A Case Study to Optimize Local Energy Management with PV Production and EV Charging

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Maintaining stability for the electrical grid in Switzerland will be a crucial and challenging task for grid providers. Furthermore, reducing energy cost is an important need for households in these uncertain times. This work proposes a linear optimization approach to minimize energy cost by buying and selling energy from and to the grid and using locally produced PV power and an EV charging station. Additionally, grid stability can be improved by using dynamic prices.

Introduction and Objectives

Installing photovoltaic (PV) panels on the roof promotes a house owner from an energy consumer to a prosumer. Additionally, the growing demand for electrical energy due to the increasing numbers of electrical vehicles (EV) and heat pumps will have an impact on electricity costs for house owners. Furthermore, current geopolitical threats negatively influence energy prices. Given higher energy prices and the possibility that house owners take an active part in energy trading, the demand for cost-optimized energy management is more urgent than ever. The objective of this thesis is to develop a cost-optimization model for an apartment building with one EV. The building includes uncontrollable loads (e.g. lighting), PV production as well as an EV charging station.

Research Design

The data for the different types of loads as well as the availability of the EV stems from the research partner and represents an apartment building with PV panels on the roof. To improve self-consumption of the locally produced PV power, a constraint is set that defines self-consumption to be at least 20%. The time frame for the simulation is one day. To consider the differences of production as well as consumption over the year, four days are selected that represent a typical day for each season. For the optimization, the management science method Linear Programming is applied. The optimization task that of the model is to minimize energy cost for the house owner.

Results

The simulation shows that the specific building can reduce costs by 1 to 3%. It is expected that the results are much better with further development which is the subject of discussion in the next chapter. The self-consumption constraint described above did not have much impact on the results. In different scenario runs, it is set to 0% as well as 50% and the results did not change. Only when the threshold is set to 100%, it has a negative impact on the overall energy costs. Furthermore, more dynamic prices can shift peak loads and hence flatten load curves. Figure 1 shows the load distribution when dynamic price are applied. In this work, the researcher makes sure that reasonable data has been chosen or where necessary, scientific estimations are made.

Implications and Recommendations

There are several possibilities to improve the results of the simulation. Further work on peak reduction can be made by including penalties for peak times into the objective function. Furthermore, the energy flow from the grid to the EV could be reversed, so that the EV also acts as a temporary battery storage. The model could also be extended by a house battery that stores additional energy when PV production exceeds the load demand or when the energy price is low. Also, this case study is only done with one building, with one charging station. Today, more buildings and charging stations could exchange energy locally to a lower price than offered from the energy provider.

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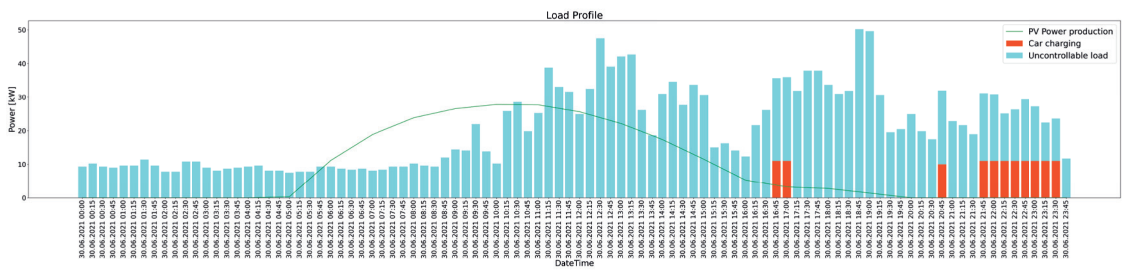

Figure 1: PV-, load and charging profile