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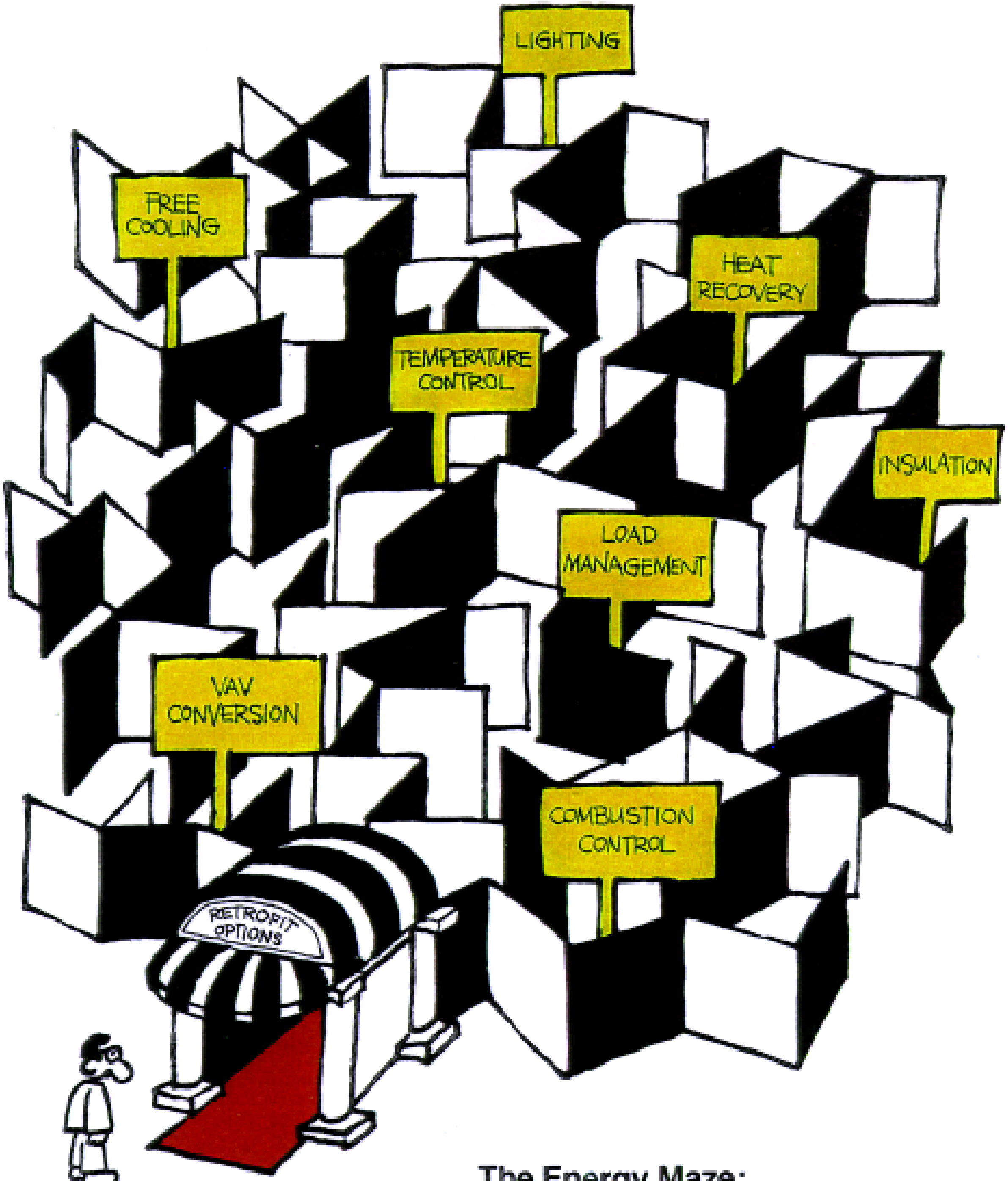

