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Application of Battery Storage for Compensation of Forecast Errors of Wind Power Generation in 2050

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Abstract

Transmission system operators have to buy control power to cover deviations in energy production of wind power plants due to prediction errors. The risk of errors is immanent to any prediction. This leads to financial risks, especially for the unexpected large deviations. Therefore large-scale integration of wind power could oblige the system operator to allocate more spinning and supplemental energy reserve. This would cause more operation costs, in order to balance wind power prediction errors in a certain time period. Battery storage technology can be used to supply backup power for wind power plants. However, the high cost of battery storage systems (BESS) is the major drawback for their commercial applications. Gradually decreasing costs of batteries can bring BESS in a competitive positon for balancing wind prediction errors. By analyzing the application of BESS as means to balance prediction errors, the resulting cost associated with wind generation prediction errors in a liberalized electricity market in the year 2050 is assessed. The result shows, that BESS is an outstanding alternative for short-term balancing in order to reduce the cost of prediction uncertainties.

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*Keywords:*wind power forecast error; electricity markets; battery energy storage system; balancing energy

1. Introduction

Wind turbines will contribute to European future electricity generation to a high degree. Due to the intermittent nature of wind power (WP), the importance of accurate forecasts is increasing. In order to deal with imperfect wind power prediction, system operators have to face additional cost as a result of increasing reserve levels. The

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unexpected large forecast deviations would cause more operating costs, because it requires more balancing energy to balance the wind power forecast errors (WPFEs) and the cost of balancing energy will be calculated with balancing energy price. Previous studies have presented different ways to minimize the cost of balancing energy. A sophisticated trading strategy can avoid more cost caused by short-time forecast errors [1]. Virtual power plants can be also an alternative to reduce the cost for balancing energy [2]. Some studies have investigated that a BESS can serve as a backup energy resource in combination with wind power plants. An optimal operation strategy of a battery energy storage system can not only support the physical safety of the power system but can also be economically profitable trading at the electricity market [3-4].

In this paper, an improved efficiency and a sinking cost of different types of batteries in the year 2050 were assumed. The relationship between the spot price of electricity in day-ahead market and the residual load was researched in order to get a simple model to forecast the spot price in the year 2050. In addition an operation strategy of the BESS is proposed, which depends on the spot price for electricity.

In section II, the model used to characterize day-ahead spot price of electricity in the year 2050 is presented and the balancing energy price is assessed. In section III, an operation strategy of a BESS associated with balancing energy price is proposed. In section IV, two simulations aimed on balancing WPFEs without the BESS in year 2011-2012 and with the BESS in year 2050 is presented, the economic benefit with applications of different battery types is discussed. Finally, section V presents the conclusions of this study.

Nomenclature

BEP	balancing energy price
BESS	battery energy storage system
EPEX	European Power Exchange
FWP	forecasted wind power
SMP	spot market price
TSO	transmission system operator
WP	wind power
WPFEs	wind power forecast errors
WPP	wind power plants

2. Modeling spot market pricing

2.1. German power market

The European Power Exchange (EPEX SPOT) is a spot market for power. It operates day-ahead power markets and intraday power markets. The day-ahead markets are organized by an auction process and closed on 12:00 p.m. one day before the respective delivery day. The intraday markets are organized by continuous trading. The intraday markets open on 3:00 p.m. one day before the respective delivery day and close up to 45 minutes before physical delivery. The control reserve is utilized in order to balance the forecast errors until the real-time operation. Furthermore, the day-after-market can be considered as the last chance to change the delivery plan. It closes 4:00 p.m. one day after the delivery day. The transmission system operator (TSO) is responsible for the physical balance between production and consumption. Based on the cost of the control reserve, the TSOs will publish the price of the balancing energy each month for the previous month, when the up-regulations increase generation or reduce consumption and the down-regulations decrease generation or increase consumption.

In order to simplify the marketing process, only the day-ahead markets and the payments for balancing energy due to WPFEs will be considered in the following simulations presented in this paper.