Passive Solar Design Strategies: Guidelines for Home Builders

Instructor's Manual

Prepared by:

Passive Solar Industries Council
and
National Renewable Energy Laboratory

Prepared for:

The U.S. Department of Energy
Office of Conservation and Renewable Energy

Preface

This manual has been assembled to provide PSIC-approved instructors basic information and assistance in putting on a residential workshop using the notebook, *Passive Solar Design Strategies: Guidelines for Homebuilders.*

First a little background. The builder guidelines project had its roots in the Solar Showcase in New Mexico in 1983. The developer of the Eldorado subdivision in Santa Fe wanted some help in quantifying performance and approached us at the Los Alamos National Laboratory. The three-worksheet guidelines that resulted were effective and are still used. Today, there are more than 600 passive solar homes in Eldorado, probably the largest aggregation in the world (see the article by Mark Conkling in the Nov/Dec 1991 issue of *Solar Today*). These original "guidelines" were just worksheets containing no real guidance and no cooling analysis.

The guidelines project with PSIC and NAHB was started in 1987 after I had moved to NREL (then SERI). Several years later we have the product you will be presenting in the workshop. It is the end result of an enormous amount of work by many dedicated and knowledgeable folks. It is important for me to emphasize that the format for these workshops has evolved based on the experience of several pilot workshops and more than a dozen subsequent regular workshops given by all the parties. It is your responsibility to present this material.

In presenting the workshop, keep it lively and interesting. Insert your personality, experience, and knowledge. The slides and accompanying materials are a great asset and you should rely primarily on them. But, it will spice up the day a lot if you can fill in with some *well designed* local examples (perhaps some of your work), a few good anecdotes, and a little humor. Do your homework. Be thoroughly familiar with all of the material. Answer questions, but don't get bogged down. Do a *BuilderGuide* demonstration using a projection panel. It is a full day; at the end your audience should be eager to get out there and do it, and know how to do it right.

This manual contains instructions that will help you work with PSIC to develop a customized, local version of *Passive Solar Design Strategies* and to develop the applicability map. The more you are involved in this process, the better you will understand it and be able to convey the concepts to your audience.

The major problem in getting passive solar and energy conservation into common practice has always been one of education - transferring the knowledge and enthusiasm from a small group to the larger community of homebuilders. It is a slow process, but one that will bear great fruits. I am pleased that you are willing to put in your time and personal energy to help it along a little faster.

Doug Balcomb
December 1991
Golden, Colorado

OneStep®
INDEX SYSTEM

Contents:

CUSTOMIZING

Passive Solar Design Strategies: Guidelines for Home Builders

of the
Passive Solar Industries Council

There are several options available in developing a Guidelines book. It is important to exercise these carefully and consistently.

1) Choose a name for the Guidelines. This can either be the name of a weather site (Hartford, Connecticut) or a well-recognized region (Central New England). For a workshop in Omaha, we chose to call the book "Southeastern Nebraska". This name appears in the Guidelines as the name on the title page and as the footer throughout the book.

2) Identify a parent site. This defines the data file that will be used to generate the numbers in the Guidelines. The choice is from 205 locations within the 48 contiguous United States. Do not make books or make workshops in locations where there is no heating load (southern Florida or southern Texas). You may select a parent site that is outside the region where you will be presenting the workshop, if it more suitable than any site within the region. This can happen hear state boundaries, for example, El Paso, Texas was used in the Guidelines for Las Cruces, New Mexico (30 miles apart, both within the Rio Grande valley).

3) Identify the site name that will be listed on the various tables in the Guidelines. Generally this will be same as the parent site but it does not have to be. Use a name for a specific location and not the name of a region. The name chosen should be for a location that has a climate that is quite similar to that of the parent site. Examples: the parent site is El Paso, Texas, the site name is Las Cruces, New Mexico; the parent site is Fargo, North Dakota the site name is Moorhead, Minnesota (just across the river); the parent site is Washington, DC (data are for Dulles), the site name is Alexandria, Virginia. The site name will appear in the Guidelines where specific site data are given, such as the performance table on page 6.

4) Identify the heating degree days for the site. This can be a little different than the HDD for the parent site. Use data from Climatography of the United States No. 81. This number is entered in the Guidelines Production Program during execution and used to make a proportional correction to all the heating loads. Note that whereas the heating calculations are corrected, the cooling calculations are not. Therefore be careful in wandering too far from the cooling climate of the parent site. You can find cooling degree days in No. 81.

5) Develop text that will be added to the acknowledgements page of the Guidelines and send to PSIC. The space available is about one-half column. The Acknowledgements cannot exceed one page. PSIC will print this out in the same font and paste it on the page. Acknowledgements should recognize assistance from organizations that help in organizing the workshop.

REGIONAL TEXT IN BUILDER GUIDELINES
(Other than site location)

Page	Column	Paragraph	
3	2	1	Heating degree days change with location
4	3	2	Conservation, auxiliary heat and summer cooling performance levels
4	3	4	Modifications to the base case for energy savings
5			Performance potential table values
11	1	3 + 4	Air change rates may change
12	2	1	The number of glazings varies
12	2	4	Last sentence on north windows versus east or west varies with latitude
14	1	3	Effectiveness of tilt varies with location
16	2	Figure	Distances A, B and C vary with latitude
21		Table	Values vary with location
22	2	1	Number of glazings and type of coating if any will vary
24		Table	Values vary with location
26	1	4	The effectiveness of glass roofs varies with latitude
27		Table	Values vary with location
29		Table	Values vary with location
31		Table	Values vary with location

Page	Column	Paragraph	
32	2	1	Effect of skylights varies with latitude and climate
32	2	Table	Ditto
33	3	Figure	Angles A and B vary with latitude
38		Tables	Values vary with location
39		Tables	Values vary with location

J.D. Balcomb, SERI, 8/20/91

APPLICABILITY MAPS

for
Passive Solar Design Strategies: Guidelines for Homebuilders

of the
Passive Solar Industries Council

In most cases, an applicability map should be developed and included in the Guidelines. This map defines the region where the Guidelines apply and explains how to make minor corrections to the worksheet numbers within the region in order to account for climate differences across the region. The applicability map should be inserted into the Guidelines book immediately following the title page. Examples of applicability maps are attached.

STEPS TO MAKING AN APPLICABILITY MAP:

1) Get weather booklets for the state. from PSIC.
   a) Climatography of the United States No. 60
   b) Climatography of the United States No. 81

   If the region will overlap more than one state, get books for all states.

2) Read the section in No. 60 about the climate of the region. If you have any other information on the climate of the region, such as books published by the state, get these and read them too.

3) Look up all weather sites within 80 miles of the parent site in No. 80, using the map, excluding sites where there are precipitation data only. Screen these to include only sites listed in heating degree day table.

4) List heating degree days (HDD) and elevations for these sites. These data are in No. 80.

5) On the map in No. 60, locate the sites and label them with the HDD data. It can be hard to find some of the sites; use both maps to help locate them. Draw a line outside the locations where the heating degree days reach either +10% above the HDD for the parent site or -10% below the HDD of the parent site. Use topography and your knowledge of the weather patterns as a guide in drawing the line, for example, you might draw the line along a mountain ridge.

6) If possible get a topographic map for the region. Use this to guide where to draw the line, generally along lines of constant altitude.

7) Sites which fall within the area drawn in (5) are covered by the Guidelines book. Note that these may include some sites that are outside plus or minus 10% of the HDD for the parent site, for example, in situations where there are islands of sites within the area due to local mountains.

8) Use your judgement and the knowledge from (2) to refine the boundaries. Regions that include mountains, valleys, and seashore or lakeshore are the most difficult to deal with. In cases where you will be defining applicability maps for more than one Guidelines book, carve up the whole region as best as you can, generally avoiding overlapping regions. Use state boundaries to limit regions where this seems to be good idea. You may even have a case where the parent is outside the region, for example where the best site is just over the state line and you want, for political reasons, to keep the region within one state. In defining regions, think ahead to the problems that others may face in defining regions that will be adjacent to yours. Try to include sites that would otherwise not fall in any region, even if this would exceed the plus-or-minus 10% variation guideline. Generally, however, don't stretch the region beyond plus-or-minus 20% of the parent site HDD.

9) Get a good map for the state. We usually use a road map, since it will be familiar to the user. The maps in No. 60 are *not* recommended. Photocopy the portion of the map that defines your region. Draw the region boundary on the map using a dark marking pen. Draw an open circle around the parent site. Draw smaller solid circles at the sites where you have HDD data from (3). Include a scale of miles to help the user. Enlarge or reduce the map using a photocopier so that it will fit properly on part of the page.

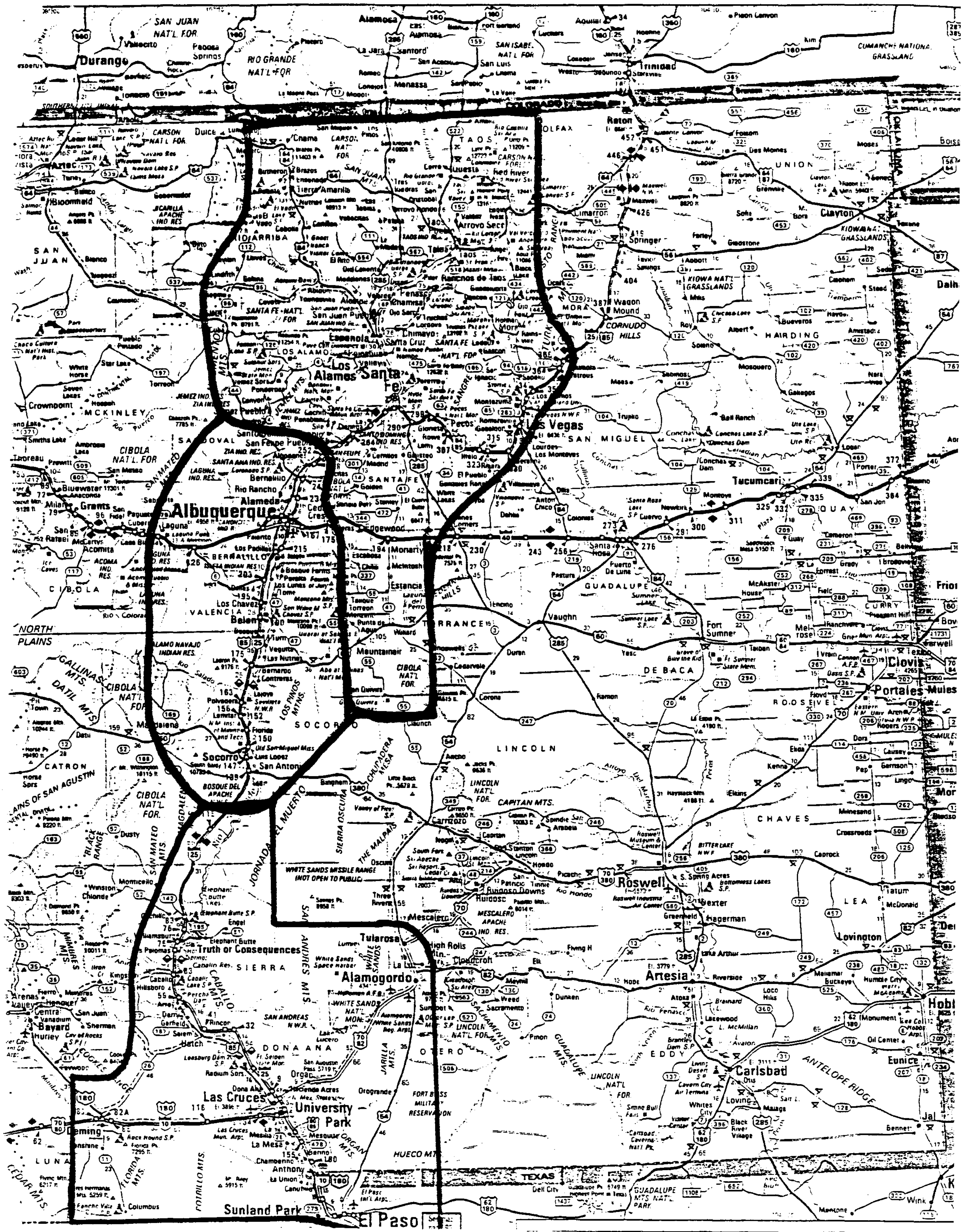
10) Fill out the text on the applicability page. Tailor this to fit your situation. The attached applicability page for Albuquerque is a good example (except that the dots are omitted). The map for Santa Fe is an example in which the data were taken from a local source and adjusted by SERI. Acknowledge all data sources. Be sure to state where the parent site is, even if it is outside the region.

11) List the HDD data for the sites in the region. These data will appear both on the applicability page and in Table C1 of the worksheet reference tables. Filling out Table C1 is done on the computer screen during the process of running the Guidelines Production Program at PSIC; you must provide the list of sites site and HDD information to PSIC so that it can be included in this Table. This will also cause this information to be printed on the viewgraphs during the production process.

12) Send the finished map and the desired text to PSIC for inclusion in the Guidelines book. PSIC will lay out the page, using a consistent font.

13) Make a viewgraph of the applicability map to be used during the Guidelines workshop, perhaps enlarging the map for readability.

14) Sample maps and Examples of completed pages are included here for your reference.



Durango
SAN JUAN NAT'L FOR
RIO GRANDE NAT'L FOR
Alamosa
Trinidad
COMANCHE NATIONAL GRASSLAND
COLORADO
Aztec
Bloomfield
Chama
CARSON NAT'L FOR
TAOS
Raton
COLFAX
Des Moines
UNION
Clayton
Tierra Amarilla
RIO ARRIBA
Taos
Ranchos de Taos
Cimarron
Springer
KIOWA NAT'L GRASSLANDS
SAN JUAN
Wagon Mound
MORA
HARDING
SANTA FE NAT'L FOR
Espanola
Chimayo
Los Alamos
Santa Fe
Pecos
Las Vegas
SAN MIGUEL
Crownpoint
MCKINLEY
SANDOVAL
CIBOLA NAT'L FOR
Grants
Milan
Bluewater
Laguna
Acomita
Bernalillo
Rio Rancho
Alameda
Albuquerque
BERNALILLO
Edgewood
Moriarty
Estancia
Tucumcari
QUAY
San Jon
Santa Rosa
GUADALUPE
Vaughn
CIBOLA
VALENCIA
Los Chavez
Belen
TORRANCE
Mountainair
Fort Sumner
DE BACA
Clovis
Portales
ROOSEVELT
CURRY
NORTH PLAINS
CIBOLA NAT'L FOR
Magdalena
SOCORRO
Socorro
San Antonio
CATRON
LINCOLN
Corona
Carrizozo
CAPITAN MTS.
CHAVES
Roswell
WHITE SANDS MISSILE RANGE (NOT OPEN TO PUBLIC)
Ruidoso
Ruidoso Downs
MESCALERO APACHE IND. RES.
Tularosa
Truth or Consequences
SIERRA
Alamogordo
Cloudcroft
Artesia
Lovington
LEA
Hobbs
OTERO
EDDY
Carlsbad
DONA ANA
Las Cruces
University Park
Deming
LUNA
Sunland Park
El Paso
TEXAS
Columbus
Anthony
Mesilla
Hatch
Silver City
Bayard
Hurley
Eunice
Jal

Applicability of the Albuquerque Guidelines

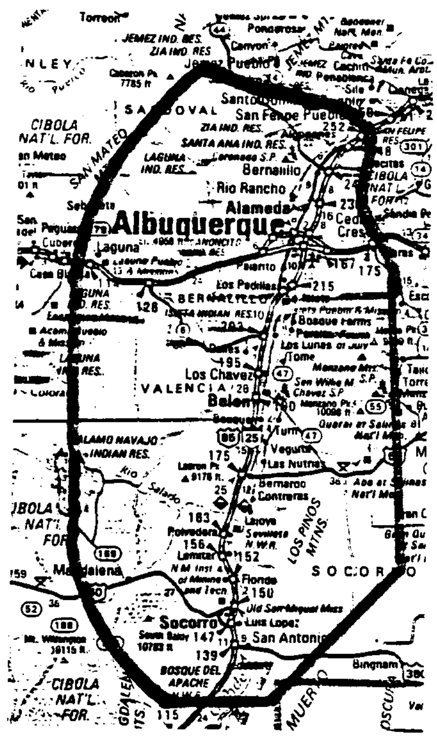
Albuquerque has a very sunny climate with a significant need for winter heat and a moderate need for summer cooling. It is a very favorable location for passive solar heating. The amount of time that summer cooling is needed can be reduced significantly through the use of shading and natural cooling strategies. Evaporative cooling is a very suitable and economical method for providing the remaining cooling load.

Most of the general guidelines are applicable throughout the central Rio Grande valley. However, numbers which appear throughout the Guidelines were calculated using weather and solar data taken from the Albuquerque SOLMET data set. Thus most numerical values throughout the Guidelines apply only to Albuquerque.

The complex topography of New Mexico leads to an equally complex variation in long-term weather. Solar radiation is generally quite high and varies only slightly in the central valley region; however, temperatures are somewhat more variable.

The annual heating calculations of **Worksheets I and II** can be extended to the area north and south of Albuquerque by using the base-65 F heating degree day value for the actual location on line E of Worksheet I. The approximate zone of applicability is confined to the central valley south of the Cochiti Dam as outlined on the map below. Heating degree days for a few weather-station locations within this zone are given. It is recommended that the Guidelines for Santa Fe should be used for locations east of the Sandia and Manzano Mountains.

Worksheet III is generally applicable thoughout New Mexico. The calculations on **Worksheet IV** are quite sensitive to the local climate and are applicable only within the immediate vicinity of Albuquerque.



Location	Heating Degree-days
Albuquerque	4414
Bernalillo	4733
Laguna	5046
Socorro	4104
Belen	4432
Bosque del Apache	3965

Applicability of the Santa Fe Guidelines

Santa Fe has a cold but sunny climate with a major need for winter heat and little need for summer cooling. It is a very favorable location for passive solar heating; however, summer comfort can be achieved without the need for air conditioning through the use of shading and natural cooling.

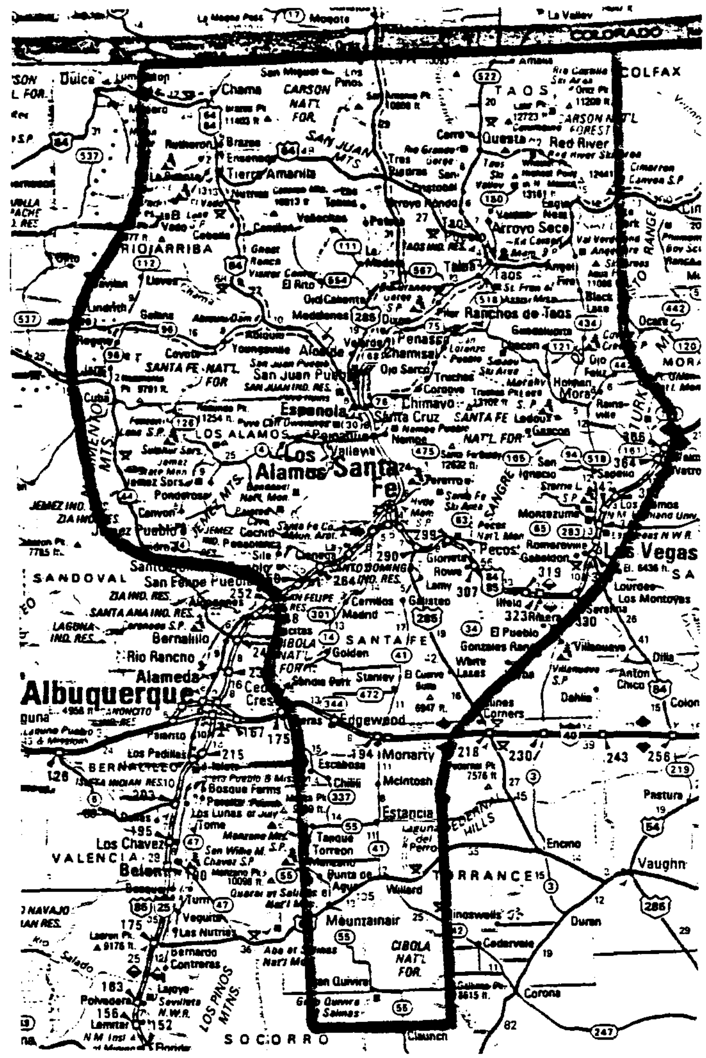
Most of the general guidelines are applicable throughout the north-central New Mexico region. Numbers which appear throughout the Guidelines were calculated using Santa Fe temperature data taken from the New Mexico Climate Manual* and solar clearness data taken at the Los Alamos National Laboratory corrected upwards by two percentage points to account for the Santa Fe climate. Thus most numerical values throughout the Guidelines apply only to Santa Fe.

The complex topography of New Mexico leads to an equally complex variation in long-term weather. Solar radiation is generally quite high and varies only moderately in the central mountain region; however, temperatures are much more variable, depending primarily on elevation.

The annual heating calculations of **Worksheets I and II** can be extended to the area around Santa Fe by using the base-65 F heating degree day value for the actual location on line E of Worksheet I. The approximate zone of applicability is outlined on the map. Heating degree days for several locations within this zone are given.

Worksheet III is generally applicable thoughout New Mexico. The calculations on **Worksheet IV** are quite sensitive to the local climate and are applicable only within the immediate vicinity of Santa Fe.

* *New Mexico Climate Manual: Solar and Weather Data,* NMERDI 2-72-4523 (1985).



Location	Heating Degree-days
Santa Fe	5958
Los Alamos	6387
Cuba	7095
Jemez Springs	5281
Las Vegas	6063
Valmora	6094
Taos	6827
Eagles Nest	9298
El Vado	7729
Mountainair	5490
Tajique	5995
Estancia	5637
Gran Quivera	4979

Applicability of the Las Cruces Guidelines

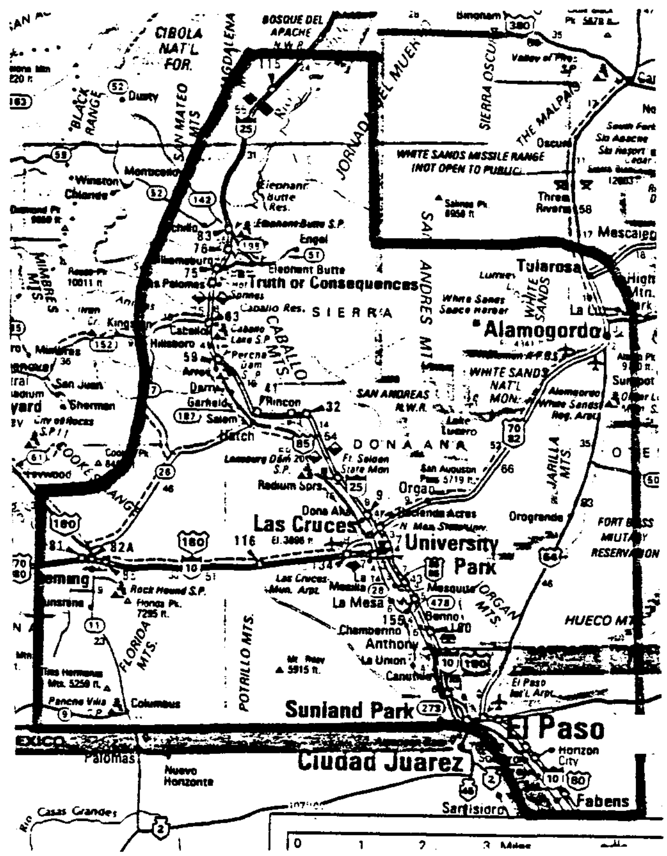
Las Cruces has a very sunny climate with a significant need for both winter heat and summer cooling. It is a very favorable location for passive solar heating. The amount of time that summer cooling is needed can be reduced significantly through the use of shading and natural cooling strategies. Evaporative cooling is a very suitable and economical method for providing the remaining cooling load.

Most of the general guidelines are applicable throughout the south-central New Mexico region. However, numbers which appear throughout the Guidelines were calculated using weather and solar data taken from the El Paso SOLMET data set. The heating numbers were corrected to account for the somewhat greater heating degree days in Las Cruces (3118 HDD) compared to El Paso (2664 HDD). Thus most numerical values throughout the Guidelines apply only to Las Cruces although the cooling values are actually applicable to El Paso.

The complex topography of New Mexico leads to an equally complex variation in long-term weather. Solar radiation is generally quite high and varies only slightly throughout the south-central region; however, temperatures are somewhat more variable, depending primarily on elevation.

The annual heating calculations of **Worksheets I and II** can be extended to the area around Las Cruces by using the base-65 F heating degree day value for the actual location on line E of Worksheet I. The approximate zone of applicability is within the zone outlined on the map below. Heating degree days for a few weather-station locations within this zone are given.

Worksheet III is generally applicable thoughout New Mexico. The calculations on **Worksheet IV** are quite sensitive to the local climate and are technically applicable only within the immediate vicinity of El Paso.



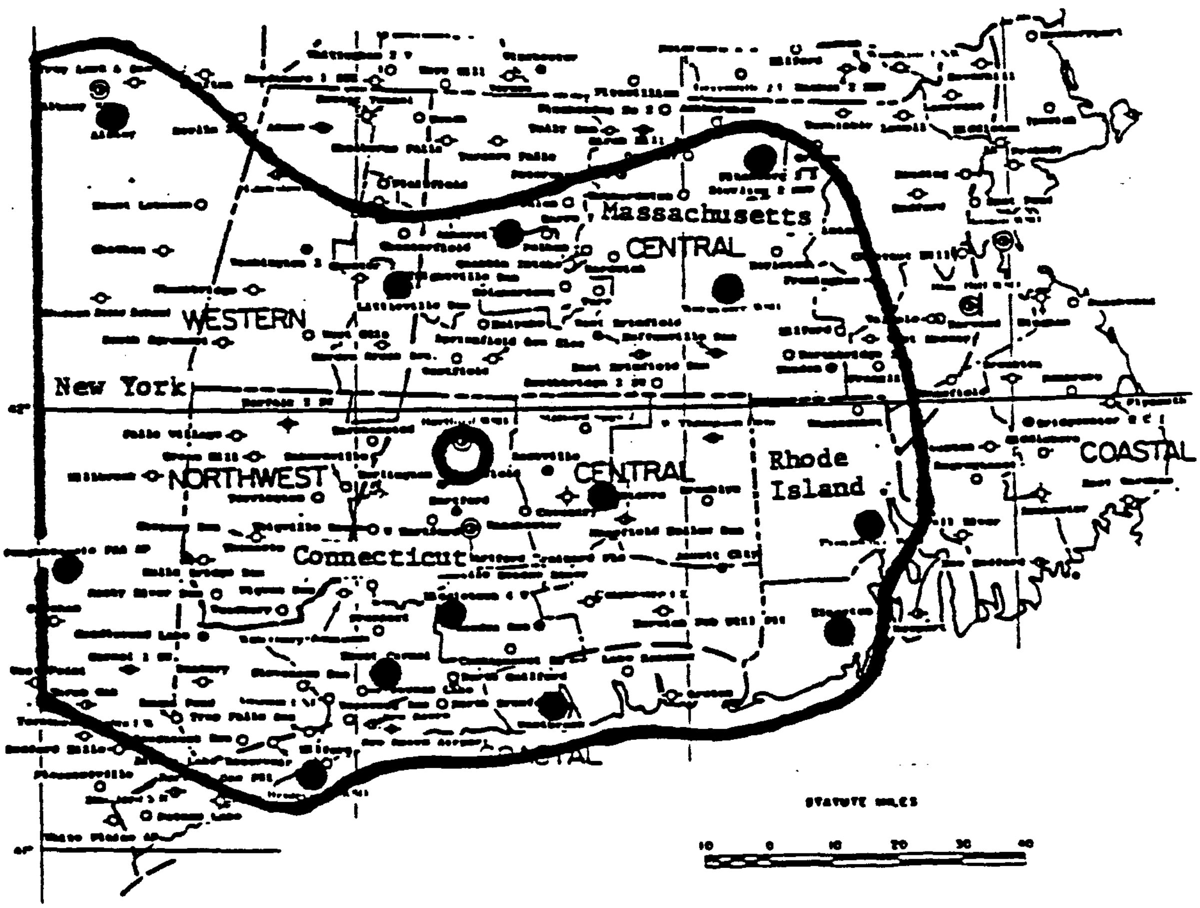
Location	Heating Degree-days
Las Cruces (NMSU)	3118
Hatch	3356
Caballo Dam	3283
Elephant Butte	3133
T or C	3404
White Sands	3539
Columbus	2949
El Paso, TX	2664
La Tuna, TX	2755
Ysleta, TX	2802

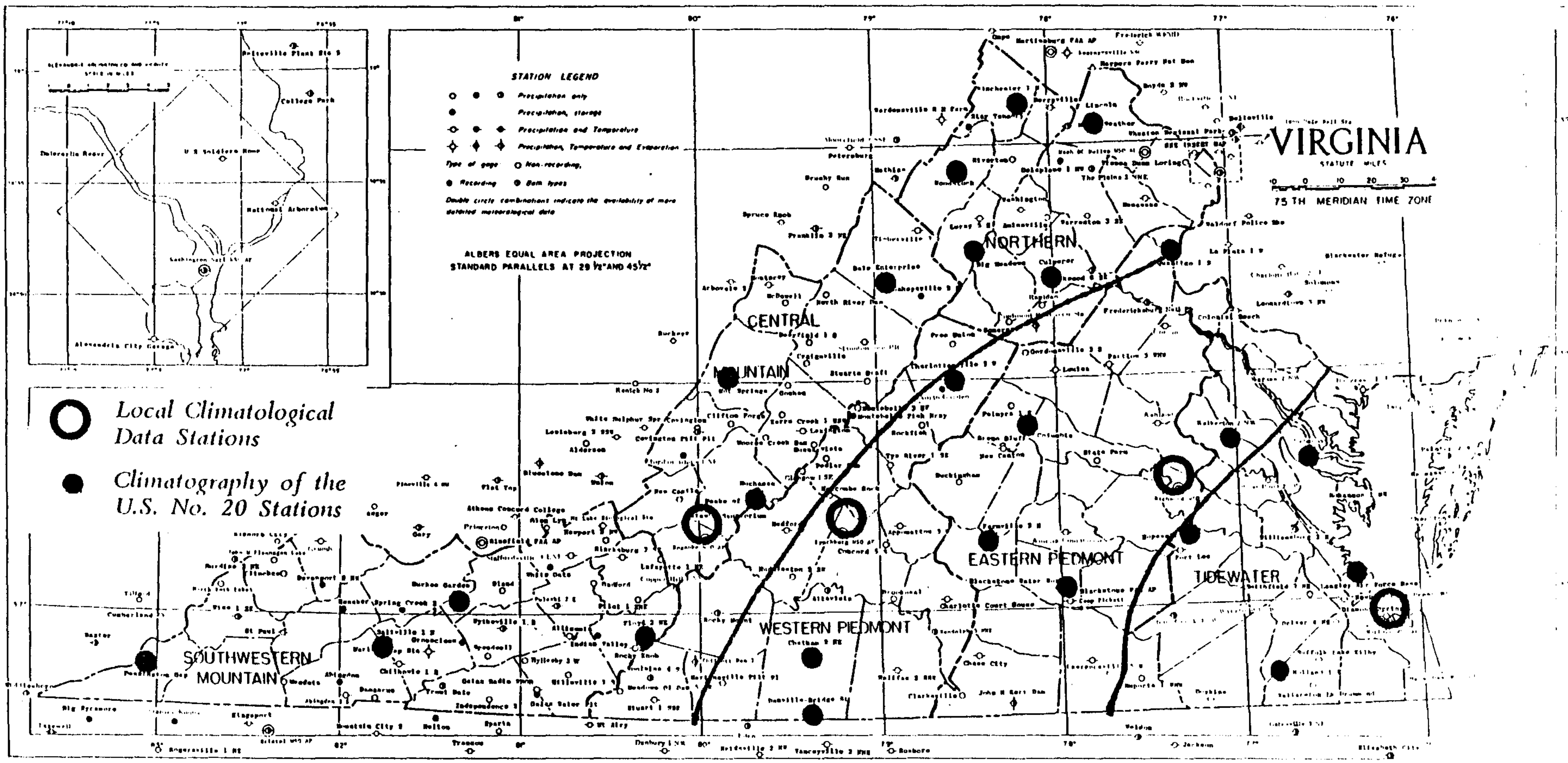
Applicability

Most of the numbers which appear in the Guidelines apply to Hartford, Connecticut including the Solar Performance Table and the Example Tables. Also the worked Example and the Cooling Worksheet IV calculation are applicable only in the region immediately around Hartford.

The general guidance related to conservation, passive solar, and natural cooling design is applicable throughout all New England.

The passive solar performance calculation of Worksheets I and II are applicable in the region around Hartford, Connecticut defined roughly by Albany NY, Amherst MA, Fitchburg MA, Providence RI, Kingston RI, Bridgeport CT, Poughkeepsie NY, and Albany NY. This region is shown on the map enclosed by the solid line. Hartford is shown by the open circle. Specific sites where degree-day data are given are shown by solid dots. The user should choose the closest location. Be advised, however, that higher heating loads may be expected in mountaineous areas.




