ENERGY FOR FUTURE – Wege zur Klimaneutralität

Der aktuelle Klimabericht der Weltwetterorganisation (WMO) weist für die Jahre von 2015 bis 2019 nach vorläufigen Berechnungen die heißeste Fünfjahresperiode seit Beginn der Messungen vor rund 150 Jahren aus. Die durchschnittliche Temperatur habe in diesem Zeitraum bereits um 1,1 Grad über jener der vorindustriellen Zeit gelegen. Die durch den fortschreitenden Klimawandel verursachten Auswirkungen (Gletscherschwund, Anstieg des Meeresspiegels, Umweltkatastrophen uvm.) werden dabei immer unmittelbarer für die Menschen spürbar. Eine vor allem von der jungen Generation initiierte und getragene weltweite Bewegung fordert entsprechende Maßnahmen ein, was durch zahlreiche Kundgebungen und Aktionen weltweit zum Ausdruck gebracht wird. Der

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SMART LOAD MANAGEMENT FOR EV CHARGING INFRASTRUCTURE IN A RESIDENTIAL COMPLEX

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Motivation

Interest in and demand for electric vehicles (EVs) is growing strongly. Reasons are the increasing awareness of climate change, as well as the commitment of car manufacturers to substantially reduce the CO_2 emissions of their fleet by 2030. One of the biggest challenges associated with this development is the provision of appropriate charging infrastructure (IS). Major questions include, not only where charging can take place (e.g. private and public charging, charging at work, etc.) and at which charging speed and capacity, but also how the temporal distribution of this load develops. Whereas for single-family buildings and small company applications, many projects have already been conducted, research on optimal IS in large-scale residential buildings and the implementation of an optimal load management (LM) for this application has been scarce. The main objective of this paper is to analyse various LM strategies for EV charging in large-scale residential buildings, determined to meet the growing demand for E-Mobility and considering to which extent these strategies may offer relief to the distribution grid. This research is carried out within the cooperative R&D project URCHARGE powered by the Austrian Climate and Energy Fund within the programme “Zero Emission Mobility” with a focus on IS.

Method

To determine the EV charging demand, we assume a scenario in 2030, with a 30% share of EVs in individual transport [1]. Our simulation includes 150 parking spaces, whereas 50 of them require charging IS. The building in total consists of 200 households with typical size distribution and household electricity consumption. Typical Austrian EV charging profiles are determined from a study analysing usual driving purpose and distance [2]. In a first assumption by our project partners, the required charging capacity per EV is determined as 1kW. This is gathered in a pool resulting in 50kW of available charging power for the 50 EVs (P_{Total_h}). Testing this assumption shall be a result of our paper. The battery capacity of the EVs is 40kWh for 80% of the cars and 60kWh for the remaining 20%. Their consumption is modelled to be slightly higher in winter than in summer, due to additional power consumption for heating and the batteries temperature sensitivity [3].

Overall, 85% of charging shall take place at home. We define the maximum charging capacity at the private stations in the building as 11kW, whereas public charging stations operate at 22kW. For the charging costs, we set different tariffs such as a flat rate, time-dependent tariff or the expected electricity spot prices in 2030, depending on renewable power feed-in, which we estimate from the potential renewable electricity capacity derived from a study carried out by TU Wien [4]. Another research question concerns the value of customer information on charging demand. We therefore assume different levels of demand foresight in the model or force to achieve a specific battery state of charge.

