A Guide to Building & Planning Solar Homes

solar homes for north carolina 2

storage distribution passive site planning collection indirect gain southern exposure thermal mass sunspace shading

Energy Division, North Carolina Department of Commerce

Solar Homes

for North Carolina II

A Design Competition Planbook • June 1999

Division
Energy
North Carolina
Department of Commerce

Contents

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Introduction

This new edition of Solar Homes for North Carolina offers North Carolina residents nine new plans for energy-efficient passive solar homes especially adapted to the heating and cooling requirements of the state. Passive solar design offers homeowners the opportunity to build homes that both conserve and produce energy, are comfortable and attractive, and are economical to operate. This planbook is intended to make this innovative technology easily accessible to North Carolinians interested in energy-efficient housing.

The first edition of Solar Homes for North Carolina was published in 1982 and has been distributed free to more than 20,000 interested North Carolinians. The nine plans in this new edition were generated in the spring of 1998 during a design competition for architects, builders and design professionals around the state. This publication provides an excellent opportunity to take advantage of the exciting new design ideas of solar experts familiar with the energy and living requirements of a North Carolina residence.

All of the homes included in this collection were carefully evaluated to ensure quality in both overall design and energy features. The review committee included energy professionals, engineers, architects, builders, developers and realtors. The plans selected represent a wide price range so that a passive solar home is offered for almost every budget. Each house in this planbook is accompanied by a description of its passive solar features and its projected energy performance compared to a home of the same size and general design without passive solar features. The comparisons give the prospective builder a basis for comparing passive homes to conventional ones.

A balance between heating and cooling needs has been strongly emphasized in the designs. The nature of the North Carolina climate requires a careful approach to passive solar heating, since faulty design or sizing of a passive system can cause summer overheating. Not only would overheating create an uncomfortable living environment, but it would cancel out the winter net energy gain of the solar system with increased air conditioning costs in the summer.

A brief description of passive solar design principles and guidelines precedes the house plans. This is a general overview; for more detailed information, a bibliography is included at the back of the publication. The North Carolina Solar Center publishes 25 factsheets on various solar energy topics, provides a reference library at the NCSU Solar House, and offers over a hundred videos through a lending service. To find out more about the Solar Center's services, call the toll-free (in North Carolina) hotline at 1-800-33 NC SUN, or visit our website at: www.ncsc.ncsu.edu.

What Is A Passive Solar House?

A passive solar house is designed to take maximum advantage of the sun for winter heating while providing for sufficient shading for summer cooling. Since the sun's path in the northern hemisphere passes through the southern sky, passive solar homes are designed to maximize southern exposure. The house can be of any shape, but it is usually sited so that the major living areas of the house are located on the south side of the house. Maximizing solar access can be achieved by orienting the house so that its long axis runs from east to west.

The majority of a solar home's windows are located on the south side so that they can receive the maximum amount of heat from the sun in winter when it is low in the southern sky. In the summer, when the sun follows a longer and higher path, overhangs located over south-facing windows and walls shade these areas from direct sunlight to reduce overheating. Overhangs located on the east and west do not shade effectively because the sun is much lower in the sky in the morning or afternoon. As far as solar performance is concerned, it makes no difference whether the solar portion of the house is on the front, the back, or the side; what matters is that the house is placed on the lot so that the solar windows face as close as possible to true south with a minimal amount of shading.

Climatic considerations.

Passive solar homes must be tailored to specific climates to function properly. The ratio of glass to thermal storage mass and the size of the passive system to the size of the house changes for various locations. The type of system used can vary too, especially in southern climates where overheating can be a problem. All of the plans in this book have been designed specifically for North Carolina's climate.

What should you expect from a passive solar system?

It is important to have realistic expectations for your solar home. Passive solar systems can contribute 30 percent to 70 percent of home heating and cooling demands, depending upon the design. The North Carolina State University Solar Demonstration House gets about 80 percent of its heat from its passive solar systems.

Be informed about solar options!

To be as prepared as possible, you should become informed about solar products, design and building practices. Take advantage of opportunities to visit and investigate as many operating solar systems and solar homes as you can. A happy solar homeowner is one whose house or solar system operates smoothly and efficiently. This is an achievable goal if you are willing to prepare yourself for the process that lies ahead. Don't let unfamiliar terms and equipment scare you. Take your time and do your research.

Advantages of A Passive Solar Home

Good passive solar homes are not difficult to design or expensive to build. However, they do require the use of basic, common-sense methods of working with the environment rather than against it. The owners of a solar home enjoy five major benefits:

- ***Comfortable*** **–** their homes are warm in the winter and cool in the summer;
- ***Economical*** **–** they receive a positive cash flow or an excellent return from their investment;
- ***Durable*** **–** their homes are built from long-lasting, low-maintenance materials;
- ***Attractive*** **–** their homes are full of light and are well connected to the outdoors; and
- ***Environmentally Responsible*** **–** their homes make efficient use of nonrenewable natural energy resources.