VIRGINIA
STATUTE MILES
75 TH MERIDIAN TIME ZONE
STATION LEGEND
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage
Non-recording
Recording
Both types
Double circle combinations indicate the availability of more detailed meteorological data
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29 1/2° AND 45 1/2°
Local Climatological Data Stations
Climatography of the U.S. No. 20 Stations
NORTHERN
CENTRAL
MOUNTAIN
EASTERN PIEDMONT
TIDEWATER
WESTERN PIEDMONT
SOUTHWESTERN
MOUNTAIN

Sample Workshop Handouts

These are sample handouts and evaluation forms for your workshop. It is your responsibility to request the correct number of copies of each handout from PSIC.

These will be shipped to the workshop site a few days before the workshop, along with the correct number of Guidelines binders and BuilderGuide discs.

PASSIVE SOLAR INDUSTRIES COUNCIL
1090 Vermont Ave., NW • Suite 1200 • Washington, DC 20005 • (202) 371-0357

Passive Solar Design Workshop

Evaluation

Please take a moment to evaluate the workshop you have just attended.
1 = very poor 5 = excellent

What is your occupation?

____

Please rate the overall workshop.	1	2	3	4	5
Was the material current and useful?	1	2	3	4	5
Please rate the expertise of your instructor.	1	2	3	4	5
Please rate the quality of the slides and viewgraphs.	1	2	3	4	5

Was the technical level	too basic	too high	just right
Was the workshop	too long	too short	just right

What additional areas would you have liked to cover?______________________________

____

What would you change?____

____

Was the workshop worth the price you paid? yes not really

Workshop location (city, state)____

(Note: This is a suggested agenda. As an instructor, you have the option to tailor your course to your specific needs and wishes. It may be desirable to break up the day by using different presenters for different sections of the workshop. You'll find that this helps to keep the audience focused. You may wish to block off this top paragraph and photocopy these two pages to use as your agenda, filling in the spaces.)

PROGRAM AGENDA
Guidelines Workshop

	PRESENTER	TIME ALLOTMENT
* Explanation of how the day will progress	________	________
* Introduction and history of the Guidelines project	________	________
* Who is PSIC? (Members are listed in back of manual-- invite participants to join)	________	________
* Introduce instructor(s) for the day	________	________
* General discussion about design/Why passive solar?/ Passive solar performance potential (use flashy slides here)	________	________

ptsfc

(START USING SCRIPT HERE)

* Part One - Introduction to the Builder Guidelines book (you will be using a site specific Guidelines book here and site specific slides if possible)/Mention applicability maps (slides only during this part) __________ __________

* Part Two - The Basics of Designing with Passive Solar (see page 15 for list of topics) (slides) __________ __________

* Part Three - Strategies for Improving Energy Performance (see page 71 for list of topics) (slides and viewgraphs) __________ __________

Discuss the WORKSHEETS and what they're for... VERY BRIEFLY (viewgraphs) __________ __________

ANYTOWN, USA (viewgraphs) __________ __________

***************************************LUNCH (12:00 - 2:00)****************************

THE WORKED EXAMPLE -- Using site specific data and a completed example go through the worksheets and tables (viewgraphs of completed worksheets) __________ __________

Learning to use and teach BUILDERGUIDE __________ __________

Explain the APPLICABILITY MAPS (Instructors will need to know how these are prepared) __________ __________

WRAPUP __________ __________

THE PASSIVE SOLAR INDUSTRIES COUNCIL

A council of building industry organizations and professionals founded to provide the industry with practical, useful information about passive solar technology and energy-efficient building. Among PSIC's products and services:

• **Passive Solar Design Guidelines** This package, often called the Builder Guidelines, was developed to assist designers and builders in easily evaluating the benefits of various energy-conserving and passive solar design options for their local area. The package includes easy-to-use worksheets and complete recommendations for over 2,000 cities and towns in the US based on climate and other factors specific to each site. These innovative design packages are being presented at workshops all over the country, in cooperation with other national, state and local building industry organizations.

• **Remodeling Guidelines** This package will allow remodelors and home owners to make informed decisions about improving the energy efficiency of their proposed remodeling projects.

• **Workshops** Using the Builder Guidelines, builders, architects, home owners, utility representatives and suppliers learn to build the most energy efficient homes possible when they participate in PSIC's national workshops. Participants are given an inexpensive method of predicting the performance of various design strategies and choosing among the options without complex technical analysis.

• **BuilderGuide** This computer software program helps the user complete the four worksheets that accompany Builder Guidelines. The program operates like a spread sheet, the user fills in the values for the building, and the computer completes the calculations and prints out the answers.

• **National Network** The membership of PSIC is as diverse as the building industry itself. All members have at least one conviction in common; passive solar building can affect their business now, and for the better. Through PSIC, members work together to provide the information, education and promotion necessary to make a positive change in the way all buildings are built.

• **Technical Committee** Technical experts from virtually every sector of the building industry review the results of research and demonstration projects from government and private sources, and act as a unique technical resource for PSIC members and the building industry as a whole.

• **Library** PSIC has acquired and catalogued hundreds of documents from national laboratories, government contractors and agencies, and private programs to form the most comprehensive library of information on passive solar currently available. The library is open to all PSIC members.

• **Promotion** PSIC works to promote the basic concept of good passive solar design, in a non-commercial, non-proprietary way, so that the overall market for a wide range of products and services--everything that can be used in the design or construction of an energy-conscious home or commercial building--can be stimulated and expanded.

• **Recognition** Membership in the Passive Solar Industries Council identifies you as one of the leading organizations or individuals committed to--and informed about--a more intelligent, more efficient way of building. Your customers and clients should be aware that you are making every effort to offer the most advanced, high-quality, energy-efficient product available.

• **Government Activities** PSIC members and staff work regularly with Federal and State government agencies, the United States Congress and the national laboratories. These relationships provide access to technical resources, research, information, and practical support for PSIC's members and programs.

• **Small Commercial Guidelines** Expected in December 1992, the Small Commercial /Institutional Guidelines will enable building owners to build more comfortable, affordable buildings by incorporating a daylighting component into existing passive heating and cooling data.

Instructor's Script

Using the Script

• Each page of the script corresponds to a slide or a slide and a viewgraph.

• On the bottom center of each page in the script you will find the page number which corresponds to a slide or a slide and a viewgraph. This number NEVER corresponds to a page in the Guidelines workbook.

• On the top left of each script page you will find a designation saying "Builder Guidelines: Preview" or "Builder Guidelines: Page ____." This tells you exactly where you are in the Builder Guidelines and allows you to tell the workshop attendees what page you're covering at any point during the workshop. They should be following along with you, page by page. The "Preview" section of the script, however, does not actually correspond to the Guidelines workbook. Preview script is that which is used at the very beginning of the program, prior to launching into the workbook.

• Each slide or viewgraph is described on the righthand side of the page. If there is text on a slide we have noted it exactly. If there is a diagram or graphic we have described it.

• The blank space to the left of the slide description is for you to xerox the picture of our slide -- or your own replacement slide.

• The "Instructor's Text" is the information we expect you to convey to the audience. We don't expect you to read it or be boring...but these are the minimum concepts that should be covered.

• The "Notes" section sometimes has a caution or extra information for you. We tried to leave as much space clear as possible so you can fill in reminders for yourself.

• There are a number of houses in the slides whose locations are unknown at this time (they are noted in the "Notes" section). Once these locations have been identified, you will receive a sheet with that information. However, feel free to substitute your own slides if you feel they are appropriate.

• The workshop should be set up with two screens, one for the slides and one for the viewgraphs. Each viewgraph in your script is coordinated with a slide. The idea is that when the script indicates it is time for a viewgraph, you will have a slide up on one screen while you're explaining the viewgraph information, which is shown on the other screen.

Builder Guidelines: Preview

Slide Text:

Workshop Agenda

A. Introduction
B. Guidelines
    Part One. Introduction
    Part Two. The Basics
    Part Three. Improving Performance
C. Worksheets
D. Worked Example
E. BuilderGuide software

Instructor's Text:

Notes:

This slide should be on the screen as the attendees enter the room.

Slide Text:

Passive Solar Design Strategies

Instructor's Text:

Good morning and welcome to the Passive Solar Design Strategies Workshop. Thank you all very much for coming. My name is ________________, and I will be teaching the workshop today.

Notes:

Slide Text:

Passive Solar Design Strategies:
Guidelines for Home Builders

Developed by:

PSIC (Passive Solar Industries Council)
NAHB (National Association of Home Builders)
NREL (National Renewable Energy Laboratory) (formerly SERI)

Funded by U.S. Department of Energy

Instructor's Text:

For today's workshop we will be using as our text Passive Solar Design Strategies: Guidelines for Home Builders. As you can see, this book was developed as a cooperative effort by... (see slide)

Notes:

Slide Text:

* Builders
* Architects
* Product Manufacturers
* Utility Representatives
* Engineers
* Professors
* Scientists
* Building Systems Experts

Instructor's Text:

The Guidelines are the result of almost a decade of research development. It is a very practical tool because of the input received from so many different sectors of the building and energy communities. The list you see here shows the wide variety of professionals who participated in the development of the Guidelines. Specifically, the Guidelines were created by Dr. J. Douglas Balcomb of the National Renewable Energy Laboratory (NREL, formerly SERI), Charles Eley Associates, and the individual members of PSIC.

Notes:

Slide Text:

Passive Solar Industries Council
(PSIC)

Instructor's Text:

The Passive Solar Industries Council coordinated the project. PSIC was formed in 1980...

Notes:

Slide Text:

PSIC Founding Members:

* American Institute of Architects
* American Wood Council
* Architectural Aluminum Manufacturers Association
* Brick Institute of America
* Building Owners and Managers Association
* International Masonry Institute
* National Association of Home Builders
* NAHB Research Foundation
* National Concrete Masonry Association
* National Wood Window and Door Association
* Northeastern Retail Lumbermens Association
* Sealed Insulating Glass Manufacturers Association

Instructor's Text:

...by numerous organizations committed to energy efficiency in building. This commitment provided by a common ground for these organizations that would not necessarily always be on the same wavelength, and in fact in many other ways compete with each other. These are the founding members of PSIC.

Notes:

Slide Text:

PSIC Regular Members:

* AFG Industries, Inc.
* American Institute of Architects
* Andersen Corporation
* Brick Institute of America
* Cardinal Insulating Glass
* Edison Electric Institute
* Libbey-Owens-Ford Co.
* National Association of the Remodeling Industry
* National Wood Window and Door Association
* Solar Energy Industries Association

Instructor's Text:

And some regular members will give you an idea of the diversity of this organization.

Notes:

Slide Text:

PSIC Member Products and Services:

* Brick
* Concrete Masonry
* Doors
* Glass
* Insulation
* Windows
* Wood

* Architecture
* Building
* Building Systems Consulting
* Engineering
* Remodeling

Instructor's Text:

As will the products and services that PSIC members provide.

Notes:

Builder Guidelines: Preview

Slide Text:

(Photo of The Guidelines)

Instructor's Text:

Now turn to the workbook.

Notes:

Slide Text:

(Photo of Norm Weaver at screen
demonstrating BuilderGuide)

Instructor's Text:

BuilderGuide is the software program that supports the Guidelines. BuilderGuide allows the user to quickly and accurately work through the calculations in the worksheets.

Notes:

Slide Text:

(Photo of PSIC's newsletter called
" Buildings: Inside & Out")

Instructor's Text:

The passive solar newsletter, Buildings: Inside and Out, containing up-to-date information on passive solar and energy efficient building design, the latest in the marketplace, and what's happening on the legislative end of things.

Notes:

Slide Text:

(Slide not complete at this time)

(Photo of Washington, DC)

Instructor's Text:

The Passive Solar Library, with hundreds of volumes of information on passive solar and energy efficient building design and construction. This is only library of its kind. The library is located in PSIC's offices in Washington, DC.

Notes:

Slide Text:

Other Guidelines available from PSIC:

* Passive Solar Design Strategies: Remodeling Guidelines for Conserving Energy at Home

* Small Commercial Building Guidelines Completion date: 1993)

Instructor's Text:

PSIC is not only involved in the development of residential guidelines, however. They have developed Residential Remodeling Guidelines, called Passive Solar Design Strategies: Remodeling Guidelines for Conserving Energy at Home, and are developing Guidelines for Small Commercial Buildings. The remodeling guidelines are currently available, and the small commercial guidelines will be completed in 1993.

Notes:

Builder Guidelines: Viewgraph

Viewgraph Description:

Applicability Map

Instructor's Text:

Note that this book has been made for this location. It was specifically made for __________, but it can be used within the boundary of the line shown.

Notes:

Instructors can feel free to make a slide instead of using a viewgraph here.

Slide Text:

Part One
- Introduction to Passive Solar
- Performance Potential

Part Two
- Basic Concepts
- Advantages
- How Systems Work

Part Three
- Specific Design Guidance
- Examples for Saving 20%, 40%, 60% compared to the Base Case

Instructor's Text:

The Guidelines we will be using today, however, focus on new residential construction and have three basic sections: We will review each section and also work through the worksheets...

Notes:

Slide Text:

* slide shows worksheets

Instructor's Text:

...which is how you will go about determining the level of energy efficiency you can achieve in your particular project.

Notes:

Slide Text:

Part One: Introduction

1. Introduction to the Passive Solar
   Design Strategies Package

2. Passive Solar Performance Potential

Instructor's Text:

Part I describes passive solar strategies that work in this climate, and how we calculate the different performance levels. Now flip to page 1.

Notes:

Slide Text:

Passive Solar Design Strategies

* Guidelines
* Worksheets
* Example: Worked Example (site specific)

Instructor's Text:

Now flip to page 2. We'll be working through three major sections of The Builder Guidelines today. The first section, called the Guidelines section, goes over general concepts of passive solar design and gives specific design guidance.

The second section of the workbook is the Worksheets. In this section users work through four simple fill-in-the-blank worksheets that will help them evaluate their specific design choices.

Finally, there is The Worked Example. This has site specific data and is what users of The Builder Guidelines will work through to determine design options for their specific locations.

Notes:

Slide Description:

(Photo of a gorgeous house)

Instructor's Text:

Here is a brief overview of what we are going to talk about for the first part of the day. Some principles of passive solar design remain the same in every climate. But the important thing about passive solar is that it makes better use of the opportunities in a house's surroundings. So, many fundamental aspects of the passive solar house's design will depend on the conditions in a small local area, and even on the features of the building site itself. Many of the suggestions in this section, called the Guidelines, apply specifically to this location, but there is also information in this section which will be useful in any climate.

Notes:

Be careful here -- there can be some confusion because the entire document itself is called Passive Solar Design Strategies: Guidelines for Home Builders, often referred to as The Builder Guidelines. Here we are referring just to the first section of the document, which is the Guidelines section.

INSTRUCTORS!!! In many cases slides of homes and building details have been provided to PSIC members and friends over the years and are simply here to illustrate a point. We have included the location when it was available.

Slide Description:

(Photo of attractive house, lit up at dusk)

Instructor's Text:

In Part Two, we'll look at basic design and construction techniques. This is also where we'll discuss the advantages of passive solar, its terminology, how it relates to other kinds of energy conservation measures, how the primary passive solar systems work, and what the builder's most important considerations should be when evaluating the use of passive solar strategies.

Notes:

Slide Description:

(Slide shows a diagram of four quadrants, with the following terms: suntempered, direct gain, sunspaces, and thermal storage wall)

Instructor's Text:

In Part Three we'll talk specifically about the techniques you'll use for suntempering, building direct gain systems, thermal storage mass walls, and sunspaces. We'll be comparing different strategies throughout the day so that you will be able to choose the type of construction, conservation and passive levels that fit your market the best.

Notes:

Viewgraph Description:

Base Case Table from page 2 of
Presentation Materials

Instructor's Text:

This viewgraph shows what would typically be built in this area and the heating and cooling energy requirements. (Explain)

Notes:

Slide Text:

Base Case
Developed for this area using typical new construction techniques based on 1987 NAHB survey.

Instructor's Text:

Developing the Base Case. The thermal performance of a base case house for this area was calculated for this location. This base case house is referred to throughout the workshop and examples are provided to show you that 20 %, 40 %, or 60 % energy savings are possible by implementing any of the design strategies. These are not recommended designs, just an indicator of strategies that would lead to these savings. You may pick and choose the approach that works best for you.

Notes:

The instructor should show the Base Case viewgraph for this location on the other screen.

The instructor must understand the concept behind NAHB developing the Base Case, but it is not important that he or she explain it to the audience. The instructor can move through this quickly, but it is important that the Base Case not be confused with the Worked Example. The Worked Example is a passive solar house; the Base Case is not.

Slide Description:

(Shows a picture of a man doing insulation work.)

Instructor's Text:

You have several options to achieve these performance levels. They work well alone or in combination as you'll see later. " Increased levels of insulation..."

Notes:

Slide Description:

(Shows beautiful home under construction
with lots of windows)

Instructor's Text:

Suntempering - by adding some south glass up to the limit where extra mass would be required if more glass were added. In suntempering, the mass of the house and furnishings is adequate for the amount of south glass.

Notes:

The location of this house is unknown.

Slide Description:

(Shows graphic of direct gain)

Instructor's Text:

And, passive solar treatment which can be incorporated in three different ways: Through Direct Gain, which adds south glass beyond the suntempering limit. Mass is added as required to store the excess solar heat.

Notes:

Slide Description:

(Shows graphic of a sunspace)

Instructor's Text:

Through using Sunspaces, which are separate, unconditioned rooms on the south side of the house.

Notes:

Slide Description:

(Shows thermal storage wall system)

Instructor's Text:

And through Thermal Storage Walls, which place the mass just behind the south windows. Or, you can use combinations of these systems.

Notes:

Slide Text:

Worksheets

Worksheet I. Conservation Performance Level

Worksheet II. Auxiliary Heat Performance Level

Worksheet III. Thermal Mass/Comfort

Worksheet IV. Summer Performance Cooling Level

Instructor's Text:

Included with the Guidelines are four worksheets and accompanying tables addressing conservation, auxiliary heating, thermal mass, comfort, and cooling.

Notes:

Slide Description:

(Shows part of worksheets)

Instructor's Text:

We will be going over the worksheets later this afternoon. The worksheets will show how well the energy conservation measures will perform, how much the solar features will contribute to the building's total heating energy needs, how comfortable the house will be and how much the total annual cooling load can be reduced.

Notes:

Be very brief here. We're still just introducing everything. The worksheets calculate annual average energy use, but peak energy demand is not reflected in average use. The worksheets are <u>NOT</u> intended to be used to size equipment.

Slide Text:

Performance Potential of Passive
Solar Strategies

Instructor's Text:

To give you an idea of the performance potential in this area we prepared a table shown on Page 6. Suntempered performance tends to be better than the Base Case but larger savings are generally only achieved with passive solar design strategies. This just gives you some options. Some are more affordable than others.

Notes:

Use the performance potential viewgraph for the location on the other screen.

Viewgraph Description

Performance Potential Table from page 3 of Presentation Materials

Instructor's Text:

(Refer to page 6 in the Guidelines)

This viewgraph shows the performance change due to adding various strategies to the base case house.

Notes:

Instructor pulls the site specific "performance potential" sheet from the presentation materials.

Builder Guidelines: Page 7

Slide Text:

Part Two: Basics of Passive Solar

Instructor's Text:

Flip to page 7.

1). Why should passive solar be used? Is it more than just a question of energy?

2). Key Concepts: Energy Conservation, Suntempering, Passive Solar

3). Improving Conservation Performance

4). Mechanical Systems

5). South-Facing Glass

6). Thermal Mass

7). Orientation

8). Site Planning for Solar Access

9). Interior Space Planning

10). Putting it Together: The House as a System

Notes:

Put the above on a viewgraph or a slide

Builder Guidelines: Page 8

Slide Description:

(Photo shows bundles of cash)

Instructor's Text:

Advantages of Passive Solar include lower energy bills all year-round,

Notes:

Go to the chart on the bottom of page 8 called "Advantages of Passive Solar". We have one slide for each bullet.

Builder Guidelines: Page 8 (continued)

Slide Description:

(Shows sunny interior space)

Instructor's Text:

Large windows and views, sunny interiors, open floor plans,

Notes:

This home is located in

Slide Description:

(Sunny interior, slate floor, brick fireplace, doors leading to the sunspace)

Instructor's Text:

Quiet, solid construction, warmer in the winter, cooler in the summer,

---

Notes:

Slide Description:

(Shows beautiful exterior shot of house,
with "sold" typed over the picture)

Instructor's Text:

High owner satisfaction with high resale value,

Notes:

This house is located in

Slide Description:

(Exterior view of a stone house in the sun)

Instructor's Text:

Natural materials often represent low maintenance, durability and reduced maintenance and repairs. Passive solar and energy efficient design incorporate ordinary materials and components that are durable and easy to repair.

Notes:

i.e., More glass means more glass to clean, or break and more shading with drapes or blinds. However, using natural materials such as brick, block or stone means less area to paint and less painted area to maintain. Greater efficiency means a smaller HVAC unit and less HVAC maintenance, etc.

Slide Description:

(Shows an oil tanker and a power plant)

Instructor's Text:

Increased independence from rises in fuel costs continue long after initial costs have been recovered. The slightly higher costs of passive solar is a profitable investment.

Notes:

Slide Description:

(Photo shows brown, smoggy air hanging over an urban scene)

Instructor's Text:

Clean, renewable energy to combat growing concerns over global warming, acid rain and ozone depletion.

Notes:

Slide Description:

(Home under construction showing
man insulating around windows)

Instructor's Text:

The most important measures for improving the house's basic ability to conserve the heat generated either by the sun or by the house's conventional heating system are in the following areas:

1. Better thermal protection.
2. Reduced air leakage while maintaining good interior air quality.
3. Glass on east, west and north need to be energy efficient and sized to provide good daylighting.

Notes:

Slide Description:

(Man installing insulation)

Instructor's Text:

There are three ways to enhance energy performance. The thermal performance is affected not only by the thermal resistance of the insulation, but also the resistance of other elements in the construction assembly, including framing, sheathing and drywall.

Notes:

The worksheet tables in The Builder Guidelines use Equivalent Construction R-Values which account for the heat flow through other materials as well as the insulation. These values are limited to typical wood frame construction systems. Masonry wall systems perform differently and have different paths of heat flow. For more information see NCMA TEK 67 and BIA Tech Notes 4 Series.

Slide Description:

(Insulation shown in attic space)

Instructor's Text:

In attics, framing effects are minimized if insulation covers the exposed ceiling joists. Use either blown-in insulation or run a layer of batts in the opposite direction off the joists, once the spaces between the joists have been insulated with batt or blown-in insulation. Insulation should extend over the walls. May require a higher truss.

Notes:

Refer to the graphic on Page 10.

Slide Description:

(A cathedral ceiling slide)

Instructor's Text:

Minimizing framing effects in cathedral ceilings is more difficult and is typically done by installing insulation over the roof decking.

Notes:

Builder Guidelines: Page 10 (continued)

Slide Description:

(Use graphic from Builder Guidelines, page 42, showing two different insulation examples)

Instructor's Text:

Slab edge insulation should be extended down from the top of the slab. Protect exposed insulation from weathering and physical damage.

The insulation varies with location:

< 2000 HDD	insulation not required
2000 - 6000 HDD	2' minimum
> 6000 HDD	4' minimum

Notes:

The text in the 3rd column on page 10 varies for each climate region. Confirm the recommended strategies from this page of the text of The Guidelines that you are teaching. The R-value varies as recommended in worksheets

Slide Description:

(Graphic of basement walls)

Instructor's Text:

If you are building a heated basement in a cold climate, the walls should be fully insulated. Typically, the lower portion, more than four feet below grade, only needs about half the insulation level of the top. However, local codes may dictate required levels of insulation.

Notes:

Changing the amount of insulation may be more costly than using the same amount for the full height because of installation costs and time.

Slide Description:

(Shows man applying foam to a joint)

Instructor's Text:

When it comes to energy conservation, sealing the house is just as important as adding insulation. The tightness of the house is measured in air changes per hour. A comfortable, energy efficient house will have approximately a third of an air change per hour. Increasing the tightness beyond these levels will improve energy performance but may cause moisture build-up, indoor air quality problems and inadequate combustion and draft air supply for fireplaces and furnaces, unless proper ventilation strategies are used.

Notes:

If air changes get below .35, mechanical ventilation will be required, which adds extra cost. Be aware of the implications of extra cost and "tightening" the house.

You may wish to use a viewgraph of the checklist on Builder Guidelines page 11 while you are going through the slides for this page.

Slide Description:

(Photo shows snow that's come in through poorly sealed sliding glass doors.)

Instructor's Text:

Seal the gaps between openings and ducts, vents or other penetrations by filling the gaps with insulation foam, or back up rod and apply a sealant. In the basement, cover and seal sump pits. Remember to seal around windows and doors, all plumbing and electrical penetrations, all headers and sills and the foundation wall and the basement slab intersection. This keeps moisture and radon out.

Notes:

Slide Description:

(Photo of vapor barrier)

Instructor's Text:

Install vapor retarders and air barriers.

Notes:

Double sealing both the outside and inside surfaces of walls with vapor retarders has proven to be detrimental in some locations, causing accelerated deterioration of wood framing elements and reducing the performance of batt insulation because of elevated moisture contents. Use only one vapor retarding barrier, located on the interior or near the interior of the wall.

Slide Description:

(Slide is the first five points on the Checklist found on Page 11)

Instructor's Text:

Flip to page 11. Here's a checklist for minimizing air leakage.

Notes:

Air infiltration can have a major impact. You should probably be looking at .5 to .35 air changes per hour for effective passive design. Tighter than .35 might create problems with indoor air quality, smoke accumulation, and humidity. In a very, very tight house humidity from people and showers will be a tremendous problem, even in a dry location. Again, with below .35 natural infiltration per house mechanical ventilation should be used. (Mechanical ventilation is not covered in this workbook.)

Slide Description

(slide shows points 6 - 10 of the Checklist from page 11.)

Instructor's Text:

Notes:

Continue discussing the checklist.

Slide Description

(Slide shows points 11 - 16 from the Checklist on Page 11)

Instructor's Text:

Notes:

(Continue discussing the checklist.)

Slide Description:

(Photo from inside, showing great view)

Instructor's Text:

Most of the reasons people want windows have very little to do with energy, so the best design will probably be a good working compromise between efficiency and other benefits, such as bright living spaces and views.

Notes:

Floor to ceiling windows give a good viewing of the lawn near the house but are not necessary for distant views. Consider what view should be captured and where the occupants will be viewing from when placing windows.

Slide Description:

(Graphic of glazing insulating values)

Instructor's Text:

Triple-glazing or double-glazing with a low-e coating on non-solar glass is advisable. Low-e glazing on these non-solar windows may be an especially useful solution because some low-e coatings can insulate in winter and shield against unwanted heat gain in summer.

Notes:

Regional text varies between double and triple pane. You may wish to explain further how low-e works.

Slide Description:

(Graphic of a quad-paned window)

Instructor's Text:

This is an example of a high-R modern window. This is a quad pane; the two inner glazings are low-e films. The window is filled with a low conductance argon gas. The R-value is in the center of the window. At this point one must be careful of heat loss through the frame. Since the best frames are less than R-8, the overall R-value of the window and frame may be closer to R-5.

Notes:

Slide Description:

(Photo of a beige townhouse showing north/west exposure)

Instructor's Text:

In cold climates, heat losses through north-facing windows should be minimized either by reduced areas of glazing or the use of glazing with high thermal resistance or R-value. On the left facade of this townhouse, north glazing is minimized. Since north windows receive little direct sun in summer, they do not present much of a shading problem. West windows may be the most problematic, and there are few fixed shading systems that will be effective enough to offset the potential for overheating from a large west-facing window.

The area of west windows on this building is also minimized for adequate control of late afternoon sun which often causes overheating.

Notes:

A fixed trellis extending 8 feet or more provides shading and enhances view by keeping sun off of viewers' eyes. North windows will receive morning and late afternoon sun in temperature latitudes. This varies with the region, as there is more north sun at higher latitudes.

Exterior shading is typically awnings, Bahama shutters, roller screens, fixed louvered roofed terraces, and reflective tints.

Interior shading systems include blinds, drapes, etc., and are generally less effective than exterior shading. This is not specifically because they require operation but because the solar heat gain is already inside the structure.

The location of this house is

Slide Description:

(Photo of the previous townhome showing the southern exposure)

Instructor's Text:

The southern exposure is on the left hand side of the same townhouse and incorporates passive solar glazing. East facing windows are generally preferred over west facing windows because the heat gains through west windows coincide with the highest ambient air temperatures.

East windows catch the morning sun. Unfortunately, this may cause potential overheating problems in the summer and should be carefully considered. On the east or right hand side of this townhouse, east windows are incorporated to provide morning sun but not exaggerated to easily control summer sun.

Notes:

Effects may be reduced with tinted, reflective, high R or Low-e glass.

Slide Description:

(Photo of a sunny breakfast space with a fireplace)

Instructor's Text:

As an example of proper design, south and east-facing windows provide a very pleasant breakfast space for this home.

Notes:

Slide Text:

Mechanical Systems:
- System Sizing
- Night Setback
- Ducts

Instructor's Text:

The passive solar features in a house and the mechanical systems will interact year round. The most effective approach will be to design the systems to work together. Three areas are worth noting: System Sizing, Night Setbacks, & Ducts.

The backup systems should be sized to provide 100% of the heating and cooling loads, but no larger. Oversized systems will cost more and the frequent cycling will waste energy.

Supply and return ducts should be located in conditioned spaces or be well-insulated if they're in an unconditioned space. In fact, even those ducts located in conditioned spaces should be well insulated. Seal all duct joints with mastic.

Notes:

In the National Association of Home Builders' Energy-Efficient House Project, all the rooms were fed with low, central air supplies, as opposed to the usual placement of registers under windows at the end of long runs. This resulted in good comfort and energy performance. The performance of even the most beautifully designed passive solar house can easily be undermined by details like uninsulated ducts, or by overlooking other basic energy conservation measures. Avoid large night setbacks in high mass homes, HC>5 and setback >5 deg. F. Try to get heat and cool at night to offset peak loads with passive solar systems. Benefit in many areas is reduced off peak utility rates.

INSTRUCTOR'S BEWARE! You'll be asked a lot of questions about sizing mechanical equipment. You should simply refer to local codes and practice. Know if the area in which you are teaching has adopted the Model Energy Code and if so, which version.

We recognize <u>The Guidelines</u> are brief on this subject, but this is because the emphasis is on house design to minimize the need for HVAC.

Slide Description:

(Photo of south facing glass, just
reflection of the sun)

Instructor's Text:

Appropriately sized south facing glass is a key component of any passive design. The glass area must provide maximum solar heating without overheating in winter or creating an excessive cooling load in the summer. To avoid overheating, increased amounts of south-facing glass must be complimented with added thermal storage. There are three types of limits on south facing glass.

Notes:

The location of this house is

Slide Description:

(Photo of a house with small amount of glass)

Instructor's Text:

The area of south-facing glass for suntempered homes should not exceed 7% of the total floor area of the house. House sheetrock, framing, and furnishings provide adequate heat storage.

Notes:

This is not regional. This is a stock number.

The location of this house is unknown.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use South Facing Glass Table from
page 4 of Presentation Materials

Instructor's Text:

Notes:

Go over the three types of limits on south-glass on the viewgraph as per the slide.

Only the larger number changes with location. It is usually 20% but can be smaller in mild climates.

Slide Description:

(Photo should show slightly more glass
than the slide above)

Instructor's Text:

For direct gain systems which have added thermal mass, the amount of solar or south facing glass should not exceed 12 % of the floor area of the house.

Notes:

Direct gain going up to 12% is not so much a thermal issue, because you could put in enough mass, but rather a consideration of liveability because if you get too much solar gain you get glare and fading due to UV radiation. In terms of liveability, in a 1500 s.f. house it's better not to exceed 180 s.f. of direct gain glass even with enough thermal mass.

The location of this house is unknown.

Slide Description:

(Third photo slide showing still more glass than previous two slides)

Instructor's Text:

To go beyond the 12% Direct Gain limit, you will be using an indirect system, such as a sunspace or thermal storage wall. However, even in these cases the total amount of south glass used as passive solar collector should not exceed 20 % of the house's floor area.

This house shows a mixture of direct gain and a sunspace in the center for a total of about 20% south glass.

Notes:

The 20% limit is based on excessive solar gains. The limit may be smaller in some mild climates. Check the guidelines text on page 14.

The location of this house is

Slide Description:

(Slide of tilted glass)

Instructor's Text:

Tilted glazings are better solar collectors than vertical. If properly designed and balanced with mass and sun control, tilted glass can be very effective and result in a comfortable indoor environment. However, tilted glazing can cause serious overheating problems and present possible problems with leakage. Ordinary vertical glazing is easier to shade, less likely to overheat, less susceptible to damage and leaking, and so is often a better year-round solution.

Notes:

This changes by region. Tilted glass might be an option in climates where heating is a major issue and cooling is not as much of an issue.

Take a clue from the Worked Example. If tilted glazing is used (SSD1) then tilted glazing may be appropriate. If vertical glazing is used (SSC1) then don't recommend tilted glazing in any case.

The location of this house is unknown.

Slide Description:

(Photo shows interior - no fireplace - no brick - carpeted floor)

Instructor's Text:

Some heat storage capacity (thermal mass) is present in all houses, gypsum board, floor coverings and furnishings. This modest amount of mass is sufficient for the sun-tempered houses. More thermal mass is required in passive solar houses.

Notes:

This mass provides sufficient thermal storage for a south glass area equal to 7% of the house floor area. This will give a temperature savings of about 10 degrees F on a clear winter day.

The location of this house is unkown.

Slide Description:

(Photo shows brick floor and wall in the sun)

Instructor's Text:

Thermal mass in a passive solar house is usually brick, tile, concrete, or concrete masonry used in floor or wall construction.

