Enhancement of Smart-Grid Control by Adding Adaptable Battery Depreciation Fees

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This paper discusses the introducing adaptable battery depreciation fees to account battery usage cost in smart-grid (SG) operation. Adaptive characteristics are calculated by a special estimated model of real battery. It is understood that the changing value of these fees will help to find more optimal solutions to control such systems.

Key words: smart-grid, battery depreciation, demand response problem, optimization.

Introduction

One of the main problems of various smart-grids is the demand response (DR) problem [1]. Due to the growth of renewable energy, the balance in the grid between generated and consumed energy is becoming increasingly difficult to maintain.

Electricity providers are introducing volatile price rates to solve this problem: a time-based program (TBP). In TBP, the price of electricity depends on the current or systematic imbalance in the grid. Thus, SG helps in solving the global DR problem by minimizing its own costs.

SG can minimize costs by load transfer. However, it is not always convenient. Therefore, there is another way. SG can accumulate cheap electricity and use it when electricity is expensive. This approach is more flexible, but it is fraught by the cost of storing electricity. Consequently, for the algorithms [2], that control the SG, it is necessary to take into account the cost of using the energy storage system (ESS).

ESS for SG is often based on a Li-ion battery (LIB). LIB is a very efficient but expensive energy storage.

Methodology

To this date, some control methods with respect to the cost of using LIB have been developed. However, many authors skip the calculation of these fees.

One of the methods restricts high current with a penalty-coefficient for the squared energy [3]. This method leads to sub-optimal solutions, since the objective function does not express the explicit total costs of SG.

Another method calculates the battery depreciation fee as a ratio of battery price to the total energy transferred over a lifetime [4]. However, this method does not take into account the variability of the characteristics of the battery during a lifetime. Therefore, this approach can cause accelerated unplanned aging of the LIB.

Hence, an idea occurs - to describe an adaptable battery deprecation fee using a model that describes the characteristics of the ESS during the simulation. It is assumed that the adaptable fee will change as the battery ages. This will allow the system to get near-optimal solutions and increase the benefits of SG through the use of ESS.

Results and Discussion

First, the optimizer controller structure is selected. It is necessary to take into account the balance between:

- ✓ Simple fast inaccurate controller.
- ✓ Sophisticated long accurate controller.

The optimizer will receives data from the battery model. This data will contain the predicted characteristics of battery loss. The controller also needs information about SG.

Battery state of health (SOH) is spent on based on the way how it is used and under what conditions. Moreover, this is a rather complex nonlinear system, where every parameter affects each other.

Figure 1 shows the structure of SG with battery estimator model.

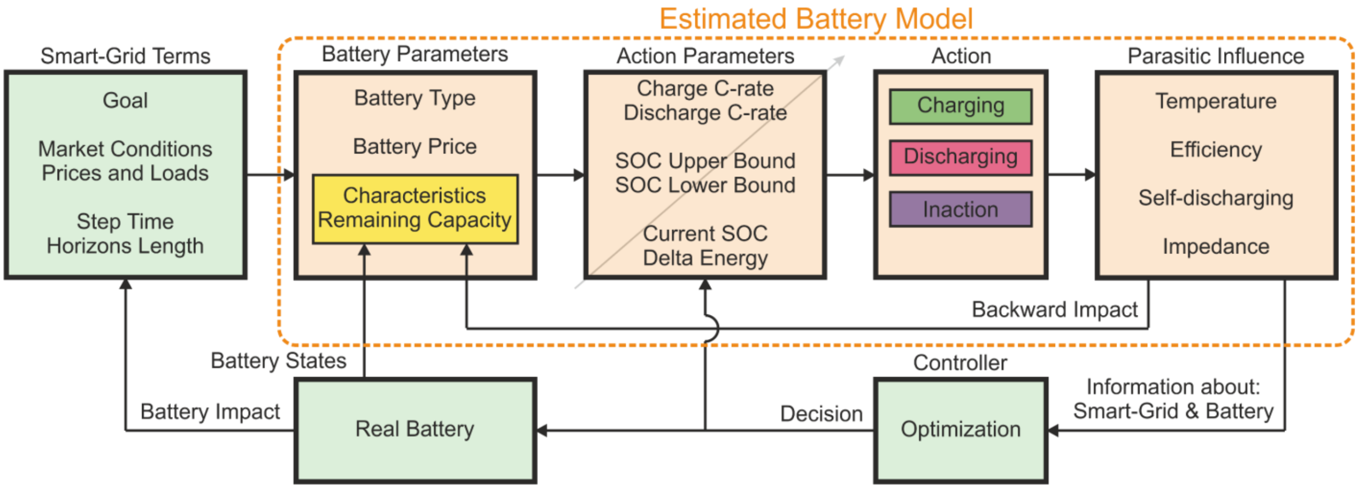

Figure 1: The structure of smart-grid with battery estimator model.

The Battery Parameters block contains battery state information. To monitor the battery, it is advisable to know the tabular values of the state of the battery over a lifetime. During operation, the states of the battery model based on real indicators from ESS sensors will be updated.

The Action Parameters block contains information about future model actions in the next step. This block is controlled by the optimizer.

The Parasitic Influence block takes into account negative parameters that affect the overall effectiveness of the LIB.

In each new optimization step, all system states are recalculated. Thus, the optimizer can more accurately predict the loss of SOH, as it knows the price of the current battery usage.

Conclusion

In this work, a method for the formation of the adaptive price of using batteries for SG was proposed. The method is based on a battery estimated model, with which you can predict the loss of SOH more accurately. If we introduce such prices into the current SG control systems, then the overall benefit of the system should increase by extending the battery life.

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