The model is set up as a linear optimization model with the aim of minimizing the costs of EV charging.

$$\sum \sum_{n,i} P_{Ch_h\,(t)} \leq P_{Total_h}$$

$$Min\ f\left(P_{Ch_p}, c_{ch_p}, P_{Ch_h}, c_{ch_h}\right) = \sum \sum \sum_{n,t,i} P_{Ch_p} * c_{ch_p} + P_{Ch_h} * c_{ch_h}$$

$P_{Ch_{p/h}}$	…	Power at public/home station	n	…	number of EVs
$c_{ch_{p/h}}$	…	Charging cost at public/home station	t	…	time period - interval 15 min
P_{Total_h}	…	Available charging power at home	i	…	number of driving purposes

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Results

In this abstract we present preliminary results that show the operation of a basic LM approach with 100% demand foresight and optimization according to demand. The results already indicate the required incentives through pricing schemes, to either achieve a shift away from load peaks for the benefit of the distribution grid or towards times of high renewable electricity generation. Figure 1 shows the charging demand for all 50 EVs at a flat rate price per kWh compared to a time of use (ToU) price with higher prices at times of high household load. At a flat rate price, the charging starts at return at the home station and largely coincides with the household load peak in the evening. ToU pricing, however, promotes a shift of charging into the household load valleys, offering relief to the distribution grid. In our final paper, we show more significant results on how different LM approaches and pricing schemes affect the load pattern.

In Figure 2**,** the load peaks of EV charging demand are displayed together with an exemplary power generation pattern of Wind and PV expected in 2030. Whereas with flat rate pricing, charging mainly occurs in the evening times when PV is not generating electricity, the ToU pricing leads to a shift into morning and noon times making use of the PV power availability – even if this type of pricing does not directly relate to renewable energy availability. The results look different, of course, if we force a certain state of charge of the battery in the morning, shifting charging load into the night hours. Our final paper aims at using electricity prices as an input to charging demand, to move charging load towards times of high renewable power generation and potentially low CO_2 impact.

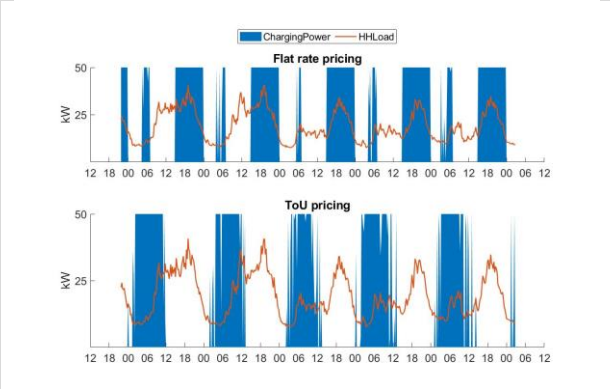

Figure 1 Charging load vs. household load

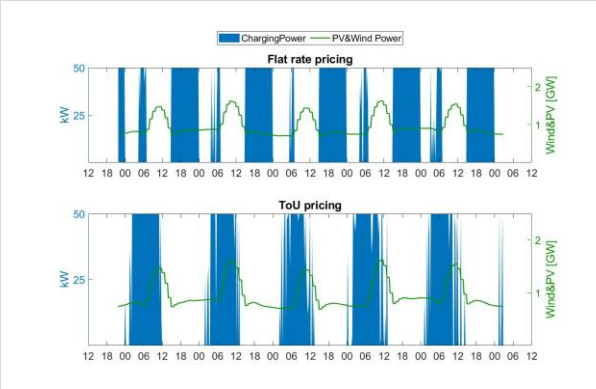

Figure 2 Charging load vs. Renewable Power

Conclusions

As can be seen from the figures above, in a scenario of 100% demand foresight, there is still potential for charging load to be shifted to times of low household demand, implying that a further decrease of the required total available charging power (50kW) is possible. This will also be elaborated for situations with less demand information in our paper. Our results show that the appropriate incentives through pricing schemes have a valuable benefit for the power distribution grid and more information about charging demand supports LM efficiency. With an increase in LM, shifting peak demand hours into "valleys", a manipulation of currently existing, very predictable load patterns occurs. Furthermore, we do see a potential impact of additional power demand through EVs on the electricity mix consumed, if peak hours increase. This leads to a negative impact on the CO_2 balance, as long as Europe's electricity market is not 100% renewable. In our final paper, we aim at analysing these vast impacts and find solutions for a beneficial distribution of the EV charging load.

References

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