

THE MIT DESIGN ADVISOR: A FAST, SIMPLE BUILDING DESIGN TOOL

Bryan J. Urban and Leon R. Glicksman
 Massachusetts Institute of Technology, Cambridge, MA

ABSTRACT

We present a software tool for architects for rapid energy simulation of early-stage building designs. Existing software tools are overly complex for early-stage design. This is problematic because the basic, early decisions can have great impact on building performance. Many energy-saving options can be incorporated at zero to moderate cost if the architect is made aware of the potential savings. After preliminary factors are decided, changing a design can be expensive or in some cases impossible. Our tool is targeted for non-technical users and requires no programming experience. The user can describe and simulate a building in minutes by selecting basic parameters (location, orientation, window size & type, insulation, etc.) from a single-page graphical interface. Expected energy consumption and thermal comfort are computed in real-time with integrated heating, cooling, and lighting energy models. Results are presented graphically for easy design comparison. The MIT Design Advisor can be found on the web at <http://designadvisor.mit.edu/>.

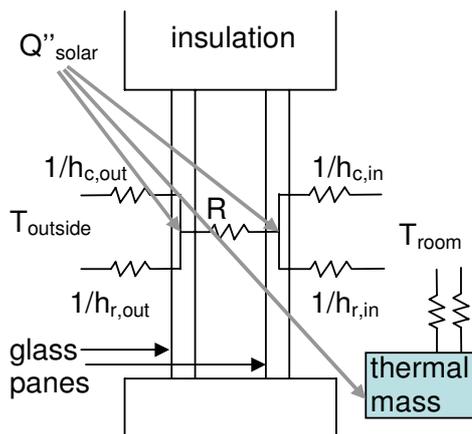


Figure 1. Thermal circuit for heat flow through a double-glazed window.

Annual energy use is calculated using hourly climate data from the MetoNorm database for a user-selected

city. Heat losses through the building envelope and through the ventilation system are balanced with the heat gains in the room (solar radiation, equipment loads, heat generated by occupants) to determine how much heating and/or cooling energy is required to maintain the room temperature within a specified range. Solar gains depend on the glazing system that is used. Basic single-, double-, and triple-glazed windows can be simulated, and choosing spectrally selective coatings will alter the amount of solar energy and visible light entering the room.

An example heat flow circuit for a double-glazed window is given in Fig. 1 (Urban 2006). Temperatures for each node of the thermal circuit are computed dynamically each hour of the year, and the room temperature is allowed to vary between user-specified upper and lower bounds. Double-skin façades that include air flow through a cavity with blinds can be modeled, and radiation exchanges between blinds and other surfaces are modeled using a radiosity method.



Figure 2. Energy use for two near-identical building designs located in Berlin with different windows.

Fig. 2 shows a typical building's annual energy consumption broken down into heating, cooling, and lighting energy. The left and right cases differ only by the window type. Low-e coated, triple glazed windows perform significantly better than the single-glazed clear windows. By comparing cases side-by-side, users can quickly see the impact of design options and justify the purchase of better equipment.



Figure 3. Thermal comfort during summer. Most occupants feel too hot near the single-pane window.

Thermal comfort is computed on a predicted mean vote scale as a function of distance from the window. Occupants near the window may receive excessive solar radiation and feel too hot or too cold, even when the room is at a comfortable temperature. Graphs illustrating thermal comfort are displayed for summer and winter conditions at several times during the day. A sample is illustrated above in Fig. 3 (Urban 2006). Thermal comfort is also computed for naturally ventilated buildings, illustrating how many hours per year a given room temperature is exceeded.

REFERENCES

- Glicksman, L.R., et. al. 2006. MIT Design Advisor. <http://designadvisor.mit.edu/>. Massachusetts Institute of Technology.
- Lehar, M.A., Glicksman, L.R. 2003. A Simulation Tool for Predicting the Energy Implications of Advanced Facades, Chapter 3, Research in Building Physics (ed. J. Carmeliet, H. Hens, and G. Vermeir), A.A. Balkema, Tokyo, pp. 513-5
- MeteoNorm Global Meteorological Database for Solar Energy and Applied Climatology. 2000. CD-ROM by MeteoTest, Bern.
- Urban, B J, Glicksman, LR. 2006 The MIT Design Advisor – A Fast, Simple Tool for Energy Efficient Building Design. IBPSA-USA Conference Proceedings.