Notes:

Added mass should be about 6 s.f. for each s.f. of direct gain glass area in excess of the 7% suntempering limit.

Builder Guidelines: Page 15 (continued)

Slide Description:

(Photo shows phase change storage panels)

Instructor's Text:

Phase change materials which store and release heat through a chemical reaction can also be used for thermal storage.

Notes:

Successfully performing components or systems may be difficult to locate at this time. The panels in the pictures were made by Dow Chemical. Dow sold the rights. They may not be available any longer.

Slide Description:

Graphic shows solar heat gain for various window orientations.

Instructor's Text:

Solar heat gain follows two basic patterns:

On north, east and west, and horizontal orientations solar heat gain peaks in the summer and is minimal in the winter. On the south orientation solar heat gain peaks in the winter and is minimal in the summer. This is why passive solar design always employs south glass.

Notes:

This slide is for 40 degrees latitude and refers to clear-day solar incident on the window.

Slide Description:

(Chart on page 15 in the Guidelines.)

"Heat Storage Properties of Materials"

Instructor's Text:

Typical heat storage properties of thermal mass materials are shown here. The values used in the analysis in the Guidelines depend on the materials' thermal properties and the material thickness. Not only is the amount of thermal mass important, the material properties and their location are important as well. The thermal storage capabilities of a given material depend on its conductivity, specific heat and density. Design issues related to thermal mass depend on the passive system type. For sunspaces and thermal storage wall systems, the required mass of the system is included in the design itself. For direct gain, the added mass must be within the rooms receiving the sunlight.

Notes:

Builder Guidelines: Page 16

Slide Description:

(Graphic showing a compass with true south)

Instructor's Text:

Flip to page 16. Compass south is different than "true south" in most cases. In this location, (read from page 16 of your Guidelines book)

Notes:

Instructor should be familiar with solar declination if asked to explain the principle.

Slide Description:

(Graphic of a house with indication of degrees off true south.)

Instructor's Text:

When glazing is oriented more than 30 degrees off true south, not only is winter solar performance reduced, but summer air conditioning loads increase significantly especially as the orientation goes west. Orientations of plus or minus 15 degrees of true south are preferred. The warmer the climate, the more east - and west-facing glass will tend to cause overheating problems. In general, southeast orientations present less of a problem than southwest.

Notes:

Be careful here. Stress the guideline "within 15 degrees of true south."

Slide Description:

(Graphic showing an "elongated house"
running east/west)

Instructor's Text:

Window layout is easiest if the house is oriented east-west having its largest wall facing south, but this is not a requirement. As a practical matter, if the house's short side has a good southern exposure it will usually accommodate sufficient glazing for an effective passive solar system.

Notes:

Slide Description:

(Photo of a subdivision layout)

Instructor's Text:

The ideal site plan will take not only the orientation of south facing glass into account, but will include the slope of the site, the individual house design, the direction of the prevailing breezes, the views, and the street layouts. Site layout is often one of the least expensive steps to a good energy efficient design.

Notes:

Slide Description:

(Graphic of diagram in column two on page 17 of The Guidelines)

Instructor's Text:

The house should be exposed to sunlight with no obstructions with an arc of 60 degrees on either side of true south, but reasonable good solar access will still be guaranteed if the glazing is unshaded within an arc of 45 degrees. The caption for this diagram is location specific.

Notes:

Use a viewgraph here also, with A,B,C values shown.

Slide Description:

Graphic of top diagram in column three on page 17.)

Instructor's Text:

Lay out lots so the houses will not shade one another.

Notes:

With proper planning, solar access will not pose a problem. But the subdivision must be laid out with this in mind.

Slide Description:

(Shows house with tree in front that would shade south wall)

Instructor's Text:

Buildings, trees or other obstructions shouldn't shade the south wall. Even deciduous trees with bare branches will reduce winter solar radiation incident by 50% or more. A myth exists that deciduous trees on south are okay. That is a mistake and shouldn't be done.

Notes:

In this photograph, the winter shading due to the tree on the left will be about 20% which is unacceptable. Make note of all the reflections of the tree branches to prove the point even further.

Slide Description:

(Shows subdivision of solar homes, bottom graphic from column three, page 17)

Instructor's Text:

Sometimes it is not possible to orient all structures in a subdivision along the east-west axis. Simply increase the amount of south facing glazing. Where the streets run north-south, creation of east-west cul-de-sacs will help ensure solar access.

Notes:

Mention the references at the bottom of Column 3, page 17 of the Guidelines. Grids allow for better traffic flow than cul-de-sacs.

Builder Guidelines: Page 18

Slide Description:

(Bubble diagram from page 18)

Instructor's Text:

Living areas should be located on the south side to benefit from the solar heat. The closets, storage areas, garage and other-less used rooms can act as buffers along the north side.

Notes:

Slide Description:

(Photo of an open floor plan)

Instructor's Text:

An open floor plan will allow the collected solar heat to circulate freely through natural convection. Open floor plans may sacrifice occupant privacy, but they add a feeling of spaciousness even in a small house.

Notes:

Slide Description:

(Photo is a breakfast nook with a north-south partition made of stone)

Instructor's Text:

Orienting internal mass walls as north-south partitions allows the mass to be warmed by morning and afternoon sun, making maximum use of the thermal mass.

The mass wall in this photo runs north/south in the center of the house plan.

Notes:

Interior partitions make better use of the thermal mass than exterior walls because both sides are exposed...there is more surface area facing into the house.

Builder Guidelines: Page 18 (continued)

Slide Text:

(Shows a clerestory window)

Instructor's Text:

South facing clerestory windows bring solar heat and daylight into the northern zones of the house.

Notes:

Slide Description:

(Graphic/cartoon shows a guy sitting sitting at his desk.)

Instructor's Text:

"Putting it all together" is important!

Many different factors will affect the overall performance: the mechanical system, the insulation, the house's tightness, the effects of the passive solar features, the appliances, and the actions of the people who live in the house.

A sensible energy-efficient house uses a combination of techniques.

Notes:

Builder Guidelines: Page 19

Slide Description:

(Slide repeats the "Checklist for Good Design" found on Page 19 of the Guidelines)

Instructor's Text:

A checklist is provided for you on page 19 which reinforces all the points we've just listed.

Notes:

Slide Text:

Part Three:
Strategies for Improving Energy Performance

1. Example Tables
2. Suntempering
3. Direct Gain
4. Sunspaces
5. Thermal Storage Wall
6. Combined Systems
7. Natural Cooling Guidelines

Instructor's Text:

Part three addresses the strategies for improving energy performance. Suntempering and other passive solar techniques are covered. Guidelines for natural cooling are provided.

Notes:

Details for all the Example Tables are found on page 54. These are for explaining concepts and trade-offs, generally. You must read Part 3, pages 22-37 carefully if you teach in several areas, because these concepts are location specific. A direct gain system may out perform a thermal storage wall in one area of the country. The reverse will be true in another area. Performance <u>and</u> Economics have to be taken into consideration. Walk the audience through each concept carefully, so they understand how to make trade offs between their Base Case House, 20 %, 40 % or 60 % savings and which is most economical.

Slide Text:

The Base Case House

Instructor's Text:

As part of the explanation of each system, example tables present the following information about a Base Case house, based on a National Association of Home Builders study of typical construction:

- Insulation levels (ceilings, walls, floors);

- Insulation added to the perimeter of the basement walls;

- Tightness (Measured in air changes per hour, ACH);

- Glass area on each side (measured as a percentage of floor area);

- The "percent solar savings" (the part of a house's heating energy saved by the solar features); and

- Three numbers corresponding to Conservation, Auxiliary Heat, and Cooling Performance. The Example tables then show how the house could be changed to reduce winter heating energy by 20, 40 and 60%.

Notes:

Use the suntempering example viewgraph.

At this point instructor will cover up everything on viewgraph but Base Case column.

Slide Text:

Design Strategies

• Suntempering
• Direct Gain
• Sunspaces
• Thermal Storage Walls

Instructor's Text:

First: Consider the energy conservation strategies and proper orientation. You must be amenable to increasing the glass on the south face of the house.

Today we'll talk about four different design strategies: suntempering, direct gain, sunspaces, and thermal storage walls.

Notes:

Slide Description:

(Photo shows interior of a sunny
room, carpets, no mass at all)

Instructor's Text:

Suntempering is the simplest passive solar system. No additional thermal mass is necessary. In a "conventional" house, about 25% of the windows face south, which amounts to about 3% of the house's total area. In a suntempered house, the percentage is increased to a maximum of about 7%.

The energy savings are more modest with this system, but suntempering is a very low-cost strategy.

Notes:

Uncover the viewgraph of the suntempered example table.

At this point the instructor will start using the set of the four example tables blown up and used for overheads - for highlighting. These example tables, pages 23, 26, 29, and 31 are site specific and won't be in the slides. Use the viewgraphs side by side with the slides.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use Suntempered Table from page 6 of Presentation Materials

Instructor' Text:

Notes:

Viewgraph corresponding to Slide 84

Builder Guidelines: Page 23

Slide Description:

(Graphic showing a suntempered building)

Instructor's Text:

The Example assumes a 1,500 sf house. The R-values indicated in the Example tables are, of course, approximate and are intended to show how incremental improvements can be achieved. All R-values in the Examples and Worksheets are equivalent R-values for the entire construction assembly, not just for the cavity insulation itself, and take into account framing and buffering effects.

However, one more general assumption is important to note here. When the examples were calculated, it was assumed that natural cooling strategies such as those described in these guidelines were used, particularly in the very high-performance systems. The greater the percentage reduction in heating energy needs using passive solar design, the more shading and natural cooling were assumed.

Notes:

The instructor will show entire viewgraph at this point.

There are, of course, other ways to achieve energy savings than those shown in the Examples. The Examples are designed to show an effective integration of strategies, and a useful approach to the design of the house as a total system. Using any of these combinations would result in excellent performance in your area. However, they are general indications only, and using the Worksheets will give you more information about your specific design.

The Examples show passive solar strategies, but an Insulation Only Example table (achieving energy savings only by increasing insulation levels, without solar features) is provided in the Summary beginning on page 54, for comparison.

The 20%, 40%, and 60% savings refer to reductions in auxiliary heat. The table shows the percent solar savings. The rest of the savings is due to conservation.

Builder Guidelines: Page 24

Slide Description:

(Graphic showing direct gain)

Instructor's Text:

The most common passive solar system is called direct gain: sunlight through south-facing glazing falls directly into the space to be heated, and is stored in thermal mass incorporated into the floor or interior walls.

Notes:

(From Page 24 of the Guidelines)

Slide Description:

(Photo of house showing a window)

Instructor's Text:

The amount of direct gain glass should never exceed 12% of the house's floor area -- meaning 5% more than the 7% suntempering limit. Beyond that, problems with glare or fading of fabrics are more likely to occur, and it becomes more difficult to provide enough thermal mass for year-round comfort related to overheating.

Notes:

Instructor must be very familiar with the glazing section on page 24, 2nd column.

Location of this house is unknown.

Builder Guidelines: Page 24 (continued)

Slide Description:

(Photo showing tile floor adjacent to direct gain windows)

Instructor's Text:

Thermal mass can be incorporated as either floor covering, walls or veneers over interior walls. If the mass is placed in the floor, it will be much more effective if sunlight falls directly on it.

A good design practice is to make the floor next to the south windows massive, because it will be in the sun during winter days. The rest of the floor can be carpeted because it is not very effective for heat storage anyway.

Notes:

For houses built with crawlspaces or basements, the incorporation of significant amounts of heavy thermal mass is a little more difficult. Thermal mass floor coverings over basements, crawlspaces and lower stories would generally be limited to thin set tile or other thin mass floors.

Slide Description:

(Photo showing light walls, dark floors.)

Instructor's Text:

When mass is required, the next best option is for interior walls or interior masonry fireplaces. Sunlit thermal mass floors should be relatively dark in color, to absorb and store energy more effectively. However, mass walls and ceilings should be light in color to help distribute both heat and light more evenly.

A rule of thumb: add 6 s.f. of mass area for every added s.f. of glass area above 7%.

Notes:

When evaluating costs, the dual function of mass walls should be remembered. They often serve as structural elements or for fire protection as well as for thermal storage.

Builder Guidelines: Page 25

Slide Description:

(Photo shows dark, heavy, stone walls)

Instructor's Text:

It is not necessary or even appropriate to use dark surfaces on mass walls as shown in this home.

Notes:

Slide Text:

(Photo shows living room with clerestory windows.)

Instructor's Text:

This slide shows a translucent plastic glazing used as a direct-gain clerestory window. The different double-wall glazing has the advantage that it softens direct beam penetration into the room and improves the daylighting quality by reducing glare and hot spots in the room.

Notes:

This is an Exolite glazing.

Slide Description:

(Use picture from page 25 showing mass location)

Instructor's Text:

Ratio of Glass to Mass: The following procedure can be used to determine the maximum allowable of direct-gain glazing for a given amount of thermal mass. If the amount of direct gain glazing to be used is already known, thermal mass can be added until this procedure produces the desired proportions.

- Start with a direct gain glass equal to 7% of the house's total floor area.

- An additional 1.0 sf of direct gain glazing may be added for every 5.5 sf of uncovered, sunlit mass floor. Carpet or area rugs will seriously reduce the effectiveness of the mass. The maximum floor mass that can be considered as "sunlit" may be estimated as about 1.5 times the south window area.

- An additional 1.0 square foot of direct gain glazing may be added for every 40 sf of thermal mass in the floor of the room, but not in the sun.

- An additional 1.0 square foot of direct gain glazing may be added for each 8.3 sf of thermal mass placed in the wall or ceiling of the room.

The effectiveness of thermal mass depends on the density of the material and thickness. For most materials, the effectiveness of the thermal mass in the floor of the interior wall increases proportionally with thickness up to about 4 inches. After that, the effectiveness doesn't increase as significantly.

Notes:

All direct gain is south facing glass. It is also called solar glass. As noted above, the "free mass" in the house will be able to accommodate this much solar energy up to the suntempering limit of 7%.

Mass in the wall or ceiling does not have to be located directly in the sunlight, as long as it is in the same room, with no other walls between the mass and the area where the sunlight is falling.

This shows ratios of mass to glass for various materials and thicknesses. The 8.3 value cited above can be modified based on this graph.

Builder Guidelines: Page 25

Slide Description:

Mass thickness graph from Page 25, Column 3

Instructor's Text:

(Explain graph)

Notes:

Builder Guidelines: Page 26

Slide Text:

Example of Direct Gain Performance

Instructor's Text:

(Explain viewgraph)

Notes:

Show direct gain example viewgraph.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use Direct Gain Table from page 7 of Presentation Materials

Instructor's Text:

Notes:

Viewgraph corresponding to Slide 94

Slide Text:

(Beautiful photo of an attached sunspace.
exterior shot)

Instructor's Text:

Sunspaces provide useful heating and a valuable amenity to homes. Sunspaces are referred to as "isolated gain" passive solar systems, because the sunlight is collected in an area which can be closed off from the rest of the house. During the day, the doors or windows between the sunspace and the house can be opened to circulate collected heat, and then closed at night, and the temperature in the sunspace allowed to drop.

A well designed sunspace will probably need no mechanical heating system, but if necessary, a small fan or heater may be used to protect plants on extremely cold winter nights.

The sunspace should be just as tightly constructed and insulated as the rest of the house.

Notes:

Explain again that a sunspace is a separate, unconditioned space. If the room is not separate from the house, then the system is direct gain.

Slide Description:

(Photo showing attached sunspace)

Instructor's Text:

A sunspace has extensive south-facing glass, so sufficient thermal mass is very important. Without it, the sunspace is liable to be uncomfortably hot during the day, and too cold for plants or people at night.

Notes:

Slide Description:

(Sunspace graphic)

Instructor's Text:

A well designed sunspace has the following components:

1) Most glass facing south
2) Little, if any, glass on west
3) Controlled overhead glass
4) Some glass on east (for morning wake-up sunlight)

Notes:

The control of overhead glass is described on page 27.

Slide Description:

(Photo shows a sunspace floor, in the sun, snow outside, flowers inside)

Instructor's Text:

The sunspace floor is a good location for thermal mass. The mass floors should be dark in color. No more than 15-25 % of the floor slab should be covered with rugs, furniture or plants. The lower edge of the south-facing windows should be no more than six inches from the floor or planter bed to make sure the mass in the floor receives sufficient direct sunlight.

The temperature in the sunspace can vary more than in the house itself, so about three square feet of four inch thick thermal mass for each square foot of sunspace should be adequate. With this glass-to-mass ratio, on a clear winter a temperature swing of about 30 F should be expected.

Notes:

Usually to obtain the three-to-one ratio of mass to glass it is necessary to use both a massive floor and a massive common wall.

Slide Description:

(Shows glass in a sunspace from the outside)

Instructor's Text:

Clear, double glazing is recommended for sunspaces. Adding the second pane makes a large improvement in energy savings. Triple-glazing or low-e coatings, on the other hand, will further improve comfort, but will have little effect on energy savings. Windows on the east and west walls should be small (no more than 10% of the total sunspace floor area) but they are useful for cross ventilation.

Notes:

Like tilted or sloped glazing, glazed roofs can increase solar gain, but they can also present big overheating problems and become counter-productive. If either glazed roofs or tilted glazing are used in the sunspace, special care should be taken to make sure they can be effectively shaded during the summer and, if necessary, on sunny days the rest of the year, too.

Also be familiar with the Performance Potential Chart on Page 6.

Slide Description:

(Photo shows sun shining into a sunspace)

Instructor's Text:

This slide and the next show an effective design approach. The sunspace east wall is glazed to provide good morning sun...

Notes:

Slide Description:

(Photo shows opposing side of the sunspace --
from the previous slide)

Instructor's Text:

...and the west wall is a mass wall to store the morning solar gains. The sunspace is protected from the afternoon west sun that would cause overheating. In this house there is a room behind this mass wall.

Notes:

Slide Description:

(Photo of a sunspace interior)

Instructor's Text:

There are a number of options for the sunspace common wall. If the wall is not massive, insulating the common wall to about R-10 is a good idea, especially in cold climates. An insulated common wall will help guard against heat loss during prolonged cold, cloudy periods.

Probably the most important factor in controlling the temperature in the sunspace, and thus keeping it as comfortable and efficient as possible, is to make sure the exterior walls are tightly constructed and well-insulated. Energy is mainly transferred by natural convection through openings in the common wall.

Notes:

1. Words found in paragraph 2, column 2 " Frame walls with masonry veneer" is considered an unusual detail for new construction.

Slide Description:

(Photo shows windows in the common wall.)

Instructor's Text:

The major means by which sunspace heat is distributed to the house is by natural convection through openings in the common wall.

Doors are the most common opening in the common wall. If only doorways are used, the open area should be at least 15% of the sunspace south-glass area. If only windows are used, the operable area should be at least 25% of the sunspace's total south glass area.

Windows will also provide light and views. The total opening in the common wall should be no larger than about 40 % of the entire common wall area.

Notes:

The reason that the window and door minimum-area guidelines are different is that convection depends on the height of the opening as well as the total open area. The slide illustrates a kitchen with a common wall and windows to the sunspace beyond.

Slide Text:

(Photo shows open windows or vents on a sunspace)

Instructor's Text:

The sunspace must be vented in the summer to prevent overheating. Operable windows and/or vent openings should be located for effective cross-ventilation. The best strategy is to place the inlets low on the windward side and the exits high on the leeward side. These ventilation areas should be at least 15 % of the total sunspace south glass areas. Where natural ventilation is insufficient, a small thermostat-controlled fan set at about 76 F will be useful. This sunspace west window is protected from summer overheating by a tree on the west side.

Notes:

Stress this point carefully. Lots of sunspaces overheated in the past because of poor or improper ventilation strategies. Many others overheat because of excess overhead, east, and west glass. Sunspaces have a bad reputation for overheating, but this is due to poor design practice.

Slide Description:

(Photo shows an exterior shot of a sunspace)

Instructor's Text:

(Explain the viewgraph)

Notes:

Instructor should use the viewgraph showing the sunspace example.

The location of this house is unknown.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use Sunspace Table from page 8 of Presentation Materials

Instructor's Text:

Notes:

Viewgraph corresponding to Slide 105

Slide Description:

(Thermal storage wall schematic)

Instructor's Text:

The Thermal Storage Wall, also referred to as an indirect gain system, is a south facing glazed wall, usually built of heavy masonry, water containers or phase change materials. The mass is separated from the glazing only by a small air space. Sunlight is absorbed directly into the wall instead of into the living space. The energy conducts through the wall and is released into the living space over a relatively long period. The time lag varies with different materials, thicknesses and other factors, but typically, energy stored in a Thermal Storage Wall during the day is released during the evening and nighttime hours.

A masonry Thermal Storage Wall should be solid, and there should be no openings or vents either to the outside or to the living space.

Notes:

This is a very effective design technique, but not particularly common. Although vents to the living space were once commonly built into Thermal Storage Walls, experience has demonstrated that they are counter productive. Vents between the Thermal Storage Wall and the house tend to reduce the system's nighttime heating capability, and to increase the temperature fluctuation in the house. Vents to the outside are similarly not recommended, they are unnecessary, complicated to build, and do little to reduce summer heat gains, which are small anyway.

Slide Description:

(Photo of two types of thermal storage walls)

Instructor's Text:

This photo shows two thermal storage walls: the upper is a translucent water wall and the lower is a concrete wall with a selective surface, 3" air space and single glazing. If a selective surface is used over the mass, single glazing will perform about the same as double glazing. If a selective surface is not used, double glazing is required. The space between the glazing and the thermal mass should be one-half to three inches.

Notes:

Become familiar with information on Selective Surfaces on page 30 - Column 3 - This is not a particularly common practice but it is effective. Instructors should be prepared to tell the workshop attendees where to get selective surface. They <u>will</u> ask every time.

Berry Solar Products, MTI Solar have it.

Slide Text:

(Photo shows a man applying a selective surface)

Instructor's Text:

This photo shows a selective surface being applied with a roller to the outside of a thermal storage wall. The selective surface is a black coating on a metal foil that reduces the flow of thermal radiation to the outside by about 90%. This increases annual performance (compared to a black wall) by [location dependent, see page 30] in [location]. Manufacturers give specific directions on how to glue the foil to the outside of the wall.

In any case, the outside surface should be very dark to absorb the maximum sun. An absorbance of 92% or greater is recommended. If brick is used, for example, the brick should be very dark and the mortar should also be dark.

Notes:

See table K, called "solar absorbencies", in the reference tables. Selective surfaces cost about $1.30 per s.f. If a selective surface is used then the glazing can be single instead of double. We recommend that a diffusing glass be used if a selective surface is used (preferably low-iron glass to give maximum transmittance). This obscures the selective surface which is not particularly attractive.

Slide Description:

(Interior of mass wall slide and viewgraph of the "Mass Wall Thickness" table on page 31)

Instructor's Text:

The interior surface of a thermal mass wall must be in direct contact with the wall without any in order to avoid thermal breaks such as air spaces. The surface can be any color, made to look like other walls in the room, or be an expression of the mass (such as brick or block). This photo shows the interior of a mass wall on the left side of the window. The effectiveness of the Thermal Storage Wall increases as the density of the material increases...For example here's a viewgraph showing Mass Wall Thickness.

Notes:

Keep this slide projected on screen while describing viewgraph.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use Mass Wall Table from page 9 of Presentation Materials

Instructor's Text:

Notes:

Viewgraph corresponding to Slide 109

Slide Description:

(Shows water wall)

Instructor's Text:

This slide illustrates the interior of a translucent water wall. The advantage of this system is that daylight is allowed to penetrate into the room. However, since there is no dark material for absorbance, the performance will be lower than if the container was dark. For example, a highly absorbing water wall can outperform a masonry thermal storage wall.

Water provides about twice the heat storage per unit volume as masonry, so a smaller volume of mass can be used. In "water walls" the water is in light, rigid containers. The containers are shipped empty and easily installed. As a rule of thumb, 30 pounds (3.5 gallons) of water or more should be provided for each square foot of glazing.

Notes:

Manufacturers can provide information about durability, installation, protection against leakage and other characteristics.

Slide Description:

Slide of a thermal mass wall below view windows.

Instructor's Text:

A common problem with thermal storage walls in residential construction is their poor aesthetics. Here's a good way of integrating a thermal storage wall into a residence that looks okay. The slide shows a thermal storage wall below windows. The appearance is normal, both from the inside and the outside.

The viewgraph shows (explain viewgraph)

Notes:

This particular wall is a water wall. The water containers are welded-steel boxes filled with water. A selective surface foil is glued to the outside surface of the metal box (facing the window). The boxes must be tightly sealed to prevent rapid evaporation of the water.

Instructor shows viewgraph of Thermal Storage Wall Example.

Viewgraph Description:

Use Thermal Storage Wall Table from
page 10 of Presentation
Materials

Instructor's Text:

Notes:

Viewgraph corresponding to Slide 111

Slide Description:

(Photo showing combined system: direct gain, sunspace, and thermal storage wall)

Instructor's Text:

Although the previous sections have presented separate discussions of four different systems, it isn't necessary to choose one and only one system. In fact, passive solar features work well in combination. For example, direct gain works very well in conjunction with a sunspace or thermal storage wall. Since thermal storage walls release energy more slowly than direct gain systems, they are useful for supplying heat in the evening and at night, whereas the direct gain system works best during the day.

Although using a sunspace, thermal storage wall and direct gain system in the same house may result in excellent performance, such combinations do require a large south-facing area, and careful design to make sure the systems are well-integrated with each other and with the house's mechanical system.

The design of the home incorporates suntempering, direct gain, a sunspace and thermal storage walls.

Notes:

This Colorado home was designed by Greg Franta. It has a sunspace on the far right. Concrete thermal storage walls are incorporated on the main level and basement level. A translucent water wall is used in the master bedroom on the upper level.

Slide Description:

(Cartoon/graphic of a man "overheating")

Instructor's Text:

The term "natural cooling" is used here to describe techniques which help a house stay cool in summer but which require little or no energy. Natural cooling techniques work to help reduce air-conditioning, not replace it. Heat exclusion and rejection are the two basic strategies at work here.

The natural cooling guidelines that we are going to cover include orientation, glazing, natural ventilation, shading, and fans.

Notes:

Slide Description:

(Photo shows a shaded street)

Instructor's Text:

Shading is particularly important in passive solar houses, because the same features that collect sunlight so effectively in winter will go right on collecting it in summer.

Notes:

"More detail on this in the next few slides. This just introduces the concept."

Slide Description:

(Photo of a well-shaded west window)

Instructor's Text:

This photo shows a well shaded west window. The percent savings is calculated from the base case number shown at the top of the accompanying viewgraph.

Notes:

Use the viewgraph showing the chart on page 33.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use Cooling Potential Table from page 11 of Presentation Materials

Instructor's Text:

Notes:

Viewgraph corresponding to Slide 115

Slide Description:

(Shows duplicate of 1st table on page 34 under title "Recommended Non-South Glass Guidelines")

Instructor's Text:

Flip to page 34.

As mentioned earlier, poorly placed windows can increase air conditioning loads dramatically. It is generally best in terms of energy performance to carefully size non-solar glazing as indicated on the slide.

As mentioned earlier, west-facing windows present particularly difficult shading problems. If glazing is added above the levels indicated, the need for shading will become even more critical.

Note on the viewgraph the added cooling loads due to unshaded windows in various orientations. Note particularly the very large number for horizontal glazing (skylights).

Notes:

Instructor should show the viewgraph of the table in the second column on page 34. This is site specific.

Builder Guidelines: Viewgraph

Viewgraph Description:

Use Added Window Cooling Table from page 13 of Presentation Materials

Instructor's Text:

Notes:

Slide Description:

(Graphic/cartoon shows tinted glass)

Instructor's Text:

Using special glazing or window films that block solar transmission (low shading coefficient) is an option often used in particularly hot climates, but the more effective they are at blocking sunlight, the less clear they are, as a rule, and so they may interfere with desirable views. It is important to note, however, that some types of low-e windows block solar transmission but also allow clear views. Low transmission coatings are not recommended for south windows.

Notes:

High "R" value windows, (superwindows, smart windows,) have all seen dramatic advances in the last few years. Be prepared to discuss somewhat and know which belong on which orientation for the house.

Slide Text:

SHADING

- Landscaping
- Overhangs
- Shading Devices

Instructor's Text:

Shading strategies generally fall into three categories: landscaping, roof overhangs and exterior or interior shading devices.

Notes:

More detail will be presented in the next few slides.

Slide Description:

(Slide showing the graphic on page 35, column 2)

Instructor's Text:

Landscaping. The ideal site for summer shading has deciduous trees to shade the east and west windows. Even small trees such as fruit trees can help block sun hitting the first story of a house.

Trees on the south side are not recommended. Even deciduous trees will shade the solar glazing during the winter and interfere with solar gain. In fact, trees on the south side can all but eliminate passive solar performance, unless they are very close to the house and the low branches can be removed, allowing the winter sun to penetrate under the tree canopy.

As a rule of thumb, there should be no shading on solar gain windows within an arc of plus or minus 45 degrees of true south.

Notes:

If a careful study of the shading patterns is done before construction, it should be possible to accommodate the south-facing glazing while leaving in as many trees as possible. (see page 17, Site Planning for Solar Access).

Builder Guidelines: Page 35 (continued)

(NO SLIDE PROVIDED BY PSIC)

Slide Description:

LANDSCAPING IDEAS:

- Trellises
- Shrubbery
- Ground Cover
- Landscape Placement
- Deciduous Trees

Instructor's Text:

Other landscaping ideas for summer shade:

- Trellises on east and west covered with vines.
- Shrubbery or other plantings to shade paved areas.
- Use of ground cover to prevent glare and heat absorption.
- Trees, fences, shrubbery or other plantings to "channel" summer breezes into the house.
- Deciduous trees on the east and west sides of the house, as shown above, to balance solar gains in all seasons.

Notes:

Landscaping placement and materials change dramatically throughout the United States. Please use a slide of your choice from your own local area.

Slide Description:

(Overhang on page 35, column 3)

Instructor Text:

Roof Overhangs: Fixed overhangs are an inexpensive feature, and require no operation by the home owner. They must be carefully designed, however. Otherwise, an overhang that blocks summer sun may also block sun in the spring, when solar heating is desired, and, by the same token, an overhang sized for maximum solar gain in winter will allow solar gain in the fall on hot days. The figure in your workbook may be used to determine the appropriate overhang size.

Notes:

Watch out for the site specific nature of the overhang. Know what the A & B angles should be for the area you're teaching. Winter is Angle A and Summer Angle B.

The instructor may want to use a viewgraph showing the same diagram with the local values of A and B filled in. Dimensions for these values of A & B are given in the last paragraph on page 35. List these also on the viewgraph.

Slide Description:

(Photo shows an external shade covering a skylight that would otherwise result in excessive summer heating)

Instructor's Text:

External shades are the most effective because they stop solar gain before the sun hits the building. A wide range of products are available, from canvas awnings to solar screens to roll-down blinds to shutters to vertical louvers. The problem of movable systems is that they require the home owner's cooperation.

Interior shades must be operated, too, and have the further disadvantage of permitting the sun to enter the house and be trapped between the window and the shading device.

Notes:

Slide Description:

(Photo shows ceiling fan)

Instructor's Text:

Ceiling fans will probably save more energy than any other single cooling strategy. As a general rule, the thermostat can be set 4 degrees higher with the identical thermal comfort if the air is moving at 100-150 feet per minute.

Refer to the chart of ceiling fan sizes on Page 36 of the Guidelines.

Notes:

Studies show that air movement can make people feel comfortable at higher temperatures. This is "enough" air movement to greatly improve comfort but not enough to disturb loose papers.

Slide Description:

(Photo shows open windows overlooking woods)

Instructor's Text:

When possible, the house should be positioned on the site to take advantage of prevailing breezes. Windows, stairwells, transoms and other elements should be located for adequate cross-ventilation in each room. As a rule of thumb, the actual open area (free vent area) for adequate ventilation should be between 6 - 7.5% of total floor area.

Screens can reduce free vent area by as much as 50 %. Casement or awning windows have a 90 % open area; double hung windows have only 50%.

Notes:

The direction of prevailing winds for the cooling season is site specific for every guidelines package, based on weather service data.

Slide Description:

(Graphic in the center column of page 37)

Instructor's Text:

In cooling climates, a whole house fan is a good idea assisting ventilation, especially in houses with sites or designs that make natural ventilation difficult.

Research indicates that a whole-house fan should pull approximately 10 ACH. A rule of thumb: for rooms with eight foot ceilings, total floor area multiplied by 1.34 will equal the necessary CFM of the fan. For 10 foot ceilings, multiply floor area by 1.67.

Natural ventilation and whole-house fans are effective at removing heat, but not at moving air. Ceiling fans, on the other hand, can often create enough of a breeze to maintain comfort at higher temperatures, and still use less power than required by air conditioning. By using natural cooling strategies and low-energy fans, the days when air-conditioning is needed can be reduced substantially.

Notes:

On the other hand, when the outside temperature is higher than about 76 F, a whole-house fan will not be very effective.

The best possible performance of a whole-house fan results when a timer, a thermostat and a "humidistat" are used, so that the fan would only operate when there is less than 60 % relative humidity and a temperature of less than 76 F.

Builder Guidelines: Page 1, Any Town, USA

Instructor's Text:

"Turn to page 1 of your "Any Town, USA" section in the back of the binder.

Notes:

Any Town, USA should be used to introduce the process incorporated in the Guidelines worksheets. A brief summary of each worksheet topic should be presented. The "Worked Example" should be used to describe the worksheets in detail.

