

# **USER MANUAL**

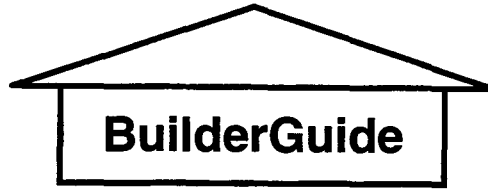
for



**ENERGY ANALYSIS SOFTWARE FOR HOMEBUILDERS**

Version 1.0 July 1990

**NATIONAL RENEWABLE ENERGY LABORATORY  
PASSIVE SOLAR INDUSTRIES COUNCIL**



**ENERGY ANALYSIS SOFTWARE FOR HOMEBUILDERS**

## **A Design Tool**

**for**

## **Passive Solar Design Strategies**

from the

**National Renewable Energy Laboratory**

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The *Builder Guidelines* computer program, BuilderGuide, automates the calculations involved in filling out the four worksheets that accompany the *Builder Guidelines*. The program operates like a spreadsheet; the user fills in values for the building, and the computer completes the calculation and prints out the answers. Extensive pop-up help provides valuable assistance along the way, largely obviating the need for a manual.

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**BuilderGuide**    **VERSION 1.0**

**July 1990**

**Note:** This is the first release of the BuilderGuide program. It has been carefully and thoroughly reviewed by knowledgeable engineers and builders and to the best of our knowledge is accurate and error free. However, it is a complex program and it is impossible for us to guarantee that it is completely free of bugs. It could possibly contain errors and produce misleading results. Users should carefully review the results to make sure that they are credible and consistent with the manual worksheet version and the data tables in the *Builder Guidelines*. Any discrepancies or serious problems in the use of the program should be reported immediately to NREL.

This computer program and manual were prepared under the sponsorship of the National Renewable Energy Laboratory and produced with funds made available by the United States Department of Energy. Neither the United States Department of Energy, the National Renewable Energy Laboratory, the Passive Solar Industries Council nor any of its member organizations, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product, software or process disclosed, or represents that its use would not infringe privately owned rights. The views and opinions do not necessarily state or reflect those of the United States government, the National Renewable Energy Laboratory, or any agency thereof. This document was prepared with the assistance and participation of representatives from many organizations, but the views and opinions expressed represent general consensus and available information. Unanimous approval by all organizations is not implied.

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BuilderGuide was produced in collaboration with the Passive Solar Industries Council (PSIC) and the National Association of Home Builders (NAHB). It is an accessory to the series of location-specific books, *Passive Solar Design Strategies: Guidelines for Home Builders*, herein abbreviated *Builder Guidelines*, disseminated by PSIC and NAHB.

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## Important

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**Please read this:** We have done our best to give you useful, accurate, and up-to-date software to help you analyze your building design. However, please be aware that any performance estimate is just that--an estimate. It would be an unfortunate misuse of the program to label these estimates as predictions of how the building will perform. The following factors contribute to uncertainties in the predictions:

Different people live differently in a house, which can have a big effect on how much energy it consumes. It has often been stated that occupant effects can result in an annual energy use that is anywhere from 70% to 140% of a reliable estimate. Some homeowners keep the thermostat low and are careful about not leaving doors and windows open in cold weather. They might be the same people who use air conditioning only when necessary and rely on open windows on mild days in the spring, fall, or summer to keep the house cool by natural ventilation. Others just don't think about it much and would rather rely on their furnace or air conditioner, paying a higher bill to the utility company. Also, different families have different personal comfort zones. Thus, two families living in two identical houses could easily have utility bills that vary by a factor of two.

Long-term average weather and solar data are used in BuilderGuide as the basis for the energy estimates. However, weather conditions during any one year can be much different from the long-term average (even without global warming).

There might be errors in the input data, variations between the description and how the house is actually constructed, or inaccuracies in the analysis procedures used in BuilderGuide.

Thus, be careful about how you convey calculation results to your prospective homebuyers. You can tell them that the estimates are based on reliable, conservative, and widely accepted procedures. These are discussed in Appendix B, although most homeowners won't want this much detail.

Given the variables described here, why bother even doing the calculations? You should do them because you want to build houses with good thermal integrity, and you want to know what you are building. A thermally well-designed house will always be more comfortable and use less energy than a poorly designed house, given the same occupants, occupant behavior, and weather conditions. In the housing market, quality sells, and thermal quality is becoming increasingly important to the buying public. Besides, when you build a house, you are leaving a legacy, perhaps for several families that will occupy the house, that will last 50 or more years. How comfortable and reliable the house is, and how great a demand it makes on the finite resources of our planet depend on the design. It is up to you--the designer and builder--to do a quality job.

## A QUICK OVERVIEW

How To Use BuilderGuide (for those in a real hurry)

- 1) Select Location
- 2) Select Base Case or Previous Case.
- 3) Fill in General Project Information worksheet.
- 4) Fill in worksheets I, II, III, and IV.
- 5) Review the summary and compare with reference case.
- 6) Continue with design development, iteratively modifying the Worksheets and reviewing the results. The reference values can be updated at any time by selecting "Lock in Reference Case."
- 7) Print the worksheets.
- 8) Save your house data on disk.
- 9) Quit.

If you can't figure out what to do, press function key F1.

For those who want to save frustration, we suggest that rather than jumping right into the program you read on for awhile.

Note: This quick overview can be displayed on the computer screen. Press F1 when the highlight is on **Initialize** in the main menu.

## INTRODUCTION

Don't be alarmed. Even if you are not computer literate, BuilderGuide is easy to use and relatively self-explanatory. Getting started is the hardest part--putting the disk into the computer and touching that first key. Give it a test drive.