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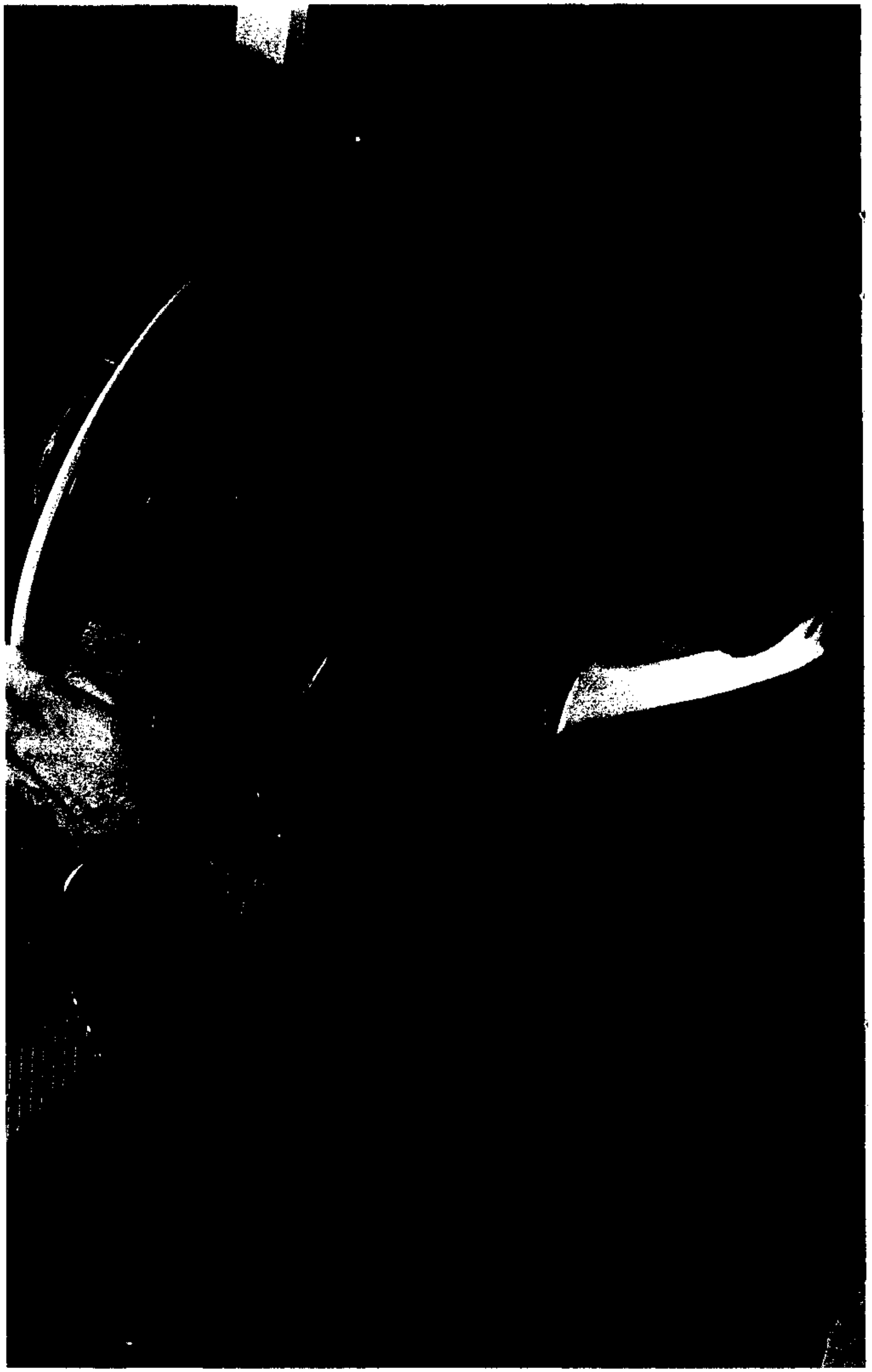
How Computers Can Help You Choose the Right Retrofit Options



The Energy Maze: How Computers Can Help You Choose the Right Retrofit Options

by James P. Waltz, P.E.

As energy costs continue to rise, the task of finding a way to cut utility bills while still maintaining a comfortable environment has taken on a new tone of seriousness. With annual energy price increases reaching nearly 50 percent in many regions of the country, building owners are stepping up their commitment to reduce energy costs.