The Worksheet tables for the city you're in (found in the Worksheet section of the Guidelines) WILL NOT be the same as those in the "Any Town" section. "Any Town" is based upon Raleigh, NC data.

Slides can't be provided on the worked example for a specific site (too costly). Use viewgraphs of worksheets. Show the entire set of worksheets and example tables on individual viewgraphs.

(Text for teaching the four worksheets in the section called "Worked Example" is up to the individual instructor, and can be found on the second page of that section. The text is essentially the same as that of Any Town, USA, but has site specific information.)

The Worked Example Building is not a Base Case House, but a passive solar house with much better performance.

Instructors must create viewgraphs of each Worksheet after they have been filled in.

Slide Text:

ANY TOWN, USA

(Use floor plan shown on page 2)

Instructor's Text:

A 1,504 square foot passive solar, single-family home is used to illustrate how to use the worksheets. A floor plan, building elevations, building sections and details are shown below. The building has an attached sunspace. The sunspace floor has a four-inch thick slab-on-grade with quarry tile set in a mortar bed. The sunspace is separated from the conditioned portion of the house by sliding glass doors and a masonry fireplace wall. Awning windows located at the top and bottom of the south wall provide outside ventilation for the sunspace.

Now look at page 3 of Any Town, USA.

South Facing windows provide direct gain solar heating to the dining area, kitchen and master bedroom. The south glazing in the kitchen and the dining area provides heat to an exposed slab-on-grade. The east portion of the house is slab-on-grade construction. The great room and the master bedroom are raised floor construction. The slab-on-grade floor in the kitchen and dining room is finished with ceramic tile so that the floor may function as thermal mass. The exterior doors are metal with a foam core center.

Notes:

Two foundation types mentioned in the Any Town, USA example are just for general discussion purposes. You may have basements in your area.

Builder Guidelines: Page 4, Any Town, USA

Slide Description:

(Various sections of the worksheets on viewgraphs)

Instructor's Text:

Notes:

You MUST know the rationale for preparing these worksheets. Read through this section several times carefully.

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 Crawlspaces		×		=	
				Total	Btu/°F-h

C. Infiltration Heat Loss

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

D. Total Heat Loss per Square Foot

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

E. Conservation Performance Level

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

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 ÷ ________ Floor Area = ________ Total Projected Area per Square Foot

B. Load Collector Ratio

24 × ________ Total Heat Loss [Worksheet I] ÷ ________ Total Projected Area = ________

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

[1 – ________ Solar Savings Fraction] × ________ Conservation Performance Level [Worksheet I, Step E] = ________ 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	=	______
					______ Total Btu/°F

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	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
					______ Total Btu/°F

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	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
					______ Total Btu/°F

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	______	×	______	=	______

______ Total ÷ ______ Total Heat Capacity = ______ °F

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]		Absorptance [Table K]		Heat Gain Factor [Table L]		Load
Ceilings/roofs		×		×		×		=	
		×		×		×		=	
		×		×		×		=	
Walls		×	na			×		=	
		×	na			×		=	
Doors		×	na			×		=	
									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		×	0.80	×		×		=	
East Glass		×	0.80	×		×		=	
West Glass		×	0.80	×		×		=	
Skylights		×	0.80	×		×		=	
									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		×	0.80	×		×		=	
Storage Walls		×	0.80	×		×		=	
Sunspace		×	0.80	×		×		=	
		×	0.80	×		×		=	
									Total kBtu/yr

D. Internal Gain

_____ Constant Component [Table N] + (_____ Variable Component [Table N] × _____ Number of Bedrooms) = _____ kBtu/yr

E. Cooling Load per Square Foot

1,000 × _____ (A+B+C+D) ÷ _____ Floor Area = _____ Btu/yr-sf

F. Adjustment for Thermal Mass and Ventilation

_____ [Table O] Btu/yr-sf

G. Cooling Performance Level

_____ (E -F) Btu/yr-sf

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

_____ Btu/yr-sf

Compare Line G to Line H

9

Any Town USA

Example

Passive Solar Design Strategies
PSIC's Guidelines for Builders

Passive Solar Industries Council
U. S. Department of Energy Solar Buildings Program
Solar Energy Research Institute
Los Alamos National Laboratory
Charles Eley Associates

Introduction

Purpose
The purpose of this document is to explain how to use the passive solar worksheets available from the Passive Solar Industries Council. Separate Worksheets booklets are available for specific locations throughout the continental USA. Each booklet contains detailed technical data for a specific location. Although the example presented in this booklet is for a moderate mid-Atlantic climate, the procedure is presented in a general manner and is intended to be used for all locations.

In addition to the Worksheets booklets and this Example booklet, Guidelines booklets for specific locations are also available from the Passive Solar Industries Council.

General Description of Worksheets
The Worksheets booklet for each location provides an easy-to-use calculation procedure, allowing the designer to estimate the performance level of a particular building design and compare it against a base-case performance level or against the performance of the builder's more conventional house.

A separate worksheet is provided for each of four separate performance levels performance level and associated target. These are described below:

Worksheet I: Conservation Performance Level: the estimated heat energy needed by the building each year from both the solar and auxiliary heating systems. The units are Btu/yr-sf.

Worksheet II: Auxiliary Heat Performance Level: the estimated heat that must be provided each year by the auxiliary heating system. This worksheet accounts for the solar savings. The units are Btu/yr-sf.

Worksheet III: Thermal Mass/Comfort: the temperature swing expected on a clear winter day with the auxiliary heating system not operating. The units are °F.

Worksheet IV: Summer Cooling Performance Level: the estimated annual cooling load of the building. The units are Btu/yr-sf.

The estimates from Worksheets I and II are based on a heating thermostat setting of 70°F. The estimates from Worksheet IV are based on a cooling thermostat setting of 78°F with no ceiling fans and 82°F with ceiling fans.

The worksheets are supported by a number of data tables. The data tables are given a letter designation and are referenced when applicable next to each worksheet entry.

A description and drawings of the example building are provided below, followed by completed worksheets. Data tables have also been included when appropriate.

Each step of the worksheets is then explained in detail.

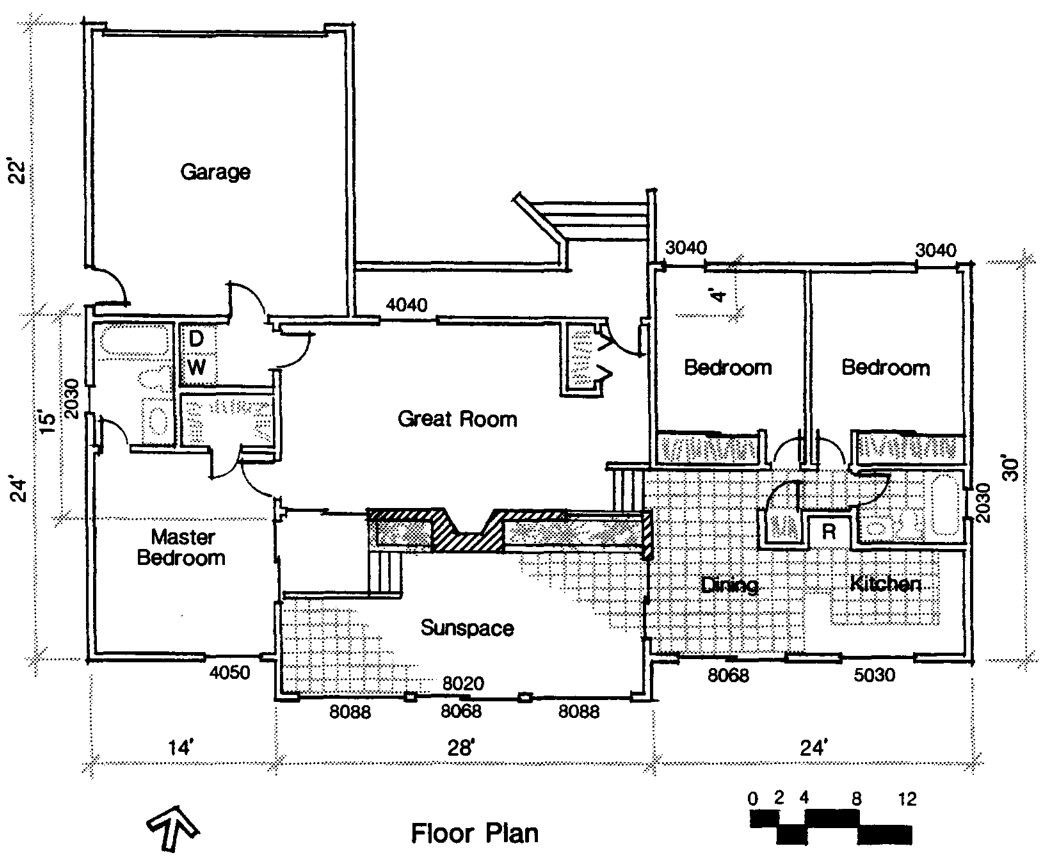
Description of Example Building
A 1,504 square foot passive solar, single-family home is used to illustrate how to use the worksheets. A floor plan, building elevations, building sections and details are shown below.

The building has an attached sunspace. The sunspace floor has a four-inch thick slab-on-grade with quarry tile set in a mortar bed. The sunspace is separated from the conditioned portion of the house by sliding glass doors and a masonry fireplace wall. Awning windows located at the top and bottom of the south wall provide outside ventilation for the sunspace.

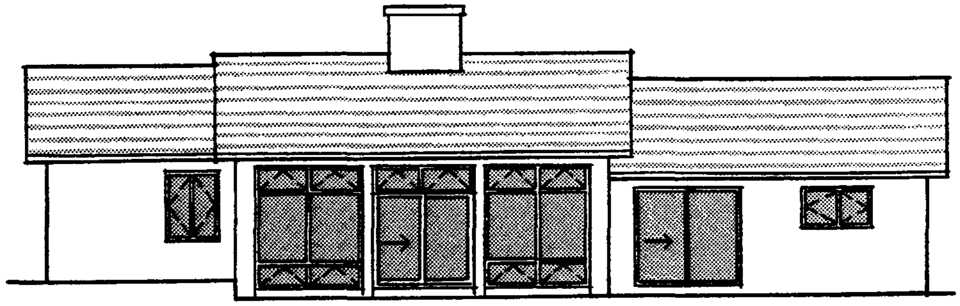
South facing windows provide direct gain solar heating to the dining area, kitchen and master bedroom. The south glazing in the kitchen and dining area provides heat to an exposed slab-on-grade.

The east portion of the house is slab-on-grade construction. The great room and master bedroom suite are raised floor construction. The slab-on-grade floor in the kitchen and dining area is finished with ceramic tile so that the floor may function as thermal mass.

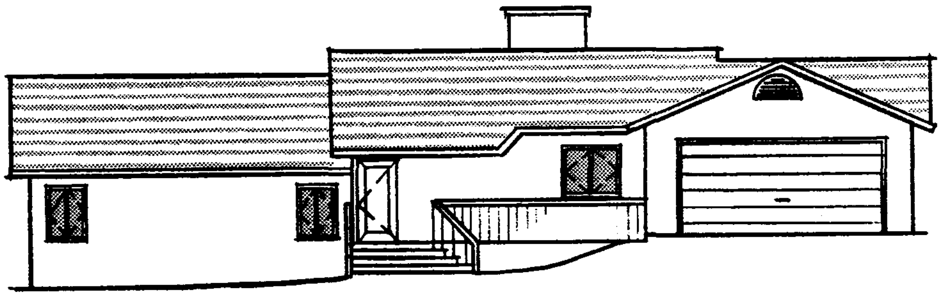
The exterior doors are metal with a foam core center.



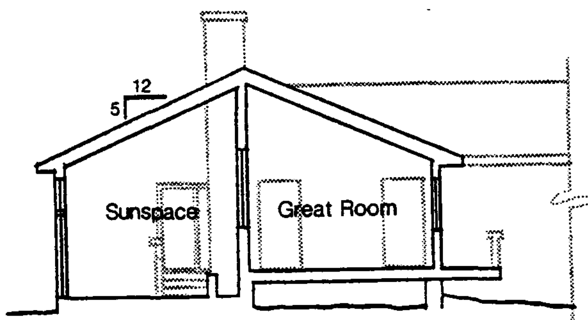
Floor Plan



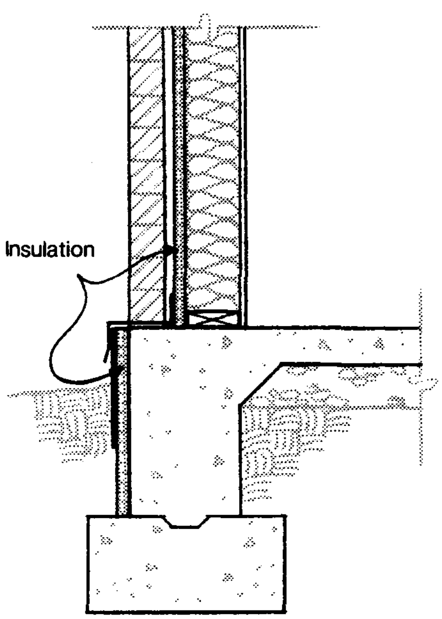
South Elevation

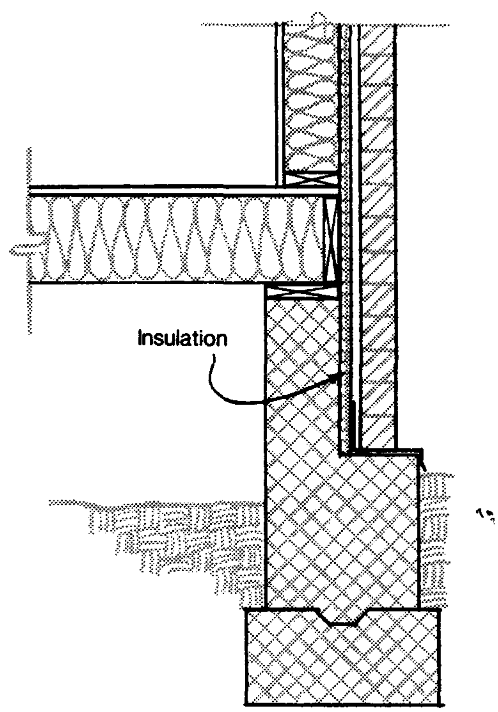


North Elevation



Section





General Project Information

Project Name	EXAMPLE BUILDING	Floor Area	1,504 sf
Location	ANYTOWN, USA	Date	
Designer			

Worksheet I: Conservation Performance Level

A. Envelope Heat Loss

	Construction Description	Area		R-value [Table A]		Heat Loss
Ceilings/roofs	R-38 IN ATTIC	1084	÷	35.9	=	30
	R-30 IN CATHEDRAL	420	÷	24.5	=	17
Walls	R-19 + RIGID INSUL.	992	÷	24.7	=	40
	R-19 @ GARAGE	140	÷	17.7	=	8
Insulated Floors	R-19 IN FLOOR OVER	784	÷	25.8	=	30
	VENTED CRAWLSPACE		÷		=	
Non-solar Glazing	DOUBLE GLAZED	52	÷	2.1	=	25
			÷		=	
Doors	METAL FOAM CORE	40	÷	5.9	=	7
			÷		=	
					Total	157 Btu/°F-h

B. Foundation Perimeter Heat Loss

Description	Perimeter		Heat Loss Factor [Table B]		Heat Loss
Slabs-on-Grade	140	×	0.3	=	42
Heated Basements		×		=	
Unheated Basements		×		=	
Perimeter Insulated Crawlspaces		×		=	
				Total	42 Btu/°F-h

C. Infiltration Heat Loss

12,483 (Building Volume) × 0.5 (Air Changes per Hour) × .018 = 112 Btu/°F-h

D. Total Heat Loss per Square Foot

24 × 311 (Total Heat Loss (A+B+C)) ÷ 1504 (Floor Area) = 4.96 Btu/DD-sf

E. Conservation Performance Level

4.96 (Total Heat Loss per Square Foot) × 3,703 (Heating Degree Days [Table C]) × 0.98 (Heating Degree Day Multiplier [Table C]) = 18,000 Btu/yr-sf

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

25,380 Btu/yr-sf

Compare Line E to Line F

Worksheet I: Conservation Performance Level

Worksheet I is essentially a heat loss calculation, similar to the type of calculation made to size heating and cooling equipment. The major difference is that the calculation does not consider heat loss through any of the passive solar systems. The following building components in the example building are not considered in the calculation:

- Heat loss through direct gain solar glazing.
- Heat loss through walls and windows that separate the house from the sunspace.

If the example building had Trombe walls or water walls, heat loss through these passive solar systems would also be excluded from the calculation.

Heat loss from the passive solar systems is excluded since the solar savings fractions in Worksheet II take these losses into account.

Step A. Envelope Heat Loss

The first step is to calculate the heat loss through the building envelope. The building envelope consists of all walls, roofs, floors, non-solar windows and doors that enclose the conditioned space of the house.

Heat loss for each envelope component is calculated by dividing the surface area of the component by the total R-value. The total envelope heat loss is the sum of the heat loss for all of the envelope components.

Table A in the Worksheets booklet contains R-values that may be used in the calculation. There are actually five separate tables labeled A1, A2, A3, A4 and A5. A separate table is provided for ceilings/roofs, walls, floors, windows and doors. The R-values in these tables include the thermal resistance of both the insulation and other materials that typically make up the construction assembly such as exterior sheathing and sheetrock. They also account for framing members that penetrate the insulation and reduce the effectiveness.

Ceilings/Roofs

There are two types of ceiling/roof construction in the example building. R-38 mineral insulation is located in an attic space, and R-30 insulation is located in the framed cathedral ceiling. The total R-value is selected from Table A1 for each ceiling/roof component. The values in Table A1 account for the buffering effect of the attic (when applicable), the ceiling material (sheetrock) and the effect of framing.

A1—Ceilings/Roofs

Attic Construction	Insulation R-value			
	R-30	R-38	R-49	R-60
	27.9	35.9	46.9	57.9
Framed Construction	**Insulation R-value**			
	R-19	R-22	R-30	R-38
2x6 at 16"oc	14.7	15.8	16.3	—
2x6 at 24"oc	15.3	16.5	17.1	—
2x8 at 16"oc	17.0	18.9	20.6	21.1
2x8 at 24"oc	17.6	19.6	21.6	22.2
2x10 at 16"oc	18.1	20.1	24.5	25.7
2x10 at 24"oc	18.4	20.7	25.5	26.8
2x12 at 16"oc	18.8	21.0	25.5	30.1
2x12 at 24"oc	19.0	21.4	27.3	31.4

The area and R-value of the two different types of construction are entered on two lines of the table under "ceilings/roofs" and the heat loss is calculated by dividing the surface area by the total R-value. Note that the ceiling over the sunspace is not included in this calculation.

Walls

There are two types of wall construction in the example building. The typical exterior wall is of 2x6 wood frame construction with R-19 mineral insulation in the cavity. An insulating sheathing with an R-7 rating is attached to the exterior surface of the framing. The wall is finished with 1/2 inch sheetrock on the inside and a brick veneer on the outside.

The second type of wall construction separates the house from the garage. This wall is also of 2x6 wood frame construction with R-19 in the cavity, but it does not have the insulating sheathing or the brick veneer. Note that the walls that separate the house from the sunspace are not included.

It is necessary to measure the surface area of each type of wall construction. The surface area may be determined by multiplying the length of wall by the average height and subtracting the area of doors and windows.

The R-value of each wall type is determined from Table A2 in the Worksheets booklet. The R-value of both wall types is 17.7 from the table, but since the first wall type has R-7 insulating sheathing, this is added to the value from the table so that 24.7 is used in the calculations. These R-values along with the associated areas are entered on two lines of the table and the heat loss is calculated by dividing each surface area by the corresponding R-value.

A2—Framed Walls

Single Wall Framing	Insulation R-value			
	R-11	R-13	R-19	R-25
2x4 at 16"oc	12.0	13.6	—	—
2x4 at 24"oc	12.7	13.9	—	—
2x6 at 16"oc	14.1	15.4	17.7	19.2
2x6 at 24"oc	14.3	15.6	18.2	19.8
Double Wall Framing	Total Thickness (inches)			
	8	10	12	14
	25.0	31.3	37.5	43.8

The R-value of insulating sheathing should be added to the values in this table.

Floors

Only the raised floor is considered in this step of the heat loss calculation; heat loss from the slab-on-grade floor is considered in Step B. There is one type of raised floor construction in the example building. R-19 mineral insulation is placed between 2x10 floor joists at 16 inches on center; the crawlspace beneath is ventilated.

The total R-value is selected from Table A3, which considers the buffering effect of the crawlspace as well as framing and the floor materials. The area and R-value is entered on one line of the table and the heat loss is calculated by dividing the area by the R-value.

A3—Insulated Floors

Framing	Insulation R-value			
	R-11	R-19	R-30	R-38
2x6s at 16"oc	18.2	23.8	29.9	—
2x6s at 24"oc	18.4	24.5	31.5	—
2x8s at 16"oc	18.8	24.9	31.7	36.0
2x8s at 24"oc	18.9	25.4	33.1	37.9
2x10 at 16"oc	19.3	25.8	33.4	38.1
2x10 at 24"oc	19.3	26.1	34.4	39.8
2x12 at 16"oc	19.7	26.5	34.7	39.8
2x12 at 24"oc	19.6	26.7	35.5	41.2

These R-values include the buffering effect of a ventilated crawlspace or unconditioned basement.

Had there been different insulation conditions for the raised floor, an additional line of the table would be completed for each condition.

If the example building had *insulated* floors over a garage or unheated basement, these components would also be included in this step.

As an alternative to insulating between the floor joists, the perimeter walls of the crawlspace could have been insulated and floor insulation eliminated. When this technique is used, the perimeter heat loss method in Step B should be used. Step A only includes floors when insulation is placed in the floor assembly.

Non-solar Glazing
Next, heat loss from the non-solar glazing is calculated. Note that the passive solar direct gain glazing is not included. Also the windows that separate the house from the sunspace are not included.

The rough frame opening of each window is generally used for the window area. This is because the R-values presented in Table A4 and most heat loss data presented by window manufacturers is for the rough frame opening. Using the rough frame opening also makes it easier to estimate window areas since windows are usually specified on the plans in terms of the rough frame dimensions.

A4—Windows

	Wood Frame	Standard Metal Frame	Metal Frame w/ Thermal Break
Double			
1/4" space	1.8	1.4	1.5
1/2" space	2.1	1.6	1.8
Low-e	3.1	2.2	3.0
Triple			
1/4" space	2.7	1.8	2.1
1/2" space	3.3	2.2	2.7

These R-values are for the entire rough framed window opening. When storm sash is added, an additional 1.1 may be added. One half the R-value of moveable insulation may also be added, when appropriate.

Windows in the example building are all double-pane wood windows with a 1/2 inch air space between the panes. The R-value for this window type is 2.1, selected from Table A4.

The non-solar window area is taken from the building plans. These values are entered in the table and the heat loss is calculated by dividing the window area by the window R-value. If the example building had more than one window type (different R-values), then additional lines of the table would be completed.

Doors
The doors are the last component of the envelope to consider. The example building has two exterior doors: the main entrance and an additional door to the garage. These have a total surface area of 40 square feet and an R-value is selected from Table A5. Note that the door that separates the garage from the exterior is not included since the garage is unconditioned.

A5—Doors

Solid wood with Weatherstripping	2.2
Metal with rigid foam core	5.9

These values are entered in the table and the heat loss is calculated by dividing the door areas by the R-value. If the example building had more than one door type (different R-values), then additional lines of the table would be completed.

Total
The heat loss of all components of the building envelope is summed at the bottom of the table and this completes Step A of the worksheet.

Step B. Foundation Perimeter Heat Loss

Foundation heat loss from slabs-on-grade, basements and insulated crawlspaces is estimated by multiplying the length of perimeter times an appropriate heat loss factor taken from Table B.

The dining area, kitchen and secondary bedrooms in the example house have slab-on-grade construction. R-7 insulation is installed around the perimeter.

The heat loss factor for the slab edge is 0.3, selected from Table B. The heat loss factor is multiplied by the perimeter to calculate the heat loss. The units of heat loss, using the perimeter method, are the same as for the building envelope calculated in the previous step. Note that sunspace slab is not included in this calculation. The slab edge perimeter adjacent to the crawlspace and the sunspace is also excluded.

Table B—Perimeter Heat Loss Factors for Slabs-on-Grade and Unheated Basements (Btu/h-F-ft)

Perimeter Insulation	Slabs-on-Grade	Heated Basements	Unheated Basements	Insulated Crawlspaces
None	0.8	1.3	1.1	1.1
R-5	0.4	0.8	0.7	0.6
R-7	0.3	0.7	0.6	0.5
R-11	0.3	0.6	0.5	0.4
R-19	0.2	0.4	0.5	0.3
R-30	0.1	0.3	0.4	0.2

When a raised floor assembly is not insulated, for instance, over crawlspaces insulated at the perimeter or basements, heat loss occurs primarily at the perimeter.

The example house does not have a basement or a heated crawlspace, but if it did, the foundation heat loss would be calculated by multiplying the perimeter of these elements by a heat loss factor selected from Table B.

When houses have heated basements, heat loss from basement walls located above grade would be included in Step A.

Step C. Infiltration Heat Loss

The heat loss from infiltration or air leakage is estimated by multiplying the building volume times the air changes per hour times a heat loss factor of 0.018.

The example building is estimated to have an infiltration rate of 0.50 based on local building experience.

The building volume is calculated by multiplying the average ceiling height by the conditioned floor area. In this example the average ceiling height is 8.3 ft. The conditioned floor area is 1,504 sf which does not include the garage or the sunspace. The resulting building volume is 12,483 cubic feet.

The units of infiltration heat loss are Btu/°F-h, the same as for the building envelope and the foundation perimeter.

Step D. Total Heat Loss per Square Foot

The total building heat loss is the sum of the heat loss for the building envelope (Step A), the foundation perimeter (Step B) and infiltration (Step C). For residences this value will range between 200 and 500. It represents the Btu of heat loss from the building envelope over the period of an hour when it is one °F colder outside than inside. This total heat loss, of course, does not include heat loss from the solar systems, including direct gain glazing.

The result of Step D, however, is the annual heat loss per degree day per square foot. This value is calculated by multiplying the total heat loss by 24 hours/day and dividing by the conditioned floor area.

Step E. Conservation Performance Level

Once the total heat loss per square foot is calculated, the conservation performance level may be calculated by multiplying the total heat loss per square foot (Step D) by the heating degree days times the heating degree day multiplier.

C1—Heating Degree Days (Base 65°F)	
Raleigh-Durham	3,703

This value is from TMY weather tapes and should be used for Worksheet Calculations. It will vary from long term averages.

The heating degree days are selected from Table C1 and based on specific locations. The heating degree day multiplier is selected from Table C2 and is based on the total heat loss per square foot (Step D) and the passive solar glazing area per square foot of floor area (Worksheet II, Step A).

C2—Heating Degree Day Multiplier

Heat Loss per Square Foot	Passive Solar Glazing Area per Square Foot				
	.00	.05	.10	.15	.20
8.00	1.03	1.05	1.07	1.09	1.11
7.50	1.01	1.04	1.06	1.07	1.10
7.00	0.99	1.02	1.04	1.06	1.08
6.50	0.97	1.00	1.02	1.04	1.06
6.00	0.94	0.97	1.00	1.03	1.05
5.50	0.90	0.94	0.98	1.00	1.03
5.00	0.86	0.91	0.95	0.98	1.01
4.50	0.82	0.87	0.92	0.96	0.99
4.00	0.77	0.83	0.88	0.92	0.96
3.50	0.72	0.78	0.83	0.88	0.93

The conservation performance level for the example building is compared to the base case conservation performance level in the next step.

Step F. Comparison Conservation Performance

The conservation performance level for the proposed design may be compared to the base case performance level for the area, given in Table D.

Table D—Base Case Conservation Performance (Btu/yr-sf)	
Base Case	25,380

Alternatively, the conservation performance level may be compared to other building designs considered by the builder to be typical of the area. In this case, the worksheets would first be completed for the typical design and the results of these calculations would be entered in Step F.

If the conservation performance level of the proposed building (Step E) is greater than the base case or typical-design conservation performance level, the designer should consider additional building insulation or reduced non-solar glass area.

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
DGC1	88	×	0.80	×	.98	=	69
		×	0.80	×		=	
SSC1	208	×	0.80	×	.98	=	163
		×	0.80	×		=	
		×	0.80	×		=	
		×	0.80	×		=	
		×	0.80	×		=	
	296 Total Area						232 Total Projected Area sf

232 (Total Projected Area) ÷ 1,504 (Floor Area) = .15 (Total Projected Area per Square Foot)

B. Load Collector Ratio

24 × 311 (Total Heat Loss [Worksheet I]) ÷ 232 (Total Projected Area) = 32.17

C. Solar Savings Fraction

Solar System Reference Code	Projected Area		System Solar Savings Fraction [Table F]		
DGC1	69	×	.423	=	29.2
		×		=	
SSC1	163	×	.433	=	70.6
		×		=	
		×		=	
		×		=	
		×		=	

99.8 (Total) ÷ 232 (Total Projected Area) = .430 (Solar Savings Fraction)

D. Auxiliary Heat Performance Level

[1 − .43 (Solar Savings Fraction)] × 18,000 (Conservation Performance Level [Worksheet I, Step E]) = 10,260 Btu/yr-sf

E. Comparative Auxiliary Heat Performance (From Previous Calculation or from Table G) 23,099 Btu/yr-sf

Compare Line D to Line E

Worksheet II: Auxiliary Heat Performance Level

Worksheet II is used to estimate the savings from passive solar systems and to estimate the auxiliary heat performance level. This is the amount of heat that must be provided to the building each year after the solar savings have been accounted for.

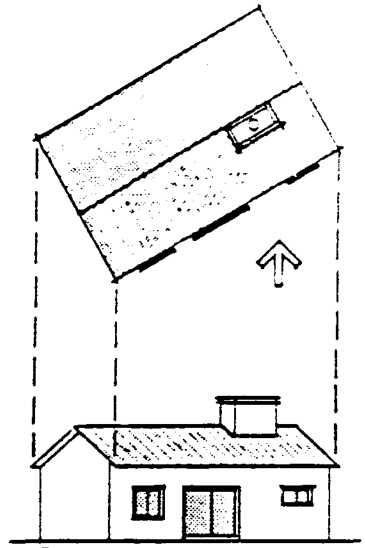
The example building has two solar systems: direct gain south glazing and a sunspace.

Step A. Projected Area of Passive Solar Glazing

The first step is to calculate the projected area of the solar glazing. The projected area of passive solar glazing is the area projected on a plane facing true south (the actual glazing may be oriented slightly east or west of true south). The projected solar glazing also accounts for sloped glazing in certain types of sunspaces.

For most solar systems the projected area may be calculated by multiplying the actual glazing area times an adjustment factor taken from Table E.

Alternatively, the projected area may be determined by making a scaled elevation drawing of the building, looking exactly north. Surface areas may then be measured from the scaled elevation drawing. This concept is illustrated in the figure below.



Projected Area of Passive Solar Glazing
The solar savings fraction is based on the projected area of solar glazing.

The worksheet allows the user to enter the rough frame area of solar glazing, since it is generally easier to measure this. The rough frame area is multiplied by a net area factor of 0.80 to account for window framing and mullions. If the net glass area is entered, the net area factor is 1.00.

The example building has two separate passive solar systems: direct gain and a sunspace. This means that two lines of the table must be completed. If the example building had other types of solar systems, for instance Trombe walls or water walls, additional lines in the table would be completed.

In the first column, the reference code for each type of solar system is entered along with a description of the system. The reference codes are shown on Tables F1 through F4 for various types of solar systems. More information about the system types is provided in the discussion under Step C of this worksheet. The reference code for the direct gain system is "DGC1" because night insulation is not proposed. The reference code for the sunspace is "SSC1" since all the sunspace glazing is vertical.

The south wall of the example building actually faces 10° east of south because of site conditions. The adjustment factor is therefore 0.98 for both solar systems as selected from Table E. Each solar system area is multiplied by the net area factor and the appropriate adjustment factor to calculate the projected area. Both the total projected area and the total area are summed at the bottom of the table.

Table E—Projected Area Adjustment Factors

Degrees off True South	Solar System Type: DG, TW, WW, SSC	SSA SSD	SSB, SSE
0	1.00	0.77	0.75
5	1.00	0.76	0.75
10	0.98	0.75	0.74
15	0.97	0.74	0.73
20	0.94	0.72	0.70
25	0.91	0.69	0.68
30	0.87	0.66	0.65

The last part of Step A is to divide the total projected area by the conditioned floor area, giving the total projected area per square foot. This value is used in Worksheet I, Step E to determine the heating degree day multiplier.

Step B. Load Collector Ratio
The load collector ratio is calculated by taking the total heat loss from Worksheet I, Step D and multiplying this value times 24 (hours/day) and dividing by the total projected area of the solar glazing calculated in the previous step.

Step C. Solar Savings Fraction
The next step is to calculate the solar savings fraction for the building. This is calculated as a weighted average of the solar savings fraction for the separate passive solar systems. The weightings are based on projected area.

The solar systems used in this step should be identical to those used above in Step A. The first two columns are simply carried down from the first and last columns in Step A.

The solar savings fraction for each individual system is taken from Tables F1 through F4 based on the load collector ratio calculated in Step B and the type of solar system. Table F1 is for direct gain systems, Table F2 for thermal storage walls, Table F3 for water walls and Table F4 for sunspaces. There are multiple columns in each table that account for system design features such as night insulation or selective surfaces.