The BuilderGuide program accesses data tables for a particular locality and, thus, is specific to this locality. These tables are the same as those printed in the *Builder Guidelines*. You tell the program which locality to use when you run the program. The program simply replicates the arithmetic and table-lookup operations that a person goes through in filling in the worksheets. There are several advantages to using BuilderGuide:

It is much faster than doing it by hand.

It eliminates the chance of making an arithmetic error in the worksheet calculations.

It automatically does table lookups for you, including any necessary interpolation.

It quickly evaluates the effect of design variations, allowing you to home in on a good design without too much work.

The pop-up help screens provide explanations, definitions, and reference data in the context where they are needed.

BuilderGuide was programmed and compiled in Prolog, an expert-system language. A follow-on program, BuilderGuide-2 has been proposed that will extend the analysis to include cost and payback calculations and greatly expand the knowledge base so that it is a true "expert at your elbow" design-assistance tool.

### Equipment and Installation

BuilderGuide is written for the IBM PC family of microcomputers and runs under MS-DOS. It requires a computer with 340K of memory. A hard disk is not required but the program runs much faster and more easily from a hard disk.

If you wish to install the program on your hard disk, refer to Appendix A. This section provides instructions for setting up a separate directory on your hard disk and copying the program to this directory.

### Getting Started

To start the program, either insert the BuilderGuide disk in your floppy disk drive (if you will be running from the floppy disk) or get into the hard-disk directory on which you have stored the program (if you are running from a hard disk).

Then, type **BG** and press Enter.

This action causes the program to load into your computer. If everything is going okay, your computer screen fills with the BuilderGuide title screen.

Throughout BuilderGuide, instructions appear at the bottom of the screen. On this title screen, it says **Strike any key to continue**. Following the title screen, there is an additional information screen. After passing through this screen, you will be asked to select a location.

## Selecting an Initial Location

At this point in the startup procedure you must select a location for your building. The computer will have read the memory to find the names of all the available location files within the directory and has displayed these names on the screen. Use the arrow keys to place the highlight on the location you want and press Enter. The computer reads the file into BuilderGuide. Try this. Your disk will have the file DENVER.BGL on it and this name will appear on the screen. Use the arrow keys to move the highlight to DENVER.DAT (or some other location file of your choosing) and press Enter. The screen will briefly show a message indicating that it is busy loading the requested file into memory.

### Getting Files for Other Locations

When you received BuilderGuide, there were data files for one or more locations on the disk. These files contain the same information that is in the worksheet reference tables of the *Builder Guidelines* except that it has been converted to a format readable by BuilderGuide. These files occupy about 16,500 bytes of disk space for each location.

To get files for other locations, you must order them from the Passive Solar Industries Council (PSIC). Data files are available for most of the 240 SOLMET locations around the United States, for which long-term temperature and long-term solar radiation data are available. PSIC can provide a list of these sites as well as the cost of providing data files for you. Files for sites in Hawaii, Alaska, southern Florida, or the southern tip of Texas are not available. The climates in these locations are outside the range for which the calculation methods in BuilderGuide were developed.

After the location file has been loaded, the main menu appears across the top of your screen:

<b>Initialize</b>	<b>Worksheets</b>	<b>Review</b>	<b>Save file</b>	<b>Print</b>	<b>Quit</b>
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## Help Is Only a Keystroke Away

BuilderGuide can be used without frequent recourse to this manual or tables of reference data. The system contains explanations and useful information that you can access by pressing F1 or one of the other function keys. When you press F1, a screen appears containing an explanation or definition of the item currently highlighted. (Computer people call this approach *context-sensitive help*.) If you press F1 now, an overview of BuilderGuide use will appear on the screen. If the message is longer than the screen, you can page through it using the PgDn key or the PgUp key. To get out of the help text, press Esc.

In the worksheets, there are many instances where additional information is displayed when you press another function key. For example, effective R-values for frame walls are displayed if you press F2 when the highlight is on the wall R-value box in worksheet I. In other cases, design guidance is provided. For example, guidance on choice of wall color is displayed if you press F3 when the highlight is on the Other Mass box in worksheet III.

Function key F2 is usually used for reference data. F3 is usually used for design guidance. If you press F2 or F3 and nothing happens, no information of this type is provided in this particular context. However, you always receive help information when you press F1. If additional information is available on another function key, this is noted at the beginning of the F1 help text.

BuilderGuide provides 350 help text files, equivalent to a 64-page appendix to this manual, available to you with a single keystroke, when and where you want it.



Try the help text. At this point, the highlight is on the word **Initialize**. Press F1. A quick overview of a typical BuilderGuide session appears. Press Esc to return to the main menu.

## THE MENUS

### Moving around in the Menu

BuilderGuide uses pull-down menus. The main menu gives you six choices listed at the top of the screen. Note that the leftmost choice, **Initialize**, is highlighted. You can move back and forth to other choices using the right and left arrow keys. Try moving between choices; note that the highlight moves from word to word.

To select a menu item, you can press the letter key corresponding to the highlighted first letter of the item. For example, to select **Worksheets**, press the letter **W** (no need to capitalize). Alternatively, you can use the arrow keys to move across the screen to an item and then press Enter when the item is highlighted. Try selecting a menu item.

If you have the highlight on a menu item and press Enter, a box drops below it containing two or more topics. These topics are the submenu items. For example, if you put the highlight on **Initialize** and press Enter, you see the following:

```
Initialize
  Location
  Base Case
  Previous Case
  Clear Worksheets
```

You can move within a submenu using the up-arrow or down-arrow key. Try this, noting how the highlight moves up and down in response.

You select a submenu item in the same way you chose a main menu item: press the letter key corresponding to the capitalized first letter of the item or move the highlight to the item and press Enter.

Simple, isn't it! You can stop reading this manual now and continue to learn BuilderGuide using the help facility, but you will miss some good stuff. We suggest that you read further.