North Carolina's Renewable Energy Tax Credit

The state of North Carolina provides a tax credit for the construction or installation of a renewable energy system to heat, cool or provide hot water or electricity to a building in North Carolina. The credit is 35 percent of the installation and equipment costs of a system, including passive and active space heating ($3,500 maximum per system), active solar water heating ($1,400 max.), and residential electricity generating systems such as photovoltaics, wind, and micro-hydro ($10,500 max.). The credit is distributed over five years. The N.C. Solar Center can provide details and guidelines to determine the income tax credit.

All passive solar homes have these common elements:

- **Collection**–To collect solar energy, double-pane, insulated windows are used on the south-facing side of the house. The glazing triggers the greenhouse effect, trapping solar energy.
- **Storage**–After the sun's energy has been collected, some heat is immediately used in the living spaces and some is stored for later use. The storage, called thermal mass, is usually built into the floors and/or interior walls. Mass is characterized by its ability to absorb heat, store it, and release it slowly as the temperature inside the house falls. Concrete, stone, brick, and water can be used as mass.
- **Distribution**–Heat stored in floors and walls is slowly released to the living spaces by radiation, convection and conduction. Open floor plans, stairwells, windows and doors allow the heat to convect throughout the house. In a hybrid system, fans, vents and blowers may be used to distribute the heat.

There are several types of passive solar systems that can be used in North Carolina homes. The most common are direct gain, indirect gain and isolated gain.

DIRECT GAIN

Direct gain is the simplest approach and usually the most economical to build. With this system, sunlight enters the house through large areas of south-facing glass. It heats the floor and walls directly. Energy from the mass in floors and walls is released to the living space when the inside air temperature or any object's surface in the room is lower than that of the mass.

The amount of south-facing glass and thermal storage mass should be balanced. If the windows collect more heat than the floor or walls can absorb, overheating occurs.

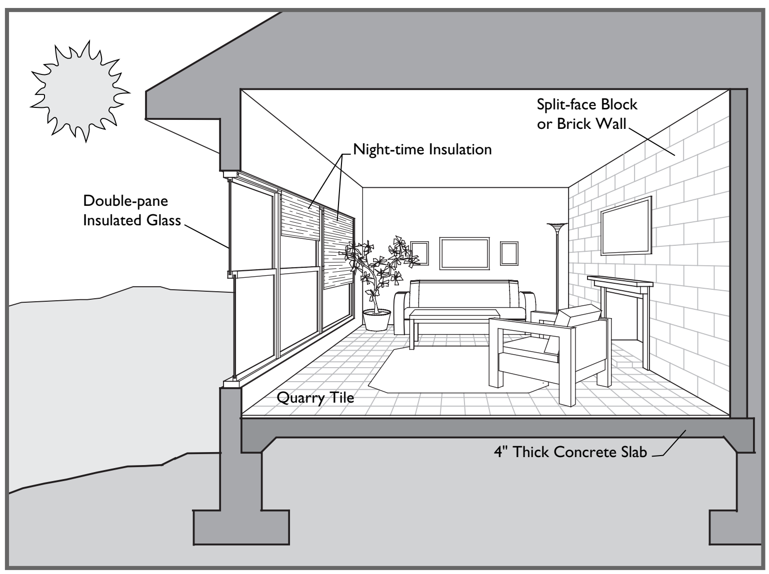


Fig. 1. Typical direct gain design section.

Advantages of a Direct Gain System:

- It is comparatively low in cost to build, since no special room has to be added.
- It provides direct heating to the living space.
- South-facing windows provide natural daylight and outdoor views.

Disadvantages of a Direct Gain System:

- It can overheat if the windows and thermal mass are not balanced.
- Large areas of south-facing glass can cause problems with glare and loss of privacy.
- The thermal mass used for heat storage should not be covered by carpet or blocked by furnishings.
- South-facing windows need summer shading and nighttime insulation in winter. This insulation is especially important for direct gain systems in colder climates because heat will be lost quickly through uncovered windows — even if they are high performance windows.

INDIRECT GAIN

In an indirect gain system, the storage mass is between the south glass and the living space. A thermal wall stores collected heat. Usually this wall is masonry (otherwise know as a "Trombe" wall) or a water wall of tubes or barrels placed several inches behind the window.

