Peak Shaving
– a cost-benefit analysis for different industries

(4) Aktive Endkunden-/Prosumerpartizipation

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Central idea:

Electric vehicles (EVs) are a potential resource due to their capability to store energy and discharge it back to the grid. Since EVs are stationary for most of the day, be it at home, work, or at other locations, bidirectional charging has a high potential to increase the utilization of EVs. One way to utilize bidirectional charging is to perform peak shaving for electrical loads. In Germany, 68 percent of employees travel to work in cars [1], which in most cases sit idle in parking spaces until the end of working hours.

Industries and commercial consumers in Germany often pay high electricity prices and have limited room to reduce their bills. Grid fee forms a significant share of total electricity price and has two components, the usage price (€/kWh) and the capacity price (€/kW) of electricity[2][3]. Capacity price is charged based on the maximum power drawn during a metering interval (usually a quarter-hourly interval) during the month or whole year[3]. In many cases, maximum power is infrequently drawn from the grid which makes it possible to shave the highest peaks via bidirectional charging.

Grid fee prices in Germany depend on annual full load hours. If the annual full load hours (FLH) of a consumer exceed 2500 hours, the capacity price increases drastically, and the usage price drops significantly compared to annual FLH less than 2500 hours. Intensive grid usage with annual FLH exceeding 7000 hours enables consumers to receive a significant discount on the grid fee. Peak shaving results in the increase of annual FLH and decrease in total capacity costs and thus enables the consumer to significantly reduce the electricity procurement costs.

Methodical approach:

A linear optimization model was developed, and its objective function minimized for the analysis. The objective function of the model consists of the grid fee and all other electricity price components (€/kWh), excluding the Value Added Tax, summed together as one component.

The constraints for the optimization are set such that the non-optimized charging of EVs is prioritized until a minimum state of charge (SoC) is reached. Once the minimum SoC is achieved, then the charging procedure switches to optimized charging until the SoC reaches maximum or peak shaving has to occur. The optimizer only shaves peak loads if the SoC of EV is above a desired SoC. The peak shaving capability of EV is constrained by the maximum discharging power of the vehicle.

The model considers load profile time series (LPTS) and electric vehicle availability as one of the inputs. The annual FLH are determined for each LPTS and is assigned a corresponding price structure for grid fee. The optimizer operates with complete foresight, matches the load with availability and decides upon peak shaving while complying with the constraints.

The availability of EVs on an industrial site is an important variable to consider. The majority of large-scale industries operate 24 hours a day, 7 days a week, and usually adopt a shift system. The availability of EVs is determined based on a three-shift system (usually 0600-1400, 1400-2200, 2200-0600) for quarter-hourly intervals. During intervals of shift change, the EV is considered to be unavailable. The driving behavior of employees is modeled to resemble that of an average German employee commuting by car.

Results:

To set a reference for the results, a base case is set up which gives the maximum possible revenues for each industry. In this base case, the EVs are assumed to have 100 percent availability on-site with 11 kW charging/discharging power and act as a stationary battery storage. The load profile data belongs to real industries from various sectors. This scenario has shown savings, excluding CAPEX of the bidirectional charging station, of up to €520,000 for certain industries with 20 EVs, although the median stands at around €22,600.

Other scenarios include changes in EV characteristics (capacity, charging/discharging power), number of electric vehicles, and waivers of renewable energy levy and electricity tax. With these sensitivities, the most important parameters and their effects on potential savings can be determined. Potential revenues for peak shaving vary widely depending on the parameterization.

Conclusion:

Utilizing electric vehicles for temporary electricity storage could have reasonable economic benefits for electric vehicle owners and other stakeholders like industries and grid operators. Peak shaving shows good promise as a way to apply bidirectional charging to generate revenue in the industrial sector. We showed that revenue potentials are highly sensitive on the load profile of the industry, the characteristics of EVs and the electricity price structure and thus can give recommendations whether industries should integrate peak shaving by bidirectionally chargeable EVs or not.

References:

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