## Preview of the Menu

We now briefly describe each menu item. You can read a complete description of each main menu and submenu item by using the help facility, but the following is a quick overview:

### Initialize

This menu gets you started. There are four submenu options. **Location** allows you to change locations, choosing from among those locations for which you have data files stored on your disk. You have already chosen a location as part of the startup procedure and do not need to choose it again. If you select **Base Case**, the computer provides default values throughout the worksheets that are typical of contemporary houses in the same location you selected. These data are useful for comparison with your building and give credible numbers as a starting point for your design. **Previous Case** allows you to load in a building description that you previously saved. **Clear Worksheets** clears all the input spaces in the worksheets, giving you a clean slate to work on.

### Worksheets

This menu is your entrance into the guts of the BuilderGuide program. Included are a worksheet that allows you to insert project information for later identification and the four worksheets that help you calculate annual heat loss, annual auxiliary heating, temperature swing, and annual auxiliary cooling. These worksheets are replicas of the printed worksheets in the

### Review

This item provides a direct comparison of the bottom-line results for the current building being analyzed and either the base case or a previous building you locked in as a reference.

### Save File

This item give you an opportunity to save your building data on the disk for later retrieval by the BuilderGuide program, either as a new file or as a replacement for an existing file on the disk. Later, you can retrieve a file you previously saved by selecting the **Previous Case** item; thus you don't have to enter all those numbers again. You can also select **Delete** to remove a file you previously saved and no longer want cluttering up your disk.

### Print

This item allows you to print out either the summary or the entire set of worksheets.

### Quit

Select this option to leave BuilderGuide. Note: save any data you want to use again before you select this option; otherwise the data are lost and you will have to type it all in again.

## DEFINING A BASE-CASE BUILDING

Select **Base Case** (within the **Initialize** menu) if you are starting a new design. The program completes the worksheets using data for a typical house in your climate zone. The

system gives a choice of floor area, number of stories and floor type (slab-on-grade, crawl space, or full basement).

Place the highlight on **Base Case** and press Enter. The system asks you to specify the number of floors. You can type in any number between 1 and 10 or use the default value of 1. Press Enter. The system then asks for the floor area (all floors combined). Type in a number or use the default value of 1500. Press Enter. The system then displays floor types. The standard floor type for your location is highlighted. You can leave this as it is or choose one of the other two types available by moving the highlight. Press Enter. The program then inserts values (default values) for this house into appropriate spaces in the worksheets.

The base case is chosen to provide a reasonable comparison for your building. It is a typical building; that is, it has the same window area on each facade (3% of the floor area) and no other solar features. The insulation levels are based on your climate zone and are typical of current construction practice based on a 1987 survey conducted by the National Association of Home Builders. Building takeoffs (wall areas, etc.) are determined for a building of typical proportions; the building has an L-shaped plan with a 25-ft section width. After the base case has been defined, you can modify any numbers that you wish.

The program then computes the results for the base-case building, places the answers into all the right places, and sets up the base case house as the reference in the summary.

**NOTE:** If you choose a 1500 sq ft single-story building and the dominant floor type in your area, the values inserted into the worksheets will be the same as those used for the example building in the *Builder Guidelines*. However, you may note some minor differences between the calculated results; these differences are because BuilderGuide rounds off the numbers and because a slightly different algorithm is used for solar savings in generating the numbers in the *Builder Guidelines*. Do not be concerned by these differences.

If you bypass **Base Case**, blanks are left in the worksheets.

## FILLING OUT THE WORKSHEETS

To get into the worksheets menu move the highlight to the second menu item, **Worksheets**, and press Enter. This will reveal the menu of the four worksheets. The highlight will be on the name of the first worksheet, **Project Info**. Press Enter. The General Project Information worksheet appears.

There are two kinds of information spaces on the worksheet: spaces with a highlighted box and spaces with information filled in. In general, you use a highlighted box to introduce information. Any information already existing in the space can be changed by deleting it or writing over it. All but one of the boxes on this worksheet are highlighted. You can type in any information you wish. For additional information, press F1.

On this first worksheet, all but one of the highlighted boxes (project, date, comment, etc.) contain optional information. We suggest that you make a practice of filling in these boxes so that your printouts will be documented. *The one box that MUST be filled in is Floor Area.* If you specified **Base Case** earlier, this number is already filled in.

Note that the name of the location is given but is not highlighted. This is the city you selected earlier. The fact that this information is not highlighted signifies that you cannot write over it.

When you finish entering the general project information, press Esc to return to the **Worksheets** menu, move the highlight to **Heat Loss** and press Enter. At last, you are into the first worksheet.

## Getting around in the Worksheets

Home	Go to the top of the worksheet
End	Go to the bottom of the worksheet
Tab (or Enter)	Move one box to the right
Shift Tab (or Left Arrow)	Move one box to the left
Esc	Move up one level. Get out of Help text.

To erase information in a highlighted field, backspace or delete.

If you selected Base Case previously, some information is already filled in, such as ceiling and wall areas and R-values. You can change any information in a highlighted box. Note also that **Heat Loss** values, appearing in the right-hand column, are not highlighted. These are numbers calculated by the program and cannot be changed directly by the user; they can be changed indirectly through changing a highlighted number. The program rounds the values to the number of digits shown; this rounding carries down the page. If you change a number, such as the ceiling area, the corresponding heat loss value changes. Try changing a value and see how the result changes.

## Help Text

As discussed previously, help text is available by pressing F1. The information provided pertains to the location of the cursor when F1 is pressed. In many cases additional help text is available by pressing another function key. If other function keys are active, this is indicated at the top of the F1 help text. To display information on another function key, press Esc to get out of help text and then press the other function key.

