Building Energy Computer Simulation An opportunity to improve design

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What it does

Computer simulation evaluates the energy performance of a building by providing estimates of minute by minute room temperature and total energy consumed on a daily or seasonal basis by heating, cooling, and storage systems.

One can easily check the consequences of passive solar or other energy saving additions or modifications to a home or other smaller building. Ideal for "what if?" analyses such as evaluating the effects of:

- adding or removing south-facing glass
- adding passive or active shading or night time insulation
- automatic or manual systems to transfer or block heat flow between a sun space and a living area

How it works

Uses a well-known analogy between the conduction and storage of heat in building materials to the operation of electric circuits. Each major component of a building, such as walls, roofs, windows, glass with passive solar gain, and thermal mass such as brick floors are simulated by equivalent electric circuit components. The time history of temperature and energy requirements of the heating and cooling system under the forcing of the local ambient climate are solved for by an electric circuit simulation computer program.

This approach of evaluating the thermal performance of a building was developed at least 40 years ago, but only recently have advances in personal computers made it accessible and affordable for small projects. In the modern simulators we use, such as esp-r from University of Strathclyde, UK, the connection to the underlying electrical circuit analogy is hidden from the designer and all equivalent electric circuit components and topologies are scaled to behave as the appropriate building materials, building geometries, and building energy systems.

Advantages over other methods

- Standard methods of building heating design give only the average heating or cooling requirements. This method gives, in addition, and estimate of the temperature variation both day and night. Therefore, this method provides an idea of the level of comfort of a particular design.
- Parameters such as area of south facing glass or shading can be easily be changed and the design reevaluated allowing optimum parameters to be chosen. It is indeed possible to automate the energy design optimization process as you require it by coupling the prediction phase of the simulator to an general searching and optimizing program which changes certain design elements under your guidance.
- This method can help avoid over- or under- design which can lead to unnecessary cost or perhaps severe overheating in a solar house.

Illustrations

Illustration 1: Building energy modeling concept. Construction elements and geometry are modeled as analog electric circuit components arranged in a specific topology and scaled to building material properties.

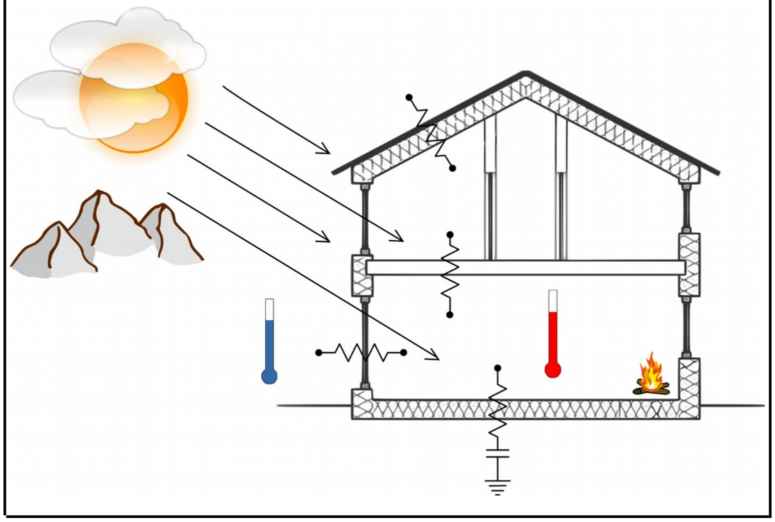

Illustration 2: Output of a simple model of an enclosed space with a heater and small thermal storage. The fluctuating outdoor temperature causes the heater to cycle to keep the interior warm. The energy consumed during cold weather and the overheating during warm weather are evaluated.

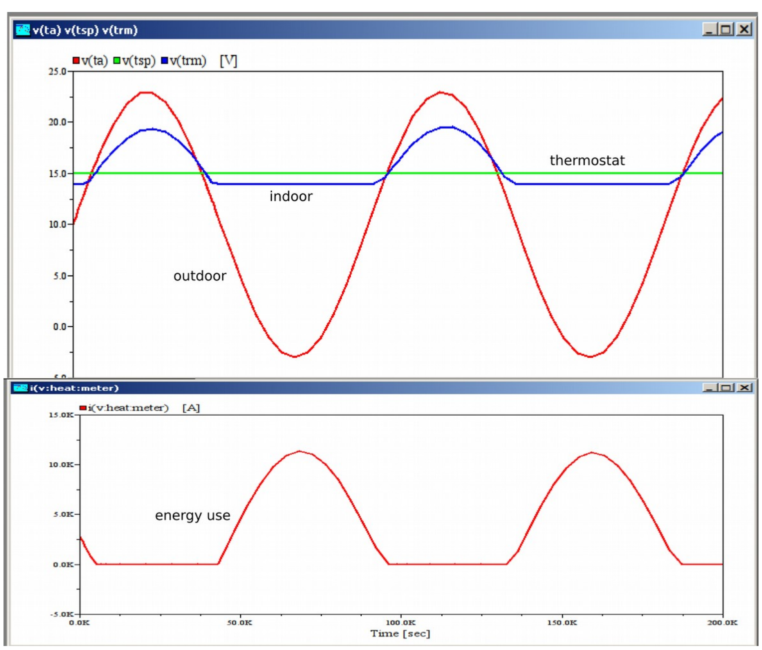

Illustration 3: Example complexity of the underlying electric circuit analog for a realistic building model. Note these details are hidden from the user and are manifested only in the simulation mathematics.

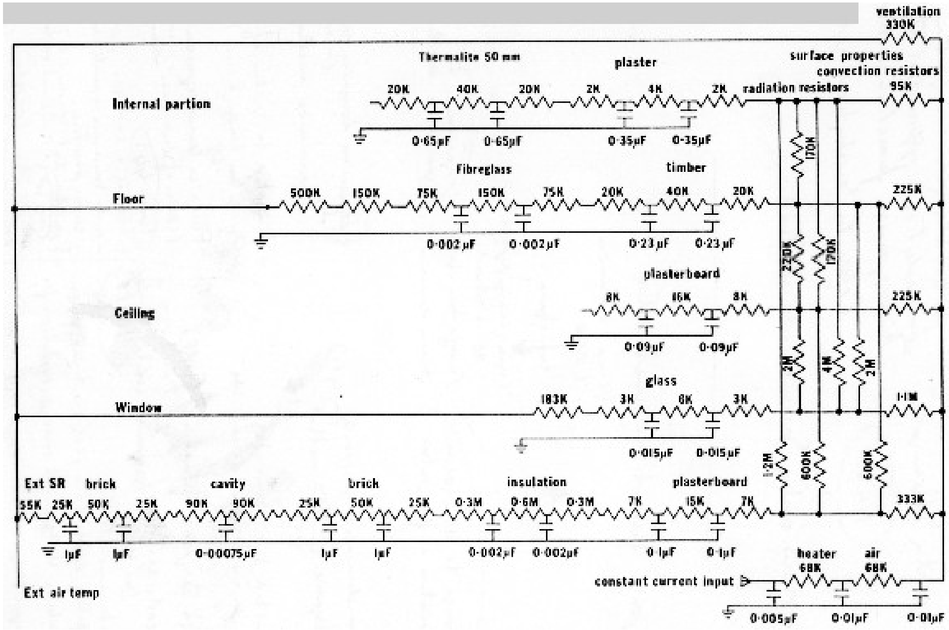

Illustration 4: User interface for the well-developed "esp-r" simulator from the University of Strathclyde, UK.