How industrial consumers can reduce their electricity costs with Battery Energy Storage Systems

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A great share of industrial electricity consumers in Germany pay about 20-35 percent of their annual electricity costs for network charges, consequently these costs are of crucial economic importance. However, some conditions in the German Electricity Network Charges Ordinance (StromNEV) allow the companies to reduce these charges: StromNEV compensates for the stabilisation of the grid load by reducing peak loads. The integration of Battery Energy Storage Systems (BESS) is one opportunity after active load management to ensure a future-oriented economic production. A careful analysis of the load profile of the consumer is the most critical point in the design process and determines the success or failure of a storage system. A finely tuned algorithm can help with the analysis.

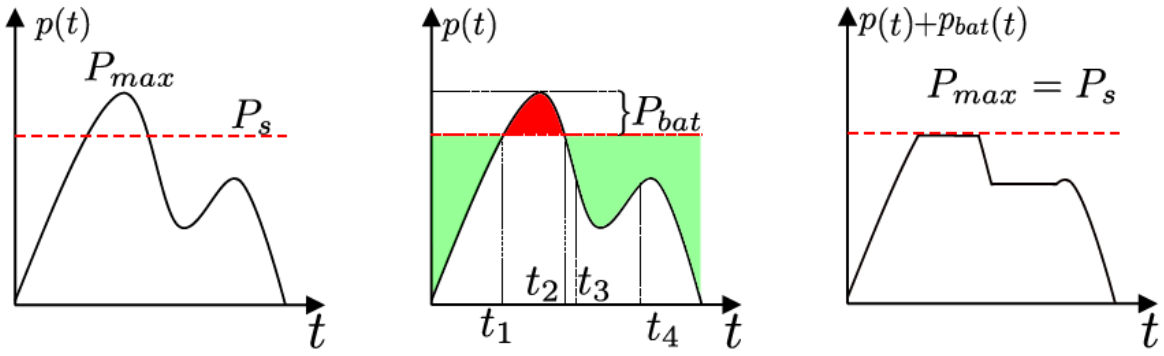

Figure 1 Peak Shaving explained: (f.l.t.r.) a) Before Peak shaving: The Maximum Peak (Pmax) exceeds the peak limit (Ps), leading b): Battery action. This peak will be capped by the operation of the BESS. c) After the action of the BESS the peak is shaved and the load profile does not exceed the peak shaving limit.

How Network Charges are set

Network Charges are based on the costs incurred by grid operators for the general operation, maintenance and expansion of the electricity grid from the transmission to the distribution level to the connection point. The charges are calculated based on specific annual costs: a power price and an energy price above and below 2,500 hours of use. The basic idea of StromNEV is to make a plausible assumption about the share of a network user to the total network costs in advance. This means companies' loads likely to contribute to the maximum annual network loads have to pay higher power prices.

$$Network\ Charges = Consumed\ Energy * Energy\ Price + Maximum\ Power\ Peak * Power\ Price$$[1]

The historic trend in Germany predicts increasing network charges (see Figure 2). Electricity consumers who purchase industrial quantities should therefore take early action to save charges.

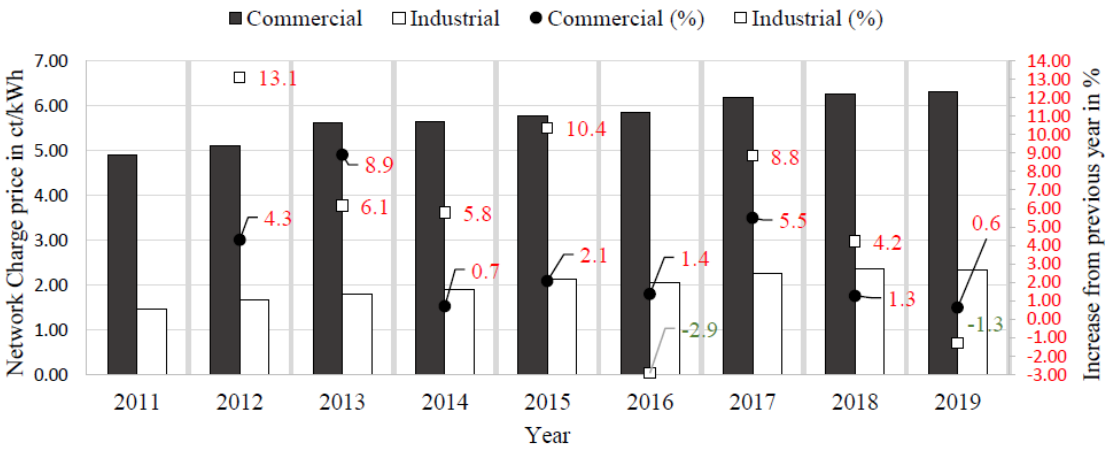

Figure 2 Network Charges price development for Commercial and Industrial Customers in Germany[2]

Save network charges through peak shaving

Paragraph 19 of the StromNEV provides the possibility to reduce network charges. It rewards companies that consume at least 10 gigawatt hours per year and reach minimum 7,000 hours of use. These hours of use are calculated based on 15-minute interval measurements of the total consumed energy and the maximum power registered in the year. Any raise in peak load increases network charges, even if the peak appears only once a year.

The application of peak shaving reduces the maximum power consumed and thus increases the hours of use. This can be achieved by applying BESS. They can be integrated into the existing power supply system with little effort and are capable of reacting to cap peaks within milliseconds. With a BESS that is precisely tailored to the particular load profile, consumers can save up to 90 percent of their network charges.