Try the help text. For example, move the cursor to ceiling R-value and press F1. You see a definition of ceiling R-value. Then press Esc and F2. The text displayed is a table of R-values that have been calculated for various ceiling and roof constructions.

## Perusing the Worksheets

At this point, we suggest you familiarize yourself with the four worksheets by scanning through them. To get out of a worksheet and back to the menu, press Esc. To get into a worksheet, place the highlight on the worksheet name and press Enter.

## Going to the Review/Summary

Before you actually change very many numbers, we suggest you have a look at the **Summary**. Get out of the worksheets and return to the main menu by pressing Esc. Move to the **Review** menu. The highlight will be on **Summary**. Press Enter. The screen shows a summary of current results. The middle column displays reference values for the base-case building. These values are identical to the left-hand column unless you have made changes. The right-hand column shows the percentage differences; if you have made no changes the values are all zero because there are no differences.

## Getting Started on a Design

We suggest you start with a base-case building having the same number of stories, the same floor area, and the same floor type that you have in mind for your building. By doing this, the program installs reasonable numbers in the worksheets, performs the calculations, and puts the results into the reference column of the summary. You can then go into each of the worksheets and make modifications inserting takeoffs, R-values, etc., for your proposed building. Finally, you can compare your results with the base case in the summary to see how you are doing.

## Selecting the Passive System Reference Code

On worksheet II, you are asked to supply a passive system reference code. This code identifies the passive system type. It **MUST** be one of the 15 four-letter codes recognized by BuilderGuide. Otherwise the program does not recognize the passive system type and a solar savings fraction of zero is computed.

To select a code, place the cursor on one of the four highlighted boxes under Solar System Reference Code in part A of worksheet II. Press Enter. The system displays a list of the 15 available options. Move the highlight to the desired option and press Enter. The system returns you to the worksheet with the reference system code inserted in the box.

You can choose as many as four passive system types. List each type on a separate line. The program does table lookups to determine the solar savings fraction (SSF) for each system and then averages the values to determine the overall SSF for the building.

Press F1 to display instructions and a description of information available on other function keys. This includes descriptions of the 15 passive system types, instructions on how to analyze systems with night insulation, and guidance on passive system selection.

## Selecting a Cooling Strategy

In worksheet III, line F, you are asked to select a cooling strategy. You **MUST** enter one of the four options recognized by BuilderGuide. The default selection is no strategy, that is, no night vent and no ceiling fan.

To select a strategy, place the cursor in the highlighted box on line F. Press Enter. The screen displays a list of four available options. Move the highlight to the desired option and press Enter. The program returns you to the worksheet with the cooling strategy inserted in the box.

The program does a table lookup to determine the appropriate adjustment for thermal mass and ventilation, depending on the strategy selected and the thermal mass, as specified on worksheet III.

### Automatic Table Lookup of Shading Factors

BuilderGuide can help you determine shading factors for simple overhangs. If the cursor is on one of the Shading Factor fields in worksheet IV, and you press Enter, a menu of overhang projection factors will be displayed. Move the highlight to the desired projection factor and press Enter. The program will perform an automatic table lookup in the location-dependent shading factor table for the orientation being considered and return with the proper value in the Shading Factor field.

For a definition of projection factor, press help key F4 with the cursor on any one of the Shading Factor fields or refer to the instruction page of the worksheets in the *Builder Guidelines*.

Note that this feature is fairly limited. It does not interpolate between the projection factors listed and will not automatically correct for other factors, such as a low-e coating or a shading strategy other than an overhang, which would decrease the shading factor. It is, however, a handy way to access the shading factor table. After noting the value or values, you can modify the shading factor as you deem appropriate.

### Recalculation (F9)

When you make changes in the worksheets, many of the calculated numbers automatically change. For example, if you change the ceiling R-value, the UA of the ceiling changes, the total UA of the building changes, and the bottom line on worksheet I changes. However, the SSF is not recalculated, although it would change, and thus the auxiliary heat is **incorrect**. This change does not occur because a complete recalculation is time-consuming, and it bogs down the editing process to do a recalculation every time a change is made. To correct the SSF and update all the calculations, you can press F9. Recalculation by pressing F9 is only active when you are in the worksheets. The update takes 3 to 30 seconds, depending on the speed of your computer. When the update is complete all the numbers in all worksheets are consistent and concurrent. When you move to **Summary - Review** the program automatically does a recalculation. This is also true before printing.

### Comparing Two Designs

Suppose you want to see the result of changing one design parameter. For example, you want to see the energy and comfort implications of adding a sunspace to your building, replacing some existing windows.

First enter the numbers for the building without the sunspace. Move to **Summary** and select **Lock Reference** (be sure you have pressed F9). Selecting **Lock Reference** freezes the results for this building in the reference column of the review. Return to worksheet II and make your changes. For this example, you would decrease the direct-gain area and add a sunspace. If the sunspace glazing is shaded you will also need to specify this on worksheet IV. When you are finished with your changes, return to **Summary - Review**. All four numbers will have changed; you can see the percentage changes directly.

### Comparing the Same Design in Two Different Locations.

What if you moved your Denver, Colorado, building to Madison, Wisconsin? How would the performance change? To analyze this, do the calculation for Denver, and lock it in as the reference. Return to **Initialize - Location** and press Enter. The program reads the disk

to determine the available location files and displays the names. Move the highlight to Madison. Press Enter to load the Madison file into the computer. Then move to **Summary - Review**. The Madison numbers appear in the Current Design column and the Denver numbers in the Reference column.

#### NOTE OF CAUTION

It will usually be necessary for you to change a few worksheet input numbers if you change the location. Most of the house-design data numbers do not depend on location; however, the Shading Factors in worksheet IV are an exception. These numbers should be updated. Another number that may need to be updated is the Heat Gain Factor for a sunspace, if your design includes a sunspace. The third exception is the heating degree day value that appears in worksheet I. This value is updated automatically to the nominal value for the location when a new location is loaded or when a data file is loaded for a previous case.

