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Modeling for reactive building energy management

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Abstract

This paper discusses the development of modeling approach for reactive energy management. The objective of reactive energy management is to adopt the long-term anticipated performance to actual situation, preserving the occupant's comfort and energy expenses. It performs continuous performance monitoring of whole building, taking into account unplanned events and system failures. Reactive energy management mechanism uses fast dynamics models with short-time simulation, able to manage the real-time observations from sensor data. This work emphasizes the development of low-order resistance-capacitance (R-C) thermal model with their equivalent state-space representation. At the end, a case study demonstrates the significance of fast dynamics reactive models to detect the discrepancies from reality.

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Keywords: Reactive energy management; Anticipative energy management; Simulation; Buildings; Occupant's comfort

1. Introduction

Buildings consume 32% of final energy consumption, in terms of primary energy consumption, this consumption reaches 40% *(source: International Energy Agency)* [1]. A careful supervision of energy management could decrease this energy consumption significantly. In most buildings, the operation of appliances need to be adjusted in response to behaviour of the building occupants, unplanned events and current weather conditions as well. Different anticipative energy management approaches were proposed for a day ahead prediction of energy cost and comfort profile [2, 3]. Anticipative energy management advises the best set-point configuration for comfort and cost to building energy management system (BEMS). However discrepancy might occur in anticipative plan, because of unscheduled event, wrong weather forecast or equipment failure. In such cases, anticipative energy management is not relevant to manage the perceived comfort level for occupants.

In previous work, some energy management schemes were discussed [4, 5, 6, 7], to solve such kind of discrepancy problems. These schemes, mainly derived from either set-points tracking with optimization or heuristics (if-then-else), are unable to detect and locate the causes for failures. Moreover, it is not always fruitful to follow the set-points

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or heuristics in spite of diagnosing and troubleshooting the different causes and failures. In order to rectify anomalies in whole buildings operation, modern building energy management systems should be designed to be "reactive" i.e to be able to take appropriate actions in case of discrepancy between plan and reality. Reactive energy management supposes to use a model that can be easily initialized in case of unplanned events. Simplified 1R-1C thermal model has been developed with a fast initialization algorithm. This model makes setting-up initial condition very easily comparison to more detailed model and preferred for diagnosis of thermal discomfort. This paper is structured as follows. First it provides a short overview of anticipative energy management and then discuss about the reactive energy management followed by a model proposal. Finally simulations show how the reactive energy management is useful to detect the discrepancy from reality.

Nomenclature

R	Resistance
C	Thermal Capacitance
Δ_r	Reactive period
Δ_a	Anticipative period
C_{air}	Air capacity
V_{in}	Indoor volume
C_{out}	Outdoor CO2 in ppm
C_{in}	Indoor CO2 in ppm
ϕ	Heat flow

2. Anticipative Building Energy Management for PREDIS/MHI

The main objective of anticipative energy management is to provide an optimized plan for upcoming hours. Anticipative energy management works usually for a 24-hour time horizon with one-hour as an anticipation period (Δ_a). It considers planned occupancy and hourly weather forecast to predict the next hour cost and comfort profile. Nevertheless, these predictions rely on slow dynamic models and intend to meet the requirements of specific research platform known as Predis/MHI. Predis/MHI is a dedicated platform for the building energy management, located at ENSE3, Grenoble-INP. The platform is equipped with different sensors to monitor the indoor thermal comfort, indoor CO2 concentration, occupant's presence and power consumption as well. Predis-MHI illustrates several aspects of building energy management under different scenarios [8]. In order to model the occupants comfort, anticipative energy

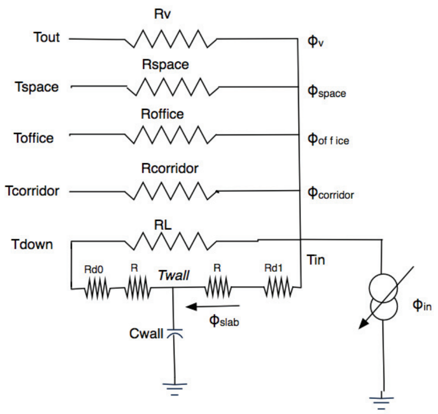

Fig. 1: RC Equivalent anticipative building model for PREDIS/MHI