoltaic electricity fed into the lower network level can be used to the largest extend in the same network level through this business model. Consequently, the load on superordinate grid levels can be relieved.

IV. Empirical Results

To refine the business idea to a customer-centric business model, all stakeholders were involved in the development and adjustment phase [2, 3] and an empirical survey was used to validate the customer acceptance [4].

Fig. 1 shows that only 13% of the sample cannot imagine to obtain their self-produced photovoltaic electricity at a public/semi-public charging station.

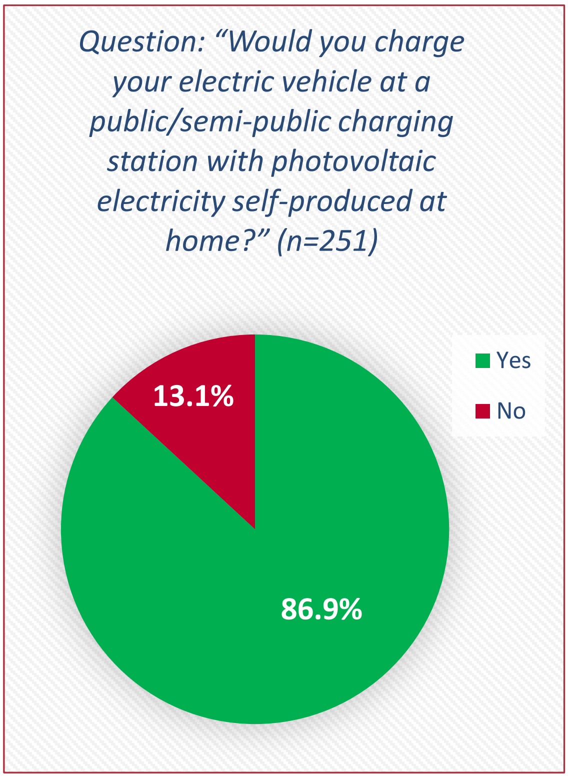

Figure 1. Results from the empirical survey of customers from the regional distribution system operator [4]
Quelle: Befragung von 1.305 ÜZW-Kunden im Oktober 2016 im Rahmen des BMBF-Verbundprojekts „CO2-arme Stadt"; Rücklaufquote = 22,2 %

After the validation of the business idea through all stakeholders, a detailed business model was elaborated. The business model was designed by means of the Business Model Builder ©, a tool created within the research phase by the project partner bozem | consulting associates | munich to guarantee an effective and iterative development approach [5].

Applying the Business Model Builder, all elements of the business model concerned with "charging of electric vehicles at public/semi-public charging stations with green electricity self-produced at home" were defined and described. Fig. 2 illustrates the basic concept of the business model.

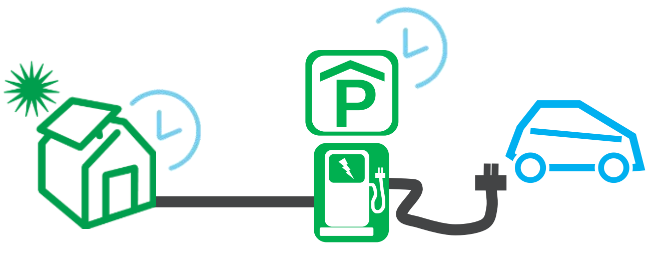

Figure 2. Schematic setup of the business model

V. Research Contribution

The business model allows private operators of charging stations, such as restaurant owners or retailers, for instance, to offer their charging stations to a certain user group (customers). These users can charge their own, green electricity at these stations which they produced at home with their own photovoltaic plant.

To distribute the photovoltaic electricity, the public electricity grid is used. This means, costs in the form of apportionments or network utilization fees occur for the users. Increasing the private consumption of photovoltaic electricity, the users can cost-efficiently charge their electric vehicles.

The operators of the charging stations do not sell their own electricity, nevertheless, they provide a significant added value to their customers. Consequently, the operators profit from non-monetary advantages concerning customer retention and promotion.

Particularly facing the growing competition through online business, the non-monetary advantages can be of even greater value than monetary advantages through the mere sales of charging electricity.

Another positive effect of this business model concerns the operators of the electricity grids, because locally used photovoltaic electricity does not strain the superordinate grids.

VI. Implementation of a Pilot Project Confirming the Technical Feasibility

The technical feasibility of the business model was confirmed in a pilot project with the regional distribution system operator as project partner. In this field-testing phase, charging stations of the project partner were equipped with microcontrollers sending the loading performance to a server.

Moreover, the photovoltaic plant of an employee of the regional distribution system operator was equipped with a microcontroller, too, in order to track the generation and usage of electricity in real time and offsetting the readings against each other.

The microcontrollers were programmed to have access to the wireless local area network, directly transferring the collected data through this connection.

VII. Profitability and Impact of the Business Model

As the public electricity grid is used to transmit the self-produced photovoltaic electricity to the public/semi-public charging stations, apportionments or network utilization fees of up to 20 cents per kilowatt hour occur.

These relatively high costs makes the business model unattractive for those users that receive a feed-in remuneration from the Renewable Energies Act (EEG) [6]. It is more economic for them to feed the photovoltaic electricity self-produced at home into the public grid.

However, as of the year 2020, the first photovoltaic plants start falling out of the EEG remuneration. Accordingly, the business model developed within this research project will suddenly become very attractive at that time. Until then, the economic operation of the business model is only possible under legal changes in favor of electromobility.

VIII. Findings

The business model was holistically developed, defined, and analyzed in its elements together with all stakeholders and implemented in a pilot project validating the technical feasibility. It generates added value of both monetary and non-monetary kind for all parties involved. An economically resilient implementation of the business model, however, will only be possible as of the year 2020 after the expiration of the EEG or after comprehensive legal changes on the energy market promoting electromobility.

IX. References

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