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Model-based economic assessment of stationary battery systems providing primary control reserve

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Abstract

Rapidly decreasing battery prices and high capacity prices on the German primary control reserve (PCR) market promote the attractiveness of battery energy storage systems (BESS) for primary control provision. In order to assess the economic feasibility in this application field, two case studies based on a 2 MWh BESS are performed. By coupling a PCR simulation model with a battery aging model, battery lifetimes are estimated. Costs and revenues occurring during the lifetime are calculated using the net present value approach. The results indicate that a BESS with a power-to-energy ratio of 1:2 is not economically feasible under the current framework. A BESS with a power-to-energy ratio of 1:1 will break even after approximately nine years of operation. Decreasing battery system prices are likely to increase the price pressure on the PCR market leading to decreasing revenues for PCR supply. Battery aging results suggest similar aging behavior for both systems presented due to the prevalence of shallow DoD cycles and the resulting predominance of calendar aging.

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Keywords: Primary control reserve; battery energy storage system; techno-economic assessment; battery aging; net present value approach

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1. Introduction

Technology development and rapidly falling battery system prices promote the attractiveness of battery energy storage systems (BESS) for different stationary applications on grid level. The ability to respond rapidly and precisely to frequency deviations makes BESS ideal candidates for primary control provision (PCP). Recently, the application of BESS on the German primary control reserve (PCR) market has seen a dynamic development regarding the number of BESS projects and the prequalified BESS power, which have been announced so far. Fig. 1 provides an overview of the market development in Germany for the period 2012 to 2017. The biggest project so far is a 90 MW project of the utility STEAG, which is planned to be realized at six different locations in 2016/2017 [2].

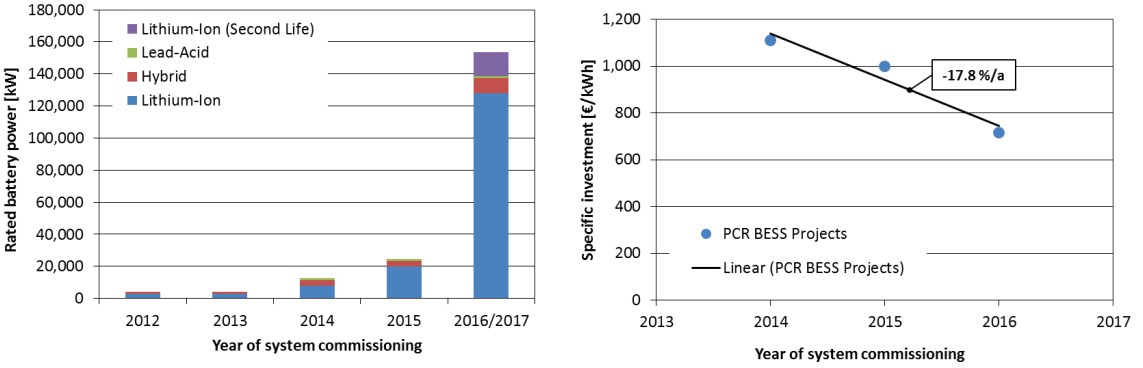

Fig. 1. Market development of BESS for PCR supply (left) and specific investment of selected realized or announced commercial BESS projects in Germany (right)

Under the assumption that all announced projects can be realized in time, the prequalified BESS power on the PCR market will reach approx. 155 MW by 2016/2017. Compared to the PCR market volume in Germany of 578 MW (2015) respectively 783 MW (2016), the market share of BESS can reach up to 27 %. Taking into account the coupled market area consisting of Germany, Austria, Switzerland and the Netherlands, the market share will reach 20 % if all BESS providers are accepted in the bidding process. Further projects in Austria, Switzerland and the Netherlands, which have not been considered in Fig. 1, might lead to an even higher market share. The market is currently dominated by Lithium-ion BESS. Stenzel et al. give an overview of recent BESS projects in Germany [3]. According to the dynamic market development the specific investment trend of realized or announced PCR BESS projects in Germany is also shown in Fig. 1. For the trend analysis, three commercial battery projects have been compared [2, 4, 5]. The trend between the first project in the year 2014 [5] and the recently announced project for the year 2016 [2] indicates a price decrease by approx. -17.8 %/a from 1,110 €/kWh (2014) to 710 €/kWh (2016), which is driven mainly by decreasing battery cell prices.

Nomenclature

BESS	battery energy storage system
C	capacity (MWh)
ch	charge
dis	discharge
DoD	depth of discharge (%)
DU	deadband utilization
E	energy (MWh)
EIS	electrochemical impedance spectroscopy
EoL	end of life
FCE	full cycle equivalents
i	discount rate (-)