

# **SIMPLIFIED BUILDING AND AIR-HANDLING UNIT MODEL CALIBRATION AND APPLICATIONS**

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Computer simulation has played an increasingly important role in the HVAC industry during the last 50 years. In the 1960s, computer software first became available to replace manual methods for sizing HVAC systems. These programs used dynamic heat transfer theories to calculate building peak heat gains, which resulted in significant initial cost reductions for the cooling system over the older manual calculation methods. Since virtually no consultants had access to computers at the time, manual methods based on dynamic heat transfer were developed and widely used. In the 1970s and 1980s, second generation automated methods (e.g., DOE-2 and BLAST) were developed using advanced dynamic building heat transfer theories and implemented in the mainframe computers of that time. The second-generation programs can simulate building hourly load, energy consumption, and other detailed system operation parameters. The second-generation programs have provided tools to engineers to effectively optimize the building system design. When these programs are used to investigate existing building retrofits, system upgrades and optimizations, calibration processes are required to match the simulated and measured energy consumption values.

Several investigators have made recommendations to calibrate DOE-2 models based on measured data. Numerous investigators have calibrated models and developed calibration procedures. Some researchers have attempted to compile “how to” manuals and methods in order to simplify this task. Unfortunately, the task has generally remained difficult and time-consuming due to the hundreds of input variables that may be adjusted and the hundreds of pages of output available for the calibration process. Simplified simulation methods, such as the ASHRAE modified bin method, were introduced to conduct energy simulations without mainframe computers. Significant research has been conducted to compare the detailed and simplified methods and to improve the agreement between simplified and detailed methods. These studies found that variances in simulation results among users are generally far larger than those

resulting from the different simulation methods, although there are significant differences between the methods when solar gains and thermal mass effects are large.

In fact, the simplified simulation method differs from the detailed simulation method only in the envelope, thermal mass and internal load treatments. Both methods use steady state methods to perform system modeling and ventilation modeling. For a typical commercial building, the internal load pattern may be modeled satisfactorily using one or more daily load patterns since the occupancy typically follows weekday and weekend patterns. Although the simplified method is incapable of dynamically simulating weather related conduction load accurately, the overall error associated with the weather dynamics is often small since the impact of envelope conduction is relatively small in many large commercial buildings.

A 31,600 m<sup>2</sup> (340,000 ft<sup>2</sup>) building was modeled as two zones and the subsequent models calibrated using the measured hourly data. The calibrated models were then used to develop the pre-retrofit energy baseline. A calibrated, simplified HVAC system model was used to identify the system faults and to optimize the system operation. It was found that certain parameters have a major influence on the cooling and heating energy consumption of typical AHUs. These signatures can effectively speed the model calibration process.

A simplified model calibration method was presented that includes model simplifications of building and AHUs, guidance for initial value selection of key input parameters, and a two-level calibration procedure using whole-building cooling and heating energy consumption data. Examples can be provided that demonstrate the model calibration process and its application for fault detection.