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Life-cycle cost analysis for constant-air-volume and variable-air-volume air-conditioning systems

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Abstract

This study presents a life-cycle cost analysis using detailed load profiles and initial and operating costs to evaluate the economic feasibilities of constant-air-volume (CAV) and variable-air-volume (VAV) air-conditioning systems. The present-worth cost method for life-cycle cost analysis is applied to a sample building located in Adana, Turkey which can be conditioned with CAV or VAV systems. In the analysis, two different uses of the building (as a school or as an office center), two different operating scenarios for air-conditioning system (scenario 1 and scenario 2) and two different economic measures (developed and developing economy) are considered. It is found, for all the cases considered, that although initial cost of the VAV system is higher than that of the CAV system, the present-worth cost of the VAV system is lower than that of the CAV system at the end of the lifetime due to lower fan-operating costs.

Keywords: Air-conditioning; Life-cycle cost; Present-worth cost; Constant-air-volume; Variable-air-volume

1. Introduction

Selecting the most suitable and economic air-conditioning system among the available many alternatives is one of the important problems that engineers usually

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Nomenclature

AHU	air-handling unit
CAV	constant-air-volume
COP	coefficient of performance
LCC	life-cycle cost
M	air-mass flow rate under real operating conditions
$\overline{M}$	seasonal average value of M
M_{dsg}	design air-mass flow rate
P_{chil}	power consumption of chiller at part load
$\overline{P_{chil}}$	seasonal average value of P_{chil}
$P_{chil,full}$	power consumption of chiller at full load
P_{fan}	power of electric motor of fan under real operating conditions
$\overline{P_{fan}}$	seasonal average value of P_{fan}
$P_{fan,dsg}$	design power of electric motor of fan
PLR	hourly part-load ratio
$\overline{\text{PLR}}$	seasonal average value of PLR
PWC	present-worth cost
Q	annual heating-energy requirement of building
Q_{chil}	hourly cooling-demand on chiller
$\overline{Q_{chil}}$	seasonal average value of Q_{chil}
$Q_{chil,full}$	hourly cooling-capacity of chiller at full load
$\overline{Q_{chil,full}}$	seasonal average value of $Q_{chil,full}$
Q_{coil}	hourly cooling-coil capacity
$\overline{Q_{coil}}$	seasonal average value of Q_{coil}
$Q_{coil,dsg}$	design capacity of the cooling coil
Q_{max}	maximum allowed annual heating-energy requirement of building
RTS	radiant time series
ST	hourly operating step of compressor
$\overline{\text{ST}}$	seasonal average value of ST
U	overall heat-transfer coefficient
VAV	variable-air-volume
VSD	variable-speed drive
YTL	new Turkish lira
ρ	density of air
ρ_{dsg}	density of the air for design condition

face. An air-conditioning system that saves operating costs usually requires a higher initial investment. In this case, engineers should decide whether it is worth paying the extra first cost for a system that has lower operating cost [1].

Air-conditioning systems can be categorized according to the transfer of heating and cooling energy between central plants and conditioned building-spaces. There are four basic system categories: all-air systems, air- and water-systems, all-water