A reference code, for instance "DGC1", is also provided for each solar system variation. These references are entered on the worksheet "Solar System Reference Code". They are also a key to additional information about each solar system as provided in *Passive Solar Heating Analysis* and other reference manuals.

F1—Direct Gain

Load Collector Ratio	DGC1 Double Glazing	Low-e Glazing	DGC3 R-9 Night Insulation
200	0.10	0.11	0.13
155	0.13	0.14	0.17
100	0.18	0.20	0.24
80	0.22	0.25	0.30
60	0.28	0.31	0.38
50	0.32	0.36	0.44
45	0.34	0.39	0.47
40	0.37	0.43	0.51
35	0.40	0.47	0.56
30	0.44	0.52	0.62
25	0.49	0.58	0.69
20	0.55	0.65	0.77
15	0.62	0.74	0.85

F4—Sunspaces

Load Collector Ratio	Sunspace Type SSA1	SSB1	SSC1	SSD1	SSE1
200	0.17	0.14	0.11	0.19	0.15
155	0.20	0.17	0.14	0.23	0.19
100	0.26	0.22	0.19	0.30	0.26
80	0.30	0.25	0.23	0.35	0.30
60	0.35	0.30	0.28	0.42	0.36
50	0.39	0.34	0.32	0.46	0.40
45	0.42	0.36	0.35	0.49	0.43
40	0.44	0.39	0.38	0.52	0.46
35	0.48	0.42	0.41	0.56	0.49
30	0.52	0.46	0.45	0.60	0.54
25	0.56	0.50	0.50	0.65	0.59
20	0.62	0.56	0.57	0.72	0.65
15	0.70	0.64	0.65	0.79	0.73

The solar savings fraction for each system is multiplied by the projected area and totaled at the bottom of the table. This total is then divided by the total projected area from Step A to calculate the weighted average solar savings fraction for the whole building.

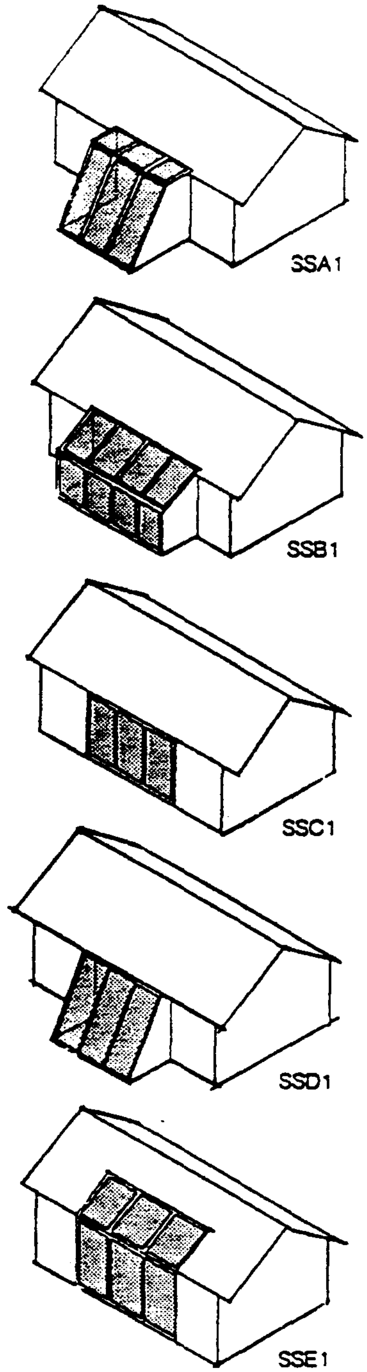
The solar savings fractions are based on reference designs. The assumptions made about these reference designs are summarized below.

Direct Gain
The direct gain reference designs are all assumed to have double-pane glass and sufficient heat storage to limit the clear day temperature swing to 13°F. For the case with night insulation, the thermal resistance is assumed to be R-9.

Trombe Walls
The Trombe wall reference designs are all assumed to have double-pane glass. The mass wall is assumed to be 12 inches thick and constructed of masonry or concrete.

Water Walls
The water wall reference designs are all assumed to have double-pane glass. The water tank is assumed to be nine inches thick, extending continuously in front of the glazing surface. The space between the water tank and the glazing is assumed to be sealed.

Sunspaces
Data is provided for five sunspace reference designs as illustrated on the following figure. Double glazing is assumed for all reference designs. Reference designs SSA1, SSB1 and SSD1 are assumed to have opaque end walls. All are assumed to have a concrete or masonry floor about six inches thick and a masonry or concrete common wall separating the sunspace from the living areas of the house. The glazing for designs SSA1 and SSD1 is assumed to be sloped at an angle of 50° from the horizon. The sloped glazing in designs B and E is assumed to be at an angle of 30°.



Sunspace Reference Designs
Data is provided for five types of sunspaces.

Step D. Auxiliary Heat Performance Level
The auxiliary heat performance level is calculated by multiplying the conservation performance level from Worksheet I, Step E, times one minus the solar savings fraction, calculated in the previous step. This value represents the amount of heat that must be provided to the building by the auxiliary heating system(s).

Step E. Comparative Auxiliary Heat Performance
The calculated auxiliary heat performance level may be compared to the performance level for a typical basecase building in the area. This may be taken from Table G and is 23,099 Btu/yr-sf.

Table G—Base Case Auxiliary Heat Performance (Btu/yr-sf)

Base Case	23,099

Alternatively, the performance level may be compared to a previous worksheet calculation made for a typical builder house.

If the auxiliary heat performance level calculated in Step D were larger than the base case auxiliary heat performance, the designer should consider increasing the size of the solar systems, adding additional solar systems or increasing insulation levels.

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	464	×	4.7	=	2181
Spaces Connected to Direct Gain Spaces	949	×	4.5	=	4271
				Total	6452 Btu/°F

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	103	×	13.4	=	1374
Exposed Slab Not in Sun	137	×	1.8	=	247
		×		=	
		×		=	
		×		=	
				Total	1621 Btu/°F

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	=	
FACE BRICK	111	×	3.7	=	411
		×		=	
		×		=	
				Total	411 Btu/°F

D. Total Heat Capacity

8484 (A+B+C) Btu/°F

E. Total Heat Capacity per Square Foot

8484 (Total Heat Capacity) ÷ 1504 (Conditioned Floor Area) = 5.6 Btu/°F-sf

F. Clear Winter Day Temperature Swing

	Total Projected Area [Worksheet II]		Comfort Factor [Table I]		
Direct Gain	69	×	866	=	59,754
Sunspaces or Vented Trombe Walls	163	×	299	=	48,737
				Total	108,491

108,491 (Total) ÷ 8484 (Total Heat Capacity) = 12.8 °F

G. Recommended Maximum Temperature Swing

13 °F

Compare Line F to Line G

Worksheet III: Thermal Mass/Comfort

This worksheet is used to calculate the thermal mass/comfort performance level, which is the temperature swing expected on a clear winter day with the auxiliary heating system not operating. A high temperature swing would indicate that inadequate thermal mass is provided in the building design, which not only creates discomfort but decreases solar heating performance.

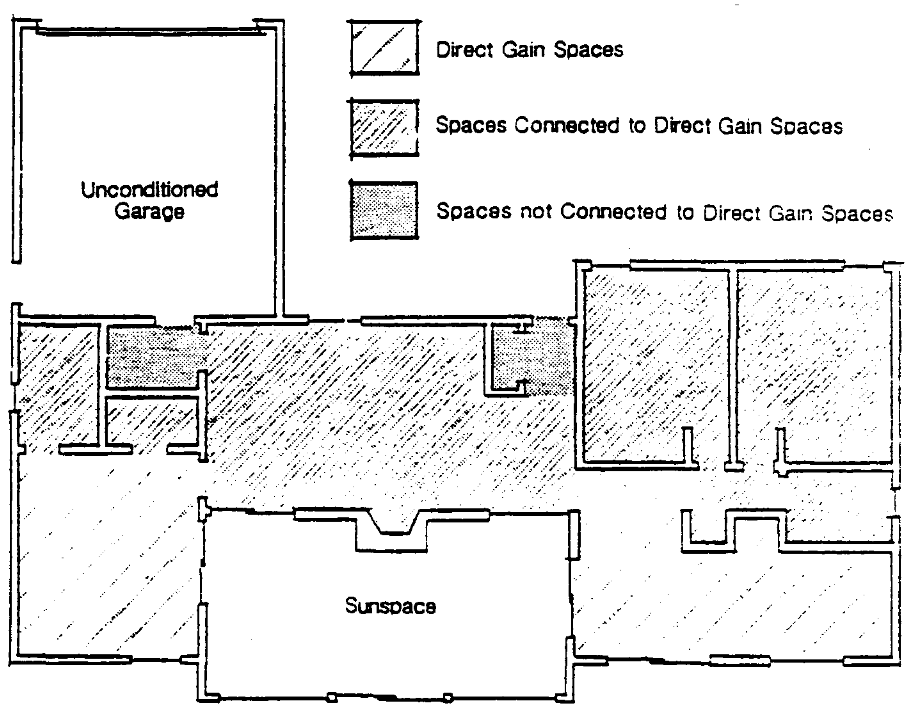
The general procedure of the worksheet is to calculate the effective heat capacity of mass elements located within the conditioned space of the building. The total effective heat capacity is then combined with the direct gain projected area to estimate the clear winter day temperature swing. Note that thermal mass elements located within unconditioned spaces such as the sunspace are not included in this calculation.

Step A. Heat Capacity of Sheetrock and Interior Furnishings

The first step is to estimate the effective heat capacity associated with low-mass construction and interior furnishings. To complete this step it is necessary that two sub-areas be identified within the building: those areas that receive direct solar gains and those areas that are connected to rooms that receive direct solar gains. This is because the mass of sheetrock and furnishings located in direct gain rooms is more effective. Rooms that are separated from direct gain spaces by more than one door should not be included in either category.

In the example building, the master bedroom, dining area and kitchen are all direct gain spaces. The secondary bedrooms, bathrooms and master bedroom closet are directly connected to the direct gain spaces. The utility room and entry foyer are not considered in this calculation since they are not connected to a direct gain space. These areas are illustrated for the example building.

The direct gain space is multiplied by 4.7 and the spaces connected to direct gain spaces are multiplied by 4.5. These products are summed and represent the effective heat capacity associated with the sheetrock and interior furnishings.



Building Sub-areas for Calculating Effective Heat Capacity
Worksheet III requires that the building be divided into sub-areas.

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

The heat capacity of thermal mass elements (other than sheetrock and furnishings) that enclose the direct gain spaces is considered in this step. The surface area of each element is measured from the building plans and multiplied by the unit heat capacity. The unit heat capacity is printed directly in the table for Trombe walls, water walls, and exposed slabs-on-grade. The unit heat capacity for other mass elements is selected from Table H1. Note that thermal mass located in the sunspace is not included in this calculation.

H1—Mass Surfaces Enclosing Direct Gain Spaces

Material	Thickness (inches) 1	2	3	4	6	8	12
Poured Conc.	1.8	4.3	6.7	8.8	11.3	11.5	10.3
Conc. Masonry	1.8	4.2	6.5	8.4	10.2	10.0	9.0
Face Brick	2.0	4.7	7.1	9.0	10.4	9.9	9.0
Flag Stone	2.1	4.8	7.1	8.5	8.6	8.0	7.6
Builder Brick	1.5	3.7	5.4	6.5	6.6	6.0	5.8
Adobe	1.3	3.2	4.8	5.5	5.4	4.9	4.8
Hardwood	0.4	1.4	1.8	1.7	1.5	1.5	1.5
Water	5.2	10.4	15.6	20.8	31.2	41.6	62.4

Exposed slabs-on-grade include those with a surface of vinyl tile, ceramic tile or other materials that are highly conductive. Slabs that are covered with carpet should not be considered to be exposed. The exposed slab area should be further reduced, when appropriate, to account for throw rugs and furnishings.

The exposed slab area is then subdivided into two areas: that which is expected to be in the sun and that which is not. As a rule-of-thumb, slab area should be considered in the sun only when it is located directly behind south glazing. In any event, the slab area assumed to be in the sun should not exceed 1.5 times the south glass area.

In the example building, the slabs-on-grade located in the kitchen and dining room are located within direct gain spaces. Some of this area is considered to be in the sun and the remainder not. These surface areas are entered in the table and multiplied by the appropriate unit heat capacity. The products are then summed at the bottom of the table.

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

The same type of calculation is performed for mass surfaces that enclose spaces connected to direct gain spaces. The primary difference is the unit heat capacity figures taken from Table H2 instead of Table H1.

In the example building, the fireplace wall and hearth are considered in this category. This area and the unit heat capacity is entered in the table and multiplied by each other. This represents the total effective heat capacity of mass elements that enclose the spaces connected to direct gain spaces.

H2—Rooms with no Direct Solar Gain

Material	Thickness (inches) 1	2	3	4	6	8	12
Poured Conc.	1.7	3.0	3.6	3.8	3.7	3.6	3.4
Conc. Masonry	1.6	2.9	3.5	3.6	3.6	3.4	3.2
Face Brick	1.8	3.1	3.6	3.7	3.5	3.4	3.2
Flag Stone	1.9	3.1	3.4	3.4	3.2	3.1	3.0
Builder Brick	1.4	2.6	3.0	3.1	2.9	2.7	2.7
Adobe	1.2	2.4	2.8	2.8	2.6	2.4	2.4
Hardwood	0.5	1.1	1.3	1.2	1.1	1.0	1.1

Step D. Total Heat Capacity
The total heat capacity is the sum of the heat capacity from Steps A, B and C. This represents the effective heat capacity of all thermal mass within the building.

Step E. Total Heat Capacity per Square Foot
The total heat capacity calculated in Step D is divided by the total floor area of the building to get the total heat capacity per square foot. The floor area used in this calculation should not include the sunspace or other unconditioned spaces. This value is calculated here for convenience, but it is not used until Worksheet IV is completed.

Step F. Clear Winter Day Temperature Swing
The clear winter day temperature swing is calculated in Step F. The projected area of all direct gain glazing is entered in the first row. This includes all direct gain systems either with or without night insulation. In the second row, the projected area of sunspace glazing and Trombe walls vented to the indoors is entered. Unvented Trombe walls and water walls are not included in this calculation since solar gain from these systems does not contribute to the temperature swing of the conditioned space.

The appropriate comfort factor is entered in the second column, selected from Table I. The projected areas are multiplied by the appropriate comfort factors and summed. This sum is then divided by the total heat capacity from Step D to yield the clear winter day temperature swing.

Table I—Comfort Factors (Btu/sf)

Direct Gain	866
Sunspaces and Vented Trombe Walls	299

Step G. Recommended Maximum Temperature Swing
The comfort performance target for all locations is 13°F. If the comfort performance level calculated in Step F had been greater than 13°F, additional thermal mass should be added to the building or direct gain glazing should be reduced.

Worksheet IV: Summer Cooling Performance Level

A. Opaque Surfaces

Description	Heat Loss [Worksheet I]		Radiant Barrier Factor [Table J]		Absorptance [Table K]		Heat Gain Factor [Table L]		Load
Ceilings/roofs ATTIC	30	×	1.00	×	.47	×	47.0	=	663
CATHED. CLG.	17	×	1.00	×	.47	×	47.0	=	376
		×		×		×		=	
Walls	40	×	na		.70	×	26.3	=	736
		×	na			×		=	
Doors	3.5	×	na		.30	×	26.3	=	28
								Total	1803 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	40	×	0.80	×	.84	×	37.0	=	995
East Glass	6	×	0.80	×	1.00	×	68.9	=	331
West Glass	6	×	0.80	×	1.00	×	73.2	=	351
Skylights		×	0.80	×		×		=	
								Total	1,677 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	88	×	0.80	×	.83	×	55.0	=	3,214
Storage Walls		×	0.80	×		×		=	
Sunspace SSC1	208	×	0.80	×	.83	×	12.2	=	1,685
		×	0.80	×		×		=	
								Total	4,899 kBtu/yr

D. Internal Gain

2,250 (Constant Component [Table N]) + (940 (Variable Component [Table N]) × 3 (Number of Bedrooms)) = 5,070 kBtu/yr

E. Cooling Load per Square Foot

1,000 × 13,449 (A+B+C+D) ÷ 1,504 (Floor Area) = 8,942 Btu/yr-sf

F. Adjustment for Thermal Mass and Ventilation

736 [Table O] Btu/yr-sf

G. Cooling Performance Level

8,206 (E -F) Btu/yr-sf

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

9,766 Btu/yr-sf

Compare Line G to Line H

Worksheet IV: Summer Cooling Performance Level

Worksheet IV is used to calculate the summer cooling performance level. This is the heat that would need to be removed from the building by an air conditioner in order to maintain comfort during the summer.

The worksheet accounts for four sources of cooling load: opaque surfaces exposed to the sun, non-solar windows, passive solar systems, and internal gain. These loads are then adjusted to account for ventilation and thermal mass.

Step A. Opaque Surfaces
Not all opaque surfaces contribute to the cooling load of the building; only those surfaces exposed to sunlight (ceilings/roofs and walls) are included in the calculation. For each ceiling and wall surface listed on Worksheet I and exposed to the sun, the heat loss should be carried over to this worksheet along with a consistent description. This heat loss is then multiplied by a radiant barrier factor when appropriate (from Table J), the absorptance (from Table K) and a heat gain factor (from Table L). The end product of this calculation is an estimate of the annual cooling load that is associated with each surface in thousands of Btu per year (kBtu/yr).

Table J—Radiant Barrier Factors

Radiant Barrier	0.75
No Radiant Barrier	1.00

Table K—Solar Absorptances

Color	Absorptance
Gloss White	0.25
Semi-gloss White	0.30
Light Green	0.47
Kelly Green	0.51
Medium Blue	0.51
Medium Yellow	0.57
Medium Orange	0.58
Medium Green	0.59
Light Buff Brick	0.60
Bare Concrete	0.65
Red Brick	0.70
Medium Red	0.80
Medium Brown	0.84
Dark Blue-Grey	0.88
Dark Brown	0.88

Table L—Heat Gain Factors

Ceiling/roofs	47.0
Walls and Doors	26.3
North Glass	37.0
East Glass	68.9
West Glass	73.2
Skylights	134.2
Direct Gain Glazing	55.0
Trombe Walls and Water Walls	12.2
Sunspaces	
SSA1	39.3
SSB1	39.3
SSC1	12.2
SSD1	39.3
SSE1	39.3

In the example building, four lines of the table are completed, two for the ceiling/roof types, one for the exterior walls with brick veneer and one for the entrance door. The wall that separates the house from the garage and the door in this wall are not included, since they are not exposed to sunlight.

The heat loss from each of these elements is carried over from Worksheet I. Note that the door heat loss is reduced by half since one of the two doors does not receive sunlight. The proposed building does not have a radiant barrier in the attic, so the radiant barrier factor is 1.00. Absorptances are selected based on the exterior building colors and the heat gain factors are from Table L.

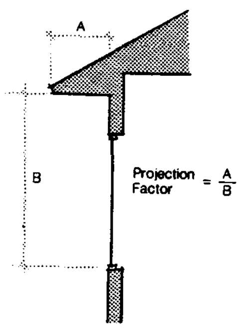
Step B. Non-solar Glazing
Cooling load associated with the windows that do not face south, i.e. those that are not part of one of the solar systems, is calculated by multiplying the surface area in each orientation times the net area factor, a shade factor (from Table M) and a heat gain factor (from Table L). This calculation gives the annual cooling load for each non-solar glazed surface. The total for the building is the sum of the cooling load for each surface.

Table M—Shading Factors

Projection Factor	South	East	North	West
0.00	1.00	1.00	1.00	1.00
0.20	0.83	0.93	0.90	0.93
0.40	0.63	0.81	0.80	0.81
0.60	0.49	0.71	0.70	0.68
0.80	0.35	0.60	0.61	0.56
1.00	0.30	0.50	0.54	0.45
1.20	0.24	0.40	0.46	0.38

The rough frame area is generally entered in the table and adjusted by the net area factor. If the net glazing area is entered instead, then the net area factor is 1.00.

Table M gives the shade factor for overhangs. The overhang shade factor depends on the orientation of the window and the projection factor. The projection factor is the overhang projection divided by the distance from the bottom of the window to the bottom of the overhang, as illustrated below.



Overhang Projection Factor
The projection factor is the overhang projection divided by the distance between the bottom of the window and the bottom of the overhang.

The north windows have a height of four feet and the bottom of the overhang is about six inches above the window head. The overhang projection is 1.5 feet. The projection factor is calculated by dividing the overhang projection by the distance from the bottom of the window to the bottom of the overhang. This is about 0.33. A shade factor of 0.84 is used in the calculations, which is interpolated between the values for a projection factor of 0.2 and 0.4

If the example building had tinted glazing, glazing films or external shading devices, the shade factors from Table M should not be used. Sunscreen and glass manufacturers usually rate the shading effect of their devices by publishing a shading coefficient. The shading coefficient is a number between zero and one that indicates how much solar heat makes it through the window compared to an unshaded 1/8 inch clear pane. This shading coefficient may be used in the calculation instead of the value from Table M.

The overhang on the east and west is at the eave, well above the window, and does not provide any useful shading. For these windows, the shade factor is 1.00.

Each glazing area is multiplied by the net area factor and the appropriate shade factor. The products are summed at the bottom of the table.

Step C. Solar Glazing
The solar systems addressed on Worksheet II reduce heating energy, but they also can increase cooling energy. The cooling energy impact of the solar systems is calculated in this step. Each solar system listed on Worksheet II should be carried over to this worksheet. The cooling energy for each system is calculated by multiplying the total surface area (not the projected area) times the net area factor, the appropriate shade factor (as discussed above) and a heat gain factor (from Table L). This calculation gives the annual cooling load for each passive solar system.

A shade factor of 0.83 is used because of south overhangs. This is based on a projection factor of about 0.2 as discussed above.

The annual cooling load associated with all the passive solar systems is summed at the bottom of the table.

Step D. Internal Gains

The last component of cooling load is from internal gain. Internal gain is heat given off by lights, appliances and people. Some of the cooling load associated with internal gain is considered to be constant for all houses regardless of the number of bedrooms or size. This is because all houses have a refrigerator and at least one occupant. Another component of cooling load from internal gain is considered to be variable and depends on the number of bedrooms. These components are accounted for separately in the calculation.

Both the constant component and the variable component are taken from Table N. The variable component is multiplied by the number of bedrooms in the house and added to the constant component to yield the total cooling load from internal gain.

Table N—Internal Gain Factors

Constant Component	2,250	kBtu/yr
Variable Component	940	kBtu/yr-BR

Step E. Cooling Load per Square Foot

This step sums the cooling load associated with opaque surfaces, non-solar glazing, passive solar systems and internal gain (Steps A, B, C and D). The sum is then divided by the floor area of the building and multiplied by 1,000 to convert the cooling energy into terms consistent with the base case cooling performance.

Step F. Adjustment for Thermal Mass and Ventilation

The total cooling load calculated in Step E is adjusted in this step to account for the effects of thermal mass and ventilation.

The adjustment depends on the total heat capacity per square foot calculated on Worksheet III, Step E, but also depends on whether or not the building has night ventilation or ceiling fans. The adjustment is entered in the blank in Step F.

Table O—Thermal Mass and Ventilation Adjustment (Btu/yr-sf)

Total Heat Capacity per SF	Night Vent w/ Ceil. Fan	Night Vent w/ No Ceil. Fan	No Night Vent w/ Ceil. Fan	No Night Vent w/ No Ceil. Fan
0.0	4,250	400	2,320	-1,600
1.0	5,550	1,480	3,620	-520
2.0	6,240	2,080	4,310	080
3.0	6,610	2,420	4,680	410
4.0	6,800	2,600	4,870	600
5.0	6,910	2,700	4,980	700
6.0	6,960	2,760	5,030	760
7.0	6,990	2,790	5,060	790
8.0	7,010	2,810	5,080	810
9.0	7,010	2,820	5,080	820
10.0	7,020	2,820	5,090	820

Total heat capacity per square foot is calculated on Worksheet III, Step E.

The example building has a total heat capacity per square foot of 5.6. It has neither night ventilation nor ceiling fans.

Night ventilation is a building operation strategy where windows are opened at night when the air is cooler. The cool night air allows heat to escape from the thermal mass elements in the building. The cooler thermal mass elements help keep the building comfortable the following day when air temperatures rise.

Step G. Cooling Performance Level

The summer cooling performance level is calculated by subtracting the adjustment in Step F from the cooling load per square foot calculated in Step E. This is an estimate of the amount of heat that must be removed from the building each year by the air conditioner.

Step H. Comparison Cooling Performance

The cooling performance level for the proposed design may be compared to the base case cooling performance level for the area, given in Table P.

Table P—Base Case Cooling Performance (Btu/sf-yr)

Base Case	9,766

Alternatively, the cooling performance level may be compared to other building designs considered by the builder to be typical of the area. In this case, the worksheets would first be completed for the typical design and the results of these calculations would be entered in Step H.

If the cooling performance level of the proposed building (Step G) is greater than the base case or typical-design conservation performance level, the designer should consider measures to reduce the cooling performance level. Such measures might include reducing non-solar glass, providing additional shading or increasing thermal mass.

Technical Basis for the Builder Guidelines

How These Guidelines Were Produced

The Builder Guideline, Worksheet, and Example booklets have each been generated by merging two files in a microcomputer. The first, containing the text, is a word-processor file which does not change from location to location. The second is a file of numbers and text which is location dependent. This file is produced by running a special microcomputer program which calculates performance numbers based on long-term monthly weather and solar data compiled by the National Oceanic and Atmospheric Administration for the particular locality selected. The merged files, with all the numbers and text slotted into their proper place, are then run off on a laser printer to produce the camera-ready copies of the booklets.

More Than a Decade of Experience

The concentrated effort of research, design, construction, and evaluation of actual buildings which started at the Passive Solar Conference in Albuquerque in 1976 has continued up to the present. It has been estimated that more than 200,000 passive solar houses have been built in the United States during this time. These Guidelines distill the wealth of experience which has been obtained from this massive effort.

Analysis Procedures

The numbers which appear in the Guidelines and Worksheets have been calculated using well established procedures for estimating the performance of passive solar and natural cooling strategies. Each of these procedures were developed at the Los Alamos National Laboratory with funding from the US DOE Solar Buildings Program.

Conservation Performance

The heat loss calculation on Worksheet I is based on a straightforward summation of the traditional elements which make up the building heat loss coefficient (excluding the solar components). The Conservation Performance Level is calculated by multiplying this loss coefficient by annual degree days. Degree-days for each month have been determined using an appropriate base temperature which accounts for an assumed thermostat setting of 70 °F, an assumed internal heat generation of 36 Btu/day per sq ft, and the building loss coefficient. This forms the basis of the Heating Degree Day Multiplier in Worksheet Table C1. The result of the Worksheet is an estimate of the annual heat required to maintain comfort, excluding both positive and negative effects due to 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 Guideline recommendations. This is a conservative assumption since there will always be some solar gains through these windows.

Passive Solar Heating Performance

Passive solar heating performance is calculated using the Solar Load Ratio (SLR) method (refs. 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 are then combined into the annual values listed in Worksheet Tables F1-F4. The SLR method gives answers which agree within about 5% of the hourly computer simulations and within 11% of the measured passive solar performance of 55 houses monitored under the US DOE Solar Program. The SSF estimates account properly for both gains and losses and thus correct for having omitted solar components from the building loss coefficient.

Temperature Swing

The temperature swing estimation on Worksheet 3 is based on the Diurnal Heat Capacity method (ref. 3). The method is an analytical procedure in which the total heat stored in the house during one day is estimated by summing the effective heat storage potential of the all the various materials in the house for a 24-hour periodic cycle of solar input (the diurnal heat capacity or dhc). 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 are approximated as 4.5 or 4.7 Btu/°F per sq ft of floor area. Worksheet Tables H1 and H2 list dhc values for various conventional materials which are often used to provide extra heat storage, assuming that these materials replace sheetrock.

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.

Summer Cooling Performance

The purpose of including the summer cooling estimates is only to determine if excessive cooling will result in a house designed for passive solar heating and to provide a rough estimate of the effectiveness of natural cooling strategies. The analysis method used is based on modified monthly degree-day method in which the day is divided into day and night periods (ref. 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 carry-over from day to night and night to day. The results reported are estimates of annual sensible cooling required by the house and do not include latent loads.

Since 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 due to 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 due to all inputs is summed and then adjusted for thermal mass and ventilation. This correction includes a constant required to achieve the calculated cooling load of the base-case house. This linearized procedure will give accurate estimates for cooling loads which are less than about 150% of the base-case house; however, it will underestimate very large cooling loads in poorly designed houses.

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 will avoid ventilation when humidity would cause discomfort.

Not for Sizing Equipment

All heating and cooling values given in the Guidelines Tables and numbers calculated using the Worksheets are for annual heat delivered or removed by the mechanical heating or cooling system. There is no direct way to use these numbers for sizing the capacity of this equipment. The methods developed by ASHRAE 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 the Guidelines in other Locations

Much of the guidance provided is applicable almost anywhere. The basic techniques of conservation, passive solar heating, and natural cooling are universal. However, a major value of these Guidelines is in providing location-specific performance values. These can vary widely, even within one State. Most of the numbers which appear in these booklets are calculated using data measured at a particular weather station and therefore apply only in that vicinity.

The applicability of Worksheets I and II can be extended somewhat by using base-65 °F degree-day values for a site which is close to the location for which the Worksheet tables were generated. The recommendation is to limit such application to sites for which the annual heating degree-days are within plus or minus ten percent of the parent location and where it is reasonable to assume that the solar radiation will be about the same as in the parent location. The procedure is simple: use the measured base-65 °F degree-days in Worksheet I, Line F, instead of the degree-days for the parent location.

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

The Cooling Performance Level results obtained from Worksheet IV are specific to the locality of the Guidelines. Within the same vicinity and within plus or minus twenty percent, the result could be adjusted, based on a ratio of cooling degree-days.

Getting Data

Heating and cooling degree-day data can be obtained from the National Climatic Center, Asheville, NC. Refer to Climatography of the United States No. 81 which lists monthly normals for the period 1951-80 on a state-by-state basis. There are over 2400 locations 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, pp 67-90, 1982.
2) J. Douglas Balcomb, Robert W. Jones, Robert D. McFarland, and William O. Wray, *Passive Solar Heating Analysis*, American Society of Heating, Cooling and Air-Conditioning Engineers, 1984.
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, Cooling and Air-Conditioning Engineers, 1987.
4) Robert D. McFarland and Gloria Lazarus, *Monthly Auxiliary Cooling Estimation for Residential Buildings*, Los Alamos National Laboratory Report, in press.

Worksheet Instructions

General
The Worksheets provide a calculation procedure to estimate the performance level of passive solar building designs. It is recommended that the results be compared to Worksheet calculations for the builder's typical house. Performance levels for the NAHB base case used in the guidelines are also provided for comparison.

A separate worksheet is provided for the four separate performance levels and associated base cases.

The worksheets are supported by a number of data tables. The tables are given a letter designation and are referenced next to each worksheet entry, when applicable.

The floor area used in the calculations should not include sunspaces, garages or other unconditioned spaces.

Worksheet I—Conservation Performance Level
This is an estimate of the amount of heat energy needed by the building each year from both the solar system and the auxiliary heating system.

For *Step A*, it is necessary to measure the net area of surfaces that enclose conditioned space. For walls, the net surface area is the gross wall area less the window and door area.

Rough frame dimensions are generally used to measure window area. The R-values in Table A4 are for the rough frame window area.

Heat loss from passive solar systems is *excluded*. The surface area of direct gain glazing, Trombe walls, water walls and the walls that separate sunspaces from the house are ignored.

Step A includes consideration of insulated floors over crawlspaces, unheated basements or garages. R-values are provided in Table A3 that account for the buffering effect of these unconditioned spaces. When insulation is not installed in the floor assembly, but rather around the perimeter of a crawlspace or unheated basement, *Step B* should be used.

The perimeter method of *Step B* is used for slabs-on-grade, the below-grade portion of heated basements, unheated basements (when the floor is not insulated), and perimeter insulated crawlspaces (when the floor is not insulated). Heated basement walls that are above grade should be considered in *Step A*.

Slab edge perimeter, unheated basements or perimeter insulated crawlspaces adjacent to sunspaces should not be included.

The conservation performance level is calculated as the product of the heat loss per degree day per square foot [Step D] and the heating degree days, adjusted for the heat loss and solar glazing per square foot. The adjustment is taken from Table C, based on data calculated on *Worksheet I, Step D* and *Worksheet II, Step A*.

Should the estimated conservation performance level be greater than desired, the designer should consider additional building insulation or reducing non-south glass area.

Worksheet II—Auxiliary Heat Performance Level
This is an estimate of the amount of heat that must be provided each year from the auxiliary heating system. It accounts for savings due to solar energy.

In *Step A* ,the user may enter the rough frame area of solar glazing, since it is generally easier to measure the rough frame area than it is the net glazing area. The worksheet includes a net area factor of 0.80 to account for window frames and mullions. If the designer enters the net glass area, then the net area factor is 1.00.

The projected area of the solar systems may be calculated using the adjustment factors in Table E or by making a scaled elevation drawing of the building facing exactly south and measuring the glazing area from the scaled drawing.

The projected area per square foot is calculated as the last part of *Step A*. This is used to determine the heating degree days adjustment used on *Worksheet I, Step E*.

The load collector ratio is calculated in *Step B*. This is used to determine the solar savings fractions in *Step C*.