A few years ago, during the "first round" of the energy crisis, owner commitment resulted in substantial energy use reductions. Savings of 15 to 20 and even 30 percent were not uncommon as a result of implementing operational procedure changes and other simple energy conservation options (ECO's). But during the current "round," instructing the building engineer to "tighten up" isn't cutting it—the options that remain fall into the major retrofit category. Many of these expensive retrofit ECO's have attractive paybacks, but they involve altering basic design, require rigorous engineering, and risk substantial loss of capital if selected wrongly.

At first glance, it would appear that the building owner has it made—after all, there seem to be hundreds of companies, ranging from equipment suppliers, contractors, temperature control manufacturers, and consultants who say they have the answer to your problem.

In fact, some building owners are besieged with representatives from various companies, each extolling the virtue of their product, many promising amazing energy and cost savings.

Left: There are various computer time-sharing companies which offer computerized building simulation programs.

With so many attractive options, what is it that keeps building owners from taking advantage of all of these energy savings alternatives? The answer, of course, is common sense.

One building engineer we spoke with recently pointed out that if he took advantage of the proposals he'd received in the last year alone (and *if* they all worked as their advocates said they would), his 26-story building would not only stop using electricity entirely, but have it to sell back to the power company.

The problem with all of these proposals the engineer had received is that they were based on highly favorable assumptions and only took into account the energy savings obtainable if *just* their proposal was implemented. Evaluating energy ECO's independently in this manner almost always leads to optimistic savings projections, with the error increasing geometrically with the number of ECO's already implemented.

For instance, in a hypothetical building (and independent of other ECO's) converting a terminal reheat system to a variable air volume system might have a simple payback of three years; ductwork modifications to increase the use of outdoor air for cooling may have a simple payback of two years, and controlling the heating and cooling of unoccupied spaces might pay for itself in two years. Since all of these ECO's have a payback of 3 years or less, it might seem like good sense to implement all three of them as soon as possible.

But what if one ECO cancels out the energy savings of the

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BUILDING ENERGY SYSTEMS AND ECONOMIC ANALYSIS BY COMM AIR MECHANICAL SERVICES CO. ALTERNATIVE 3

DESIGN CFM—TOTAL	223143.12
DESIGN CFM—OUTSIDE AIR	23066.36
DESIGN COOLING TONS	550.00
DESIGN SUPPLY AIR DRY BULB	60.13
DESIGN HEATING MBH	4057.00

MONTHLY ENERGY CONSUMPTION

MONTH	ELEC KWH	GAS THERMS	WATER 1000 GAL	ELEC DEMAND KW
JAN	407745.	2521.	0.	964.
FEB	381165.	1546.	1.	1050.
MAR	450573.	1533.	43.	1123.
APR	408608.	1227.	42.	1084.
MAY	427137.	1440.	22.	1049.
JUNE	443099.	1094.	90.	1169.
JULY	432903.	830.	97.	1177.
AUG	480899.	710.	195.	1255.
SEPT	435753.	829.	143.	1243.
OCT	450316.	1221.	93.	1177.
NOV	407104.	1735.	6.	1030.
DEC	398954.	2124.	0.	966.
TOTAL	5124250.	16809.	731.	1255.
SAVINGS— NIT OF ENERGY	663,880 KW	5,471 THERMS	1856-(1000GAL.)	1090 KW
SAVINGS= DOLLARS	RED-1 $17,818	RED-1 $1,283	RED- $1,047	4579

Left: The computer model provides detailed analysis of existing and post-retrofit energy consumption.

others? Or, suppose implementing one ECO makes installation of another ECO much more costly? How do the economies of these ECO's alter with changes in occupancy patterns (daytime janitorial?) and weather cycles; and most importantly, how are the economies changed if all three ECO's are evaluated together, and in various combinations (e.g., 1, 1 + 2, 2 + 3, 1 + 3, 1 + 2 + 3)? These are the kinds of questions that can be answered through computerized building simulation.

What's computerized building simulation?