## APPLICATIONS

### Single-Family Residential Houses

BuilderGuide was written to be particularly easy to use with single-family houses; however, it can also be used on multifamily residential buildings and certain small non-residential buildings, as discussed in the following sections.

The base-case building construction is assumed to be wood frame with cavity-wall insulation and sheetrock, as is customary in contemporary homes throughout the United States. Thus the worksheets only require the user to specify two floor areas, in part A of worksheet III. You can make modifications to account for added mass or alternate construction in parts B and C of worksheet III.

The average winter thermostat setting is assumed to be 70 degrees. This value is consistent with a daytime setting of 72 degrees and a night setback to 66 degrees. The summer thermostat setting is assumed to be 78 degrees without ceiling fans or 82 degrees with ceiling fans. These settings will result in identical thermal comfort conditions.

The level of internal heat assumed in the estimation of annual heating and cooling requirements is consistent with typical residential use. The value is 36 Btu per day per sf of floor area. This corresponds to 451 kWh per month for a 1500 sf house.

### Multifamily Residential Buildings

You can analyze apartments, duplexes, and other multifamily residential buildings with BuilderGuide. In general, follow the instructions for evaluating single-family residential houses. However, heat flow through walls or floors separating different dwelling units (party walls) should be zero, assuming that the adjacent units are kept at the same temperature. To do this, simply do not include the area of party walls or party floors in the tabulation of areas on worksheet I.

To properly account for added mass in party walls, use one-half of the actual wall thickness when you look up the heat capacity in the tables.

## Nonresidential Buildings

You can analyze a few small, nonresidential buildings with BuilderGuide; however, you should be aware that there are serious limitations.

Two factors distinguish the thermal behavior of nonresidential buildings. One is the higher level of internal heat gain from people, equipment, and lights. The other is the schedule of building use. Most nonresidential buildings are for daytime use during the normal work week; the thermostat is set back at night and during weekends.

You can use BuilderGuide only if the thermal assumptions are reasonably consistent with the building's intended use. These assumptions are given below.

- (1) The assumed building internal heat is 36 Btu per day per sf of floor area, seven days per week.
- (2) The assumed thermostat setting is a steady 70 F, seven days per week.

Although it varies with building type, the useful size limit of BuilderGuide is about 5000 sq ft.

(There are some fancy and complicated ways of fooling BuilderGuide to account for variations in internal gain and thermostat setting, but these are beyond the scope of this manual and not recommended except for a sophisticated user. The two handles available are heating degree days (to adjust for changes in balance-point temperature) and the number of bedrooms (to adjust for internal gains). Refer to the help text pertinent to internal gains in worksheet IV for the formulas used for internal gains.)

## SAVING YOUR DATA

To use or refer to your data later, you need to save the information. Move to the **Save File** menu, and press Enter. Type in any name (eight characters or less, no blanks) and press Enter. The computer saves your data in a file on the disk under the name you supplied, adding the extension name DAT. For example, if you choose the name Dream, the file name is DREAM.DAT.

To load these same data at a later time, move to **Previous Case** within the **Initialize** menu, and press Enter. The computer displays the list of available files. Move the highlight to DREAM.DAT, and press Enter. The computer places these building data into the worksheets, overriding any other data currently in the worksheets. The heating degree-day value in worksheet I, however, is automatically reset to the nominal value for the location, rather than the value showing when the file was stored; this should be reset to the desired value if the number is different.

## PRINTING YOUR RESULTS

To produce a hard copy of the worksheets, move to the **Print** menu. You can choose to print only the summary, which is just one page, or the whole set of worksheets, which is four pages. When you select either one of these options, the computer will send a facsimile of the worksheets to your printer in a flat (TTY or PLAIN) computer format. This will work with most printers.



## APPENDIX A Setting Up Your Hard Disk

The procedure for installing BuilderGuide on your computer's hard disk is described below.

Step 1. Set up a new directory called BG (for BuilderGuide) on your hard disk:

Start your computer. The C prompt appears as follows: **C : >**  
 Type **md bg**  
 Press Enter

Step 2. Get into the BG directory:

Type **cd bg**  
 Press Enter

Step 3. Copy the disk to the BG directory so that all the BuilderGuide files are on your hard disk:

Install disk #1 into your floppy disk drive (drive a).  
 Type **copy a: \*.\***  
 Press Enter.

Step 4. Start BuilderGuide:

Type **bg**  
 Press Enter.

To start BuilderGuide later, you first need to select the BG directory. From the C prompt,

Type **cd bg**  
 Press Enter.  
 Type **bg**  
 Press Enter. The program will load and you can go from there.

### Loading files for other cities:

The *BuilderGuide* floppy disk contains files for two cities, Denver and Washington DC. You will probably want to load city files for other locations into your BG directory so that you can evaluate performance in those climates. The procedure is straightforward. This disk has files for an additional 41 locations in a directory called **cities**.

Determine the file name. To do this, first select the A disk: Type **a:**, Press Enter

Switch to the CITIES directory: Type **cd cities**, Press Enter

Type **dir \p**, Press Enter. Scan the list of city files. Select the one you want to use.

Type **copy xxxxxx.BGL c:\bg**, Press Enter, (where xxxxxx is the name of the file, for example: **SANTAFE.BGL**). The file will be copied from the floppy into the **bg** directory on your hard disk where it must reside to be readable by *BuilderGuide*.

Repeat for other cities. PSIC has files for 218 locations if you can't find the one you want on the floppy.

