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Dynamic simulation of energy management control functions for HVAC systems in buildings

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Abstract

Five energy management control (EMC) functions such as outside air (OA) economizer cycle, programmed start and stop lead time, load reset and occupied time adaptive control strategy are developed and evaluated using a variable air volume heating, ventilating and air conditioning, VAV-HVAC, system level dynamic model as a simulation platform. A real time system embedded with the above EMC functions is presented. The simulation results manifest that energy savings of 17% can be achieved when the system is operated with the EMC functions and optimal set points compared with the system without such functions. These results do point out that the optimal set point strategy is very useful in achieving energy efficient operation of HVAC systems.

Keywords: Energy management control systems; HVAC systems; Adaptive control; Optimization; Building operation; Energy savings

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Nomenclature

BC	base case
CC	cooling coil
COP	coefficient of performance
COP_{max}	maximum COP
CSATS	constant supply air temperature strategy
EA	exhaust air
EMC	energy management control
EMCS	energy management control system
ENC	enthalpy cycle
SPC	stop cycle
HP	heat pump
LSATS	linear supply air temperature strategy
MB	mixing box
NC	night cycle
OA	outdoor air
OC	on–off control
OPC	occupied time cycle
PBC	proportional band control
PI	proportional-integral
RA	recirculated air
RWT	return water temperature
SA	supply air
SAT	supply air temperature
SNC	summer night cycle
ST	storage tank
STC	start time cycle
SWT	supply water temperature
WNC	winter night cycle

1. Introduction

It is estimated that heating ventilating and air conditioning (HVAC) systems consume about 50% of the total energy used in buildings [1]. By properly operating the HVAC systems, considerable energy savings can be realized. In this regard, energy management control (EMC) systems can help improve the energy efficiency of the HVAC systems in buildings and maintain a good thermal environment. Common EMC strategies used to reduce energy consumption in buildings are programmed start/stop; optimal start/stop; duty cycling; load reset; electric demand limiting; adaptive control; chiller optimization; boiler optimization; optimal energy sourcing etc. [1].

Most published papers have focused on implementing one EMC function at a time with or without optimal control algorithms [2–5]. Liu et al. [6] and Yang et al. [7] presented the start/stop