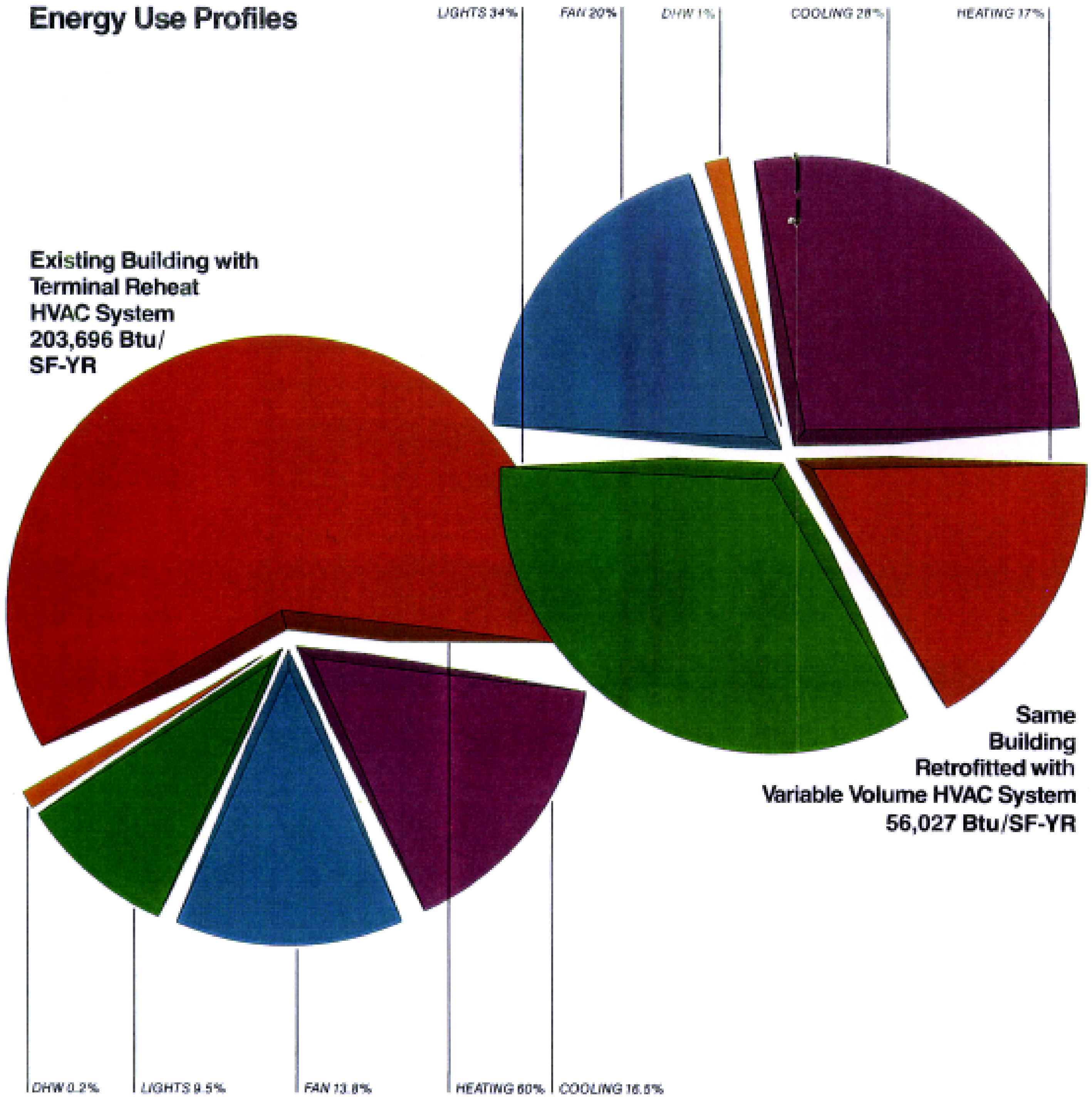
Computerized building simulation is simply the use of a mathematical model to calculate a building's energy use on an hour-by-hour basis for a typical weather year. Since there are so many factors to consider, and so many calculations to make, the model must be run on a computer. Included in the model are descriptions of the building's architecture, orientation with respect to sun and other buildings, HVAC schedules and type of equipment, thermal zones, occupancy schedules, weather data and relevant economic data. The end product of a computer simulation is a summary of heating and cooling requirements, energy consumption (by type of fuel), total costs and an economic analysis of each ECO or combination of ECO's.