During the day, sunlight passes through the south-facing glass and is absorbed by the mass. The mass heats up slowly and then releases heat to the living spaces six to eight hours later. The time lag, as the mass warms and then gives off heat, keeps temperatures in the living space fairly uniform. It also means that the heating of the living area occurs in the evening and at night, when it is most needed.

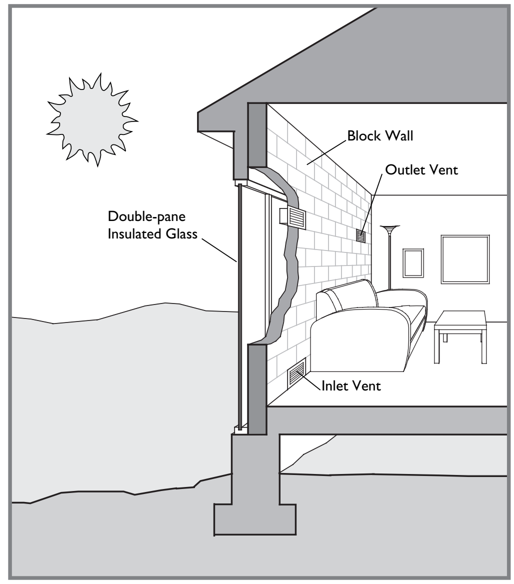


Fig. 2. Indirect gain Trombe wall section.

Advantages of an Indirect Gain System:

- The storage mass is located closer to the glass or collection area, which allows for efficient collection and storage of solar energy.
- The thermal mass prevents extreme temperature swings.
- The floor and wall area of the living space can be used with more flexibility than in a direct gain system.
- A Trombe wall system provides greater privacy on the south face of the house.

Disadvantages of an Indirect Gain System:

- The south-facing view and natural daylight are lost.
- Furniture and objects placed against or on the Trombe wall affect its efficiency in heating the living space.
- The Trombe wall heats only the room to which it is connected, so construction costs may be high relative to the contribution it makes to the overall heating needs of the house.
- The Trombe wall is a very poorly insulated wall and should be covered with exterior moveable insulation on summer days and winter days without sunshine.

ISOLATED GAIN

This system is also known as an "attached sunspace" or "attached greenhouse." An isolated gain system is designed so that the collector and storage elements can be closed off from the rest of the house during periods of extreme heat or cold. Typically, the sunspace is a separate room on the south side of the house with a large glass area and thermal storage mass. It can project from the house or be partially enclosed within the house. Sloped glazing is discouraged because it increases the possibility for overheating, glare and water leakage.

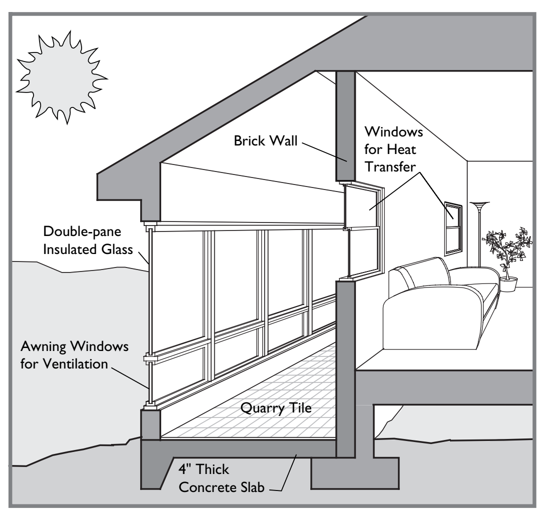


Fig. 3. Isolated gain sunspace design section.

If the sunspace is to serve as the primary heating system, you will probably want a design that is thermally isolated from the living area. This means that the sunspace can be closed off from the rest of the house by shutting the doors and windows that connect the two areas. When the sunspace is designed with sufficient mass, it can provide thermal performance better than that of Trombe walls and direct gain systems. Attached greenhouses should be designed to grow plants, with heat only being transferred to the house by conduction through an adjoining wall, not by convection through windows and doors.

Advantages of an Isolated Gain System:

- It can be physically separated from the living space, so that temperature fluctuations within the sunspace do not adversely affect the comfort of the living area.
- Due to their energy savings, attractiveness, and the appeal of having a warm sunny room on a cold winter day, sunspaces increase the resale value of a home.

Disadvantages of an Isolated Gain System:

- Heavy furnishings and rugs must be avoided to prevent shading of the thermal storage mass.
- Shading and venting are important to avoid summertime overheating.

Guidelines for Passive Solar Design & Construction

Ensure adequate solar access.

The longest wall of the home should face within 15°, plus or minus, of true south to receive maximum winter heat gain and minimum summer heat gain. Within 30° east or west of south, the results are reduced 15 percent from the optimum.

