VI–9. Computer Program For Energy Consumption Estimates

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INTRODUCTION

Energy consumption estimates were unimportant until early in the 1970's. Energy was readily available and cheap, so there was really no incentive to cut energy consumption. But all of that has changed. It is now important to us all to conserve energy. The Brick Institute of America, in July/August 1977, first published *Technical Notes* 4C, which provides a method for computing energy consumption using hand calculation methods. This document was revised in November/December 1978 to reflect changes in calculation methods in the 1977 Edition of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Handbook of Fundamentals*.

The computer program allows the user to analyze any type of building. It however does not provide for an hour-by-hour analysis. It is based upon a steady-state (heating) and steady-periodic (cooling) calculation as provided by the ASHRAE *Handbook*.

There are available in the United States today several programs which are more sophisticated, and hence more accurate. However, due to the complexity of these programs, the cost of utilizing them becomes prohibitive for their use on small residential, commercial, industrial and institutional buildings. This program and *Technical Notes* 4C were developed to provide a means for estimating fuel consumption on a comparative basis for those structures which cannot justify economically a detailed, sophisticated analysis.

It should be pointed out that due to certain inadequacies of the steady-state and steady-periodic calculation methods, the values obtained utilizing *Technical Notes* 4C and the programs are merely approximations of the energy consumption. The values obtained will estimate the annual consumption higher than actual consumption. These calculation methods do, however, provide the decision-maker with a basis for comparison for building envelope component systems, orientation, exterior color, equipment selection and type of fuel utilized. They also allow the user, if he so desires, to determine what steps may be taken in thermally upgrading existing buildings. The program as presently constituted does not incorporate any cost analysis.

COMPUTER HARDWARE

The program as now written can be used on the International Business Machines (IBM) 5100 and 5110 computers. With some revision, it could be useable on most computers. The program requires a 5100 or 5110 with 64,000 bytes of storage. In addition, an auxiliary tape drive is required. This, in essence, doubles the capacity of the machine. If permanent records are required, the hardware should also include a printer.

COMPUTER SOFTWARE

The program is written in BASIC computer language. It can be transposed to other languages. This does not increase the accuracy of the results, but will increase the speed of the computations.

The program is totally conversational with the user, and allows the user several options. The U-values, or R-values, may be input directly if previously calculated, or code numbers for materials may be given along with material thickness and the computer will calculate U-values. This is also true of other inputs to the program.

The program is stored on magnetic tapes. The total program is composed of four (4) separate programs, plus a data bank. One of the advantages of using the program is that reference to several documents is eliminated by information stored in the data bank. Included in the data bank are: climatological data, material properties, wall groups to determine Cooling Load Temperature Differences (CLTD), Cooling Load Temperature Differences (CLTD), Cooling Load Factors (CLF), and Solar Heat Gain and M Factors, if desired. An operator's manual completes the software package. The operator's manual allows even an uninitiated computer-user to take advantage of computer computations.

The program is actually four (4) separate, interlocked programs. The four (4) programs are:

1. Input
2. Listing
3. Edit
4. Report

The Input program asks the user for the necessary data. The Listing program merely allows the user to have a permanent copy of the input data. The Edit program allows the user to alter any of the inputs. The Report program merely prints the output data for the user.

The user enters into the prime program. In the Input Program, once the inputs are recorded, the user can enter the Listing Program and the inputs will be printed on the printer. This is necessary only if the inputs need to be permanently recorded. Or, the user may desire to go

directly to the Report Program, which lists the results of the calculations. One of the advantages to the user is that once this is done, he may enter the Edit Program and change any of the inputs and rerun the Report program as many times as he wishes. This does not require the user to re-input all values, but only those which he wishes to alter. This allows the user to vary the inputs to achieve the maximum number of variables for comparison and select the most energy-efficient system.

INPUT REQUIREMENTS

The program was designed to allow the user as much freedom as possible. It allows the user to input specific values for U, M, CLTD, etc., or give other information and let the computer input values it calculates. The M-Factor is a modifying factor inserted into the heat loss calculation to modify it and more nearly reflect the performance of massive elements. Either method used requires information which must be supplied by the user.

There are two methods of input available for entering climatological data. The user may desire to input the climatological data if the building is to be located in a city other than those one hundred (100) which are contained in the data bank. If the building is located in one of the one hundred (100) cities or in a city with similar climate to one of the listed cities, the user may enter the necessary data by coding in the city and the information is automatically entered into the program from the data bank. The code for the cities is two (2) numbers, the first number representing the state, and the second number representing the city. The climatological data which are required, whether by direct input from the user or by coding of the city from the data bank, are:

1. Heating Degree Days
2. Cooling Hours
3. Latitude of the location
4. Winter outdoor temperature
5. Summer outdoor temperature
6. Summer daily temperature range

The user may wish to enter directly the interior design temperatures. If he does not, the program will default and use 72°F (22°C) for winter and 78°F (26°C) for summer.

