Building-to-grid predictive power flow control for demand response and demand flexibility programs

M. Razmara a,⇑, G.R. Bharati b, Drew Hanover a, M. Shahbakhti a, S. Paudyal b, R.D. Robinett III a

a Mechanical Engineering-Engineering Mechanics, Michigan Technological University, Houghton, MI 49931, USA
b Department of Electrical and Computer Engineering, Michigan Technological University, Houghton, MI 49931, USA

Abstract

Demand Side Management (DSM) provides ancillary service to the electric grid by modifying customers electricity demand. Demand Response (DR) and Demand Flexibility (DF) programs from buildings are well-adopted ancillary services to reduce the peak demand in grids by altering the power consumption strategy. Heating, Ventilation and Air-Conditioning (HVAC) systems are one of the largest energy demands in commercial buildings. In addition, HVAC systems are flexible to provide DR service to the grid. In this study, two common configuration topologies of building integration with Energy Storage Systems (ESS) and renewables are considered. A real-time optimization framework based on Model Predictive Control (MPC) is designed to control the power flow from the grid, solar Photovoltaic (PV) panels, and ESS to a commercial building with HVAC systems. The MPC framework uses the inherent thermal mass storage of the building and the ESS as a means to provide DR. Deterministic and probabilistic analysis are studied to investigate the effectiveness of the proposed framework on Building-to-Grid (B2G) systems. Our deterministic results show that the proposed optimization and control framework for B2G systems can significantly reduce the maximum load ramp-rate of the electric grid to prevent duck-curve problems associated with increase in solar PV penetration into the grid. Based on probabilistic results, even under prediction uncertainties, electricity cost saving and ramp-rate reduction is achievable. The results show that this DR service does not affect the building indoor climate in a way noticeable to humans and its effect on the operational building costs is reduced. The B2G simulation testbed in this paper is based on the experimental data obtained from an office building, PV panels, and battery packs integrated with a three-phase unbalanced distribution test feeder. A Monte-Carlo simulation is carried out to account for uncertainties of the proposed method. Both deterministic and stochastic analyses show the effectiveness of the proposed predictive power flow control to decrease the building operation electricity costs and load ramp-rates.

Keywords:
Demand response
Demand flexibility
Building to Grid (B2G)
Building predictive control
Solar PV panel integration
Energy storage system integration
Monte-Carlo simulation

1. Introduction

Connectivity and interoperability of Building-to-Grid (B2G) systems are essential factors for a greener future of energy landscape. Developing advanced control strategies for B2G systems guarantees safety, reliability and interoperability of buildings and electric grid as energy and power hubs in a modernized grid.
Due to intermittent distributed renewable power generation and its increasing penetration into the power grid, electricity generation is changing from predictable and dispatchable to unpredictable and non-dispatchable sources [1]. By increasing small-scale distributed Renewable Energy Sources (RES), and the increase of non-dispatchable power generation ratio, the mismatch between power demand and generation occurs more frequently. Likewise, in the advent of extreme weather conditions, the demand-generation balance is jeopardized. This mismatch and volatilty of electricity price, and (iii) integration of high penetration renewables [3]. Demand Response (DR) programs are ancillary services in which end-users (in our case commercial buildings) adjust the power consumption in response to a certain signal from the grid. The DR signal may contain information regarding electricity price, incentives, or system reliability emergencies [4]. In the traditional look to the power systems, demand side is not flexible
دریافت فوری

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات