BUSINESS MODEL DEVELOPMENT ON PARKING INFRASTRUCTURE WITH HIGH SHARES OF ELECTRO MOBILITY IN SMART CITIES

Christian HAAG
Flexible Elektrische Netze FEN GmbH – Germany
chaag@FENaachen.net

Gonca GÜRSES-TRAN
Flexible Elektrische Netze FEN GmbH – Germany
gguerses@FENaachen.net

ABSTRACT

Most European cities are currently facing not only a general energy transition but also a changing automobile infrastructure with the increase of electric vehicles on the roads. This paper presents a possible business model that supports sector coupling by integrating the vehicle-to-grid concept in a car park environment. In this context, the general concept and possible tariff models are being presented.

INTRODUCTION

Policy makers and city developers around the globe are eager to reduce CO_2 and NOx emissions caused by gasoline- and diesel-engine vehicles in urban areas. The European Court of Justice is currently deciding whether to file a lawsuit against Germany for their inaction in the context of high emission levels in cities [1].
Therefore, new approaches stipulate a radical elimination of vehicles that are causing those emissions, putting forward clean and sustainable solutions. Another difficulty in inner cities is the high penetration of individual cars searching for vacant parking spaces, which results in a waste of time, energy and infrastructure resources. Smart cities of the future not only need to come up with innovative navigation solutions to the closest parking spaces, but also tackle the threats and opportunities of the electromobility roadmap. Higher shares of electric vehicles (EVs) in urban areas alter the need for a reliable energy distribution but also offer new balancing measures for the electric city grid. Especially in urban areas, where there is little chance to charge an electric car at one's own home or workplace, central solutions are needed.

Generally, in order to succeed with the European energy transition, sector coupling is needed, knowing that the overall complexity of the whole system becomes more challenging and more vulnerable.
If we are to believe current press reports, the German federal government intends to prohibit vehicles with internal combustion engines in inner cities [2, 3].
A German court has recently decided that a ban of individual cars is in line with German law. Another challenge is the charging of electric vehicles in inner cities, especially for local residents who do not own a garage or commuters. When it comes to charging at the workplace, it is both legally and fiscally disputed [4].
Here, an obstacle for the widespread distribution of electromobility can be identified. If we take a closer look at inner cities and the surrounding areas, an increasing number of renewable energy (RE) generators is reported, which often produce too much energy in low-load periods and similarly cannot supply peak load periods sufficiently.
Usually, this energy is first dispensed via the distribution grid before it is transmitted to load-intensive areas, i.e. to the consumers, via the transmission grid. This procedure not only results in significant transmission losses but also causes high network surcharges that are then paid by the respective electricity consumers in that area. As a consequence, more and more stakeholders are interested in deploying distributed energy storage to reduce the mismatch between the intermittent supply and uncertain demand. Currently, however, the purchase and operation of large batteries is neither economical nor easy to implement within inner cities due to the lack of space.

ELECTRIC VEHICLES SERVING AS AN ENABLER FOR A SUCCESSFUL ENERGY TRANSITION

Various stakeholders, partly with divergent interests, need to be involved in the energy transition: (municipal) utilities, regional grid operators, car park operators, billing service operators and EV users. In the future, even more stakeholders have to be addressed such as car sharing service providers and other services (i.e. public transport etc.).

Classical Sharing Infrastructure

At the moment, the number of EVs in Germany is limited and the technical setup is primarily focusing on charging the battery of the cars. Currently the utilization of the battery is exclusively for powering the car. Nevertheless, charging is also challenging due to the fact that only bigger cities are equipped with sufficient charging points. In cities like Cologne or Aachen, approx. 50 charging points are available for public or semi-public use in the inner- city area. In total, the area of North Rhine-Westphalia is equipped with around 3.000 charging points (numbers are strongly varying between agencies). Business models for EVs are limited due to the missing bidirectional charging possibility which could have been provided by the currently implemented charging poles. But EV drivers can benefit from inner city charging hubs such as parking garages.

