ENERGY SCHEMING 1.0

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ABSTRACT

This paper describes software for the Apple Macintosh microcomputer that aids architecture students and professionals in incorporating energy considerations in the earliest phase of the design process. The user interface is a "sketch pad" environment that has been designed to foster design activities rather than analysis and allows users to input a building by drawing it at any level of detail. It provides an evaluation of the building's loads for 24 hours for four days. Calculation algorithms are simplified, both to speed up the computer's response time and to minimize the amount of specification the user must be burdened with. The program is written in "C" and will run on the Macintosh SE or Macintosh II. *Energy Scheming 1.0* is currently being Beta tested.

KEYWORDS

Architecture, Design, Energy, Macintosh, Software

INTRODUCTION

Energy Scheming 1.0 has conceptual and functional innovations that facilitate broad, effective, and sophisticated energy considerations at preliminary design stages. These considerations are extremely important because early form, organizational and operational decisions determine a building's loads and the extent to which mechanical and electrical systems may be optimized. In order for a building to reach its full energy conservation potential, it must be designed to reduce and appropriately schedule its loads before the mechanical and electrical systems are designed. This early consideration of energy in design sets the stage for energy to be considered throughout the project.

The software is directed at users who are knowledgeable in building design but are not experts in energy. This includes most practicing architects and architectural students. As a design tool, we expect it to be used in professional offices by members of the schematic design team, a group not currently served by energy analysis software. *Energy Scheming 1.0* has been specifically designed to fit with the beginning of the design process, so it will "feel right" to this group. It uses the highly graphic and easy-to-use Apple Macintosh microcomputer, which will help break down this group's traditional resistance to computers.

GRAPHIC INTERFACE

Energy software is frequently structured by the relatively narrow energy concerns rather than broader architectural concerns. *Energy Scheming 1.0* presents energy ideas in ways that are useful to the designer at the beginning of the design process and that match other things the designer is considering at that time. Designers work first primarily in a synthesis mode, bringing ideas together, not in an analysis mode. During schematic design, information and problem analysis must be presented in a way that is generative of architectural form and that helps the designer understand how the forms suggested by energy concerns fit with the forms suggested by other architectural issues such as composition or structure. The schematic design stage proceeds very rapidly, involving experimentation with many ideas and combinations of ideas. These considerations are broad and conceptual rather than detailed and fine, so information should be accessible and quick to use.

Energy Scheming 1.0 , is compatible with a large range of architectural considerations because it is centered around drawing as the primary means of design investigation and its non-hierarchical organization allows the user to concentrate on any aspect of the architectural problem in any order. *Energy Scheming 1.0* recognizes that the act of drawing is the means not the end of architectural design investigation; drawing is a "conversation" between the designer and the paper. An architect does not imagine a completely thought-out design and then draw it up, but rather proposes an idea graphically, gradually using the evolving graphic image to stimulate the brain to reorganize connections and make associations not consciously included in the original idea. The designer then builds on ideas by reiteratively drawing and inspecting the image. This "discovery by drawing" is fundamental to creative design thinking. *Energy Scheming 1.0* supports this graphic method of design thinking and integrates its energy evaluations within this environment. The energy concerns do not structure or dominate the design investigation, allowing the user to consider a full range of architectural issues.

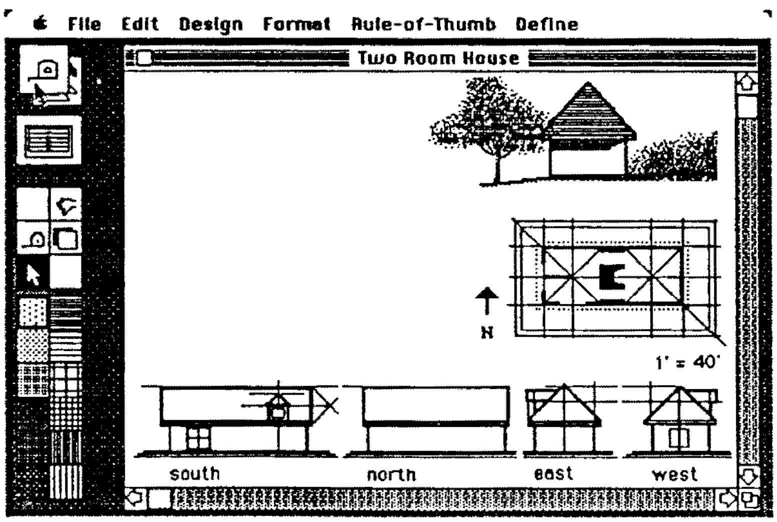

Fig. 1. Graphic Input

The screen shows a building being drawn in elevation and plan, with the palette of drawing tools to the left and a selection of "pull-down menus" across the top. This sketch pad resembles popular paint programs and allows the user to sketch freely, without having to pause to define every building element.

