HYBRID ENERGY STORAGE SYSTEM FOR PEAK SHAVING APPLICATION IN INDUSTRIES

Panagiotis MOURATIDIS[1], Maximilian SCHNEIDER[1], Stephan RINDERKNECHT[1]

Motivation

The integration of renewable energies and the increasing market share of electric mobility set new challenges for the stability of the electricity grid. Industries were for long time considered as pure electricity consumers that could not actively contribute to the grid stability [1]. However, the integration of small generation units and the application of energy storage make the industries capable of accomplishing this goal [2]. Industries tend to create high power peaks during operation, for example due to the startup of machinery. Power peaks are inconvenient for the electricity network, since they impair the power quality as well as the grid stability. In order to cope with this issue, the energy operators introduce the so-called power price. The power price defines what an industry should pay for its maximum power demand within a fixed period. The power price should be paid additionally to the energy price. The industries can initiatively improve their electricity costs by reducing their power peaks, i.e. by applying Peak Shaving (PS). Energy storage is a flexible option for industries to implement peak shaving, since no additional scheduling for their production and generation is needed. As long as the nominal capacity and power of the energy storage is appropriately dimensioned, it can compensate for the power peaks, keeping the industry around a predefined power limit [3].

In this work, a Hybrid Energy Storage System (HESS) capable to enable peak shaving application for small industries is presented. The presented HESS combines the advantages of a lithium-ion battery and a flywheel. The lithium-ion battery features a high energy density, while the flywheel features a high power density. Using the flywheel for the high and the battery for low dynamic part of the power peaks, among others, a reduced aging of the battery is achieved.

Methodology

The HESS built within the framework of the publicly funded project “PHI-Factory” can been seen in Figure 1. The Kinetic Energy Storage System (KESS) having a nominal power of 100 kW and an energetic capacity of 1.4 kWh is designed and built by the Institute for Mechatronic Systems within the previous project “ETA-Fabrik” as described in [4]. The Battery Energy Storage System (BESS) consists of four parallel-connected battery systems of the company AKASOL AG each of them having an energetic capacity of 30.6 kWh.

Figure 1: Hybrid Energy Storage System 1: Flywheel, 2: Lithium-ion battery

[1] Technische Universität Darmstadt, Institut für Mechatronische Systeme im Maschinenbau, Otto-Berndt-Str. 2, 64287 Darmstadt, Deutschland, +49 6151 16-23259, panagiotis.mouratidis@tu-darmstadt.de, www.ims.tu-darmstadt.de/energiespeicher

Results

The developed HESS is capable of compensating the power peaks and thus reducing the electricity costs. In order to divide the power between the energy storage units, a power dispatch strategy using a frequency dependent allocation was applied. The BESS compensates the low dynamic part, while the KESS the remaining high dynamic part. The results of a peak shaving test application in the model factory “ETA-Fabrik” are presented in Figure 2.

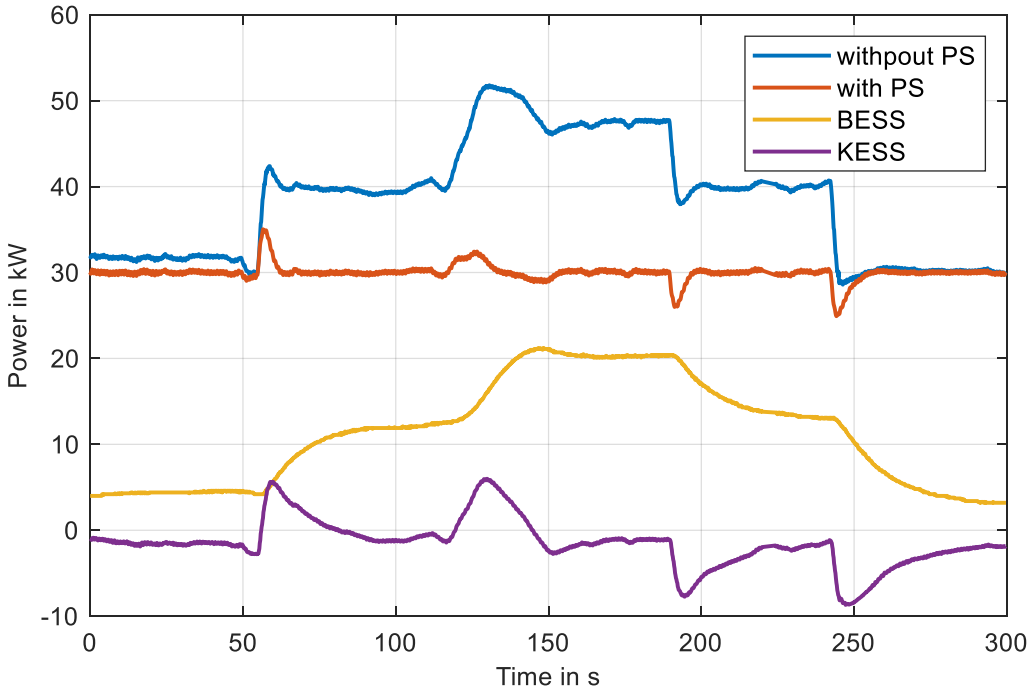

Figure 2: Peak Shaving (PS) applied on the ETA Factory limiting the power consumption at around 30 kW

It is obvious that through the HESS the power consumption of the factory is limited around the target value of 30 kW. The KESS responds faster than the BESS and allows for a spare operation of the latter. In this way, the high power density of the KESS and the high energy density of the BESS are synergistically combined.

Acknowledgement

The German Federal Ministry for Economic Affairs and Energy finances the Project “PHI-Factory”, grant number 03ET1145A: Flexible power management of production plants in order to increase their energy efficiency fulfilling the requirements of the prospective distribution grids based in renewable energy generation. **Online: http://phi-factory.de/**

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

References

[1] S. von Roon and T. Gobmaier, “Demand Response in der Industrie: Status und Potenziale in Deutschland,” Forschungsstelle für Energiewirtschaft e.V., München, Dec. 2010.

[2] T. Plößer, B. Niersbach, J. Hanson, and N. Roloff, “PHI-Factory: Provision of Network Services by a Flexible Factory,” in International ETG Congress 2017, Bonn, Deutschland, Nov. 2017, pp. 554-549.

[3] Oudalov, R. Cherkaoui, and A. Beguin, “Sizing and Optimal Operation of Battery Energy Storage System for Peak Shaving Application,” in 2007 IEEE Lausanne Power Tech, Lausanne, Switzerland, Jul. 2007, pp. 621–625.

[4] L. Quurck, M. Richter, M. Schneider, D. Franz, and S. Rinderknecht, “Design and practical Realization of an innovative Flywheel Concept for industrial Applications,” Technische Mechanik, vol. 37, no. 2-5, pp. 151–160, 2017.