Costs and benefits.

To conduct a computerized building simulation for a typical 250,000 square foot high-rise office building would cost around $12,000, or about five cents a square foot. Assuming a typical annual energy cost to operate the building of between $2 and $3 per square foot, the study costs equal just two to three percent of annual energy costs.

Besides providing the essen-

Energy Use Profiles



tial function of ranking all ECO's in a reliable and accurate way, numerous surveys and studies show that energy savings of 15 to 30 percent or more are typically identified during the study. These savings can usually be achieved with conservation retrofit projects having simple paybacks in the one to three year range.

The computer modeling process.

With some understanding of the benefits, the next question might be: "How much work and effort and time are involved?" Modeling a building on the computer involves a number of steps, including extensive data gathering, design of the model, simulation on the computer and interpretation of the results. Each step is critical to the accuracy and usefulness of the model and must be conducted with great care. At times even the most innocuous errors can invalidate the entire effort.

During the data gathering phase, the building owner/operator may be expected to provide: ■ "As-builts" or construction drawings of the building. ■ Personnel occupancy schedules. ■ Utility records. ■ HVAC equipment operating schedules. ■ Inventory and schedule of operation for other equipment (computers, kitchens, etc.). ■ Financial data (owner's cost of capital, etc.).

The engineer performing the modeling will survey the building and add to the above data more technical information. Air flow rates, lighting levels, samples of zone temperatures, analysis of HVAC control operation, condition of equipment and many other factors will be recorded and entered into the model. Depending on the condition of existing records, knowledge of the building engineer/operator, and the size, complexity and age of the building, this phase can take from one to three weeks.

Left: The two charts show energy use before and after a building was retrofitted with a new HVAC system. Computerized building simulation was used to identify the prime conservation targets.

ECONOMIC COMPARISON ALTERNATIVE 1 EXISTING BUILDING
ALTERNATIVE 2 SUN CONTROL FILM

FIRST COST DIFFERENCE (ALTERNATIVE 2 - ALTERNATIVE 1).....$ 42060.
EQUITY COST DIFFERENCE (ALTERNATIVE 2 - ALTERNATIVE 1).... 2103.
ANNUAL OWNING AND OPERATING COST DIFFERENCE
(NEGLECTING INCOME TAXES AND DEPRECIATION)........... 10240.
PRESENT WORTH OF ANNUAL OWNING AND OPERATING COST
FOR 5 YEARS AT 15.000%................................ 34345.
REVENUE PENALTY FOR FLOOR AREA DIFFERENCE................ 0.

YR	PROFIT&LOSS DIFFERENCE	CASH FLOW DIFFERENCE	CUMULATIVE CASH FLOW	DISCOUNTED CASH FLOW TO EQUAL EQUITY DIFFERENCE	DISCOUNTED CASH FLOW TO EQUAL 1ST COST DIFFER.
0				-2103.	-42060.
1	-4514.	3377.	3377.	1276.	3377.
2	-4278.	3567.	6944.	509.	3567.
3	-4019.	3775.	10719.	203.	3775.
4	-3735.	4003.	14722.	81.	4003.
5	-3424.	4253.	18975.	33.	4253.

PAYBACK ON EQUITY=1.0 YEARS INCREMENTAL RETURN ON EQUITY=164.74%
PAYBACK ON INVESTMENT=0.0 YEARS INCREMENTAL RETURN ON INVESTMENT=0.0%

HOLDING
L 23 C 01 SYSTEM AVAILABLE

Left: A typical output from a computerized building simulation summarizing the economic differences between two energy conservation alternatives.

Designing the model.

Armed with all of this data, the engineer then converts the data into a form acceptable to the computer. This phase is a critical one, since the engineer must translate the data into a workable model without omitting critical data which would invalidate the results. Two human elements are critical to success: the first is extensive experience with the specific computer program chosen, and the second is in-depth knowledge of the mechanical, electrical and control systems contained in the building.