The dimensions and orientation of the building must be entered by using a coordinate system. The coordinates of the corners are input which establishes wall lengths and also establishes the orientation. The vertical axis represents a north-south direction and the horizontal axis represents an east-west direction. The user enters the coordinates of the first corner as 0,0. Then, moving clockwise, he inputs the remainder of the corners. The wall defined by the first two sets of coordinates then becomes Wall #1 on the report, and so on. The program can accept as many as twenty (20) different walls. Additional information on the structure must be given for each wall, such as glass area, door area, number of stories, height of each story, height of foundation wall above grade, and height of foundation wall below grade. The computer then calculates all of the areas of each opaque wall and the floor and roof areas.

The properties of each building element must be entered into the program. The user may wish to enter them directly. If so, he enters the U-value and weight for each element. If the user desires, he can ask the computer to calculate these values for all of the elements. He does this by entering by code each layer and the thickness, in inches, (mm) of each layer. The computer then calculates the U-value, wall weight and M-Factor of that element.

The user must input the infiltration and/or ventilation data. This can be done by one of two methods, hourly air changes, and leakage per lineal foot of crack at doors and windows.

The user must input the type of heating and cooling equipment to be used, i.e., forced air, hydronic, central air-cooled, etc. If the information is available, he should also input the size of the heating unit and also the efficiency of the heating unit. These are important factors in computing annual energy consumption. If these values are not known, the computer will use eighty per cent (80%) efficiency and assume a twenty per cent (20%) oversizing of equipment. While this may not give an exact annual energy consumption, for comparison purposes it is valid.

The user inputs the type of fuel to be used for heating. The computer selects the proper heating value for each fuel from the data bank. This is used to determine the total amount of fuel required on an annual basis.

It should be noted that this program does not include an energy analysis for heat pumps. This requires a much more complicated calculation method than this program provides. However, the hourly and annual heating and cooling loads do apply. The program does preclude being used as a comparison between heat pumps and other types of heating and cooling systems.

OUTPUT

The output, or report, portion of the program is broken into six (6) different parts. They are:

1. Title Page
2. Table of Contents and Introduction
3. Report Summary—Energy Requirements
4. Component Analysis
5. Summary of Component Analysis
6. Building and Climate Data

The Title Page of the report gives the date, the designer, the sponsor of the report, and the building and its location.

The Table of Contents and Introduction of the report contains the six items listed above. It also contains introductory remarks. It, in essence, states the purpose of the program. It also has included a disclaimer clause.

The Report Summary—Energy Requirements portion contains the hourly and annual heat losses and heat gains. It also contains the type of heating and cooling systems, type of fuel, other miscellaneous items pertaining to the equipment, and the annual fuel requirements for both heating and cooling.

The Component Analysis provides information on each wall. This information is a breakdown for the opaque portion, windows, doors, and opaque portion of the wall

below grade. The information for each of these includes the area, the hourly heat loss and heat gain, and a percentage of the hourly heat loss and heat gain attributable to each portion.

The Summary of Component Analysis lists each and every component which has an effect on heating and cooling loads. The component includes, but is not limited to: infiltration, occupants, lighting, appliances, and latent heat gain. The listing includes hourly heat losses and heat gains for each component and the percentage of the total heat loss and heat gain attributable to that component.

The Building and Climate Data portion of the report gives the climate data used in the input portion of the program. Also listed are the areas, U-values, M-factors, shading coefficients, and cooling load factors for each wall.

SUMMARY

This program enables the user to size equipment and compute estimated annual fuel consumption for any type of building in any U.S. location. This is accomplished at a much faster rate than can be achieved using the hand calculations outlined in Brick Institute of America *Technical Notes* 4C. It should be noted that the annual fuel consumption computed using this program in most cases will be higher than actual fuel consumption.

The user, by taking the hourly heat losses and heat gains, will be able to properly size the heating and cooling equipment. Due to the speed of computer operation and the edit portion of the program, the user is able to compare systems, orientations, etc., to make design decisions which can be energy-conserving and economical at a much faster rate than was possible before.

NOTE: While metric values are shown in this paper, the computer program at present does not have metric capabilities. It is now capable of utilizing only U.S. Customary Units.

REFERENCES

1. *Technical Notes* 4, Brick Institute of America, McLean, Virginia
2. *Technical Notes* 4A, Brick Institute of America, McLean, Virginia
3. *Technical Notes* 4B, Brick Institute of America, McLean, Virginia
4. *Technical Notes* 4C, Brick Institute of America, McLean, Virginia
5. *Technical Notes* 4D, Brick Institute of America, McLean, Virginia
6. *Technical Notes* 4E, Brick Institute of America, McLean, Virginia