Facing solar surfaces to the south is not enough to ensure their performance; you must also make sure that the area to the south is clear of obstructions that would block the sun from reaching them. There should be no significant blockage between 9 a.m. and 3 p.m., solar time, in the winter. At North Carolina's latitudes, this means that the area extending 45° south from the outer southern corners of the solar surfaces should be kept clear of obstructions that would block the sun.

Size south-facing windows and thermal mass appropriately.

- In *houses with no internal mass*, the maximum allowable area of south-facing glass is 7 percent of the floor area.
- *Direct gain systems* can be up to 12 percent of the floor area in south-facing windows. However, every 1 square foot of south-facing glass over the 7 percent must be accompanied by 5 square feet of 4-inch-thick masonry.
- *Sunspaces* should include only vertical glass. (Sloped glazing can cause serious overheating). Every 1 square foot of south-facing glass must be accompanied by 3 square feet of 4-inch-thick masonry.
- *Thermal storage or Trombe walls* should be 8- to 12-inch-thick masonry. The outside of the masonry wall should be coated with a selective surface and the inside surface should be free of coverings. The outside of the glass should be covered or shaded in summer.

Minimize east and west windows.

During the summer, the east and west sides of the house are exposed to the sun's rays at a low angle for long periods of the day. Reducing windows on these sides can greatly decrease summer heat gain. Unlike the summer sun, the winter sun is low and stays primarily to the south, so east and west windows receive little solar benefit during cold months. A reduction of east and west windows can significantly reduce winter heat loss through the glass.

Match the solar heating system to your lifestyle and the room use.

Different designs require varying degrees of interaction — from seasonal shading that needs to be added or removed twice a year, to movable insulation that needs to be adjusted twice or more daily. Many solar homeowners enjoy interacting with their house because it gives them an opportunity to experience the effects of the cycles of nature in a more personal way. However, you need to be comfortable with the level of interaction that your house requires.

Consider occupancy patterns when choosing a system. What are the heating, lighting and privacy needs after sunset? A Trombe wall might be a logical choice for a room requiring privacy. A living room, on the other hand, which needs daytime and early evening heat and has a higher lighting requirement, might benefit from a direct gain system or sunspace.

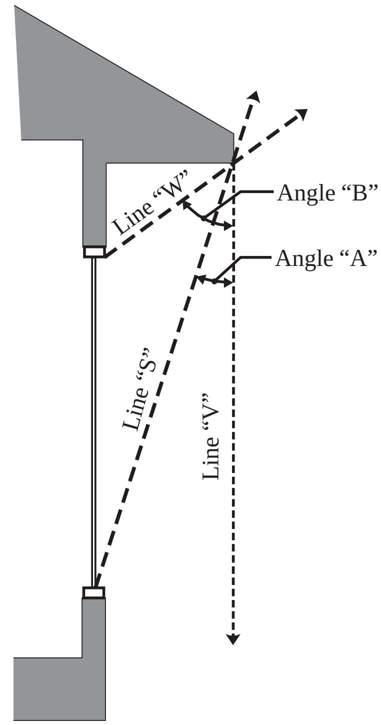


Fig. 4. Optimum overhang diagram.

Size overhangs properly.

To prevent summer gains, Angle “A” in Fig. 4 between Line “S” and Line “V” should be approximately equal to the latitude, minus 18.5°. To prevent winter shading, Angle “B” between line “W” and Line “V” should be approximately equal to the latitude, plus 18.5°. An overhang designed with this formula will provide shade well into summer and full sun through the coldest part of winter.

Plan your room layout to take advantage of the sun’s path.

Rooms should match solar gain to the time of day the room is used. For example, kitchens and dining rooms are natural choices for the east or southeastern portion of the plan. The rooms benefit from early morning sun but are protected by the rest of the house from the afternoon sun. The family room, living room and bedrooms lend themselves to a south or southwestern location, where they will be warmed by the afternoon sun for evening use.

Place rooms with low heating, lighting and use requirements on the north side of the building to reduce the effect of winter heat loads. Areas that are not consistently occupied, such as utility rooms, storage rooms, hallways, closets and garages, are good choices. Also, rooms that generate high internal heat gain levels, such as the kitchen or laundry room, work well on the north side. This can reduce the normally higher heat loss through north walls while not interfering with solar access.

Lightweight materials should be lighter in color.

When light energy strikes a surface, it is absorbed and converted into heat energy. If the material does not have sufficient storage mass, the material will release heat it cannot store to the room air, causing overheating. Lighter colors are more reflective so they absorb less energy from sunlight.

Masonry walls can be any color in direct gain systems.

