From parking garage to battery storage

Focus on charging management

In the age of electromobility, multi-storey car parks are being transformed into charging stations. In Schwäbisch Hall, research is being conducted into how a multi-storey car park can even become a large, virtual battery storage facility that can be controlled to serve the grid. The calculation of the load forecast, which is influenced by a variety of factors, is of central importance.

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As co-operators of the Langer Graben multi-storey car park, which dates back to the 1980s, Stadtwerke Schwäbisch Hall faced the challenge of installing contemporary e-charging infrastructure during the refurbishment. Instead of an elaborate and expensive power grid reinforcement outside and inside the property, the energy provider opted for an intelligent charging and load management system from its associated company enisyst GmbH. The Stuttgart University of Applied Sciences is involved as a scientific partner in the development of a solution for monitoring and optimising charging and load management via the research project "Smart_E_Park". This is funded by the state of Baden-Württemberg as part of the "Intelligent grid connection of multi-storey and underground car parks" funding programme. The long-term goal is to turn the car park into a grid-serving energy storage facility, with the batteries of the parked electric vehicles acting as a bilaterally usable energy buffer, for example for Redispatch 2.0.

Figure 1: Parking garage "Langer Graben", copyright: Hallywood Productions/Stephan Baraniecki

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Balancing and distributing charging loads

What challenges did and do the project partners face? The new transformer at the Langer Graben car park is designed for a maximum of one megawatt of power. In the multi-storey car park, around 100 of the total of almost 500 parking spaces were equipped with charging boxes, each of which allows up to 22 kilowatts of charging power. If all 100 charging parking spaces were occupied and charging at 22 kW, the transformer capacity would be exceeded by a factor of about 2. The charging system must therefore be able to control the charging processes in such a way that electricity supply and demand as well as charging capacity are in harmony and the system as a whole remains stable. This is ensured by the cascading connection system with intelligent distribution boxes from enisyst. The system is designed to balance and distribute loads. This means that if more vehicles need to be charged, the specific charging power is throttled. But the system would also be able to prioritise individual charging points, for example, for people who are willing to pay extra for faster charging. The charging infrastructure has been in operation since the reopening of the car park in October 2021 and is working according to plan. However, the utilisation of the e-charging parking spaces is only around 25 per cent today.

The particular challenge - and so far there have been only rudimentary findings - is to determine a typical load curve for a multi-storey car park with e-charging points. A reliable load forecast is an indispensable prerequisite for the planned use of the bidirectionally connected e-mobiles in the car park as energy storage. Mathematically, 100 vehicles with 80 kWh charging capacity could store up to eight megawatt hours of electricity in the Langer Graben multi-storey car park, i.e. more than twice the annual electricity consumption of an average household. Although only a portion of this could be used as a control reserve, this would still be an attractive scenario for the grid operator.

The challenge of forecasting

There were and are many parameters to be researched in order to create the load curve: When do e-mobilists charge? What types of vehicles and battery capacities are involved? In which battery charging status do they reach the charging point? How long and how much electricity do they charge? The hardly surprising answer is: the refuelling behaviour of electric vehicle owners in the car park is completely different from that of combustion vehicles. With the latter, the tank is often driven almost empty and then filled up again completely. Electric vehicles, on the other hand, are charged more often and usually only partially and - depending on the parking time - even when the charge level is still high. The multitude of volatile factors makes forecasting complicated.

Nevertheless, it has been possible to generate a utilisation forecast that corresponds quite accurately with reality. On the one hand, an app was developed that records which vehicles charge where, for how long and with what power. The second input source was public data from car parks in North Rhine-Westphalia, which provided information on how long vehicles typically stand in a car park and what the occupancy rate is at what time of day. The data from both sources was combined and a load curve was modelled from it with the support of learning algorithms and artificial intelligence developed by the

Stuttgart University of Applied Sciences. This work has not yet been fully completed, but the forecasts already achieve an approximation to the actual situation of over 90 percent.

Further strengthening the data basis

Figure 2: copyright: Hallywood Productions/Stephan Baraniecki

It must be taken into account - and this is one of the reasons why further research is necessary - that the previous load forecasts are based on low occupancy rates of the wallboxes. With further spread of electric vehicles and more frequent use of the e-parking garage, some parameters of the charging behaviour and the system load may change. A very dynamic development can be expected in the electromobility market, and factors such as urban and neighbourhood development, for example through changes in shopping behaviour, can also have an influence on user behaviour. For these scenarios, further data must be continuously collected and insights gained. In the end, a database should be available that makes it possible to use the batteries connected to the charging system in the multi-storey car park as a virtual energy store. The fact that technical rules still have to be created for this is another matter. The operator, Stadtwerke Schwäbisch Hall, says it will be ready to act when the electric car becomes the standard means of transport.

What is already certain is that the data gained in Schwäbisch Hall will not be directly applicable to other car parks that are being converted into multi-charging stations: It makes a difference whether people park their e-mobile in a big-city car park during the day while shopping, or whether the car park is located in an old residential quarter without associated underground car parks and functions as a kind of filling station for the night.

Further steps in planning

The next project steps in the Langer Graben multi-storey car park address, among other things, the further broadening and validation of the database and bidirectional charging. enisyst GmbH is already working on this future scenario in practice elsewhere. Furthermore, the practical connection of the Langer Graben e-parking garage to the network control centre of the Schwäbisch Hall public utility company is on the agenda.
Also on the to-do list is the integration of the charging processes into the consumption billing of Stadtwerke Schwäbisch Hall. Up to now, users have paid for the electricity they draw with their parking ticket on site or with a mobility card from Stadtwerke Schwäbisch Hall. In the future, it should also be possible to invoice the car park charging electricity via normal consumption billing. The realisation of flexible charging tariffs every quarter of an hour is also being considered. They are also an instrument for grid load control, because customers can fill up with electricity at low cost when there is a large supply of electricity.

Conclusion: Implementing intelligent charging management in car parks and controlling it to serve the grid is a complex task. Its realisation requires a lot of technology and know-how. In order to be able to control an e-parking garage proactively and use it as a large battery storage facility, a lot of information and data must be processed and evaluated. There is no way around this groundwork, and there is still a long way to go. It is therefore to be welcomed that a municipal utility like Stadtwerke Schwäbisch Hall is doing pioneering work here and is significantly paving the way for a new world of mobility.

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