In this business model, the parking garage operator offers parking spaces with the possibility of charging at a limited output of about 11 kW, since the connection of the parking garage to the public grid cannot easily be upgraded. Typically, a parking garage in Germany has a connection of 300 to 500 kW, which means a charging power for 30 to 50 EVs. One step further, a smart charging management could give priority to those EV drivers who pay extra for a fast charging service. In the meantime, other EV users with the basic subscription are connected to max. 3.5 kW. At the end of the day, the EV driver must be certain that the car is charged to at least 80% of the battery capacity. By this means, the EVs can also function as dispatchable loads for the distribution grid.

Future Sharing Infrastructure

EV users with bidirectional charging possibilities, in particular, are being addressed because they provide the greatest added value for all stakeholders in this business model scenario. Car manufacturers such as Mitsubishi, Nissan and BMW have already launched corresponding products [5]. In the following, the overall concept "urban EV parking garage" will be presented and also the roles and the revenue models of the individual stakeholders will be described in more detail.

Utilities would use the city battery as intermediate storage for both, renewable as well as conventional energy generation. Mostly, utilities operate their own power plants to generate electricity which are more resistant to fluctuations and can operate to optimal setpoint, with the objective to achieve highest efficiency and concurrently store surplus energy within the "city battery". Using the transmission grid to feed-in surplus energy can thus be avoided. In Germany, for instance, there is also the possibility to offer the surplus energy in a tender auction on the control reserve market, provided that there is a sufficiently high (aggregated) output [6]. The minimum bid amounts and prequalification requirements depend on the targeted quality of the tendered reserve capacity which is differentiated into primary, secondary, and tertiary control reserve (note that batteries are also suitable for primary control reserve due to very fast response times). A first estimation would imply a need for approximately 250 electric vehicles on site. The average capacity of an e-car battery is 30 kWh and the available output 40 kW; however, a responsible use of the battery is desired, which can only be ensured at a withdrawal of 20% from the batteries' capacity. The installation of a 100 kWp solar system on the roof would yield another intendency of the municipal utilities.

Moreover, the construction and operation of charging infrastructures is not part of a DSO's regular business and therefore relieves the DSO from its cost-intensive EV task of infrastructure development. *Figure 1* shows a draft of the urban parking garage setup. Car park operators can offer three tariff models for parking customers.

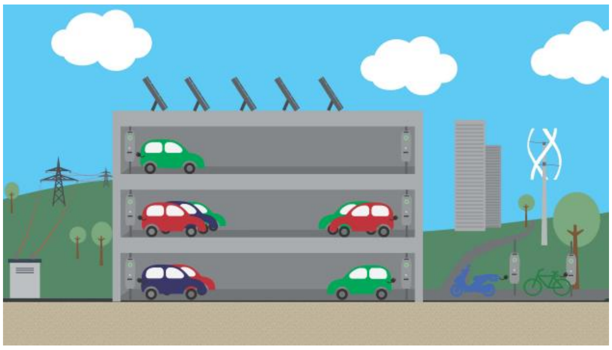

Figure 1: Possible setup of a EV-parking garage

The EV drivers have to state both the type and the manufacturing year of the electric vehicle when registering to order the subscription via app. This information enables the operator to check the bidirectional charging possibility of the vehicle. The possibility to charge and discharge electric vehicles in a bidirectional manner is indispensable for further steps and is thus considered as given. Two of the three models would focus on commuters as their target group, i.e. those who drive into the city for work or those who live there. These models can ensure a high forecasting reliability. Commuters that work in the city will park their car at least from around 9 am to 5 pm and commuters who live in the city will park their car from around 7 pm to 7 am. The third tariff targets regular travelers, for example weekend shoppers or visitors of residents in the respective city. *Table 1* depicts exemplary tariff models with estimated costs.

In correspondence with the active subscriptions, the car park operator could precisely estimate the need for expanding the charging poles and plan investments accordingly. Furthermore, the operator also knows the exact power output and capacity available, which, on the other hand, is important for the municipal utilities. Another specification of the tariff models could be a prioritized load which would be a further flexibility for the operator. Vehicles that are charged slowly can provide their energy for other EVs that subscribed for fast-charging. This approach is particularly advantageous at nighttime, during sunless days or in case the car park's grid connection is overloaded. By equipping the car park with a stronger grid connection upon its construction, very high expenses and efforts need to be taken into account: such inner-city constructional measures are not only critical in terms of implementation but are always accompanied by the need for several permits and consequently further cost components.

