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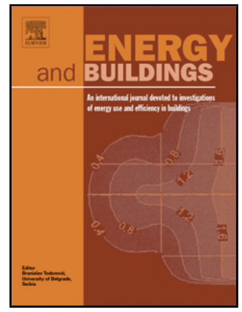

Title: Distributed Air Conditioning Control in Commercial Buildings based on a Physical-Statistical Approach

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Distributed Air Conditioning Control in Commercial Buildings based on a Physical-Statistical Approach

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Highlights

- An HVAC control algorithm is constructed based on thermal attributes of building
- Hybrid physical-statistical models are implemented in control optimization framework
- Each zone has its specific operation plan based on thermal and occupancy attributes
- The optimization framework includes price signals and human performance
- Adaptive physical-statistical models capture asset degradation rate in the system

Abstract

This paper presents a method to optimally control a commercial building air conditioning operation based on building thermal physics and human behavior. Control plans are developed for zone cooling and according to occupancy patterns at zone levels, and using a novel response model developed in this paper. The thermal response model is a statistical model, which is built on the basis of insights gained from physics-based model of zone thermal behavior. The control model attempts to optimize cooling system scheduling on the basis of occupancy patterns, price signal from utilities and human comfort and productivity. The optimization follows an on-demand routine, such that zone level air conditioning starts at a time epoch that is optimal according to zone thermal response and cooling requirements. We toss the term "pre-occupy" control. We also develop, what we call, "post-occupy" control, where the system shutdown follows thermal inertia and cooling requirements at the time that the zone is expected to become unoccupied. The thermal response modeling of a zone and the two control modes are considered major contributions of this article. EnergyPlus reference models are used to train our models and illustrative examples are presented.

Key Words: smart control; HVAC; thermal response; operation planning; human behavior

1. Introduction

Over the years, Heating, Ventilation and Cooling (HVAC) designers endeavored to meet building heating and cooling demands within the specifications defined by standards and often designed on the principles of oversizing and conservative safety and reliability requirements [1,2]. Traditional Building Energy Management System (BEMS) were programmed using some sensory data and PID controllers, and pre/post occupy operation scheduling was determined through trial and error procedures without directly taking into account human occupancy factor and building thermal characteristics [3–5]. However, research studies are all indicative that human factor and building thermal characteristics play important roles in building energy consumption. With BEMS having information on building's thermal-physical characteristics, and human occupancy and behavior, one would expect more energy