Actually, it is best to use colors in the middle range of the absorptivity scale to diffuse the light energy over the entire storage mass in the room. These colors need to be somewhat darker than the lightweight materials. (The absorption range of natural or colored concrete masonry falls in this range without paints or special treatment being necessary). If the storage mass is too dark in color, there will be high surface temperature at surfaces exposed to the direct rays of the sun while other locations on the same wall may be storing very little of the day’s solar energy. Masonry in Trombe walls should always be dark colors to increase absorption.

Rugs and wall tapestries also can reduce the effect of storage mass to a great degree. It is wise to plan in advance to match the type of thermal storage to the room’s use.

Distribute the mass through the room.

In direct gain systems, performance is fairly insensitive to the locations of the mass in the room. It is relatively the same whether the mass is located on the floor or on the east, west or north walls. It is important to put some mass in direct sun, but rarely is it possible to expose all the required thermal mass because of furniture and floor coverings. Comfort is improved if the mass is distributed evenly around the room because there is less chance of localized hot or cold spots. Light colored, lightweight materials "bounce" the sun to more massive materials as long as they are in a room with lots of sun. Also, massive materials in walls that are not in direct sunlight can act as a "heat sink," absorbing excess heat from the air and serving to reduce temperature swings.

Consider night window insulation.

Generally R–9 night insulation over double-pane windows provides an approximate 20 percent to 30 percent increase in annual solar performance over systems using double-pane windows without night insulation. Window insulation can be heavy drapes, quilted shades or accordion blinds.

Select a good site for your solar house.

A good passive solar house requires more than just a good design and quality construction. It also requires that the plan and the site be considered together during the design phase to ensure that they work together to optimize solar performance. The best designed solar house plan will not work unless it is placed properly on a building site that allows solar access. Similarly, a lot with clear solar access provides little advantage to the building placed upon it unless the building is designed and oriented to take advantage of the site's solar potential.

- Look for roads that run from east to west. Since standard subdivision practice calls for lot lines perpendicular to the street and houses facing parallel to the street, this is the easiest way to find lots suitable for siting houses with the long axis running from east to west.
- If your plan has a solar front, look at lots on the north side of the street; if it has a solar back, look on the south side.
- Look for lots that are deep from north to south to allow a maximum amount of control over the solar access zone.
- Look for flat or south-sloping lots that allow maximum solar access. Avoid north-sloping lots, since the potential for solar surfaces is reduced and obtaining solar access is more difficult.
- Find out about zoning regulations and restrictive covenants in the development.

Use landscaping to your benefit.

Consider the effect of plants on your electric bill. Trees and shrubs can cut air conditioning use in the summer by 20 percent to 40 percent. The following guidelines can help to maximize the benefits of landscaping:

- Leave the south side of the house open to the sun in winter months from 9 a.m. to 3 p.m. In North Carolina that usually means a wedge-shaped area extending 45° from each southern corner. Avoid planting trees in this area. Overhangs will block any unwanted southern sun.
- Shading the east and west sides of the house can provide the greatest cooling energy savings. Give priority to the west, because heat from the late afternoon sun adds a great deal of heat gain to the house after it has built up heat all during the day.
- Plant to shade areas surrounding the house. This reduces the air and ground temperatures around the house. Shrubs and vines may be good and fast-growing alternatives to trees.
- Try to reduce the amount of pavement close to the house by using ground covers.
- Shade the roof. However, trees should not be planted closer than 10 to 15 feet from the house's foundation.

Energy Efficiency

A passive solar home should be built with maximum attention to energy efficiency details. Insulation levels should be higher than specified in the building code (see Table 1). Windows and doors should meet recommended air infiltration standards. Infiltration or air leakage should be reduced by careful caulking and weather-stripping. If the structure is not energy efficient before adding passive solar features, you will still need a good deal of supplemental heat.

Windows on the north side should be used in moderation to balance the light coming from the south side of the house and to provide cross ventilation. Eastern and western windows generally do not add much to winter net heat gain and will add to overheating problems in the summer. Winter night heat loss from windows can be reduced by the use of moveable insulation, either inside or outside the house.

Any well-insulated and weatherized house needs good ventilation to reduce problems from indoor air pollution and help control humidity inside the house. Natural ventilation should be used in the attic through soffit and ridge vents. Ventilation and air circulation in the basement is important to reduce mold and mildew growth. Bathrooms and kitchens should have quiet, variable speed, exhaust systems vented to the outside.

Overview of Solar Home Plans

The following passive solar home plans have been specifically adapted to the heating and cooling requirements of this state. They represent a range of sizes and architectural styles. Each design is accompanied by a floor plan and drawing of the house, a description of the home's passive solar features, as well as a table showing the projected energy consumption. Working or construction drawings are available for each of the solar home plans in this book, with the exception of the student entry, and are available from the architect, designer or builder. The name and contact information for each house is published alongside the plans.