GRAPHIC INPUT

In most energy software the building must be described in numeric abstractions rather than the set of graphic abstractions which designers use. *Energy Scheming 1.0* addresses these limitations at two levels. Conceptually, it is a design tool rather than an analysis or evaluation tool. This means that its primary goal is to help the user synthesize or create an energy efficient building rather than to evaluate an already conceived one. Functionally, its user interface is designed to fit with the mental processes, information structures, and graphic methods a building designer uses at the beginning of the design process. Input to *Energy Scheming 1.0* is handled in two ways. Locations and dimensional data such as areas and lengths are "taken off" directly from the on-screen drawings using graphic tools similar to those used to make the drawings. Physical properties of materials such as conductance are associated with common architectural descriptions of materials such as brick and are input by selecting materials or assemblies. The information being communicated is about architectural elements, rather than just energy-related elements. For example, walls are described in terms of their finish or structural materials rather than their R-values. This means that the user can get an energy evaluation of a proposed design without putting in prematurely detailed or numeric descriptions of those building parts which are normally described in qualitative terms at early design stages. Because conceptual design is done with visual abstractions, it is crucial that design tools consider energy issues in these terms.

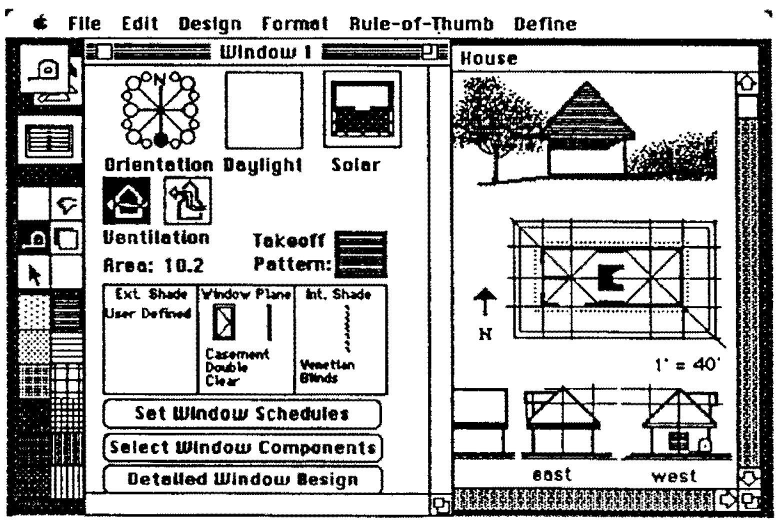

Fig. 2. Window Specifications

The specification input screen displays icons of the building floor plan in which the user identifies the daylight and solar zones that the window belongs to. The second set of icons allows the user to input orientation and ventilation information. The three boxes below the area show the window type in terms of three primary layers; external to the window, in the placeof the window, and internal to the window. The window design may be changed at two levels of detail: "Select Window Components" or "Design Window Design." The window schedule button allows the user to set the operating schedules for shades and ventilation. The user then selects thetakeoff tool from the palette and uses the tape measure cursor to measure the area of the window.

