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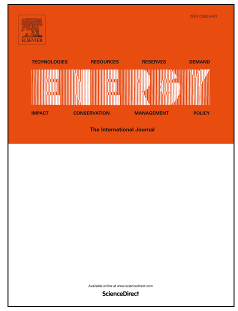

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Battery Life-Cycle Optimization and Runtime Control for Commercial Buildings Demand Side Management: A New York City Case Study

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Abstract

In metropolitan areas populated with commercial buildings, electric power supply is stringent especially during business hours. Demand side management using battery is a promising solution to mitigate peak demands, however long payback time creates barriers for large scale adoption. In this paper, we have developed a design phase battery life-cycle cost assessment tool and a runtime controller for the building owners, taking into account the degradation of battery. In the design phase, perfect knowledge on building load profile is assumed to estimate ideal payback time. In runtime, stochastic programming and load predictions are applied to address the uncertainties in loads for producing optimal battery operation. For validation, we have performed numerical experiments using the real-life tariff model serves New York City, Zn/MnO_2 battery, and state-of-the-art building simulation tool. Experimental results shows a small gap between design phase assessment and runtime control. To further examine the proposed methods, we have applied the same tariff model and performed numerical experiments on nine weather zones and three types of commercial buildings. On contrary to the common practice of shallow discharging battery for preventing phenomenal degradation, experimental results show promising payback time achieved by optimally deep discharge a battery.

Keywords: battery integration, commercial building, demand side management, stochastic programming.

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1. Introductions

1.1. Motivation

Metropolitan areas in U.S are facing stringent electric power supplies on peak demands. For example, Fig. 1 shows that in most of the locations of the New York City (NYC), the electricity peak demands are higher than the supply capacities, which is a direct result of continuously increasing loads, and closing of several coal and nuclear power plants due to economic and environmental concerns [1].

On the other hand, peak-to-average load ratio is an important indicator for efficiency operation of the grids. Fig. 2 demonstrates the comparisons of the historical New York State peak and averaged loads. It is shown that peak loads could be more than 80% higher than averaged loads. It is projected the peak-to-average load ratio is even higher for NYC. A lot of generation capacities are built to meet the peak demands which last only for a short period of time.

Figure 1: Percentage utilization of the distribution network by 2018 without any demand response initiative as projected by ConEd (2009) [2]

Figure 2: Comparisons on New York State peak and averaged loads [3].

Instead of enhancing generation side capacities, an alternative is to improve the Demand Side Management (DSM). It changes demands through various methods such as demand response, energy efficiency, customer-sited energy storage, and etc [4, 5]. DSM provides numerous benefits. First, there are environmental concerns to build more bulk generations, especially in the densely populated