Modifications

These new solar home plans represent a significant amount of work by professionals around the state. Since each building site is different and every homeowner has special requirements, it is strongly recommended that the potential homeowner consult the listed architect, builder or design professional for any necessary modifications or site visits. Plans provided by architects registered in North Carolina must be sealed by that architect if they are to be used for construction in the state. By sealing their plans, architects assume a certain level of professional liability; therefore, any modifications to the plans must be made by the architect of those plans.

Each individual architect, residential designer or builder who has a plan in this book has the right to set his or her own conditions for the sale of the plans. Prices indicated in this book for plan sets may change at any time to include the addition of various required services. The N.C. Solar Center provides a free design review assistance service, with a staff member available to answer design questions and give advice. The Solar Center also publishes a directory of building professionals from around the state who provide solar design and construction services.

General Specifications

Table 1 describes energy efficiency features generally used in the passive solar plans compared to a house built to meet the minimum North Carolina Building Code. It should be noted that the plans are a result of an integrated design procedure by which the solar systems are matched to the energy efficiency features, overall house plan, and location of the house. So, it is important not to make changes that might downgrade the insulation or other efficiency features of the passive designs.

Energy Efficiency Specifications: Building Code vs. Solar House

Feature	1996 Building Code House	Passive Solar House
1. Insulation*		
Slab Floors	R-5	R-10
Frame Floors	R-20	R-20
Walls	R-16	R-23
Ceilings	R-31	R-40
2. Windows	<1% of floor area is allowed to be single-paned glass; if glass area is >1% & <23% they must be double-paned; if >23% & <33% they must be double-paned with low emissivity glass.	Double glazing with night insulation or "northern low-e." No more than 2% on west, 4% on east and north, and at least 7% but no more than 20% on south if sunspace or Trombe wall used.
3. Infiltration	Standard weatherization resulting in one air change per hour.	Standard weatherization, plus vapor barrier on exterior walls, sill and sole plate sealants, and joint sealant for frame and masonry resulting in 1/2 to 3/4 air changes per hour.

* R-values stated are for the total wall, ceiling or floor including sheetrock & decking.

Projected Energy Consumption

Included with each solar house plan is a table of its projected heating and cooling energy use. These figures should be viewed as a relative measure of the home's performance in much the same way as miles-per-gallon figures are used for new cars. Just as driving patterns affect automobile gasoline mileage, occupant lifestyle determines the actual amount of energy consumed for heating and cooling. The Passive Solar Industries Council's *BuilderGuide* software was used to calculate these savings in five different cities: (1) Cherry Point in Zone I; (2) Raleigh in Zone II; (3) Greensboro and Charlotte in Zone III; and (4) Asheville in Zone IV. (See the zone map on page 12).

The performance table that accompanies each house plan contains energy calculations in million Btus (MMBtu) for the passive solar design built to high efficiency standards (Current Design), a similar conventional house built to the current building code (Reference Design), and the percentage increase (as a negative) or decrease in performance. The calculations for each city include: (1) **Conservation Performance** — the total annual heat loss of the building shell, excluding the solar features (an indication of the efficiency of the building shell); (2) **Auxiliary Heating Performance** — the amount of energy required to heat the house (reflects the contribution of the solar features); and (3) **Cooling Performance** (total annual cooling load or amount of energy required to cool the house).