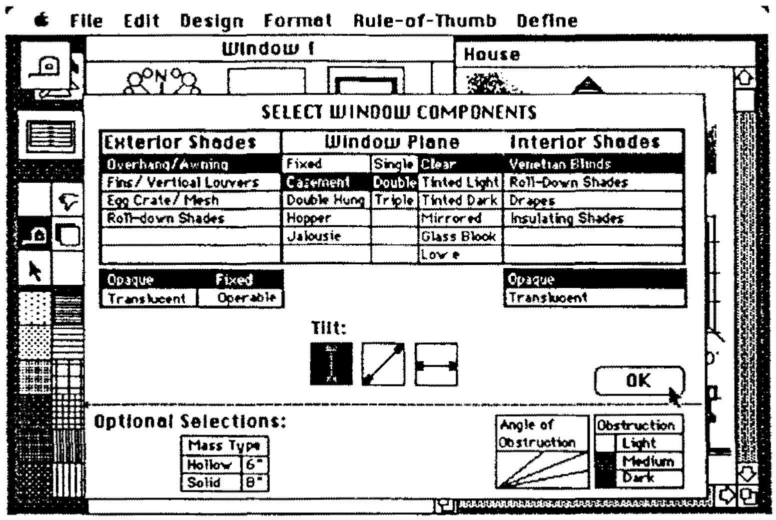

Fig. 3. Describing Windows

This screen appears when the user chooses "Select Window Components." It allows the user to select, from a small component list, a window design that's particular to the building being developed. A graphic representation of these choices appears in the three boxes on the window specifications.

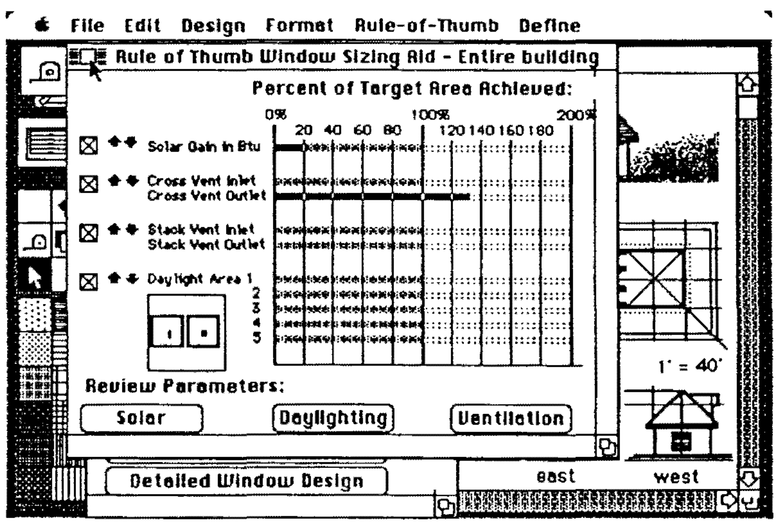

Fig. 4. Rule of Thumb Design Aids

An important part of our software is a set of graphic design aids that provide rule-of-thumb performance information that the designer can see while sketching without leaving the rapid, intuitive mode of thinking that characterizes preliminary design. The example shows the window sizing aids. An optimal window size is calculated according to several criteria which the user selects such as desired solar savings fraction for solar heating, amount of venting aperture needed for cross ventilation, etc. As the userdraws "takeoffs" with the tape measure cursor, the graph bars show how much of the optimum window aperture has been accommodated.

RULE OF THUMB DESIGN AIDS

Within *Energy Scheming* there are two levels of calculations. The first is a rule of thumb that gives instantaneous feedback about the sizing of isolated component. *Energy Scheming 1.0* gives the user rule of thumb guidance on solar heating ventilation, stack ventilation, and day-lighting for windows. This calculation method allows an interactive development of architectural elements like elevations in that the designer can simultaneously compose the elevation for appearance and size the windows for energy considerations.

ANNUAL LOAD ANALYSIS

The second level of calculation is more precise and evaluates the building's loads for up to 24 hours for four days selected from 24 days for each of four climates. The user may also create his or her own climate files. For each hour the program calculates the net energy flow, including the conductive losses or gains, the internal and solar heat gains, and infiltration losses or gains for one thermal zone. The program can show the effects on solar heat gain of exterior and interior shading devices, both operable and fixed. The effects of daylighting appear indirectly in the form of reduced gain from lights as a result of natural illumination from either clear or cloudy skies. Passive cooling through cross or stack ventilation is also calculated. The net energy flow from the sources above is applied to the thermal mass which is used for both heating and cooling. The calculations proceeds rapidly because the algorithms are simplified to reduce calculation time. This simplification is appropriate because at this preliminary stage of design one is interested in being in the "ball park" in order to compare alternatives; precise predictions of energy use are not critical at this stage. *Energy Scheming's* calculation procedures allow the kind of rapid feedback that is imperative to the beginning of the design process.

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