The solar systems used in *Step C* should be identical to those used in *Step A*. The first and last columns of *Step A* are simply carried down.

The solar savings fraction is determined separately for each type of passive solar system by looking up values in Tables F1 through F4. The sunspace system types are shown beneath Table F4.

If the auxiliary heat performance level calculated in *Step D* is larger than desired, the designer should consider increasing the size of the solar systems or adding additional solar systems, i.e. thermal storage walls.

Worksheet III—Comfort Performance Level
This is the temperature swing expected on a clear winter day with the auxiliary heating system not operating.

This worksheet requires that two sub-areas be defined within the building: those areas that receive direct solar gains and those areas that are connected to rooms that receive direct solar gains. Rooms that are separated from direct gain spaces by more than one door should not be included in either category.

Thermal mass elements located in unconditioned spaces such as sunspaces are not included.

An exposed slab is one finished with vinyl tile, ceramic tile or other highly conductive materials. Carpeted slabs should not be considered exposed. The exposed slab area should be further reduced by about 50 percent to account for throw rugs and furnishings.

As a rule-of-thumb, exposed slab area should be considered to be in the sun only when it is located directly behind south glazing. The maximum slab area that is assumed to be in the sun should not exceed 1.5 times the adjacent south glass area.

In *Step F*, the projected area of solar glazing calculated on Worksheet II is used to calculate the comfort performance level. The projected area of water walls and unvented Trombe walls is excluded in this step.

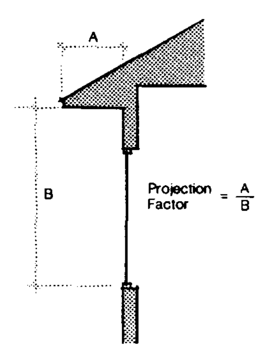
A high temperature swing indicates inadequate thermal mass or too much direct gain solar glazing. If the comfort performance level is greater than desired (13°F recommended), additional thermal mass should be added to the building or direct gain glazing should be reduced.

Worksheet IV—Summer Cooling Performance Level
This is an estimate of the annual cooling load of the building—the heat that needs to be removed from the building by an air conditioner in order to maintain comfort during the summer.

In *Step A*, only the envelope surfaces that are exposed to sunlight are to be included. For instance, floors over crawlspaces and walls or doors adjacent to garages are excluded.

Steps B and C of the worksheet account for solar gains. They use the rough frame area since this is easier to measure. The worksheets include a net area factor of 0.80 to account for window frames and mullions. If the net window area is used, the net area factor is 1.00.

Table M gives the shade factor for windows with overhangs based on a projection factor. The projection factor is the ratio between the horizontal projection of the overhang from the surface of window and the distance from the bottom of the window to the bottom of the overhang. When windows have sunscreens, tints or films, the shade factors in Table M should not be used. Instead, a shading coefficient should be determined from manufacturers' literature.



If the cooling performance level is greater than desired, the designer should consider reducing non-south glass, providing additional shading or increasing thermal mass.

This section is reserved for your hardcopy and viewgraph Presentation Materials.

Only those instructors who ordered a set of Guidelines for their own climate are will be receiving Presentation Materials.

Marketing and Coordinating

a Workshop Using the

Passive Solar Design Strategies: Guidelines for Home Builders

TABLE OF CONTENTS

CO-SPONSORS: HOW TO GET THEIR ENDORSEMENT/FINANCIAL SUPPORT/IN-KIND SERVICES

As an instructor there are three primary ways that allow you to determine whether your workshop was a success or not: 1) your attendees seemed satisfied with the information you presented; 2) you received positive evaluations about the effectiveness of your instruction; and 3) you turned a profit. While you have a lot of control over the first two, the third of these factors will perhaps be your biggest challenge. It's very difficult for a workshop to generate a profit without a co-sponsor to help defray expenses. But, it might not be as tough as you think to find a few organizations willing to help you out. Though some co-sponsors might be turned off by the prospect of simply writing you a check, they might be much more open to helping you out in other ways -- and it all comes out the same in the end. It is, however, very important that you find one or more organizations to assist you or you may find yourself swamped, both financially and physically.

One key to recruiting co-sponsors is to use your first one as a springboard to bringing others in. Approach them with the bandwagon theory: "I've gotten the local Home Builders to sign on, as they want to be a part of promoting energy efficiency in our community. Your organization can benefit from being associated with this program, too. Let's make this a joint effort and show unified support for energy and environmental conservation."

And, get the heads of those local organizations who have agreed to co-sponsor your workshop to pick up the phone and talk to their colleagues at other organizations. Play on their sense of community and spirit of cooperation.

The following will provide you with some suggestions for possible co-sponsors and how they might be willing to assist you in putting on a workshop.

A. Local Home Builder Associations: HBA's can access seed money from their national office, NAHB, and the workshop should be couched as an opportunity to provide their members with a service, something they are always in search of. Tell them that the workshop will not only educate the members on energy efficient construction concepts, which will help them to sell homes, but it might give them the opportunity to hook up with potential customers who are looking to buy or build a high quality passive solar home. HBA's will also respond to the opportunity to be associated with a "green" issue -- they tend to get a tough rap on these issues and any chance to appear environmentally conscious should be extremely important to them, both from a marketing and lobbying standpoint.

If the HBA can't afford to help you out financially, ask them to let you use their meeting facilities, equipment, borrow a staffer for a few hours, etc. They might be able to provide you with envelopes for mailing, and perhaps even postage. Ask if you can use their name as a co-sponsor, as this will provide you with credibility and help you in drawing in other potential co-sponsors.

B. Local Contractor Associations: Sell the co-sponsorship as a member service. The workshop will give contractors a chance to meet local developers for whom they might do work. Many of the same ideas for the HBA apply to the contractor's association as they also can provide facilities, equipment, and staff time, among other things. Be creative -- remember, anything they donate means you don't have to pay for it. That's money in your pocket.

HBA's and contractor associations are also good groups to play off of each other. They are often in competition in attempting to recruit members, and won't want to be left behind in a large event in their industry. They will also see a lot of benefit in being associated with a "green" issue.

C. Local AIA Chapters: AIA chapters also have facilities, etc., to lend. Architects will have an interest in meeting up with developers, home builders, and home owners who might have need for their services. The difficulty you will run into here is that a workshop oriented toward the home builder may be very different than one oriented toward the architect, and therefore an AIA group may not want to be involved in a "builders'" workshop. However, if you feel comfortable addressing the needs of both groups in your workshop, and can convince them that it will work, you have the makings of a very successful event both through co-sponsorship and the audience you will draw.

Architects also like to be associated with "green" issues. Where the environment is concerned, the rap on them isn't as bad as it is for the builder, but they want to be recognized as being on the cutting edge of design, and design that helps to conserve energy certainly falls into that category.

D. State Energy Offices: A co-sponsorship will provide you with tremendous credibility, as it shows the state's commitment to energy efficiency. Typically they're good for a contribution, but if not they can still print, mail and promote through their offices to help defer costs.

E. Utilities: This could be your best opportunity, as many utilities have new residential programs. Money is often available for seminars just like these. Utilities want to spend money on the "right" programs. Being identified as "green" is also important for utilities.

F. Real Estate Agencies: As an opportunity to bring in potential customers, agencies might co-sponsor a workshop. They would definitely have to be workshops oriented toward the home buying public.

G. Building Product Companies: Brick, glass, concrete masonry, tile and other manufacturers who make products used in passive solar buildings are great co-sponsors. They want to be associated with passive solar construction, and they want builders, contractors, architects and home buyers to think of them when considering what products to use in building their houses. Try the HBA's associate member list for some local manufacturers. Larger ones may even be interested in co-sponsoring a series of workshops.

AUDIENCES YOU SHOULD TARGET

Prior to attempting to land your co-sponsors, it is important to identify the audience for whom you will be tailoring your workshop. Obviously, your experience will dictate those you will feel most comfortable teaching, and who will most likely be your target groups, at least initially. It is important to remember that a workshop tailored to builders may not be exactly right for architects, and vice versa. You might want to consider holding more than one workshop to address the needs of all the potential audiences in your area.

The following are some of the main groups you might wish to focus on, and what might pique their interest.

A. Local Home Builders: First, The Guidelines were designed by builders for builders, so if there is an ideal audience for a workshop, this is it. The Guidelines is an extremely practical tool, and builders relate to it and understand its concepts very well.

Second, builders will want to stay on top of the current trends in building and learn new techniques they can use in constructing their homes to make them more marketable. Energy efficient homes are certainly more marketable, so use this angle when appealing to this audience. To draw builders, they must be convinced that learning passive solar concepts and incorporating them in their homes will provide them with more opportunities to sell homes. That is the bottom line.

Third, builders will be drawn by the lure of potential home buyers being in the audience. Therefore, to help you get builders in, you should conduct a two-fold promotion, focusing on both builders and home buyers. You might think about having the home buyers stay for the first part of the workshop, with a networking lunch to follow or extended coffee break mid-morning so the builders can make some business contacts. The builders could then stay on for the more technical portion of the day and the home buyers could leave.

B. Potential Home Buyers: The appeal to home buyers is the opportunity to learn about the potential for energy savings in the home. Consumers are becoming much more environmentally aware, and are always concerned about saving money. The opportunity to learn about such energy/cost saving measures is an important marketing angle in attracting home buyers to your workshop. Remember, however, that the worksheet portion of the workshop may be too technical for most home buyers, so you may want create a joint workshop to include home builders as well. This also gives home buyers a chance to talk with builders who are committed to building energy efficient homes.

C. Local Contractor Associations: The lure for this group is the potential business for the contractor. They want to meet builder/developers in order to drum up business for themselves. Therefore, you may want to market your buyer/builder workshop to the contractors as well. Also, adding knowledge about passive solar and energy efficient building to his or her repetoire opens up new doors for a contractor.

D. Local AIA Chapters: The appeal is much the same as it is for the contractor. The architect gains knowledge about these concepts, and therefore becomes much more marketable. If you want, you can attempt to draw builders and architects to the same workshop, however you will need to be adept at addressing the needs and interests of both groups, which can be challenging. However, if you have a building background, you might think about team teaching the workshop with someone possessing an architectural bent to address those needs, or vice versa.

E. Utilities: Renewables are becoming increasingly important to public utility commissions. Demand side management programs depend on good conservation strategies and reducing or shifting peak loads: The Guidelines can help utilities measure the benefits. Also, a passive solar workshop provides a utility the opportunity to keep its employees educated on the most recent energy efficiency developments.

F. State Energy Offices: Workshops will provide state energy offices with information they can pass on to their constituents. They also want to be aware of the latest and best energy conservation products and projects. Also, they simply want to support and promote energy conservation, and attending workshops shows that they are doing that.

G. University Students: Any student -- architecture, architectural technology, building technology, energy studies, mechanical engineering, etc. -- will want and need to know the ins and outs of renewable energy in building, and passive solar is of course a critical facet of this. Perhaps you can even talk with local universities to explore the possibilities of working the workshop into the regular curriculum as a one-day seminar.

HOW TO PROMOTE YOUR WORKSHOPS

Once you secure your co-sponsor(s) and determine your target audience, your next task is to promote your workshop. This will require time, some money, and above all, ingenuity. It may be the most time consuming aspect of the entire process, but it is by far the most important because without a substantial promotional push, the chances of your workshop succeeding are greatly diminished.

Many people are scared off by the idea of promotion because they identify it with the outlay of a lot of money. However, with some creativity and the help of some co-sponsors you'll be surprised at the mileage you can get out of a small amount of capital.

A. Free or inexpensive advertisements: If local associations can't provide money, assistance, or time, they may still be willing to provide ad space in their association newsletter free of charge. Get the associations to give you space in as many issues as possible leading up to the event. Inexpensive ads in local newspapers and trade publications are also effective. Flooding the market is important. A product manufacturer may be willing to pay for ad space in a trade magazine, or perhaps include information about your program in an ad they might be running. This needs to be discussed very early in the game, however, as any publication of significant size often sells their ad space at least a month in advance, and sometimes far earlier.

B. Brochures and flyers: If you are going to promote, you will have to have some sort of brochure or flyer. They are easy to mail, easy to carry (both for you and who you give them to), and can be done relatively cheaply. As mentioned above, try to get organizations to take care of the cost of printing, or at least the design or typesetting of a brochure. They may have a design person on staff or have a good relationship with one that will cut you a break on price. Include in them the essentials: Date and time of workshop; location (directions if necessary); price; any cosponsors; registration form and return address; phone number to call for information; and of course, a brief sketch of what it is about and perhaps what they will receive.

The brochures do not have to be fancy, just easy to read, informative, and a little creative. If you have PC capabilities, something can be done very easily with even a Wordperfect program and laser printer. If you don't have a laser, an organization will most surely allow you to at least plug in a disc and use their printer.

C. Promotion in person: Local associations will often allow you to make a presentation at a membership meeting or event and talk about your workshop for a few minutes, or at least an officer might give you a plug while doing his announcements. You can certainly have literature about the workshop available at the meeting for attendees. Make sure to point out all the reasons that that particular audience might benefit from the workshop, and who the other attendees will probably be.

If an association is holding a local or regional trade show or convention, they may provide you with a small amount of space to promote the workshop, or at least put up some signs and literature. If you are able to achieve this, try to set up a workshop date that will take best advantage of when the trade show takes place.

D. Mailing: Certainly an effective way to get your word out is through targeted mailing. Depending on the association or company, you may be able to get mailing lists free of charge. If they can run them on labels for you, so much the better. They might do the mailing for you, help you with a marketing letter, do a mail merge for you, maybe even pay for your mailing. Mailings should be very easy to digest, should be clever but not complicated, should have the important information jumping out at the reader (what it is, how they'll benefit). Your brochure should be set up like this anyway, so it can be used in the mailing as well. You might want to print the brochure with a blank panel for the mailing label, so it can be simply folded over and stapled. For ideas, look at some of the brochures you receive that catch your eye.

While direct mail generally averages around a 2% - 5% return, that number can be increased significantly through a series of follow up calls. This goes much easier if you have someone to help you. Also, mailings can be expensive, so getting a cosponsor to pick up the tab for this will be very helpful.

E. Coverage in publications: Not only can you get promotion from ads, but also from articles. Trade publications can run articles about your workshop and how it relates to the building industry, how passive solar can be beneficial to home buyers (mentioning your workshop as a means of learning more about it), or how building professionals benefit from knowledge of passive solar design. Try regional and local magazines, weekly and suburban newspapers, and university or adjunct program announcements, among other possibilities.

F. Regional Marketing: This idea is catching on. Consider coordinating your marketing efforts with others who might be doing the same workshop at different times of the year. You can share costs and hit a wider range of potential attendees.

The Guidelines often cover a climatic region rather than a specific city or state. State energy offices, HBA's, and local governments from all the surrounding states shoudl be taped support.

PROMOTIONAL TIMELINE

Once a tentative date for your workshop has been determined, a timeline outlining your promotional efforts and when to take care of the details of your workshop is very important. It helps to keep you organized and acts as a checklist and reminder of what remains to be done to prepare for your workshop. It is critical that you follow it as closely as possible. It is easy to let things slide when you get busy, but come the day of your workshop you'll be glad you didn't when the attendees are fighting for the chairs.

An excellent idea to keep you on track is to recruit some help in the form of a workshop coordinator. College students can be good for this role, and you could give them free admittance to your seminar in return. Also, a cosponsor might agree to give you a few hours of a staff person's time per week to help you out. Even if you can get someone to help you stuff envelopes, or lick stamps, it can be a huge help.

A. <u>6 months out</u>:

* Secure cosponsors -- after a call or visit make sure to get their commitment in writing.
* Determine audience you wish to target

B. <u>4 months out</u>:

* Set exact course date & time
* Arrange for workshop location
* Obtain moderator (optional) and instructor (if necessary) for course -- moderator might be someone representing cosponsor, providing them with a plug
* Prepare instructor biography for use in promotional pieces
* Prepare budget (include projected expenses and anticipated registration fee)
* Contact PSIC to inform of intent to hold workshop
* Acquire mailing lists for targeted audience
* Begin design of brochures, flyers, other mailing pieces
* Write advertisement(s)

C. <u>3 months out</u>:

* Begin promotion
    - print brochures, flyers, etc.
    - mail first notice of workshop
    - put first ads in newsletters, newspapers, etc.
    - make personal appearances at meetings, etc.

D. 2 months out:

* Conduct 2nd mailing
* One week after mailing, conduct telephone follow up
* Put 2nd advertisement in local newspaper, newsletter, etc.
* Personal appearances

E. 1 month out:

* Notify PSIC of the parent site for the Guidelines, how the title and footers should read, what the acknowledgements should say, and what basement configuration should be used in the Guidelines
* If you are the instructor, complete your applicability map using the instructions in your Instructor's Manual
* Sign and return your Instructor's Agreement to PSIC
* Confirm all registrations within 2 days of receipt
* Arrange audio-visual equipment and materials
* Reproduce hand-outs
* Confirm meeting space size and set-up
* Confirm any food orders (lunch, coffee breaks, etc.)
* Send letter of confirmation to facilities manager of meeting space regarding any room prices, food set-up, audio visual rentals, etc.
* Conduct final mailing
* One week after mailing, conduct telephone follow-up
* 3rd round of ads
* Any other personal appearances

F. 1-2 weeks out:

* No less than 10 DAYS prior to meeting, contact PSIC with final order amount for Guidelines workbooks (PSIC ships 7 days in advance of date, but will work to arrange shipping beyond that if necessary)
* Prepare badges for moderator, preregistrants, yourself; purchase extra blank badges for walk-ins
* Prepare list of preregistrants
* Make arrangements for on-site registration (an assistant - perhaps support staff from cosponsor - can be extremely beneficial for registration. You probably won't need them past 1/2 hour after course begins)
* Assemble and package all handout material

G. 2-3 days prior to workshop:

* If you are the instructor, take time to re-review your course outline and materials as final preparation for course

H. 1 day prior to workshop:

* Check facilities
  - review details with facility manager
  - check meeting room set-up
  - check audio/visual equipment, lights, extension cords, podium and microphone, etc.
  - give meal guarantee if necessary (this may be required 72 hours in advance, but usually they will accept increased guarantee up to 24 hours or less in advance) and confirm coffee
  - set up registration area and publications area
  - check locations of nearest telephones, restrooms, lights, controls, etc.
  - determine need for directional signs
  - take time to re-review your course outline

I. Day of course:

* Arrive at least one hour prior to start of program
* Check facilities
  - reconfirm times for coffee breaks, meals
  - check that room is set up properly++
  - if time, recheck a\v equipment to ensure in proper working order
  - set up registration table -- lay out badges, any preliminary handouts (unless you want them to be at each work station -- this takes longer but eliminates bottleneck at registration table), etc.
  - Put sign-in sheet for walk-ins, with space for address, phone number, company, at registration table
  - Have assistant at table marking off list preregistrants as they arrive
* At beginning of course, make certain to identify and thank cosponsors, organizations who lent space, time, any assistance
* Discuss PSIC and point out membership form in inside cover of binder
* At end of course, collect all evaluation forms, any membership applications they wish to turn in

J. Immediately following workshop:

* Send thank you's to all cosponsors, moderator, anyone who assisted in putting on the workshop
* Contact PSIC to discuss workshop
* Send list of attendees and any membership applications to PSIC

HOW TO SET UP YOUR SEMINAR ROOM

Room should be set up in schoolroom style, with two projection screens, one on each side of front of room. These will be used for overheads and slides. Overhead and slide projectors should be set up in such a way as to not obstruct audience view. There should be a table up front for the instructor to put materials on, and one or two tables in back of the room for handout materials. There should also be a registration table just outside the door with a sign-in sheet and registration list.

Lighting should be dimmed for portions of the visual presentation, but not so much that audience cannot see books or what they are writing.

Ideal audience size can vary depending on the size and configuration of your room. More than 100 participants could be difficult to seat close enough to the screens for adequate viewing.

BUDGETING THE WORKSHOP

Ideally, virtually all of your costs would be covered by your co-sponsors. However, invariably there will be certain items that co-sponsors for one reason or another won't end up paying for or doing through their own organization. This will give you an idea of how much each item might cost. Obviously, the strategy is to work your way from the most costly to the least when attempting to get your co-sponsors to pick up the tab. The asterisks identify those items that most likely could be taken care of by the co-sponsor. It is up to your negotiating skills to get as many of these items paid for as possible.

All of these prices will vary with the city in which you hold your workshop and the number of workshops you are holding. Those quoted under "Instructor Expenses" will of course be eliminated if you are teaching the course yourself.

A. Costs:

i. Instructor Expenses

Instructor Fee................$750 - 1500 per workshop -- depending on level of preparation and coordination

Instructor Flight.............$500

Instructor Hotel..............$75/night

Instructor Car................$50/day

Instructor Food...............$40/day

Instructor Per Diem...........$20/day

ii. Workshop Expenses

* Room Rental -- If you are comfortable taking care of all of the set-up, equipment rentals, food, coffee, etc. yourself, then it should not be a problem to get an organization to provide you with a room in their building. However, there is a lot of work that goes into putting this together on your own, and for the price of renting a room at a hotel, plus renting the equipment and ordering your food from them, you have the comfort of knowing that they are taking care of all of those details. You of course need to check with them periodically and make sure of everything just prior to the workshop, but using a hotel eliminates a lot of the headaches you might otherwise have. A hotel might even provide you with the room for free if you have them cater your lunch. If you are having someone sponsor your lunch, then that cost is defrayed and you can use that lunch as a bargaining chip with the hotel. They will negotiate prices (tell them that if this workshop is a success, you have plans for others), so haggle with them a little.

Room rental ....$100 - 500/day

Podium and microphone..............$50/day

Overhead projector.................$50 - $75/day

Slide Projector....................$50 - $75/day

Projection Screen..................$25 per screen/day

PC with LCD display for BuilderGuide
Demo (optional)....................$200 - $350 (LCD alone: $100 - 150)

Brochure design....................$100 - 150 for simple design

Printing of brochure
(1000 cps. at quick copy).....$250 - 500 (more for fancy paper)

Mailing of brochure................$145 (approx. 500 pieces @ .29/piece; extras use as handouts)

Xeroxing of evaluation forms,
handouts, extra worksheets, etc....$25 - $50

Coffee.............................$7 per head

Purchasing of Guidelines...........$30/set for 30 or more participants

B. Income Sources:

i. Attendees

The amount to charge each attendee is up to the instructor, but generally for a one-day workshop past instructors have charged between $50 and $125 a head, inclusive. Many factors will affect what you charge, however, such as whether you will be providing a non-sponsored lunch, if you will give an early-bird registration discount, if you charge extra for walk-ins, or whether you will give home buyers only attending half the course a discount, etc. Some co-sponsors like utilities and state energy offices have provided funds to subsidize the entrance fee. (So it has been as low as $25.)

ii. Co-sponsor cash donations

Generally co-sponsors are asked to contribute $1,500 apiece toward the workshop, so it is obvious the importance of getting as many co-sponsors as possible. Some smaller organizations may not be able to afford this amount, so let them give whatever they might be comfortable with. See list of co-sponsors for possibilities.

iii. Other types of donations

Outside of a simple cash donation, organizations can offset your costs in many other ways -- by paying for your printing (see if they'll just take the master of your brochure and take care of printing, stuffing and mailing, for example), picking up A/V costs, having one of their members sponsor the lunch, etc. See list of co-sponsors for more possibilities.

WHAT PSIC PROVIDES

- Helpful hints on organizing and holding a workshop
- List of qualified instructors
- Others in your area who have expressed an interest
- Instructor's agreement
- Instructor's Kit (including a script, slides, and Instructions)
- Passive Solar Design Strategies: Guidelines for Home Builders
- BuilderGuide discs and User's Manual
- Evaluation forms
- PSIC Information (newsletters, pamphlets, etc.)

HOW TO SELECT AN INSTRUCTOR

A. The PSIC Instructor

Bringing in a seasoned instructor that PSIC recommends is never a bad idea. These individuals have taught numerous workshops, know a great deal about building, passive solar concepts, and the Guidelines themselves. They have long been committed to passive solar as an energy-efficiency measure, and are energetic about the difference it can make in a home. Also, some feel that bringing in an expert from out of town lends an air of credibility to the presentation.

B. The Local Instructor

An instructor from the immediate vicinity can be extremely effective. He or she can refer to examples that the audience is most likely familiar with, can talk at length on how these concepts will work in that particular area, and can answer questions of a local nature. Also, if well-known, a local instructor can be a superb draw for your workshop.

C. Team Teaching

Perhaps the most effective method, but maybe more difficult to put together, is team teaching. Ideally, a local expert can be teamed up with a seasoned instructor to provide a two-pronged approach. The instructor can carry the bulk of the load, with the local expert providing specific local information. The best scenario would be to find someone who will volunteer to provide the local angle. It is an opportunity for them to perhaps get their business a little plug and something to put on their professional or company resume. Also, the out-of-town instructor will have to be paid, so you'd like to avoid doubling up on that cost. You may, however, need to pay them a modest fee.

Also, using instructors with different backgrounds (i.e., an architect and a builder, or builder and university professor) to team up will :1) Allow you to market the course to a more diversified audience; 2) Make for a more interesting course, as it provides different perspectives; 3) Better address the needs and answer the questions of your diversified audience; and 4) Provide diversity to the day.

SAMPLE MATERIALS FROM PAST WORKSHOPS

Enclosed is a sample agenda of how your day might go. This of course is simply a suggested agenda, and you will no doubt alter it to best suit your needs. Make sure to give yourself plenty of time to go through each section of the Guidelines.

Enclosed also is a sample instructors resume. You can use virtually any format, but it is a good idea to have maybe a one paragraph blurb that summarizes the experience and accomplishments of your instructor. You might use that along with a copy of a professional resume.

EQUIPMENT AND MATERIALS CHECKLIST

The following is a checklist for your use to help you make certain that you have all the materials and equipment you need for the course. It is a good idea to check this about a week before your course takes place to give you some time to get anything you might have overlooked. Check it again the day before your course and make sure all A/V equipment is set up and that you have all of your materials to take with you the day of the course.

EQUIPMENT

___ Overhead projector
___ Slide projector
___ Projection screens (2)
___ Podium and mike (if using)
___ PC and LCD display panel(if using)
___ Registration table
___ Publication table
___ Instructor work table
___ Pads and pencils for attendees

MATERIALS

___ Guidelines workbooks (including a few extra)
___ Extra worksheet copies
___ Evaluation forms
___ Pens for viewgraph work
___ PSIC information
___ Any handouts
___ Viewgraphs
___ Slide carousel prepared
___ BuilderGuide discs
___ Co-sponsor materials or displays
___ Registration forms
___ Sign-in sheets
___ Preregistered list

WHO YOU SHOULD THANK

It is very important that you give credit where credit is due. ANYONE that helped you in putting together your workshop, ESPECIALLY your co-sponsors should be thanked before, after, and during the course. They sponsor you in order to get as much exposure as possible, so give them all that you can and they may be willing to help you out in the future. Companies and organizations often have signs that you can use in the room or at the registration table to let everyone know they were a part of the workshop. You might have a slide made to have on the screen as attendees walk in that thanks the co-sponsors. They may have materials or displays you can put up. This part is easy -- do whatever you can to work their names in.

You can also alter the workbook covers to reflect the names of your co-sponsors. Just be sure that the complete title of the book, PSIC and SERI's name remain visible.

Also, make sure to mention the Guidelines were created, talk a little about PSIC and SERI -- mention SERI's new status as a national laboratory as well as their new name: The National Renewable Energy Laboratory or NREL -- and mention that there is information inside their workbooks about PSIC and how they can join.

Make sure to thank anyone that helped you stuff envelopes, lick stamps, make phone calls, whatever. This means a lot to them and they will be much more likely to help you out in the future if you show them how much you appreciated their help. You might even take them out to lunch as a thank-you gesture. A little food can go a long way.

WRAPPING IT UP

A. Evaluations

Make certain that everyone fills out an evaluation form. It will be of benefit to you to know where your strengths and weaknesses lie, and what portions of the course might need some polishing. As the attendees file out at the end of the day, stand by the door and have them hand you their evaluations. Then send the forms back to PSIC (if you would like to keep your evaluations, just make copies and send them to us).

B. Selling BuilderGuide

Remind them that a BuilderGuide order form is in the back of the workbook, and encourage them to order this product from PSIC.

Tips for Dealing Effectively with Audiences

Attitude

The single most important factor is ensuring the success of this or any other workshop is speaker enthusiasm. Interest and commitment -- or the lack of them -- to energy conservation and solar energy is easily transmitted to audiences, who are likely to take the same attitude, regardless of their level of sophistication.

We hope that the audiences are already interested in passive solar techniques to improve the quality of houses they build or design; and we hope they want to learn more about how to do that -- but it is up to the speaker to:

-- maintain and increase interest

-- gain the audience's confidence

-- convince the workshop participants to implement at least some of the techniques presented.

The material must be made interesting as well as informative. No one wants to hear a lecture. Solar energy is a practical, profitable option for builders, and should be presented that way.

Know your room and equipment.

-- Set up at least one-half hour before the workshop begins

-- Check out the equipment to make sure it's in working order. You'll need: a slide projector, an overhead projector, two screens, and an easel with markers, or a blackboard

-- Have your first slide up when the audience arrives

Don't darken the room more than necessary to see the slides, or you will lose contact with your audience.

Don't distribute the handouts until you are ready to begin talking about them, or the audience will probably be paging through the materials instead of listening to you. Save distribution of extra handouts (pamphlets, additional resources, etc.) for after the workshop.

Hold questions until the end of the presentation. Otherwise, you may find yourself answering questions that are explained later in the workshop.

If questions are reserved until the end, you may have better control over the length of the workshop, and participants with no questions are free to leave during the question-and-answer period.

You don't have to know everything. If you get a question you can't answer, say so. Don't invent answers, or pretend to have expertise you don't have, or you will lose credibility. Offer to find out the information, if you can, and then follow up. PSIC will offer you assistance if we can, and if we can't, we'll direct you to someone who can.

Handling the Audience

Be aware of -- and try to avoid -- distracting mannerisms such as:

-- jingling pocket change

-- pacing back and forth

-- rushing

-- filling pauses with "Y'know" or "uhh"

Be aware of -- and try to do more of -- habits that have a positive effect:

-- smiling

-- gesturing

-- speaking distinctly but naturally

-- using eye contact

-- really seeing and speaking to individuals in the audience, not just a faceless mass.

Place a clear plastic pocket here for your BuilderGuide discs.

USER MANUAL

for

BuilderGuide

ENERGY ANALYSIS SOFTWARE FOR HOMEBUILDERS

Version 1.0 August 1990

SOLAR ENERGY RESEARCH INSTITUTE
PASSIVE SOLAR INDUSTRIES COUNCIL

BuilderGuide

ENERGY ANALYSIS SOFTWARE FOR HOMEBUILDERS

A Design Tool for

Passive Solar Design Strategies

from the

Solar Energy Research Institute

written by

Dr. J. Douglas Balcomb
Program Design and Passive System Expertise

Norman Weaver, Alexander Lekov, Nancy Birkenheuer
Programming

in conjunction with the

Passive Solar Industries Council

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.

BuilderGuide VERSION 1.0 August 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 SERI.

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.

CONTENTS

Important

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 to 200 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 Reference`**.
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 time, 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 that 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 effects 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.

Equipment and Installation

BuilderGuide is written for the IBM PC family of microcomputers and runs under MS-DOS. It requires a computer with at least 340K of memory. A hard disk drive is recommended: however, the program can be run from floppy disks.

Getting Started

The first step is to install the program on your computer. The particular procedure to be followed depends on whether you will be running from a hard disk or from floppy disks. See Appendix A for instructions. When installation is complete, select the hard-disk directory or the floppy disk that contains the program files.

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:

```
Initialize   Worksheets   Review   Save file   Print  Quit
```

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, in many instances 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 most often used for reference data. F3 is most often 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 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 *Builder Guidelines*.

`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. This menu also allows you to change the reference to the current case by selecting **`Lock Reference`**.

`Save File`

This item gives 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 them 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.

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` during initialization, blanks are left in the worksheets.

After the base case has been defined, you can modify the base-case values in the worksheets to correspond to your house design, as described in the following section.

After making changes in the worksheets, you can see the effects of the changes on the bottom-line results by using the `Review` option. This allows you to quickly compare the revised results with the comparable results for the base case. The `Lock Reference` option allows you to replace the base case with the modified building you have defined in the worksheets so that you can easily study incremental changes in the design.

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. The software allows you to place the cursor on a non-highlighted field even if you cannot change 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. You are now 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
Right Arrow	Move one character to the right in a field
Enter	Move one field forward.
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 by 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.

> WARNING: The program does no range or error checking on your entries. It will accept numbers even though they may be impossible or silly values. As with the worksheet forms in the *Builder Guidelines*, or with any computer program, the dictum is "garbage in, garbage out." If you are unsure, you can protect yourself in several ways. First you can look at the number that has been inserted in the field by the program during the setup of the base case. This is a reasonable value, typical of houses in your location. Your number should not be vastly different. Second, you can refer to the help screen for that field (press F1). This will define the variable and often give an example. It also gives you the units of the number. Thirdly, you can refer to the example problem given the *Builder Guidelines*. This gives a completely filled-out set of worksheets for a particular house that has a variety of features. This illustrates how to deal with several common situations.

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. If you do 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 worksheet 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.

In most situations, the procedures should be familiar to persons who have done heat-loss calculations. Several special cases that may be confusing are described below.