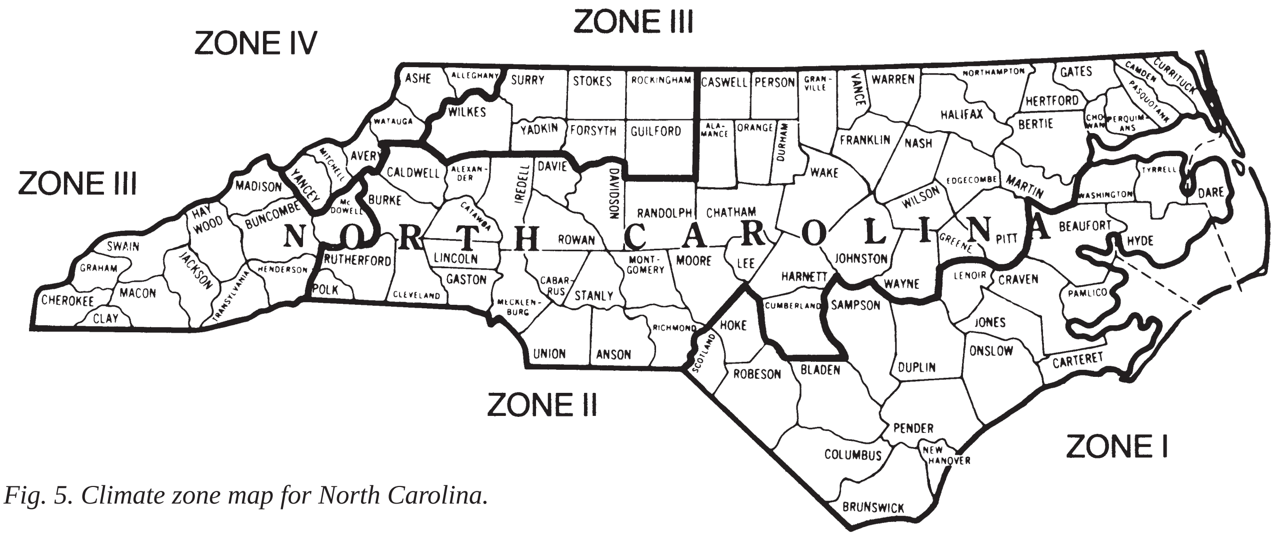


Fig. 5. Climate zone map for North Carolina.

It is possible to derive an estimate of the money saved by these plans by converting the difference in Btus into dollars; however, the results are only an estimate because of the wide range of variables that will affect real world performance. Some of these variables are: (1) type and efficiency of heating and cooling system used in the house; (2) local price of electricity and fuel; (3) variations in local weather patterns and climatic conditions; (4) how occupants operate the house, including thermostat set points, use of natural ventilation for cooling and internal heat gains from appliances, lights and equipment; (5) attention paid to energy details by the builder during construction; and (6) the quality and type of insulation, windows and doors. Given these considerations, a general estimate of energy savings can be calculated using the following formulas.

Natural Gas: @ $0.65/therm = $6.50/million Btu (MMBtu). With an 80% efficient furnace and 10% duct losses, the cost of useful heat in the house is $9.03/MMBtu.

Electricity: @$0.085/kiloWatt-hour = $24.90/MMBtu. With a standard heat pump (SEER of 10 at a coefficient of performance (COP) of 2.9 (290% efficient) in summer, a HSPF of 7.2 at a COP of 2.1 in winter), and 10% duct losses, the cost of useful heat in the house is $9.54/MMBtu in summer and $13.17/MMBtu in winter.

Wood: @$80/cord = $3.04/MBtu. With a new wood stove at 70% efficiency, the cost of useful heat in the home is $4.34/MMBtu (not including the time and effort costs).

Propane: @$0.89/gallon = $10.77/MMBtu. With an 80% efficient furnace and 10% duct losses, the cost of useful heat in the house is $14.96/MMBtu.

Example: 2,000-square-foot-house in Raleigh with a SEER 10 heat pump and a 50% reduction in heating and cooling due to passive solar features.

Reference Design Heating = 32,000 Btu/yr-sf; Currrent Design Heating = 16,000 Btu/yr-sf;
Reference Design Cooling = 12,000 Btu/yr-sf; Current Design Cooling = 6,000 Btu/yr-sf.

