BUILD SIMUL (2014) 7: 21 – 33
DOI 10.1007/s12273-013-0150-7

Comparison of HVAC system modeling in EnergyPlus, DeST and DOE-2.1E

Xin Zhou[1], Tianzhen Hong[2], Da Yan[1] (✉)

[1] *Department of Building Science, School of Architecture, Tsinghua University, Beijing 100084, China*
[2] *Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA*

Abstract

Building energy modeling programs (BEMPs) are effective tools for evaluating the energy savings potential of building technologies and optimizing building design. However, large discrepancies in simulated results from different BEMPs have raised wide concern. Therefore, it is strongly needed to identify, understand, and quantify the main elements that contribute towards the discrepancies in simulation results. ASHRAE Standard 140 provides methods and test cases for building thermal load simulations. This article describes a new process with various methods to look inside and outside the HVAC models of three BEMPs—EnergyPlus, DeST, and DOE-2.1E—and compare them in depth to ascertain their similarities and differences. The article summarizes methodologies, processes, and the main modeling assumptions of the three BEMPs in HVAC calculations. Test cases of energy models are designed to capture and analyze the calculation process in detail. The main findings are: (1) the three BEMPs are capable of simulating conventional HVAC systems, (2) matching user inputs is key to reducing discrepancies in simulation results, (3) different HVAC models can be used and sometimes there is no way to directly map between them, and (4) different HVAC control strategies are often used in different BEMPs, which is a driving factor of some major discrepancies in simulation results from various BEMPs. The findings of this article shed some light on how to compare HVAC calculations and how to control key factors in order to obtain consistent results from various BEMPs. This directly serves building energy modelers and policy makers in selecting BEMPs for building design, retrofit, code development, code compliance, and performance ratings.

Keywords

building energy modeling programs,
comparative tests,
DeST,
DOE-2.1E,
EnergyPlus,
HVAC,
system modeling

Article History

Received: 22 March 2013
Revised: 11 July 2013
Accepted: 12 July 2013

1 Introduction

Computer simulation is one of the most effective and economical methods to predict and analyze building energy consumption and performance. The simulation industry has developed rapidly since the 1960s, with hundreds of building energy modeling programs (BEMPs) developed and used around the world. Well known BEMPs include DOE-2 and EnergyPlus from the U.S. Department of Energy, ESP-r from the University of Strathclyde, U.K., and DeST from Tsinghua University, China. These BEMPs are widely used in the design stages of new energy efficient buildings, the planning stages of energy retrofits for existing buildings, and the development of building energy codes and standards and energy labeling programs in the building industry. However, an increasing number of practical applications have shown that large discrepancies exist in results from different modelers using different BEMPs for the same building. This is a large problem for the simulation industry and is consequently the subject of more attention. Some believe that the simulation methodology is flawed and attribute the discrepancies to the different calculation engines of different BEMPs. This lack in confidence may hinder the development and application of BEMPs. Consequently, it is important for the simulation industry to understand the reasons for these discrepancies and define the application scope of each program. To solve the problem and promote the development of BEMPs, detailed comparison of BEMPs' calculation engines is a fundamental and significant step.

E-mail: yanda@tsinghua.edu.cn