## APPENDIX B Technical Basis for the Calculations

### How the *Builder Guidelines* Were Produced

The text of the *Builder Guidelines* book is generated by merging two computer files. The first is a word-processor file containing the text; it does not change from location to location. The second contains numbers and text and is location dependent. This second file is produced by running a computer program that calculates performance numbers based on long-term monthly weather and solar data compiled by the National Oceanic and Atmospheric Administration for a particular location. The merge operation slots the numbers and text in the second file into their correct locations in the first file. The merged file is then laser printed to produce the camera ready manuscript.

### The Location Data Files in BuilderGuide

When you select a particular location, the program loads a data file for this location into the computer memory. This file contains numbers identical to the numbers in the reference tables of the *Builder Guidelines* for this location.

### Worksheet Calculations

The BuilderGuide program replicates the operations that a person performs in filling out the worksheets. Thus the answers are the same either way (assuming the person makes no arithmetic errors).

### Analysis Procedures

The worksheet procedure was developed using simple, well-established methods for estimating the performance of passive solar heating and natural cooling strategies. These procedures (described below) were developed at the Los Alamos National Laboratory with funding from the U.S. Department of Energy Solar Buildings Program. See the references for more information.

#### Worksheet I - Annual Heat Loss

The heat-loss calculation is based on a straightforward summation of the traditional elements that make up the building heat-loss coefficient (excluding the solar components). BuilderGuide calculates the annual heat loss by multiplying the heat-loss coefficient by annual degree days (times 24 to convert from days to hours). Degree days for each month were determined using an appropriate base temperature that accounts for an assumed thermostat setting of 70 degrees, an assumed internal heat generation of 36 Btu/day per sq ft of floor area, and the total building loss coefficient. This forms the basis of the table of heating degree day multipliers. The result of the worksheet is an estimate of the annual heat required to maintain comfort, excluding both positive and negative effects resulting from the solar components. In this estimate, no solar heating credit is given to east, west, and north windows, because it is assumed that these will be protected by vegetation or other shading in accordance with the *Builder Guideline* recommendations. This is a conservative assumption because there will always be some solar gain through these windows.

## Worksheet II - Annual Auxiliary Heat

The tables of passive solar savings fractions are calculated using the solar load ratio (SLR) method (references 1 and 2). Monthly solar savings fraction (SSF) values are determined using correlation fits to the results of hourly computer simulation calculations for a variety of climates. These 12 values are converted into an annual value and entered into worksheet Tables F1-F4. The SLR method gives answers that agree within about 5% of the hourly computer simulations and within 11% of the measured passive solar performance of 55 buildings monitored under the Solar Buildings Program. The SSF estimates account properly for both solar gains and heat losses through the solar aperture and, thus, correct for omitting the solar components from the calculation of annual heat loss.

## Worksheet III - Temperature Swing (Thermal Mass/Comfort)

The temperature swing estimate on worksheet III is based on the diurnal heat capacity (dhc) method (reference 3). The method is an analytic procedure in which the total heat stored in the building during one day is estimated by summing the effective heat storage potential of all the various materials in the building for a 24-hour periodic cycle of solar input. Rooms with direct gain are assumed to have radiative coupling of the solar heat to the mass. Rooms connected to rooms with direct gain are assumed to have convective coupling, which is rather less effective, especially for massive elements. The dhc of the sheetrock, framing, and furniture is approximated as 4.5 or 4.7 Btu/°F per sq ft of floor area. Worksheet Tables H1 and H2 list the increased value of diurnal heat capacity for various conventional materials that are often used to provide extra heat storage, assuming these materials replace sheetrock. These tables are reproduced within the help text (press F2 when the cursor is within the dhc box).

The only numbers in worksheet III that are location dependent are the comfort factors, taken from Table I. The direct-gain comfort factor is 61% of the solar gain transmitted through vertical, south-facing double glazing on a clear January day. The driving effect of sunspaces and vented Trombe walls is assumed to result in one-third this value, based on data from monitored buildings. The origin of the 61% factor is described in the references.

## Worksheet IV - Annual Auxiliary Cooling

The purpose of including the summer cooling estimates in BuilderGuide is to (1) determine if design elements added to promote passive solar heating will cause excessive summer cooling loads and (2) provide a rough estimate of the effectiveness of solar shading and natural cooling strategies. The analysis method is based on a modified monthly degree-day procedure in which the day is divided into day and night periods (reference 4). All estimates are derived from correlations based on hourly computer simulations. Solar, conduction, and internal gains are estimated for each half-day period in each month. Delay factors are used to account for heat carryover from day to night and night to day. The results are estimates of annual sensible cooling delivered by the air conditioner and do not include latent loads.

Because the original Los Alamos monthly procedure is too complex to be implemented in a worksheet, a simplified procedure is adopted on worksheet IV. Heat Gain Factors and Internal Gain Factors in Tables L and N are the calculated annual incremental cooling loads resulting from a one-unit incremental change in the respective heat input parameter (that is, a one-unit change in UA, glazing area, or number of bedrooms). The combined heat load resulting from all inputs is summed and then adjusted for thermal mass and ventilation. This correction includes a constant required to match the calculated cooling load of the base-case building. This linearized procedure gives accurate estimates for cooling loads that are less than about 150% of the base-case building; however, it underestimates very large cooling loads in poorly designed buildings.

The adjustment factors for ventilation properly account for maintaining comfort in hot and humid climates. Ventilation is restricted to times when the outside dew-point temperature is less than 62 °F. This restriction avoids ventilation when high humidity might cause discomfort.

### **Not for Sizing Equipment**

All heating and cooling values given in the *Builder Guidelines* Tables and numbers calculated using the worksheets are for annual heat delivered or removed by the mechanical heating or cooling system. **You cannot directly use these numbers for sizing the capacity of this equipment.** The methods developed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers for sizing equipment are well-established and are recommended. The purpose of the guidance provided in these booklets is to minimize the operating time and resources consumed by this equipment.

