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Energy storage control algorithm for suppression of fluctuation of wind farm output power

***Abstract**. Paper consists of a brief introduction of the background of the problem, the description of proposed control algorithm along with the simulation results of its operation. Said analysis assumes 3 variants of ESS parameters. Next, the results are analyzed for expected lifecycle of considered energy storage.*

Keywords: energy storage, wind farm, renewable energy sources.

Introduction

In recent years issues like global warming, pollution a high priority problems and there has been increased interest in the Renewable Energy Sources (RES) [1]. RES, such as wind and solar power plants, have significant potential of reducing greenhouse gas emissions and decreasing the dependence on fossil fuels [2]. However the RES experience larger power variation than traditional power plants due to their dependence on the unpredictable forces of nature. Polish grid regulations require a wind farm to not generate power with sudden dips and spikes (d) exceeding 1.5% of reference power and should not have P_{st} (short-term flicker factor) above 0.35 [3, 4]. One of the ways to meet the quality requirements is to use ESS to stabilize the power output of RES.

Proposed method

A control method of the ESS is proposed in order to reduce the negative influence of the wind farm on the power system. The method relies on setting of 10 second, 30 second or 60 second intervals at a fixed output level for the wind farm and using the storage system to absorb all deviations. (Fig.1a). A histogram of 1 second power changes is illustrated in Fig. 1b.

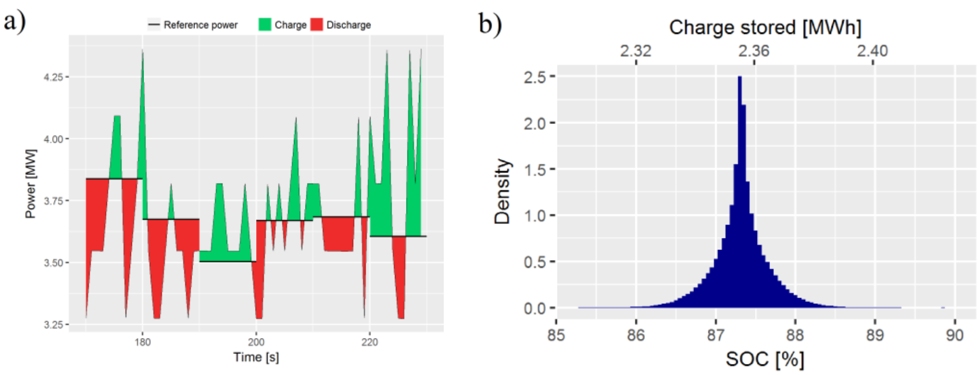

Fig.1. Variation of active power (P_{wf}) compared to fixed power levels (P_{ref}) at 10 second intervals (a), Histogram of ESS SOC level for ESS (P=1.35MW, E=2.70MWh) (b).

Simulation results

The basis for the simulation is the data (1 second samples) from a operating wind farm consisting of 13 wind mills 2.3MW each (29.9MW total).

Simulations take 3 li-ion ($LiFePO_4$) ESS variants of various sizes were taken into consideration. A series if analyses were carried out to determine the fraction of the time in which the ESS was able to maintain set power levels is presented in Fig. 2a and boxcharts of SOC levels during ESS operation.

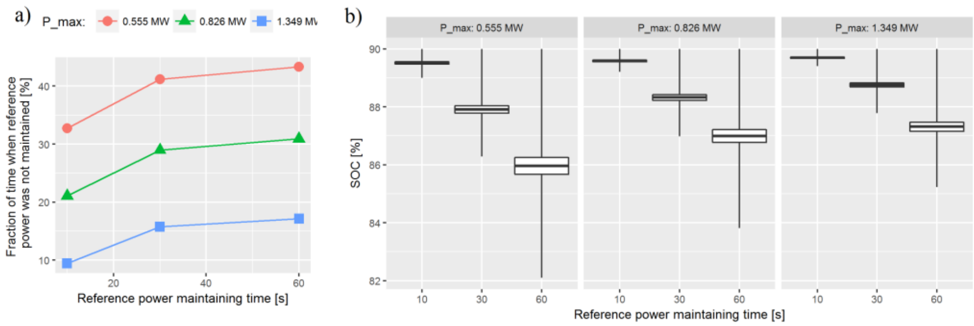

Fig.2. Fraction of time of not maintaining reference levels (a), Boxchart of SOC during each conducted simulation (b).

A cycle lifetime of considered ESS were then estimated. The analysis was conducted based on: detailed wind farm power data, the calculated ESS response and the expected number of cycles chart. Including the influence of the C-rate and the depth of discharge.

Conclusion

The paper introduces the proposed ESS control method for improving power quality. The control algorithm was then the object of analysis which illustrate its operation, showing data like each consecutive wind farm set reference power level, the distribution of wind farm power level. Based on said distribution, three variants of $LiFePO_4$ energy storage system parameters were determined with power corresponding to 95%, 99% and 99.9% quantile of wind farm power changes. Then the SOC value during ESS operation was calculated as well as the fraction of power level maintaining time and expected ESS lifetime during its operation.

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