CONCLUSION

This paper proposes an implementation that converts car parks that are located close to train stations in a first phase. There, an adequately large and grid connection to the robust railway grid is already available, which is rarely used at full capacity [7]. Depending on the existing infrastructure AC or DC solutions can be implemented.

Table 1: Exemplary tariff models for the e-car park for private customers

	City worker	**City resident**	**Frequent urbanist**
Parking/charging time	9 a.m. to 5 p.m.	6 p.m. to 7 a.m.	Irregular
Normal charging speed	5 kW	5 kW	5 kW
Fast charging (22 kW)	extra 50 % (monthly fee)	extra 50 % (monthly fee)	extra 50 % (monthly fee)
Holiday option **>=14 days of parking in a row**	reduced by 50% (monthly fee)	reduced by 50% (monthly fee)	reduced by 50% (monthly fee)
Monthly costs	100 €	100 €	75 €
Duration of subscription	12 months	12 months	6 months

In any case, transformation to the target voltage level of the carpark needs to be realized. The proposed option would particularly be interesting at night since the rail traffic frequency is significantly reduced during the night time hours. That kind of location could additionally be interesting for car sharing or car rental companies. The fact that the vehicles might usually stay longer inside the car park, thus making more output available, could be an advantage for the DSO. Moreover, the electric vehicles come from only one or two different manufacturers, which has a positive effect on the charging infrastructure. The frequency of vehicles booking as well as utilization, on the other hand, is difficult to control. If there are no long-term bookings, which is the exception in car sharing and renting, short-term rentals could impede the planning. In this case, the deviation of tariff models is rather complex and will therefore not be specified any further.

Future studies could analyze tariff models in more detail by integrating possible revenues from current energy markets. In addition to that, information from battery ageing studies should be taken into account for the business model in order to also reflect on possible downsides of a bidirectional utilization of the energy storages. Depending on the location of the proposed urban car park, assessments of the most suitable distributed energy generator types and sizes could be carried out with a better prediction in terms of profitability of the whole system.

Lastly, one promising technical solution of the EV car park would be, as mentioned before, a full direct current (DC) implementation. A purely DC version of the car park enables easier integration of fast charging technologies and comes along with lower costs and higher efficiencies for the overall solution that is presented in this paper.

REFERENCES

[1] Spiegel Online, 2018, Are Driving Bans Coming for German Cities? – The Diesel Diseaster, 21.02.2018, http://www.spiegel.de/international/ germany/emissions-violations-have-german-cities -facing-driving-bans-a-1194269.html (Accessed: 28 February 2018).

[2] AutoZeitung, 2017, Metropolen wollen Dieselautos bis 2025 aussperren. Available at: http://www.autozeitung.de/zev-benziner-diesel-verbot-bis-2050-116894.html (Accessed: 27 February 2017).

[3] Groscurth, H.-M., Bode, S. and Teichmann, F., 2011, Machbarkeitsstudie: Eigenversorgung des Schienenverkehrs der Deutschen Bahn mit Strom aus erneuerbaren Energien.

[4] Gesetz zur Elektromobilförderung, 2016, §40

[5] Ullrich, S., 2016, Das Auto wird zum Speicher. Available at: http://www.erneuerbareenergien.de/ das-auto-wird-zum-speicher/150/3882/93468/ (Accessed: 27 February 2017).

[6] Next Kraftwerke, 2013, Präqualifikation für den Regelenergiemarkt, 2 October. Available at: https://www.regelleistung.net/ext/static/prequalification (Accessed: 12 February 2018).

[7] Groscurth, H.-M., Bode, S. and Teichmann, F., 2011, Machbarkeitsstudie: Eigenversorgung des Schienenverkehrs der Deutschen Bahn mit Strom aus erneuerbaren Energien, p. 11.