### **Using BuilderGuide in Nearby Locations**

The applicability of worksheets I and II can be extended somewhat by using the base-65 °F degree-day value for a site which is close to the location for which the worksheet tables were generated. We recommend limiting such applications to sites where the annual heating degree-days are within plus or minus 10% of the parent location and where it is reasonable to assume that the solar radiation is about the same as in the parent location. The procedure is simple: Use the measured base-65 °F degree-day value in worksheet I, line F, instead of the degree-day value for the parent location.

Worksheet III depends only slightly on location. The only variables are the Comfort Factors in Table I, which only change with latitude. Thus, this worksheet can be used anywhere within 4 degrees of latitude of the parent location.

The cooling estimate obtained from worksheet IV is specific to the location. Within the same vicinity and within plus or minus 20%, the result could be adjusted, based on a ratio of cooling degree days. However, this adjustment is not done automatically within the worksheet.

### **Getting Data**

Heating and cooling degree-day data can be obtained from the National Climatic Center, Asheville, NC. Refer to *Climatology of the United States No. 81* which lists monthly normals for the period 1951-1980 on a state-by-state basis. More than 2400 locations are listed in this data base.

## References

- 1) J. Douglas Balcomb, Robert W. Jones, Robert D. McFarland, and William O. Wray, "Expanding the SLR Method", *Passive Solar Journal*, Vol. 1, No. 2, 1982, pp. 67-90. Available from the American Solar Energy Society, 2400 Central Ave. Unit B-1, Boulder, CO 80301.
- 2) J. Douglas Balcomb, Robert W. Jones, Robert D. McFarland, and William O. Wray, *Passive Solar Heating Analysis*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 1984. Available from ASHRAE, 1719 Tullie Circle, NE, Atlanta, GA 30329.
- 3) J. Douglas Balcomb and William O. Wray, *Passive Solar Heating Analysis, Supplement One, Thermal Mass Effects and Additional SLR Correlations*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, 1987. See ASHRAE address above.
- 4) Robert D. McFarland and Gloria Lazarus, *Monthly Auxiliary Cooling Estimation for Residential Buildings*, LA-11394-MS, Los Alamos National Laboratory, Los Alamos, NM 87545, 1989.
- 5) J. Douglas Balcomb and Alexander B. Leko, *Algorithms for Builder Guidelines*, SERI/TP-254-3492, Solar Energy Research Institute, Golden CO. Also contained in the *Proceedings of the 14th Passive Solar Conference*, Denver, June 19-23, 1989. See ASES address above.

## APPENDIX C - Worksheets

The following pages contain the four blank worksheets from the *Builder Guidelines*. The format of the BuilderGuide worksheets is essentially identical to these. You might want to transcribe the results of the BuilderGuide calculations to copies of these worksheets. Alternatively, you can obtain a hard copy of your BuilderGuide results using the **Print** option.

# General Project Information

Project Name _____	Floor Area _____
Location _____	Date _____
Designer _____	_____

## Worksheet I: Conservation Performance Level

**A. Envelope Heat Loss**

Construction Description	Area	+	R-value [Table A]	=	Heat Loss
Ceilings/roofs	_____	+	_____	=	_____
_____	_____	+	_____	=	_____
Walls	_____	+	_____	=	_____
_____	_____	+	_____	=	_____
Insulated Floors	_____	+	_____	=	_____
_____	_____	+	_____	=	_____
Non-solar Glazing	_____	+	_____	=	_____
_____	_____	+	_____	=	_____
Doors	_____	+	_____	=	_____
_____	_____	+	_____	=	_____
Total					_____ Btu/°F-h

**B. Foundation Perimeter Heat Loss**

Description	Perimeter	×	Heat Loss Factor [Table B]	=	Heat Loss
Slabs-on-Grade	_____	×	_____	=	_____
Heated Basements	_____	×	_____	=	_____
Unheated Basements	_____	×	_____	=	_____
Perimeter Insulated Crawspaces	_____	×	_____	=	_____
Total					_____ Btu/°F-h

**C. Infiltration Heat Loss**

	_____	×	Air Changes per Hour	×	.018	=	_____ Btu/°F-h
	Building Volume						

**D. Total Heat Loss per Square Foot**

	24	×	Total Heat Loss (A+B+C)	÷	Floor Area	=	_____ Btu/DD-sf
--	----	---	-------------------------	---	------------	---	-----------------

**E. Conservation Performance Level**

	_____	×	Heating Degree Days [Table C]	×	Heating Degree Day Multiplier [Table C]	=	_____ Btu/yr-sf
	Total Heat Loss per Square Foot						

**F. Comparison Conservation Performance** (From Previous Calculation or from Table D)

			_____ Btu/yr-sf
--	--	--	-----------------

**Compare Line E to Line F**

# Worksheet II: Auxiliary Heat Performance Level

## A. Projected Area of Passive Solar Glazing

Solar System Reference Code	Rough Frame Area	Net Area Factor	Adjustment Factor [Table E]	Projected Area
_____	_____	× 0.80	× _____	= _____
_____	_____	× 0.80	× _____	= _____
_____	_____	× 0.80	× _____	= _____
_____	_____	× 0.80	× _____	= _____
_____	_____	× 0.80	× _____	= _____
_____	_____	× 0.80	× _____	= _____
_____	_____	× 0.80	× _____	= _____
Total Area				_____
				_____ sf
				Total Projected Area
				_____
				+
				_____
				=
				_____
				Total Projected Area per Square Foot

## B. Load Collector Ratio

$$24 \times \frac{\text{Total Heat Loss [Worksheet I]}}{\text{Total Projected Area}} = \text{_____}$$