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[1] Badeda, Julia; Modeling and Steering of Multi-Use Operation with Uninterruptible Power Supply Systems Utilizing the Example of Lead-Acid Batteries; ISEA; 06.2020.

[2] Gloria, Luan Leão, „Evaluation-tool development for peak-shaving employing Li-Ion battery storage systems at different C&I customers", MA thesis, 04.2020; on the basis of: Bundesnetzagentur (BNetzA): Monitoringbericht, 2018. URL: https: //www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/DatenaustauschundMonitoring/Monitoring/Monitoringberichte/Monitoring_Berichte_node.html [last checked 2019-11-14]

What can go wrong when designing a BESS

In order to optimally design a BESS for the requirements of a C&I company, its load profiles must be analysed in detail. Companies with a yearly consumption of more than 100,000 kilowatt hours have a record of their electricity consumption in quarterly hour intervals.[3] The quality of the underlying data is decisive for the quality of the system at a later stage. Aggregated load data can give a false picture of the real load profile and lead to errors in the design of the overall system. The sizing of the battery based on the aggregated quarter-hour profiles can lead to undersized BESS for the real operation, and thus jeopardises the reduction of network charges. Such aggregation hides information on the actual oscillation behaviour of the real load. ABO Wind examined the impact of these possible errors on the system sizing with differently aggregated profiles.[4]

What does this imply for the company? If a storage is designed for a threshold of 7,000 hours of use and an error of 5 percent appears in the peak shaving power only 6,666 hours of use are reached. Consequently, in the worst-case, such a faulty design leads to the company missing its chance of an 80 percent discount on the network charges at the end of the year.

Preventing errors with a specific sizing algorithm

Calculations with higher time resolutions reduce the risk of error in the analysis. At a 1-minute interval, for instance, the amplitude of oscillations around the average is bigger and therefore more realistic.

Figure 3 compares a profile with three different averaging aggregation. The original data was measured in 2-second steps. Already the 1-minute average data shows that peaks of seconds are not considered in the profile and are lost for the sizing algorithm. This leads to reduced power sizes of the battery for the same peak shaving threshold, that needs to be reached.

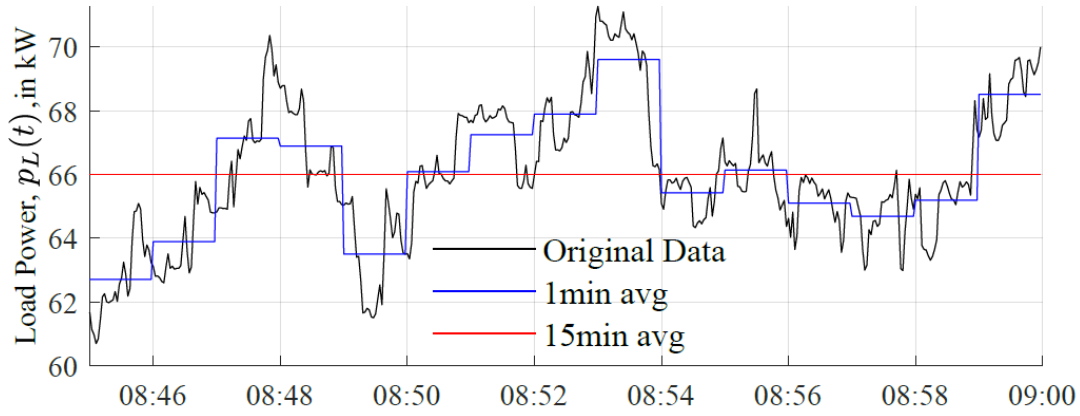

Figure 3 Comparison of different aggregation profile intervals[5]

A 15-minute aggregation leads to higher errors due to lack of power than smaller aggregation times. In addition, the analysis also highlighted, besides BESS' power miscalculations, a limiting energy capacity in some events especially at higher values of peak shaving power. These errors are more relevant when based on the 15-minute then the 1-minute profile.

Conclusion

Two sources of errors occur when using aggregated data:

1. miscalculation of BESS's power
2. miscalculation of BESS's capacity

Both errors might occur independently from each other. It could be that the BESS cannot use the power although it has enough energy available or it has the required power accessible but there is not enough energy. Results show that peak shaving power errors up to 13 percent are possible. It is to be expected that load profiles with a higher instantaneous load amplitude oscillation around the 15-minute average will result in a higher possible peak shaving error.

Another source of uncertainty is given due to changes in production profiles, which becomes extremely apparent under the current circumstances of the COVID 19 outbreak. Therefore, sensitivity analysis of load profiles with a deep insight into the internal processes should be the basis for every peak-shaving calculation.

A finely tuned sizing algorithm takes into account not only the battery power characteristics and aging profiles, but also the errors resulting from the aggregation of the company's available 15-minute power profiles. In this way a highly economical and safe sizing can be achieved. BESS are rarely used for one application only. Combined applications require more mathematical analysis to consider the interaction of the multi-purpose application. This aspect is also considered in the specific sizing algorithm.

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[3] According to §55 of the Metering Act (MsbG) Gesetz über den Messstellenbetrieb und die Datenkommunikation in intelligente Energienetzen (Messstellenbetriebsgesetz - MsbG). URL: https://www.gesetze-im-internet.de/messbg/__55.html [last checked 2019-11-15]

[4] Gloria, Luan Leão; Evaluation-tool development for peak-shaving employing Li-Ion battery storage systems at different C&I customers.; Master Thesis; 26.03.2020

[5] Gloria, Luan Leão; Evaluation-tool development for peak-shaving employing Li-Ion battery storage systems at different C&I customers.; Master Thesis; 26.03.2020