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Calibration and validation of a solar thermal system model in Modelica

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Abstract

Recent advancements in the domain of modeling physical processes offer opportunities to use equation based modeling environments, such as Modelica, for the simulation of building heating, ventilation, and air- conditioning (HVAC) systems. The current work demonstrates Modelica capabilities in a case study of real building solar thermal system simulation. The simulated system is part of an innovative ENERGYbase building, designed according to the so called Passivhaus standard. Model calibration and validation procedure is developed to include optimization based parametric adjustments of component models using the monitoring data during a single week. The calibrated system adequately reproduces half a year of real system operation. Future work will concentrate on application of the developed calibration and validation methodology in the whole year overall building energy simulation.

Keywords

passive house,
HVAC system modeling,
model calibration,
validation case study,
Modelica libraries,
equation based simulation environment

Article History

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1 Literature review

In spite of the large number of available building energy software tools (DOE 2008), a real building system performance usually differs from the operation predicted by simulations (Trcka and Hensen 2010). In addition to achieving the closer match between simulations and real building operation, the researchers point out an overall need for the building simulation tools to support flexible modeling environments which allow simulations of alternative building system configurations. One of such flexible modeling environments is provided through usage of Modelica, an object oriented equation based modeling language (Modelica 2010). Modelica is also found to offer significant modeling advantages for building energy simulations in comparison to procedural tools, such as Matlab/Simulink (Sodja and Zupancic 2009) or TRNSYS (Wetter and Haugstetter 2006).

Thus, Modelica may offer viable alternatives to provide desired correspondence between simulation and monitoring data, at the same time satisfying the required modeling flexibility. However, necessary prerequisites for broader usage of the Modelica simulation environment in building energy simulations are suitable modeling libraries containing basic building and system simulation models. Although significant efforts focused on development of such models in the past (Yuan and O'Neill 2008; Matthes et al. 2006; Wischhusen and Schmitz 2004; Hoffmann and Kahler 2003; Felgner et al. 2002), to date no commercially of publicly available library was found to offer a range of validated building and system simulation models comparable to typical procedural building simulation tools. Even the most comprehensive state-of-the-art Modelica building simulation libraries are still under development (Wetter 2009), not validated, and do not include models of all building components whose performance may be of interest to heating, ventilation and air-conditioning (HVAC) system design practitioners.

The current research aims to demonstrate Modelica capabilities, calibrate and validate the available models for simulation of real solar thermal building systems, achieving

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