## C. Solar Savings Fraction

Solar System Reference Code	Projected Area	System Solar Savings Fraction [Table F]
_____	_____	× _____ = _____
_____	_____	× _____ = _____
_____	_____	× _____ = _____
_____	_____	× _____ = _____
_____	_____	× _____ = _____
_____	_____	× _____ = _____
_____	_____	× _____ = _____
Total		_____ + _____ = _____
		Total Projected Area
		Solar Savings Fraction

## D. Auxiliary Heat Performance Level

$$\left[ 1 - \frac{\text{Solar Savings Fraction}}{\text{Conservation Performance Level [Worksheet I, Step E]}} \right] \times \text{_____} = \text{_____ Btu/yr-sf}$$

## E. Comparative Auxiliary Heat Performance (From Previous Calculation or from Table G) \_\_\_\_\_ Btu/yr-sf

Compare Line D to Line E



# Worksheet III: Thermal Mass/Comfort

## A. Heat Capacity of Sheetrock and Interior Furnishings

	Floor Area		Unit Heat Capacity	=	Total Heat Capacity	
Rooms with Direct Gain	_____	×	4.7	=	_____	
Spaces Connected to Direct Gain Spaces	_____	×	4.5	=	_____	
					<b>Total</b>	<b>Btu/°F</b>

## B. Heat Capacity of Mass Surfaces Enclosing Direct Gain Spaces

Mass Description (include thickness)	Area		Unit Heat Capacity [Table H]	=	Total Heat Capacity	
Trombe Walls	_____	×	8.8	=	_____	
Water Walls	_____	×	10.4	=	_____	
Exposed Slab in Sun	_____	×	13.4	=	_____	
Exposed Slab Not in Sun	_____	×	1.8	=	_____	
_____	_____	×	_____	=	_____	
_____	_____	×	_____	=	_____	
_____	_____	×	_____	=	_____	
					<b>Total</b>	<b>Btu/°F</b>

## C. Heat Capacity of Mass Surfaces Enclosing Spaces Connected to Direct Gain Spaces

Mass Description (include thickness)	Area		Unit Heat Capacity [Table H]	=	Total Heat Capacity	
Trombe Walls	_____	×	3.8	=	_____	
Water Walls	_____	×	4.2	=	_____	
_____	_____	×	_____	=	_____	
_____	_____	×	_____	=	_____	
_____	_____	×	_____	=	_____	
					<b>Total</b>	<b>Btu/°F</b>

## D. Total Heat Capacity

**(A+B+C)** **Btu/°F**

## E. Total Heat Capacity per Square Foot

**Total Heat Capacity** ÷ **Conditioned Floor Area** = **Btu/°F-sf**

## F. Clear Winter Day Temperature Swing

	Total Projected Area [Worksheet II]		Comfort Factor [Table I]	=		
Direct Gain	_____	×	_____	=	_____	
Sunspaces or	_____	×	_____	=	_____	
Vented Trombe Walls	_____					
	<b>Total</b>	÷	<b>Total Heat Capacity</b>	=	_____	<b>°F</b>

## G. Recommended Maximum Temperature Swing

\_\_\_\_\_ **°F**

**Compare Line F to Line G**

# Worksheet IV: Summer Cooling Performance Level

## A. Opaque Surfaces

Description	Heat Loss [Worksheet I]	Radiant Barrier Factor [Table J]	Absorp- tance [Table K]	Heat Gain Factor [Table L]	Load
Ceilings/roofs	_____	X	_____	X	_____ = _____
_____	_____	X	_____	X	_____ = _____
_____	_____	X	_____	X	_____ = _____
Walls	_____	X	na	X	_____ = _____
_____	_____	X	na	X	_____ = _____
Doors	_____	X	na	X	_____ = _____
					Total

kBtu/yr

## B. Non-solar Glazing

Description	Rough Frame Area	Net Area Factor	Shade Factor [Table M]	Heat Gain Factor [Table L]	Load
North Glass	_____	X	0.80	X	_____ = _____
East Glass	_____	X	0.80	X	_____ = _____
West Glass	_____	X	0.80	X	_____ = _____
Skylights	_____	X	0.80	X	_____ = _____
					Total

kBtu/yr

## C. Solar Glazing

Solar System Description	Rough Frame Area	Net Area Factor	Shade Factor [Table M]	Heat Gain Factor [Table L]	Load
Direct Gain	_____	X	0.80	X	_____ = _____
Storage Walls	_____	X	0.80	X	_____ = _____
Sunspace	_____	X	0.80	X	_____ = _____
_____	_____	X	0.80	X	_____ = _____
					Total

kBtu/yr

## D. Internal Gain

$$\text{Constant Component [Table N]} + \left( \frac{\text{Variable Component [Table N]}}{\text{Number of Bedrooms}} \right) = \text{_____ kBtu/yr}$$

## E. Cooling Load per Square Foot

$$1,000 \times \frac{\text{_____}}{(A+B+C+D)} \div \text{Floor Area} = \text{_____ Btu/yr-sf}$$

## F. Adjustment for Thermal Mass and Ventilation

$$\frac{\text{_____}}{\text{[Table O]}} = \text{_____ Btu/yr-sf}$$

## G. Cooling Performance Level

$$\frac{\text{_____}}{(E-F)} = \text{_____ Btu/yr-sf}$$

## H. Comparison Cooling Performance (From Previous Calculation or from Table P)

$$\text{_____ Btu/yr-sf}$$

Compare Line G to Line H

# BuilderGuide

A Simple, User-Friendly PC Program  
Analyse Annual House Energy Performance

Evaluate:      Improved Insulation  
                    Passive Solar Savings  
                    Sufficient Thermal Storage  
                    Natural Cooling

Do the Numbers, Do Them Right