Window Areas

Window areas are entered in two worksheets. Solar glazing (oriented within 45 degrees of true south) is entered on worksheet II. Non-solar glazing (all glazing that is not within 45 degrees of true south) is entered on worksheet IV. The sum of all non-solar rough-frame glazing areas entered on worksheet IV is automatically transferred into worksheet I and appears in the non-highlighted field labeled **Non-Solar Glazing**. This is done to assure consistency within the worksheets. The value cannot be modified on worksheet I, but can only be changed by modifying one or another of the entries on worksheet IV. The R-value of this glazing, however, is entered on worksheet I.

If your design has portions of window area that are oriented within 45 degrees of true south but that are shaded from direct-beam sun all winter, this area should be counted as non-solar glazing. The area of these portions should be included within the north window area on worksheet IV because it receives very little sun in summer.

Note that all glazing areas are entered as rough-frame areas. This is the size of the hole that is left in the wall by the framers and not the actual window area. A separate entry, called the Net Area Factor is used to convert these areas to actual net window areas. A value of 0.80 is entered into the Net Area Factor fields when the program is first loaded, but the fields can be changed if you have better values.

Note that the window areas carried into worksheet I from worksheet IV are rough-frame areas. Thus, for consistency, the associated window R-value should be a whole-window number (including frame effects) and not just the center-of-window value. This distinction can become particularly significant if you are using one of the new high-R window designs now coming into the marketplace. Indeed, frame effects are usually important in determining appropriate window R-values. Use help key F2 to call up a table of effective whole-window R-values for conventional window options.

Describing Floor Heat Loss

Several options are available to describe floor heat loss for different types of floor construction. For most house designs, you will use one of the rows in Section B of worksheet I, *Foundation Perimeter Heat Loss*. In these cases the heat loss is most accurately described by multiplying the house external perimeter length (ft) by a heat-loss factor (Btu/ft-hr-F, sometimes called an F-factor). Refer to help text F2 for representative heat-loss factors.

The two exceptions are cases in which the first floor is of frame construction and insulation is placed within this framing. This can occur when the first floor is located over a crawl space or over an unheated basement. In these situations the heat loss is most accurately described by dividing the floor area (sq ft) by an effective R-value (sq ft-hr-F/Btu), and the entry is made in Section A of worksheet I, *Envelope Heat Loss*. Refer to help text F2 for representative effective R-values.

Some house designs will have more than one floor type. The floor heat loss for these houses can be described by making multiple entries in worksheet I, using a separate entry to describe each floor type. Divide up the floor plan and enter appropriate measurements for each type into the appropriate row of the worksheet. Refer to the help text for guidance. Note, however, that in measuring the perimeter of a floor type, you should not include sections that lie internal to the floor plan of the house (for example along a line separating a section of crawl space from a section of slab-on-grade) because there will be no significant heat flow between the sections.

Selecting the Passive System Reference Code

On worksheet II, you are asked to supply a passive system reference code for each entry of solar glazing. 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 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 Heat Loss of the ceiling changes, the total Heat Loss 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`. Selecting `Lock Reference` transfers the four bottom-line results for this building into 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 in the summer you will also need to specify the Shading Factor 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 Climates

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 sq ft of floor area. This corresponds to 451 kWh per month for a 1500-sq-ft 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 sq ft 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 fewer, 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. Note that only data that refer to the house design are saved. The four reference values are not saved.

To load saved 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 there. 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.

Because the program prints a replica of the worksheets just as they appear on the computer screen, each worksheet requires two pages of printout, making the print process fairly time consuming.

APPENDIX A Program Installation

Program Installation on a Hard Disk

It is recommended that you install BuilderGuide in a separate directory on your computer's hard disk as 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(s) 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.
If there is only one disk, proceed to step 4.

Install disk #2 into your floppy disk drive.
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. BuilderGuide will load.

Running BuilderGuide from Floppy Disks

BuilderGuide can be run from one or more floppy disks, although frequent disk access will cause the program to run more slowly. If you have a system equipped with a 3 1/2 inch disk drive or a high-density 5 1/4 inch disk drive, you can run directly from this drive since all the files required will fit on one disk. The procedure is as follows:

Insert the BuilderGuide disk into the drive.

Type: `BG`
Press Enter. BuilderGuide will load.

If you do not have a hard disk and your system can read only low-density 5 1/4 inch disks, then you will need two floppy-disk drives to run BuilderGuide. The procedure requires one extra step as follows:

Insert Disk #1 into drive A and Disk # 2 into drive B.

Type: `Path B:`

Press Enter. (This DOS path command instructs the computer to search the B drive for the main BuilderGuide program. This is the only file stored on Disk #2. All other files must be stored on Disk #1.)

Type: `BG`
Press Enter. BuilderGuide will load.

APPENDIX B Technical Basis for the Calculations

Worksheet Calculations

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

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. In performing table lookups, BuilderGuide interpolates within the appropriate table.

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. Summer solar gains through all windows, as modified by Shading Factors, are accounted for in worksheet IV.

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 the 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/^{O}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 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 ^{O}F. This restriction prevents 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 ^{o}F degree day value for a site that 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 ^{o}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 *Climatography of the United States No. 81* which lists monthly heating degree day 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, 1989, Los Alamos, NM 87545.

5) J. Douglas Balcomb and Alexander B. Lekov, *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.

BuilderGuide Help Text

General Project Information

This section is self explanatory and simply provides a place to record general project information. Typical information is usually:

Project Name
Location
Designer
Floor Area
Date

Floor area is defined as the total area enclosed by the exterior of the building walls. The area of each floor is computed and these are then added together. Basements and unconditioned spaces, such as a garage or sun space, are not included.

Thus a two-story house measuring 25 by 40 ft exterior wall dimensions would have a floor area of 2000 sq ft. A split-level house with 500 sq ft at the lowest level, 1000 sq ft at the intermediate level and 500 sq ft at the highest level would also have a floor area of 2000 sq ft.

Floor area is used on all four worksheets. Heat loss, auxiliary heating, and auxiliary cooling are all normalized to this number.

Worksheet I: Conservation Performance Level

This worksheet is for basic information about the shell of the building to be analyzed to estimate the annual heat los through the shell, assuming that the average inside temperature is held at 70 degrees. This heat loss excludes the solar elements on the south side of the building. These are accounted for in Worksheet II.

A. Envelope Heat Loss

The first column of this section is provided to enter descriptive text. For roof/ceilings, as example, the text might be R-38 in attic or R-30 in cathedral ceiling.

All ceilings and roofs over heated spaces should be included; however, roofs over sun spaces should not be included.

All ceilings or roofs with the same R-value, except those over unheated spaces, should be combined into one entry. Separate listings should be made for ceilings or roofs with different R-values.

The second column is for the area in square feet of each component. Ceiling area is based on exterior wall dimensions. For typical attic construction with insulation located directly above the ceiling, the ceiling area should be entered and not the area of the pitched roof above the attic.

For a single-story house, with a flat ceiling throughout, the ceiling area will equal the floor area; for a two-story house with equal sized floors, the area will be one-half the floor area.

For cathedral roofs, the area should be the actual sloped area of the roof.

Include all ceiling or roof area above conditioned spaces. Do not include any area above buffer spaces, such as garages or sun spaces. Do not include the area of roof overhangs.

To determine the sloped area for a roof over rooms with a cathedral ceiling, multiply the floor area by the following factor:

Pitch	Slope	Factor
Flat	0 degrees	1.00
4 in 12	18 degrees	1.05
5 in 12	23 degrees	1.08
6 in 12	27 degrees	1.12
7 in 12	30 degrees	1.16
8 in 12	34 degrees	1.20
10 in 12	40 degrees	1.30
12 in 12	45 degrees	1.41

For example, the area of a cathedral ceiling having an 8 in 12 pitch over a 200 sq ft living room is 200 x 1.20 = 240 sq ft.

For pitches not listed in the F2 help-text table, the factor can be calculated as follows:
factor = square root (1 + pitch squared)

Thus, for 8 in 12 pitch,

factor = square root (1 + (8 1/2)) = 1.20

For example, the area of a cathedral ceiling having an 8 in 12 pitch over a 200 sq ft living room is 200 x 1.20 = 240 sq ft.

Column three, R-value is provided to list the thermal resistance of each component. The higher the R-value, the better the insulating capability. R-value is given in units of F-hr-sq ft/Btu. It is not the number on the batt of insulation. All effects, such as parallel heat flow paths through joists and insulation, the buffering effect of the attic and of the inside and outside air should be taken into account. The result is called an effective R-value.

R-value must be determined in a manner consistent with the definition of ceiling or roof area. For effective R-values that have been calculated for typical constructions are as shown in Table A1:

Attic Construction

Insulation R-value	R-30	R-38	R-49	R-60
Effective r-value	27.9	35.9	46.9	57.9

Cathedral Ceiling Construction

Roof Framing	Insulation R-value			
	R-19	R-22	R-30	R-38
2x6 at 16\" oc	14.7	15.8	16.3	-
2x6 at 24\" oc	15.3	16.5	17.1	-
2x8 at 16\" oc	17.0	18.9	20.6	21.1
2x8 at 24\" oc	17.6	19.6	21.6	22.2
2x10 at 16\" oc	18.1	20.1	24.5	25.7
2x10 at 24\" oc	18.4	20.7	25.5	26.8
2x12 at 16\" oc	18.8	21.0	25.5	30.1
2x12 at 24\" oc	19.0	21.4	27.3	31.4

The quotient of the area divided by the R-value is listed in the fourth column. This number is the rate of heat flow from the house to the outside air through the ceiling, in Btu per hour, for each one degree of inside-outside temperature difference.

Under the section "walls", all external walls that enclose heated spaces should be included. Do not include walls between the house and a sun space, Trombe walls or water walls. The effect of these solar elements will be accounted for on Worksheet II.

All walls that have the same R-value may be combined together.

Wall area is defined as the total opaque wall surface of the house, measured on the outside, through which heat flows from the inside air to the outside air.

Wall area about the attic insulation line should not be included; however, the wall area does extend up to the roof line of roms with cathedral ceilings.

Total external wall area can be estimated by measuring the house perimeter (excluding the sunspace, if any, and any Trombe walls or water walls) and multiplying by the wall height. Opaque wall area is then estimated by subtracting the rough-frame areas of all windows and doors from the total external wall area.

The wall R-value is the resistance to heat flow through the wall. The higher the R-value, the better the insulating capability. R-value is given in units of F-hr-sq ft/Btu. It is not the number on the batt of insulation. All effects, such as parallel heat flow paths through studs and insulation, the insulating effect of wall-board and sheathing, and the buffering effect of the inside and outside air films should be taken into account. The result is called an effective R-value.

R-value must be determined in a manner consistent with the definition of wall area. For effective R-values that have been calculated for typical constructions, see Table A2:

Single-wall Framing	Insulation R-value			
	R-11	R-13	R-19	R-25
2x4 at 16\" oc	12.0	13.6	-	-
2x4 at 24\" oc	12.7	13.9	-	-
2x6 at 16\" oc	14.1	15.4	17.7	19.2
2x6 at 24\" oc	14.3	15.6	18.2	19.8

Double-wall Framing	Total Thickness, inches			
	8	10	12	14
	25.0	31.3	37.5	43.8

The R-value of insulating sheathing added to the wall should be added to the values provided in the table.

The value in the fourth column is the quotient of the wall area divided by the wall R-value. This number is the rate of heat flow from the house to the outside air through the walls, in Btu per hour, for each one degree of inside-outside temperature difference.

The section titled insulated floors is to be used specifically for cases in which the insulation is placed in the floor, as is sometimes the case in crawl space or basement construction. If the floor is uninsulated and the insulation (if any) is located along the house perimeter, skip this element and fill in Part B - "Foundation Perimeter Heat Loss" instead. In any case, heat loss from the entire first floor of heated spaces must be accounted for, either here or in Part B.

Floor area over a crawl space or basement should be determined using exterior wall dimensions.

R-value to be listed in the third column is the resistance to heat flow through the floor. The higher the R-value, the better the insulating capability. R-value is given in units of F-hr-sq ft/Btu. It is not the number on the batt of insulation. All effects, such as parallel heat flow paths through floor joists and insulation, the insulating effect of the flooring, and the buffering effect of the crawl space, perimeter walls, earth berming, and inside and outside air films should be taken into account. The result is called an effective R-value.

R-value must be determined in a manner consistent with the definition of floor area. For effective R-values that have ben calculated for insulated typical constructions, and are provided in Table A3- Insulated floors.

Framing	Insulation R-value			
	R-11	R-19	R-30	R-38
2x6 at 16\" oc	18.2	23.8	29.9	-
2x6 at 24\" oc	18.4	24.5	31.5	-
2x8 at 16\" oc	18.8	24.9	31.7	36.0
2x8 at 24\" oc	18.9	25.4	33.1	37.9
2x10 at 16\" oc	19.3	25.8	33.4	38.1
2x10 at 24\" oc	19.3	26.1	34.4	39.8
2x12 at 16\" oc	19.7	26.5	34.7	39.8
2x12 at 24\" oc	19.6	26.7	35.5	41.2

These R-values apply to an insulated floor over a ventilated crawl space or unconditioned basement. The values for the floor alone have ben increased by R-6 to account for the buffering effect of the underlying space and the resistance of the perimeter.

The quotient of floor area divided by floor r-value, listed in the fourth column, "heat loss", is the rate of heat flow from the house to the outside air through the floor, in Btu per hour, for each one degree of inside-outside temperature difference.

For non-solar glazings, the area is determined in Section B of Worksheet IV. It is the sum of the east, west, north and skylight window areas listed in that Worksheet. The area refers to the rough frame opening.

Non-solar glazings are windows on the east, west, and north sides of the house. This is all glazing that faces outside wan arc of 45 degrees either side of true south but does not include south windows (within 45 degrees of true south) or any glazing on sunspaces, Trombe walls, or water walls.

Solar gains through non-solar glazing are not accounted for in computing solar savings because it is assumed that these windows will be shaded, in accordance with the natural cooling design recommendations. This is a conservative assumption since some solar gains will always be present through all windows.

The non-solar glazing R-value to be listed in the third column is the resistance to heat flow through the window glass and frame. The higher the R-value, the better the insulating capability.

R-value is given in units of F-hr-sq ft/Btu. It is not the number for the glazing alone. All effects, such as parallel heat flow paths through the window frame and the window edge (where the spacer is located) and the buffering effect of the inside and outside air film, should be taken into account. The result is called an effective R-value.

The definition of window R-value should be consistent with the rough-frame-opening definition of the window area.

Refer to manufacturer's literature for window R-values or use the values provided in Table A4:

	Wood Frame	Standard Metal Frame	Metal Frame w/ Thermal Break
Double			
1/4\" space	1.8	1.4	1.5
1/2\" space	2.1	1.6	1.8
low-e	3.1	2.2	3.0
Triple			
1/4\" space	2.7	1.8	2.1
1/2\" space	3.3	2.2	2.7

These R-values are for the entire rough-frame window opening. When storm sash is added, an additional 1.1 can be added. One half the insulating value of movable insulation may also be added, when appropriate.

The heat loss through non-solar glazing assemblies is listed in the fourth column. This number is the rate of heat flow from the house to the outside air through non-solar glazing, in Btu per hour, for each one degree of inside-outside temperature difference.

In the section doors, include the area and R-values of all external doors entered into heated spaces. Do not include doors between the house and a sunspace or external sunspace doors. The effect of this solar element will be accounted for on Worksheet II. Combine all doors that have the same R-value. The area should be rough frame opening. Typical door areas in square feet are:

Door Size	Rough Frame Opening, sq ft
2-0 x 6-8	14.9
2-6 x 6-8	18.3
3-0 x 6-8	21.6
3-6 x 6-8	25.0
3-6 x 8-0	28.6

The door R-value is the resistance to heat flow through the door. The higher the R-value, the better the insulating capability. R-value is given in units of F-hr-sq ft/Btu. It is not the insulating value of the door itself. All effects, such as parallel heat flow paths through the frame and the buffering effect of the inside and outside air films, should be taken into account. The result is called an effective R-value.

R-value must be determined in a manner consistent with the rough-frame definition of door area. For effective R-values that have been calculated for typical constructions, see Table A5.

Solid wood with weather stripping	2.2
Metal with rigid foam core	5.9

The quotient of the door area divided by the door R-value is the rate of heat flow from the house to the outside air through the doors, in Btu per hour, for each one degree of inside-outside temperature difference.

The sum of the values in the fourth column of Section A, "Envelope Heat Loss", is the rate of heat flow from the house to the outside air through the ceilings, walls, insulated floors, non-solar glazing and doors, in Btu per hour, for each one degree of inside-outside temperature difference.

B. Foundation Perimeter Heat Loss

The first column of this section is provided for descriptive text. Typical foundation systems are slab-on-grade, heated and unheated basements and crawlspaces with perimeter insulation.

In the column headed Perimeter, enter the perimeter of each applicable foundation systems.

Remember, unheated basements and crawlspaces under insulated floors are addressed in Section A of this Worksheet.

For slab-on-grade construction, do not include the length between the house and a sunspace or the length of sunspace external foundation. The effect of this solar element will be accounted for on Worksheet II.

Heat loss factor measures the ease with which heat flows from the floor to the exterior through the house perimeter. The lower the heat loss factor, the better the insulating capability. Heat loss factor is given in units of Btu/F-hr-ft. It is not the insulating value of the insulation itself. All effects, such as the insulating effect of the ground and parallel heat flow paths around the insulation should be taken into account. Typical heat loss factors for slab-on-grade construction are provided in Table B.

Perimeter Insulation	Heat Loss Factor
None	0.8
R-5	0.4
R-7	0.3
R-11	0.3
R-19	0.2
R-30	0.1

For slab-on-grade, the values in this table can also be used if insulation is placed under floor slab (usually extending into the house about two feet), instead of being placed on the foundation wall.

Heat loss factors for heated basements are also given in Table B:

Perimeter Insulation	Heat Loss Factor
None	1.3
R-5	0.8
R-7	0.7
R-11	0.6
R-19	0.4
R-30	0.3

This number is the annual average rate of heat flow from the house to the outside air from a heated basement, in Btu per hour, for each one degree of inside-outside temperature difference.

If the basement is not heated, but the insulation strategy is perimeter insulation rather than insulation in floor above the basement, which would be addressed in Section A, insulated floors, the heat loss factors for the foundation walls on an unheated basement are provided in Table B:

Perimeter Insulation	Heat Loss Factor
None	1.1
R-5	0.7
R-7	0.6
R-11	0.5
R-19	0.4
R-30	0.3

This number is the annual average rate of heat flow from the house to the outside air from an unheated basement, in Btu per hour, for each one degree of inside-outside temperature difference.

The approach for an insulated crawlspace wall, rather than an insulated floor over an uninsulated crawlspace is similar to that for an unheated basement with insulated foundation walls. The heat loss factors for crawlspace walls are also provided in Table B:

Perimeter Insulation	Heat Loss Factor
None	1.1
R-5	0.6
R-7	0.5
R-11	0.4
R-19	0.3
R-30	0.2

The heat loss listed in the fourth column of Section B is the annual average rate of heat flow through each foundation component from the house to the outside air through the perimeter, in Btu per hour, for each one degree of inside-outside temperature difference.

The sum of the values in the fourth column of Section B is the annual average rate of heat flow from the house to the outside air through the house perimeter, in Btu per hour, for each one degree of inside-outside temperature difference. Heat loss through insulated floors is not included since it is counted in Part A.

C. Infiltration Heat Loss

Section C is to predict the average annual heat loss due to air infiltration. There are more accurate methods of prediction ranging from the ASHRAE "Linear Foot of Crack Method" to actual blower door tests. However, for system comparisons, keeping air changes at about 0.5 to 0.35 air changes per hour (ach) will usually be adequate. ASHRAE suggests that when air changes drop below 0.35 ach, mechanical ventilation systems should be installed to maintain healthy air quality.

The building volume is entered in the first blank. To be conservative, this should be estimated based on the external walls.

Do not include the volume of unheated basements or sunspaces.

An adequate estimate of building volume can be made by multiplying the floor area times the average wall height. For example, a 1500 sq ft, single story house will normally have a volume of 1500 x 8 = 12000 cubic feet.

In the second blank, enter the air change rate in changes per hour.
Refer to the checklist on minimizing air leakage on page 11 of the Builder Guidelines. If you follow this guidance, it is reasonable to assume an average leakage rate of 0.5 ach.

House infiltration rates vary widely depending on the tightness of construction, the inside-outside temperature difference, and the wind. Typical instantaneous values for careful construction range from nearly nothing to over 2 air changes per hour (ach). The corresponding value averaged over the whole winter will typically be within a range of 0.4 ach to 1.0 act.

House leakage area can be measured using a blower-door. If such a test has ben performed, then winter-average infiltration can be estimated (very roughly) by dividing the house air leakage rate, measured at 50 Pascals, by 20. For example, if the leakage rate measured with an inside-outside pressure difference of 50 Pascals is 2000 cfm and the house volume is 12000 cu ft, then the leakage rate during the test is 2000 x 60 / 12000 = 10 ach (the factor of 60 is needed to convert hours to minutes). The corresponding winter-average leakage rate will be about 10/20 or 0.5 ach.

If the house has a controlled ventilation system, then the air changes per hour can be calculated from the equation:

$$\text{ach} = 60 \times (\text{air flow, in cfm})/(\text{house volume})$$

For example, if the fan air flow is 150 cfm and the house volume is 12000 cf, then the air change rate is = 60 x 150/12000 = 0.75 ach.

If the ventilation system has heat recovery, then multiply the ach value obtained from the above equation by:

(1 - heat recovery efficiency factor)

For example, if the above system has a heat recovery efficiency of 60% (a typical value), then the effective ach value is:

$$0.75 \times (1 - 0.6) = 0.30$$

The value 0.018 is a constant, it is the heat capacity of air at sea level. If the elevation of the site is known, a more accurate prediction may be calculated, but this constant will be the same for all comparisons of passive solar design strategies at a given location.

Elevation above sea level, ft	Heat Capacity
0	.0180
1000	.0174
2000	.0167
3000	.0161
4000	.0155
5000	.0149
6000	.0143
8000	.0132
10000	.0122

The product of the building volume in cubic feet, air changes per hour and the heat capacity of air is the heat required to heat the infiltration air, in Btu per hour, for each one degree of inside-outside temperature difference.

Section D of Worksheet I is used to calculate the total heat loss in Btu per heating degree day per square foot of floor area. The total heat loss per square foot is the product of 24 hours per day and the total heat loss through the building envelope, through the foundation perimeter and due to air infiltration divided by the floor area.

This number is the heat required (under steady conditions) to maintain a one degree temperature difference between the inside air temperature and the outside air temperature. If the temperature difference is greater than one degree, the heat required would be larger in direct proportion.

Note that this number does not include heat loss through any solar glazing, such as south windows or sunspaces. The effect of these solar elements will be accounted for on Worksheet II.

Typical values for this number are as follows:

Super-insulated houses	2 to 4
Well-insulated houses	4 to 6
Typical contemporary US house (depending on climate)	5 to 10
Typical pre-1965 US house	7 to 17

Section E, Conservation Performance Level, provides the heat loss in units of Btu per year per square foot of floor area. The total heat loss per square foot is carried down from Section D of this Worksheet. The conservation performance level is the product of this heat loss value times the heating degree days times a heating degree day multiplier. Both the heating degree days (DD) and DD multiplier may be obtained from Table C. The heating degree days value is the sum of the difference between 65 degrees F and the daily average outside temperature for each of the 365 days of the year (if the difference is negative, the number is not added).

Heating degree-days have been tabulated for many years by the National Weather Service as a useful measure of the relative severity of the winter climate.

The National Weather Service value for this location is automatically placed into this space (from "Climatography of the United States, Series 81", for the 1951-80 time period). For degree-day numbers for nearby locations, refer to Table C 1 in the Worksheet Reference Tables of the Builder Guidelines, or to NWS publications. It is recommended that the number used be within plus or minus 10% of the original value.

The heating degree day multiplier depends on the heat loss per square foot (Line D) and the total projected area per square foot (Line A of Worksheet II). This multiplier corrects the base-65 F degree days to the proper base temperature to account for typical residential occupancy conditions. The occupancy conditions assumed are as follows:

1) the average winter thermostat setting is for 70F (for example, 72F in the day and evenings and 66F at night)

2) the daily average internal gain from lights, appliances, and people is 36 Btu per sq ft of house floor area. This is 481 kWh per month for a 1500 sq ft house.

The product of these values is an estimate of the annual heat that will be required, per square foot of floor area, to maintain 70 degree comfort through a typical winter, not counting any benefit associated with solar glazing. This heat must come from either the heating system or from solar gains. The net reduction in this number due to solar gains will be determined on Worksheet II.

Annual heat loss is an indicator of the quality of conservation in the house. The most obvious ways to reduce loss are to increase R-values or decrease infiltration. However, you should be aware that the compactness of the floor plan also affects heat loss. For the same floor area, a house with an extended floor plan will have larger wall and ceiling areas, and a longer perimeter than a house with a more compact rectangular or square plan. A two-story house will have much less exterior surface area than a single-story house of the same floor area.

Section F Comparison Conservation Performance is obtained from Table D. This value is the annual heat loss for a base-case house, built in accordance with contemporary insulation levels in your climate zone, as determined by a 1987 NAHB survey of building practices. This gives you a reference point for comparison with your number.

Worksheet II: Auxiliary Heat Performance Level

Section A. Projected Area of Passive Solar Glazing

In the first column, enter descriptive text for the passive solar systems being used. Typical systems are:

Direct-Gain System
Sunspace System
Trombe Wall System
Water Wall System

Include only systems that face within 45 degrees of true south.

Various codes are used in Table F, Solar System Saving Fractions, for use in Section C of this Worksheet. These codes may be used here to describe the passive solar systems.

All direct-gain systems performance estimates assume that the house mass is in accordance with the guidelines. Specifically, if the direct-gain net window area exceeds 7% of the floor area, mass is added equivalent to six sq ft of 3-inch thick concrete for each sq ft of added direct-gain window. Performance increases with increasing mass.

DGC1 - Ordinary clear double glazing.
DGC2 - Either low-e clear double glazing or clear triple glazing.
DGC3 - Clear double glazing with R-9 night insulation.

Refer to the diagram in the Worksheet Reference Tables of the Builder Guidelines. Choose the system that is the most similar to your design. All glazing is assumed to be double.

SSA1 - Attached sunspace. Glazing sloped at 50 degrees to the horizontal. Opaque end walls.

SSB1 - Attached sunspace. South vertical glazing plus an equal area of roof glazing sloped at 30 degrees to the horizontal. Opaque end walls.

SSC1 - Semi-enclosed sunspace (the house wraps around the sunspace - the sunspace shares three common walls with the house). Vertical glazing only.

SSD1 - Semi-enclosed sunspace. Glazing sloped at 50 degrees to the horizontal.

SSE1 - Semi-enclosed sunspace. South vertical glazing plus an equal area of roof glazing sloped at 30 degrees.

The Trombe wall is assumed to be 12 inches thick and to be made of concrete. Double glazing unless noted otherwise.

TWF3 - Unvented. Flat-black surface (98% absorptance).

TWA3 - Unvented. Selective surface applied to the Trombe wall outside surface (94% absorption, 10% emittance). Single glazing.

TWJ2 - Unvented. Selective surface applied to the Trombe wall outside surface (94% absorption, 10% emittance). Single glazing.

TWI4 - Unvented. Flat-black surface. R-9 night insulation is used.

The water mass assumed is 1/2 cubic foot per square foot of glazing (7.5 gallons per sq ft of glazing). Glazing is double unless noted otherwise.

WWB4 - Flat-black surface. R-9 night insulation

WWA3 - Flat-black surface (89% absorption).

WWC2 - Selective surface applied to the water wall outside surface (94% absorption, 10% emittance). Single glazing.

When selecting a system or a combination of systems, a priority is to choose a system that fits the life style or architectural fashion desired. Most will want some direct gain and many will choose only direct gain. Some want the character in a house that a sun space provides.

A Trombe wall or water wall stores heat for the night and is an ideal compliment to balance direct gain. Do not vent the Trombe wall to either the inside or the outside. Unvented Trombe walls do not increase temperature swing and have the least impact on summer cooling of all passive system options.

Between systems of the same type, there will be some difference in performance. These are described on page 6 of the Builder Guidelines. These differences are more pronounced in colder climates and locations with less winter sunshine.

Refer to Part 3 of the Builder Guidelines for more guidance on system selection and for design tips.

If you use night insulation with an R-value other than R-9, you can calculate the correct solar savings fraction by assuming that you have a mixed system - part with R-9 night insulation and part with no night insulation. This does not apply to sunspaces that benefit little by night insulation.

Multiply the area of your solar system by each of the two factors in the following table. This gives you the correct areas to use.

Your night insulation R-value	Factor to be used for R-9 system	Factor to be used for system w/o NI
0	0.00	1.00
1	0.43	0.57
2	0.63	0.37
3	0.75	0.25
4	0.83	0.17
6	0.92	0.08
9	1.00	0.00

EXAMPLE:

If you have 100 sq ft of direct gain and use R-4 night insulation, you would analyze this as a mixed system with 83 sq ft of direct gain with R-9 night insulation (system DGC3) and 17 sq ft of direct gain with no night insulation (system DGC1). This is equivalent to saying that 83% of the potential savings from using R-9 night insulation as obtained with R-4 night insulation.

Please note, however, that the good solar performance of any system with night insulation depends on its correct daily use and that experience has shown that this is often not realized in practice.

In the second column of Section A, enter the area of the wall opening left by the carpenters. It is normally designated by a window code, for example 3046 refers to 3’ 0\" by 4\" 6\", corresponding to an area of 13.5 sq ft.

All openings of the same solar system type should be combined into one total as though they were one area.

The net area factor, 0.80, provided in the third column of Section A is typical for predicting the net glass area of residential windows. It may be greater for large windows with thin mullions or smaller for a window with lots of little panes. If you know the net glass area, you can calculate the net area factor and insert the number here.

Take, for example, a standard 34" x 76" glazing unit framed into a 38" x 80" opening. The net glass area (inside the glass spacers) is about 33" x 75" corresponding to an area of 17.2 sq ft. The rough frame opening corresponds to an area of 21.1 sq ft. Therefore, the Net Area Factor is 17.2/21.1 or 0.815.

The Adjustment Factor provided in Table E and to be listed in the fourth column of Section A, serves two functions: (1) it corrects for solar glazing orientation other than true south, and (2) it corrects for glazing tilt that is other than vertical. The adjustment factor is the projected area divided by the actual area. The adjustment Factor is 1.00 if the glazing is vertical and faces true south.

Projected area is defined as the area that would be measured on a true-south elevation drawing of the house. The projected area is less than the actual area because of the foreshortening that occurs if the viewpoint is not perpendicular to the glass.

Projected-area adjustment factors have been calculated for the reference designs for different orientations, as follows:

Degrees off true south	Solar System Reference Code DG, TW, WW, SSC1	SSD1, SSA1	SSB1, SSE1
0	1.00	0.77	0.75
5	1.00	0.77	0.75
10	0.98	0.75	0.74
15	0.97	0.74	0.73
20	0.94	0.72	0.70
25	0.91	0.69	0.68
30	0.87	0.66	0.65

Refer to page 16 of the Builder Guidelines to determine the magnetic declination for your area (deviation of true north from magnetic north).

If your solar system geometry does not correspond to one of the reference systems, they you must calculate the adjustment factor. To do this, determine the projected area and divide by the actual area.

A fairly easy way to estimate the projected area is to measure it from an elevation of the building, drawn to scale. The elevation should be drawn from a true-south viewpoint.

The most common situation for which this is required is a sunspace that does not correspond closely to the description of one of the five reference sunspace systems.

The tables of solar savings fractions are based on the assumption that the solar glazing is not shaded in the winter. This is good design practice. If however, some of the glazing is shaded this must be accounted somewhere in the calculation. The most accurate approach is not to list the winter-shaded south glass area as solar glass. Instead, you should include it in the non-solar glass area on worksheet IV. It can simply be added to the north glass since the solar heat gain factor will be small due to extensive summer shading.

Adjustment factor can also be used to account for winter shading of solar glass. To do this, multiply the adjustment factor of the unshaded glass by the shading coefficient of the solar glass and divide by 0.88. The shading coefficient used should refer to winter sun-angle conditions.

It is generally recommended that the solar glass not be shaded in the winter.

The Projected Area to be listed in the fifth column is calculated by multiplying the Rough Frame Area by the Net Area Factor by the Adjustment Factor. Appropriate adjustments should be made for night insulation and winter shading.

Projected area is the net glazing area that would be measured on a true-south elevation drawing of the house. The projected area is less than the actual net area because of the foreshortening that occurs in a viewpoint that is not perpendicular to the glass.

The total projected area, divided by the floor area is the total projected area per square foot, used to determine the Heating Degree Day Multiplier in Section E of Worksheet I.

Take care to see that this number does not exceed the guideline in the second column on page 14 of the Builder Guidelines or winter overheating may occur.

B. Load Collector Ratio

Load Collector Ratio is provided in the appropriate table to look up the solar savings fraction for each of your solar system types.

The Load Collector Ratio, or LCR, is a parameter developed by the Los Alamos National Laboratory to facilitate calculation of solar savings. It is the single most important passive solar design number. It gives the size of the solar system in relation to the house requirement for heat. LCR is defined as the Total Heat Loss (in units of Btu per degree-day) divided by the Total Projected Area. (In case you are curious, the number 24 on this line is to converts from days to hours in order to put Total Heat Loss into the proper units).