The final step in model design involves preparation of economic data for input. Such information as the cost of capital, the installation/retrofit cost for each ECO, annual maintenance costs, insurance costs, utility rate schedules, taxes and adjustments for inflation are needed for an honest economic analysis.

What simulation provides.

Once the necessary data has been prepared, entered into the computer, and tested for its validity, simulation can begin. Each energy-saving measure considered is first run through the computer model individually. After ranking the measures according to economic attractiveness, the most economical options are combined in different groupings to determine the energy savings overlap in each group and resulting economic effectiveness.

Typical outputs from a computerized building simulation include: financial comparison of energy conservation alternatives, including payback periods and internal rates of return on alternative investments; monthly and annual summaries of energy consumption; and additional data such as HVAC system thermal load profiles which aid in interpreting and confirming the validity of the results.

"Alternative comparisons of ECO's will be accurate within 5%."

Interpretation of output.

The most important aspect of computer simulation is interpretation. All computer output (including the restatement of the input data) should be evaluated and interpreted to verify both proper input and simulation. The accuracy of the results hinge on this point. Properly done, the computer model will match actual facility energy consumption within 10 percent. Based on such a model, alternative comparisons of ECO's will be accurate within 5 percent. In addition, it is possible to create a "fingerprint" or characteristic profile of energy use in a facility to focus on sources and uses of energy. The chart on page 6 shows a profile that was developed for a large office building using computerized building simulation. It demonstrates prime conservation targets of heating, air moving and lighting. The owners of this building are now working to reduce energy consumption in exactly these areas through a combination of operational and HVAC system retrofit.

Effective execution of energy conservation retrofits require highly skilled professionals.

Finding the right computerized building simulation engineer.

Occasionally, the owner's building design engineers have enough knowledge and background to perform the simulation. Engineers with strong experience in the field can perform surveys and run the building model with the use of computer programs available through time-sharing companies.

But, before jumping into the study with existing staff, a thorough assessment of staff capabilities must be made. Realistically, the minimum requirements would include: thorough knowledge of how building systems and equipment really work, first-hand knowledge of the construction trades and how they implement modifications to existing buildings, and extensive knowledge of and experience with the specific computer program proposed for the study.

Only a limited number of professionals possess the knowledge, skill and experience needed to sort through the complex maze of conservation options and identify those options that will make the most efficient use of the owner's scarce financial resources. As always, the right professional with the right tools will provide the owner with the answers he needs.

"Only a limited number of professionals can do the job."

The Ten Best-Selling Business Books

Compiled by Henry Holtzman

This list is based on survey results (January 15, 1981) compiled from retail bookstores throughout the United States.

1. **Crisis Investing,** *by Douglas R. Casey (Stratford Press/Harper... $1[illegible]50) (1)**
Investment opportunities in the coming "Depression."

2. **Nothing Down,** *by Robert G. Allen (Simon & Schuster...$10.95) (2)*
Buying real estate on less than a shoestring.

3. **What Color Is Your Parachute?,** *by Richard N. Bolles (Ten Speed Press... $5.95) (3)*
How to change careers and jobs.

4. **Everyone's Money Book,** *by Jane Bryant Quinn (Delacorte... $14.95) [illegible]*
A guide to spending, saving, and investing.

5. **How You Can Become Financially Independent by Investing in Real Estate,** *by Albert J. Lowry (Simon & Schuster...$10.95) (4)*
How to make something out of very little.

6. **How to Prosper During the Coming Bad Years,** *by Howard J. Ruff (Warner Books...$2.95) (7)*
Staying green while everyone else is in the red.

7. **Murphy's Law—Book Two,** *by Arthur Bloch (Price/Stern/Sloan... $2.50) (6)*
Son of the original "Murphy's Law."

8. **The Coming Currency Collapse,** *by Jerome F. Smith (Books in Focus ... $12.95)***
Another survival book for business.

9. **How to Sell Anything to Anybody,** *by Joe Girard (Warner Books ... $2.25) (8)*
Top car salesman tells how he sells.

10. **Murphy's Law,** *by Arthur Bloch (Price/Stern/Sloan...$2.50) (9)*
The original "Murphy's Law" strikes back.

* *(1) —indicates previous position on the list.*

** *—indicates the first appearance on the list.*