LCR is a useful design index for passive solar houses. Guideline values for LCR for various locations are listed in Table 2-1 of the book "Passive Solar Heating Analysis" by Los Alamos published by ASHRAE. Typical values are in the range from 20 to 130. Sixty of these guideline values are:

AL	Birmingham	41	MD Baltimore	29	ND Bismarck	29
AZ	Phoenix	66	MA Boston	32	OH Columbus	46
	Winslow	25	MI Detroit	47	OK Oklahoma City	30
AR	Little Rock	34	Traverse City	63	OR North Bend	29
CA	Los Angeles	61	MN Minneapolis	39	PA Pennsylvania	30
	Sacramento	46	MS Jackson	48	Pittsburgh	54
	SanFrancisco	42	MO Kansas City	25	RI Providence	28
CO	Denver	19	St. Louis	29	SC Charleston	51
CT	Hartford	36	MT Dillon	18	SD Rapid City	20
FL	Apalachicola	74	Great Falls	26	TN Nashville	39
GA	Atlanta	37	NB No. Platte	18	TX Amarillo	26
ID	Boise	28	NV Ely	16	Corpus Christi	108
IL	Springfield	28	Las Vegas	43	Dallas	46
IN	Evansville	34	NH Concord	36	El Paso	40
IA	Burlington	27	NJ Newark	29	UT Salt Lake City	22
KS	Dodge City	22	NM Alburquerque	26	WA Seattle	48
KY	Lexington	35	Los Alamos	18	Wi Madison	30
LA	Lake Charles	73	NY Albany	42	Green Bay	37
ME	Caribou	33	NC Raleigh	33	WY Casper	16

The value of the load collector ratio should never be less than 16.

The load collector ratio is the 24 hours per day time the total heat loss from line D of Worksheet I divided by the total projected area (not the total projected area per square foot of floor area).

C. Solar Savings Fraction (SSF)

SSF is the fraction of the heat required by the rest of the house that is saved by the solar systems. It is a net savings. It accounts for the annual useful solar gains into the house minus the annual heat losses from the solar elements.

If there is only one system, then this SSF is identical to that determined above. If it is a mixed system, then the whole-house SSF will be intermediate between the individual SSFs of the various systems.

The solar system reference code and projected areas are carried down for each passive solar design strategy from Section A of this worksheet. The system solar saving fractions are obtained from Table F for each system type. The products of the area and system solar saving fractions for each system type are totaled. The total is divided by the total projected area to result in the Solar Saving Fraction (SSF) of the building.

D. Auxiliary Heat Performance Level

The auxiliary heat performance level is an estimate of the annual auxiliary heat required to maintain 70 degree comfort inside the house, assuming normal occupancy patterns and normal weather and solar conditions. Units are Btu per year per square foot of floor area. The number has been calculated by correcting the Annual Heat Loss determined on Worksheet I to account for the savings due to solar.

Annual Auxiliary Heat is heat delivered by the building heating system per sq ft of floor area. To determine the annual fuel requirement, this number must first be multiplied by the house floor area, divided by the heating system efficiency, and then divided by the heat content of one unit of fuel (in consistent units).

Example:

Annual Auxiliary Heat	20000 Btu/sq ft
House Floor Area	1500 sq ft
Furnace Efficiency	60%
Fuel Heat Content	1030 Btu/cu ft

Annual Gas Use = 20000 x 1500/0.60/1030 = 48,500 cu ft

Annual Auxiliary heat can be saved either by reducing heat loss or by increasing solar savings fraction.

To increase solar saving fraction, you can increase the area of your solar system, add additional solar systems, or choose a system with higher performance. See the table on page 6 of the Builder Guidelines for an indication of the relative performance of various passive systems in your location.

Note that increasing passive solar area will usually increase both winter temperature swing and summer cooling loads although there are pronounced differences in the magnitudes, depending on passive system selection. Adding indirect system area (Trombe wall or sunspace) will generally increase temperature swing much less than adding the same area of direct gain and also have a smaller adverse effect on summer cooling.

The auxiliary heat performance is determined as the difference of unity minus the solar savings fraction multiplied times the Conservation Performance Level from Section E of Worksheet I.

E. Comparative Auxiliary Heat Performance

This value, obtained from Table G is used to compare the auxiliary heat performance of the base case house to the house being analyzed. The base case house is a hypothetic home built in accordance with contemporary insulation levels in your climate zone, as determined by a 1987 NAHB survey of building practices. This gives you a reference point for comparison with your number.

Worksheet III: Thermal Mass/Comfort

A. Heat Capacity of Sheetrock and Interior Furnishings

This section is to account for the comfort contribution provided due to the effects of thermal mass in lightweight framing, and furnishings within rooms with direct gain and rooms connected to direct-gain rooms. The first column is used to enter a description of each of these rooms, if desired.

The second column is used to enter the floor area of each room with direct gain and for the rooms in direct contact to rooms with direct gain.

The third column provides the typical heat capacity of gypsum wallboard and furnishings based on the floor area of the room. The value of 4.5 Btu/F per square foot of floor area is used to calculate the total heat capacity for rooms with direct gain. For rooms in contact with rooms having direct gain, the value is based on a heat capacity of 4.5 Btu/F per sq ft of floor area (2.6 due to sheetrock and 1.9 due to furnishings).

The product of these unit heat capacities and the respective floor areas is the total or diurnal heat capacity. Diurnal heat capacity refers to thermal mass that effectively stores solar heat carried over from the day into the following night.

The calculated value provided for in the fourth column is the total diurnal heat capacity of the gypsum wallboard, framing, and furnishings within the house, assuming framed construction. The total diurnal heat capacity value in Btu/F is the sum of the two numbers above.

B. Heat Capacity of Mass Surfaces Enclosing Direct Gain Spaces

Diurnal heat capacity refers to thermal mass that effectively stores solar heat carried over from the day into the following night.

The first column on Worksheet III, Section B. is for listing a description of the thermal storage elements in direct gain spaces. A portion of the exterior wall of a room that is primarily direct gain may be a water wall or Trombe wall. Direct gain thermal storage mass may be a slab or it may be interior walls. For interior walls, walls having a north-south orientation may be well sunlit. Walls oriented on an east west axis are often too deep within the structure to receive direct sunlight.

In the second column, enter the area in square feet of each of the components providing mass in direct gain spaces:

Trombe Walls
Water Walls
Slab Area Exposed to Sunlight
Slab Area Not Exposed to Sunlight
Interior Walls Exposed to Sunlight
Interior Walls Not Exposed to Sunlight

Sunspaces are considered to be direct gain spaces from the standpoint of analyzing thermal mass effects and predicting the level of comfort to be provided.

The third column includes some values of unit heat capacity for various thermal storage elements. Additional values are listed in Table H, for use with walls that may be in direct gain rooms. The heat capacities listed in Table H may be added to total the heat capacity for an entire construction. the values listed on the worksheets are specifically for Trombe walls, water walls and slab systems.

If the floor is covered by carpet or shaded by furnishings but sunlit, include it under "Exposed Slab Not in Sun". treat walls with wall hangings, pictures or shaded by furnishing similarly.

When entering the area of slab-on-grade floor that is in the direct sun at least part of the day on a sunny winter day, do not exceed 1.5 times the area of the direct-gain windows through which the sun shines on the floor.

Tiles, brick, linoleum, or other solid materials do not inhibit penetration of heat through to the slab and thus floor surfaces covered with these materials can be analyzed as if they were not covered. Rugs covering the floor or furnishings that shade it greatly reduce the transfer of solar heat to the underlying slab. If a portion of the slab is in the sun but is covered, include this area under "Exposed Slab Not in Sun".

A detailed computation is not necessary here. The key criteria is whether the floor is located to the north of a direct-gain window, so that it will be directly sunlit part of the day, and is uncovered. In estimating the surface in the sun do not exceed 1.5 times the area of the direct-gain windows through which the sun shines on the floor.

Good design practice is to expose a narrow strip of floor slab just north of a direct-gain window. Run the window down to within six inches above the floor to expose the maximum floor area to the sun. This strip can be about as wide as the window height, or somewhat wider. Other floor slab out of the direct sun is so ineffective that little heat storage potential is lost by covering it with carpet.

The rule of thumb for wall and ceiling mass is as follows: If the surface within a direct-gain room is located so that it is connected by line of sight to the place where the sun first strikes in the room, then it should be included here. (This mass is radiatively coupled to solar gains and is therefore quite effective.) Surfaces that do not have this line-of-sight connection should be included in Part B even though they are in a direct-gain room. (Without radiative coupling, heat is transferred to the mass only by air convection, which is much weaker.)

Generally it is good design practice to use a light color on all wall and ceiling surfaces in direct-gain rooms, whether the surface is massive or not. This is especially true if the wall surface is in the direct sun. The light color diffuses the heat (and light) more uniformly throughout the space and usually increases heat storage effectiveness. The effectiveness of massive wall surfaces not in the sun can be enhanced somewhat if they are darker in color, but the effect is not large and the negative effect on room aesthetics can be pronounced.

Massive floors should be dark in color, to store the heat low in the room and improve comfort.

Enter the exposed mass surface area. Do not include any area that is covered by an insulating material or by cabinets or bookshelves.

If the mass is floor mass in the sun, other than slab-on-grade, follow the same rules as for Exposed Slab in Sun to determine the area.

The proper heat capacity to use in this calculation is the diurnal heat capacity, dhc. Diurnal heat capacity is the number of Btus that are stored in mass on a sunny winter day and then returned to the room a few hours later (per degree of room temperature swing per square foot of mass surface area).

	Thickness, inches						
Material	1	2	3	4	6	8	12
Poured Conc.	1.8	4.3	6.7	8.8	11.3	11.5	10.3
Conc. Masonry	1.8	4.2	6.5	8.4	10.2	10.0	9.0
Face Brick	2.0	4.7	7.1	9.0	10.4	9.9	9.0
Flag Stone	2.1	4.8	7.1	8.5	8.6	8.0	7.6
Builder Brick	1.5	3.7	5.4	6.5	6.6	6.0	5.8
Adobe or Earth	1.3	3.2	4.8	5.5	5.4	4.9	4.8
Hardwood	0.4	1.4	1.8	1.7	1.5	1.5	1.5
Water	5.2	10.4	15.6	20.8	31.2	41.6	62.4

For qualifying uncovered wall or ceiling mass exposed to a direct-gain room on only one side, determine heat capacity from the table, based on the material and its thickness. If the mass is exposed to direct-gain rooms on both sides, use one-half the wall thickness but enter the total area of both sides of the wall.

The table can also be used for floor mass in the sun, other than slab-on-grade. If the surface is dark in color, multiply the value from the table by 1.3 and enter the result. If the mass is light in color, enter the table value.

For an exposed slab-on-grade floor in the sun that is covered by hardwood flooring, enter a value of 3.5 Btu/F-sq ft for the diurnal heat capacity.

Multiplying the unit heat capacities by the surface area of the respective thermal storage components provides the diurnal heat capacity of other mass in direct-gain spaces. The sum of the diurnal heat capacities of each element results in the total diurnal heat capacity for the mass surfaces enclosing direct gain spaces.

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

As previously discussed, diurnal heat capacity refers to thermal mass that effectively stores solar heat carried over from the day into the following night.

The first column is provided to list descriptions of mass surfaces enclosing spaces connected to direct gain spaces. The second column is for listing the surface area of Trombe walls, water walls or other thermal storage elements facing into rooms connected to direct-gain spaces.

The unit heat capacities are provided for Trombe walls and water walls. The product of the surface area and the unit heat capacity results in the diurnal heat capacity for these systems. The total diurnal heat capacity is the sum of the mass components enclosing spaces connected to direct gain spaces. the values provided are for the back sides of Trombe or water walls. The surface areas that are to be listed are the surface areas of Trombe walls or water containers facing into rooms connected to direct-gain spaces.

Thermal mass surfaces may be located either on walls or ceilings, as well as floors. Massive floors, walls or ceilings not in direct-gain rooms have negligible diurnal heat storage effectiveness and should not be included anywhere on Worksheet III.

D. Total Heat Capacity

This is the sum of the totals from Parts A, B, and C, that is, the total diurnal heat capacity of the house. It is the heat stored each day and returned to the house each night during a recurring cycle of clear winter days, per degree of room temperature swing (assuming that the temperature profile is sinusoidal in shape - a correction for the fact that the temperature profile is not sinusoidal will be included later).

E. Total Heat Capacity per Square Foot

This is the quotient of the total heat capacity of the house divided by the total floor area of the conditioned spaces in the house. The floor area of the conditioned space is carried over from the General Project Information worksheet.

Total Heat Capacity divided by the Conditioned Floor Area is used on Worksheet IV in the determination of the cooling adjustment for thermal mass in Table O.

A value of 2.8 is typical for a frame house with no added mass.

F. Clear Winter Day Temperature Swing

This value is carried over from Worksheet II and is the projected areas of the south facing glazing for each of the passive solar systems used in the building construction.

The comfort factor is taken from Reference Table I for your location. For direct gain systems, it is 0.61 times the January clear-day solar gains transmitted through vertical-south double glazing. The 0.61 factor includes a correction for the fact that the typical room temperature profile is not sinusoidal.

The comfort factor for sunspaces and thermal storage or water wall systems is 0.203 times the January clear-day solar gains transmitted through vertical-south double glazing. The 0.203 factor corrects for the fact that the temperature profile is typically not sinusoidal and for the reduced net gain of a sunspace or vented Trombe wall compared to direct gain.

The sum of the products of total projected area and comfort factors for each of the passive solar features is determined. The sum is divided by the total heat capacity of the house to estimate the clear day temperature swing in the building. This is the estimated temperature swing that would be experienced in the house during a recurring cycle of clear winter days assuming that the house is otherwise unheated (or has a steady level of heat). This temperature variation is due to direct solar gains and indirect gains from a sunspace or vented Trombe wall. It is the Total Daily Solar Gains divided by the Total Heat Capacity.

Temperature swing is important in determining whether your house will be comfortable. If it is too large, you will have to open windows on clear winter days and will lose valuable heat.

Temperature swing is also an indicator of whether you have sufficient mass to store the solar heat due to direct gain. If the temperature swing is too large, direct-gain performance will suffer and the solar savings fraction estimates on Worksheet II will be overly optimistic.

If your temperature swing exceeds the recommended maximum temperature swing, typically 13 degrees, you should re-design to reduce the value to less than 13 degrees. This can be accomplished by either increasing the heat capacity or decreasing the direct solar gains.

To increase heat capacity, add mass surface in the house. Thick mass in direct-gain rooms is much more effective than in other rooms; however little heat capacity is gained beyond a thickness of four inches (due to the insulating effect of the outer layers of the mass). Thin mass (one inch or less) has about the same effectiveness in connected rooms as in direct-gain rooms. Floor mass in the sun is much more effective than floor mass not in the sun. Mass walls with both sides exposed to direct-gain rooms (such as north-south partitions) are more effective than massive exterior walls. You can experiment with added mass and see the effect on the heat capacity totals and on temperature swing.

To decrease direct solar gain, you have two choices.

1) You can simply reduce the area of direct-gain glazing.
This will reduce your solar savings.

2) You can convert some direct-gain glazing to an indirect system (a sunspace, Trombe wall or water wall) without much effect on solar savings. (Solar savings may increase or decrease, depending on the details of the design.) An unvented Trombe wall or water wall adds essentially nothing to temperature swing. A sunspace or vented Trombe wall will result in roughly one-third as much temperature swing as the same area of direct-gain.

Note: Indirect systems also have much less summer cooling consequence than direct gain. See worksheet IV.

The value of 13 degrees Fahrenheit is based on a reasonable range of human comfort assuming that the average temperature is the preferred temperature (for example 65 F to 78 F). If the range is larger than this, the house will be considered uncomfortable; most people will vent heat during the day and supply backup heat at night.

This temperature swing is also consistent with the amount of mass that was assumed in making the calculations of solar savings fraction for direct gain systems.

In cold, cloudy climates sunny mid-winter days may be rare and thus it may be unlikely that the average inside temperature will ever be in the comfort range without backup heat, or only rarely so. Nonetheless, a maximum value of 13 degrees for this calculated number is still recommended as good passive solar design practice.

Worksheet IV -- Summer Cooling Performance Level

A. Opaque Surfaces

Ceiling/Roofs

The first column is simply the system description.

The second column, heat loss, is carried over from Worksheet I. It is the ceiling or roof area divided by the R-value.

The radiant barrier factor, in the third column, accounts for the reduction in ceiling heat flow resulting from installation of a radiant barrier in the attic. The factor may be obtained from Table J. If there is no radiant barrier, the number should be 1.00.
Experiments indicate that ceiling heat flow can be decreased 25% by a radiant barrier. Therefore, a radiant barrier factor of 0.75 is
suggested.

The radiant barrier should have a low-emittance surface, such as aluminum foil, installed to face into the attic. The low-emittance surface must face an air space in order to be effective, that is, it must not be in contact with any other material. It is recommended that it should be installed either above or below the roof rafters with the metallized surface facing downward. Installation on top of the ceiling insulation with the shiny surface facing up will also work, but effectiveness may decrease in time as dust accumulates.

Table K provides Absorptances for ceilings/roofs. This is the fraction of the solar energy incident on the roof that is absorbed as heat (the rest is reflected).

If some of the wall is shaded by a tree or other object, this can be accounted for by reducing the solar absorptance. For example if 75% of the wall is in the sun and 25% is shaded, and the surface absorptance is 0.5, then the effective absorptance is:

$$(0.75 \times 0.5) + (0.25 \times 0) = 0.375$$

Because of soiling and roughness of the surface, few roofs will have an absorptance less than 0.70.

Typical roof absorptances are provided in Table K and these are:

Color	Roof Absorptance
Gloss white	0.50
Semigloss white	0.53
Light green	0.64
Bright green	0.67
Medium blue	0.67
Medium yellow	0.71
Medium orange	0.72
Medium green	0.73
Light buff brick	0.73
Bare concrete	0.77
Red brick	0.80
Medium red	0.87
Medium brown	0.89
Dark blue-grey	0.92
Dark brown	0.92

The Heat Gain Factor, obtained from Table L, is the roof heat gain factor for this location.

Multiplying the numbers in each of the columns provides the incremental annual cooling load due to conduction through this attic or roof element.

Walls

The first column is used solely to write in descriptions of the wall systems.

The heat loss, as with ceilings/roofs, is carried over from Worksheet I. It is the wall area divided by the R-value.

The absorptances for walls are the fraction of the solar energy incident on the unshaded wall that is absorbed as heat. If some of the wall is shaded (for example by a large tree or by facing into a garage), the solar absorptance from the table should be multiplied by the fraction of the wall that is not shaded.

For example, if the absorptance is 0.6 and 40% of the wall is shaded, the correct value to enter would be 0.6 x 0.6 = 0.36.
Typical absorptances are provided in Table K and are:

Color	Absorptance
Gloss white	0.25
Semigloss white	0.30
Light green	0.47
Bright green	0.51
Medium blue	0.51
Medium yellow	0.57
Medium orange	0.58
Medium green	0.59
Light buff brick	0.60
Bare concrete	0.65
Red brick	0.70
Medium red	0.80
Medium brown	0.84
Dark blue-grey	0.88
Dark brown	0.88

The value obtained from Table L for the fourth column is the wall heat gain factor for this location.

The load, determine by multiplying the values in each of the columns, is the incremental annual cooling load due to conduction through this wall element.

Doors

The process is identical for doors as for walls. The first column is for descriptions, and the second is carried over from Worksheet I. It is the door area divided by the R-value. Absorptances are the same as for walls. The absorptance is the fraction of the solar energy incident on the unshaded doors that is absorbed as heat. If some of the doors are shaded (for example by a large tree or by facing into a garage), then the solar absorptance from the table should be multiplied by the fraction of the area that is not shaded.

For example, if the absorptance is 0.6 and one of the two doors enters into a garage, the correct value to enter would be 0.30.

The value for the fourth column is the door heat gain factor for this location, obtained from Table L.

The fifth column is the incremental annual cooling load by conduction through doors.

The total of the fifth column is the incremental annual cooling load due to conduction through all opaque elements. It is the sum of the loads above.

B. Non-solar Glazing

The first column is for the descriptions of North East and West facing glass and skylights.

For each of the locations, enter the combined area of all window openings that face within 45 of the compass orientation listed.
This is the area of the wall opening left by the carpenters. This is normally designated by a window manufacturer's code, for example, 3046 refers to 3'0"x 4'6" corresponding to an area of 13.5 sq ft.

The net Area Factor is the net glass area divided by the area of the rough frame opening. Typically this value is 0.80 for residential-size windows. It may be greater for large windows with thin mullions or smaller for a window with lots of little panes. If you know the net glass area, you can calculate the net area factor and replace the value listed in column three. Otherwise, the value 0.80 should be used.

Enter the appropriate shade factor from Table M in column four. The shade factor is the annual cooling load due to the window divided by the annual cooling load that would have been incurred by an unshaded, clear-glass, double-glazed window.

If the window is unshaded and has clear double glazing, enter 1.00. For single glass, use 1.136.

Shade factor depends on climate, shading geometry and window orientation. Reference Table M lists shade factors for roof overhangs in your location. Shading is perhaps the easiest, most pleasant and most cost-effective way to reduce cooling loads. Shade from trees is very effective, especially if the tree is big, has a dense leaf canopy, and is close to the house. A shade factor of 0.1 to 0.3 would be a reasonable choice. A tree not only provides shade against direct sun and diffuse sky but shades the ground in front of the window.

Exterior louvers can provide effective shade. Louvers are most effective on the north and south sides of the house if they are horizontal and sloped downward. On the east and west sides they are most effective if they are vertical, preferably aimed southeast or southwest (to admit winter sun and exclude summer sun). Some shade screens have micro-louvers and are extremely effective.

To use Table M, first determine the projection factor for the window. Projection factor is the horizontal projection of the overhang divided by the vertical distance between the bottom of the window and the edge of the overhang. This procedure is discussed in detail on page 35 of the Guidelines. The Worksheet instructions in the Builder Guidelines contains a diagram showing these dimensions.

If the window is shaded by a screen or other device, you must estimate a shade factor. For window products, such as shade screens, you should refer to the manufacturer's literature. This will normally list a shading coefficient (SC). By long-standing convention, SC is defined as the transmittance of the window with the element in place divided by the transmittance of single glazing. The SC for unshaded double glazing is 0.88. To use an SC, divide by 0.88.

Shade factor = SC / 0.88

Lacking other information, you can use a shade factor of 0.8 to account for the reduced transmittance due to a normal low-e coating. Ordinary insect screens have a shade factor of about 0.6.

Because of the geometrical complexity of sun angles, ground reflectance, and sky diffuse radiation, it is often not accurate to simply multiply shading factors due to multiple effects. However, lacking better information, it is often one's only recourse.

The shade factor depends not only on house design but also on the location.

The heat gain factor from Table L is the incremental annual cooling load of one added square foot of vertical, unshaded, double-glazed, clear window in each orientation. Column five is for use to list the heat gain factor for each orientation and for skylights.

Multiplying the values in each of the columns results in the load for each of the orientations and for skylights. The product of these multiplications is listed in column six.

When completing the line for skylights, some aspects are different than for vertical glazings in walls. If the skylight is unshaded and made of clear double glass, enter 1.00 as the shade factor. If it is single glass, enter 1.136.

The shade factor is the annual cooling load due to the skylight divided by the annual cooling load that would have been incurred by an unshaded, clear, double-glazed skylight.

For skylight products, such as shade screens, refer to the manufacturer's literature that will normally list a shading coefficient (SC). By long-standing convention, SC is defined as the transmittance of the skylight with the element in place divided by the transmittance of single glazing.

Many skylights are plastic domes that may have a lower shading coefficient than glass. Refer to product literature.

Lacking other information, you can use a shade factor of 0.8 to account for the reduced transmittance due to a normal low-e coating.

Shading due to trees is very effective, especially if the tree is tall enough to hang over the roof, has a dense leaf canopy, and is close to the house. A shade factor of 0.2 to 0.5 would be a reasonable choice.

Skylights are popular and very effective in allowing daylight into the center rooms of a house to reduce the need for artificial lighting. This not only saves electricity for lights but can save cooling energy (if correctly designed) because of reduced heat from the lights.

However, unprotected skylights allow huge solar gains in summer, leading to a large addition to the air-conditioning load.

When designing skylights:

1) Don't oversize. A room can usually be adequately daylight with a skylight that is 5% of the room floor area.

2) Use a skylight that can be opened to provide an outlet for heat and help vent the whole house.

3) Shade the skylight. A variety of products can be positioned to go either outside (most effective and most difficult), inside (easiest and least effective), or within the glazing. Tinting the glazing or using a reflective coating is not very effective because it cuts out desired light - why not just use a smaller skylight?

4) Use louvers to provide effective shade for skylights. Some shade screens have micro-louvers and are extremely effective. Many skylight shading products are available.

5) Use a vertical, or near vertical, south-facing skylight (this would probably be called a roof monitor by an architect). This is like a south window, letting in winter sun and heat but minimizing summer solar gains. The total of column six is the incremental annual cooling load due to all non-solar glazing. It is the sum of the four numbers above.

C. Solar Glazing

The first column is used to list the descriptions of the various passive solar design strategies used in the particular building. The system may be direct gain, storage walls, sunspaces, or combinations. Theses systems, for cooling performance are analyzes about the same way as non-solar glazing.

The rough frame are is carried over from Worksheet II. Each value is the sum of all direct-gain system, storage wall, and sunspace.

The net area factor of all systems, unless modified to accurately represent actual construction, should be 0.80.

As with non-solar glazing, the appropriate shade factor is entered in column four. Shade factor is the annual cooling load due to the window divided by the annual cooling load that would have been incurred by an unshaded, clear-glass, double-glazed window.

If the window is unshaded and has clear double glazing, enter 1.00. For single glass, use 1.136.

Shade factor depends on climate, shading geometry and window orientation. Table M in the Builder Guidelines lists shade factors for roof overhangs in your location.

Overhangs on south windows must be carefully designed to admit winter sun and shade summer sun. Refer to the Natural Cooling section of the Builder Guidelines for appropriate south overhang angles and dimensions for your location.

Also refer to the discussion on landscaping for summer shade. DO NOT locate any trees on the south side of the house, even deciduous trees, unless they are quite tall, very close to the house, and have had all lower branches removed to allow winter sun to penetrate under the tree canopy.

Shade screens that can be put in place during the summer months and removed in the winter offer a good solution to the problem of controlling summer solar gains through south windows.

Shading of tilted south glazing, such as a sunspace with overhead glazing, is especially important. Overhangs are not a practical solution. A removable shade screen is the most practical and effective answer.

To use Table M in the Builder Guidelines you will first need to determine the projection factor for the window. Projection factor is the horizontal projection of the overhang divided by the vertical distance between the bottom of the window and the edge of the overhang. The Worksheet Instructions in the Builder Guidelines contains a diagram showing these dimensions.

If the window is shaded by a screen or other device, you must estimate a shade factor. For window products, such as shade screens, you should refer to the manufacturer's literature. This will normally list a shading coefficient (SC). By long-standing convention, SC is defined as the transmittance of the window with the element in place divided by the transmittance of single glazing. The SC for unshaded double glazing is 0.88. To use an SC, divide by 0.88.

Shade factor = SC / 0.88

Lacking other information, you can use a shade factor of 0.8 to account for the reduced transmittance due to a normal low-e coating.

Ordinary insect screens have a shade factor of about 0.6.

Because of the geometrical complexity of sun angles, ground reflectance, and sky diffuse radiation, it is often not accurate to simply multiply shading factors due to multiple effects. However, lacking better information, it is often one's only recourse.

The heat gain factor, to be listed in the fifth column, obtained from Table L, is the incremental annual cooling load of one added square foot of vertical, unshaded, double-glazed, clear, south-facing window.

The multiplication of the values in second through fifth columns provides the incremental cooling load due for each system and is listed in the sixth column.

To reduce the potential of overheating, only vertical glazing should be used for any of the solar features.

The sum of the values in the sixth column is the incremental cooling load due to the all solar glazing.

D. Internal Gain

The first value for the incremental annual cooling load due to an internal gain to be listed is a constant value from Table N. This value is typical of the residential internal gain that does not scale with occupancy.

Internal gain is heat within the house generated by lights, appliances and people. This is sometimes called casual gains.

The second value, also obtained from Table N, is dependant on the number of people and is thus multiplied by the number of bedrooms.

The sum of these values is the incremental annual cooling load due to internal gains (cooling required to remove heat from lights, appliances, and people).

E. Cooling Load per Square Foot

The cooling load per square foot of construction is determined by summing the cooling loads due to opaque surfaces, non-solar glazing, solar glazing, and internal gains.

The multiplication by 1,000 is to convert values from kilo BTtu to Btu.

The product of 1,000 time the total cooling load is divided by the total floor area. The total floor area is carried over from the General Project Information Worksheet.

The quotient is the uncorrected annual cooling load divided by the floor area.

F. Adjustment for Thermal Mass and Ventilation

Identify your cooling strategy:

Ceiling Fan - A paddle fan is used in each major room. This increases air movement over the body to improve summer comfort. The comfort effect is roughly equivalent to a reduction in air temperature of four degrees. The adjustment is calculated based on a thermostat setting of 82 degrees whereas a setting of 78 degrees is used if there is no ceiling fan.

Night Ventilation - Windows are opened at night when outside conditions are favorable.
This cools the house and reduces the need for air conditioning, both at night and during the next day. Night ventilation is assumed only when outside humidity conditions will not cause discomfort. (Night vent is not used when the outside dew-point temperature is greater than 62 degrees.) If natural ventilation through the house is impaired, by trees or neighboring houses, a whole-house fan is
recommended to achieve the desired level of ventilation.

The number selected from Table O is dependent on the amount of thermal mass which is listed on Line E of Worksheet III, "Total Heat Capacity per Square Foot."

This adjustment accounts not only for thermal mass and ventilation but adjusts the uncorrected sum to agree with the correct cooling load for the base-case house.

G. Cooling Performance Level

This number is an estimate of the annual sensible heat that must be removed from the house by the cooling system to maintain comfort (78 F without a ceiling fan or 82 F with a ceiling fan). It is useful primarily to compare with another calculation, for example, with a Base Case (non-solar) house.

The number is the Cooling Load per Square Foot (Line E) minus the Adjustment Factor (Line F).

You can reduce cooling load in several ways. Refer to the various values of incremental cooling load to determine which is the biggest offender; work on it first.

1) Reduce cooling load due to opaque surfaces (part A). This is seldom large. It can be reduced by increased insulation levels, lighter colors, or installation of a radiant barrier in the attic.

2) Reduce cooling load due to non-solar glazing (part B). This load is often large. It can be reduced by the use of smaller windows and skylights (but be careful not to compromise natural ventilation) or by better shading of the windows and skylights.

3) Reduce cooling load due to solar glazing (part C). This load can be large. It can be reduced by using smaller south windows (at the price of lower winter solar heating contribution), installing removable shade screens, converting direct-gain glazing into an indirect system, or using vertical glass instead of sloping glass on a sunspace.

4) Use a more effective summer cooling strategy, for example night ventilation or ceiling fans.

5) Increase building mass. This will also increase both summer and winter comfort (see Worksheet III).

H. Comparison Cooling Performance

This number is listed for comparison with your result. The Annual Auxiliary Cooling for a base-case house of the same floor area, built in accordance with contemporary insulation levels in your climate zone, as determined by a 1987 NAHB survey of building practices. The house has 3 percent of the floor area in unshaded windows on each side (12 percent total). This gives you a reference point for comparison with your number. the comparison number may be this value listed in Table P, or it may the result of a previous analysis of the residence being designed.

9) To alert PSIC to any potential workshop sites.

10) Fees for teaching will be negotiated for each workshop separately.

Instructor should sign and date this letter of agreement and return the original to PSIC.

____

SIGNATURE DATE

PASSIVE SOLAR INDUSTRIES COUNCIL

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BUILDER GUIDELINES

INSTRUCTOR'S LETTER AGREEMENT

WITH PASSIVE SOLAR INDUSTRIES COUNCIL (PSIC)

Instructor's Name____

Title____

Firm____

Address____

Phone____

Potential Workshop Sites__________________________________

____

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Instructor will receive the following items for each workshop:

1) A complete copy of the Builder Guidelines Package including the Guidelines, the Worksheets and a worked Example for the locality where the workshop is being presented. (Instructor should give the correct title to PSIC staff.)

2) A set of approximately 126 slides.

3) An Instructor's Manual.

4) A copy of the "Anytown, USA Example" which describes how to use the worksheets in a generic example.

5) Sufficient copies of the evaluation sheet to give one to each workshop participant.

6) Sufficient copies of the PSIC membership application and general information package to give one to each workshop participant.

The instructor agrees to the following:

1) To use the most up-to-date Guidelines and BuilderGuide package, which will be obtained from the Passive Solar Industries Council.

2) To use the "standard PSIC/NREL cover" either inserted into a binder. PSIC will provide binder covers and/or spines or will provide a cover which is sufficient for color xeroxing.

3) To give full credit to PSIC/NREL/DOE for the development and ownership of the Guidelines software and workshop information.

4) To acknowledge the Technical Committee for their industry review.

5) To include a PSIC membership services and application form in every workshop package.

6) To provide PSIC an accurate list of attendees of the workshop, including name, affiliation, address and phone for tracking and updating purposes.

7) To provide an accurate count of Guidelines booklets and BuilderGuide discs sold both to participants and to others) so PSIC can determine the actual number of copies which have been distributed to the general public.

8) To hand out and diligently try to collect completed evaluation forms from the workshop participants and to return them to PSIC.

9) To alert PSIC to any potential workshop sites.