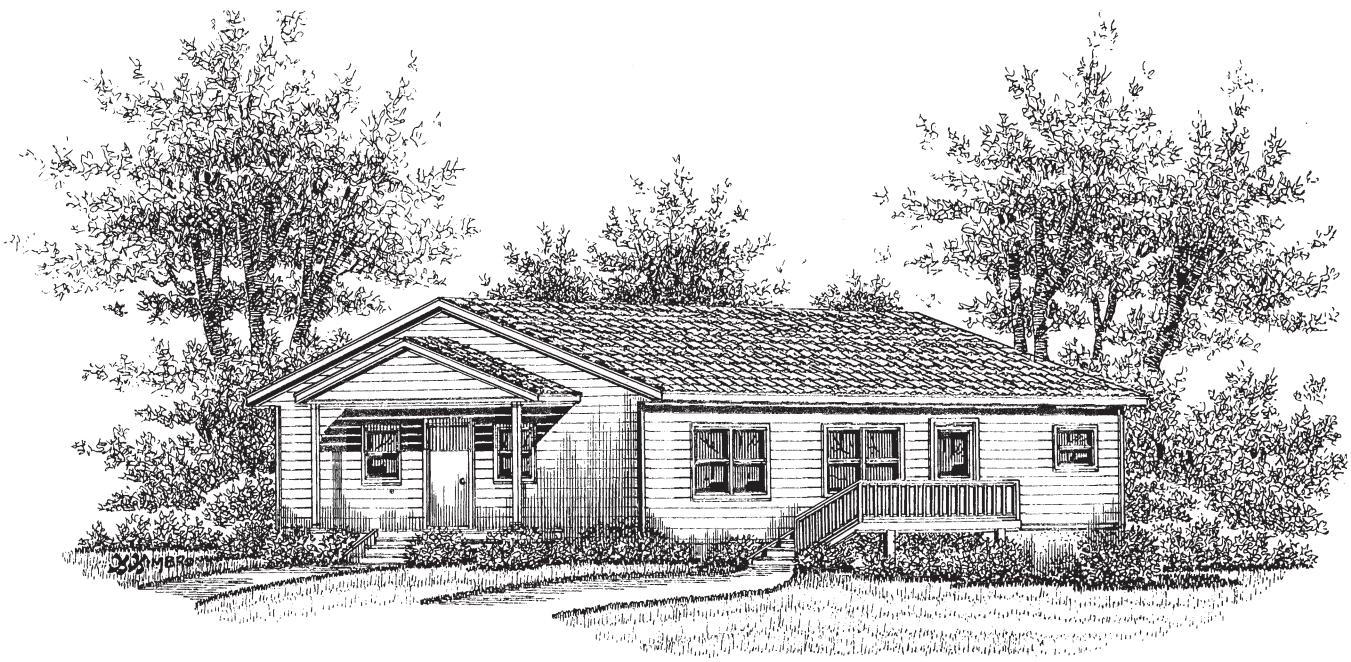
2,000 sf x (32,000 - 16,000)Btu/yr-sf = 32,000,000 Btus or 32 MMbtus heating savings
2,000 sf x (12,000 - 6,000)Btu/yr-sf = 12,000,000 Btus or 12 MMbtus cooling savings

(32 x $13.17) + (12 x $9.54) = $535.92 in energy savings per year or about $44.66 a month. This monthly savings would offset the monthly mortgage increase from financing an additional $6,084 in construction costs at 8% for 30 years.

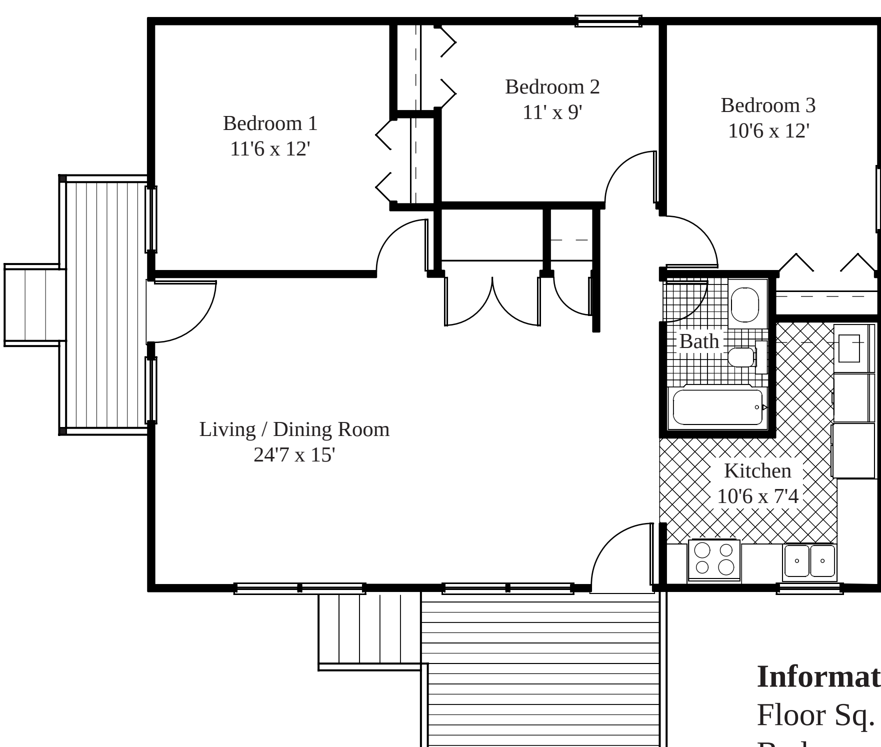
This, of course, does not take into account the increase in comfort, daylighting, durability or environmental benefits — qualities that make solar homes not only cost effective but also enjoyable places to live.

Solar House Plans

Plan One



Main Floor Plan



Information
Floor Sq. Ft.: 1,008
Bedrooms: 3
Baths: 1

Durham, N.C.
Plan available from the N.C. Solar Center

This affordable passive home design was developed by Richard Harkrader for the Western North Carolina Habitat for Humanity affiliate. It features a very efficient use of floor space and excellent passive solar performance due to its compact footprint, quality energy efficient details and flexible design and construction options.

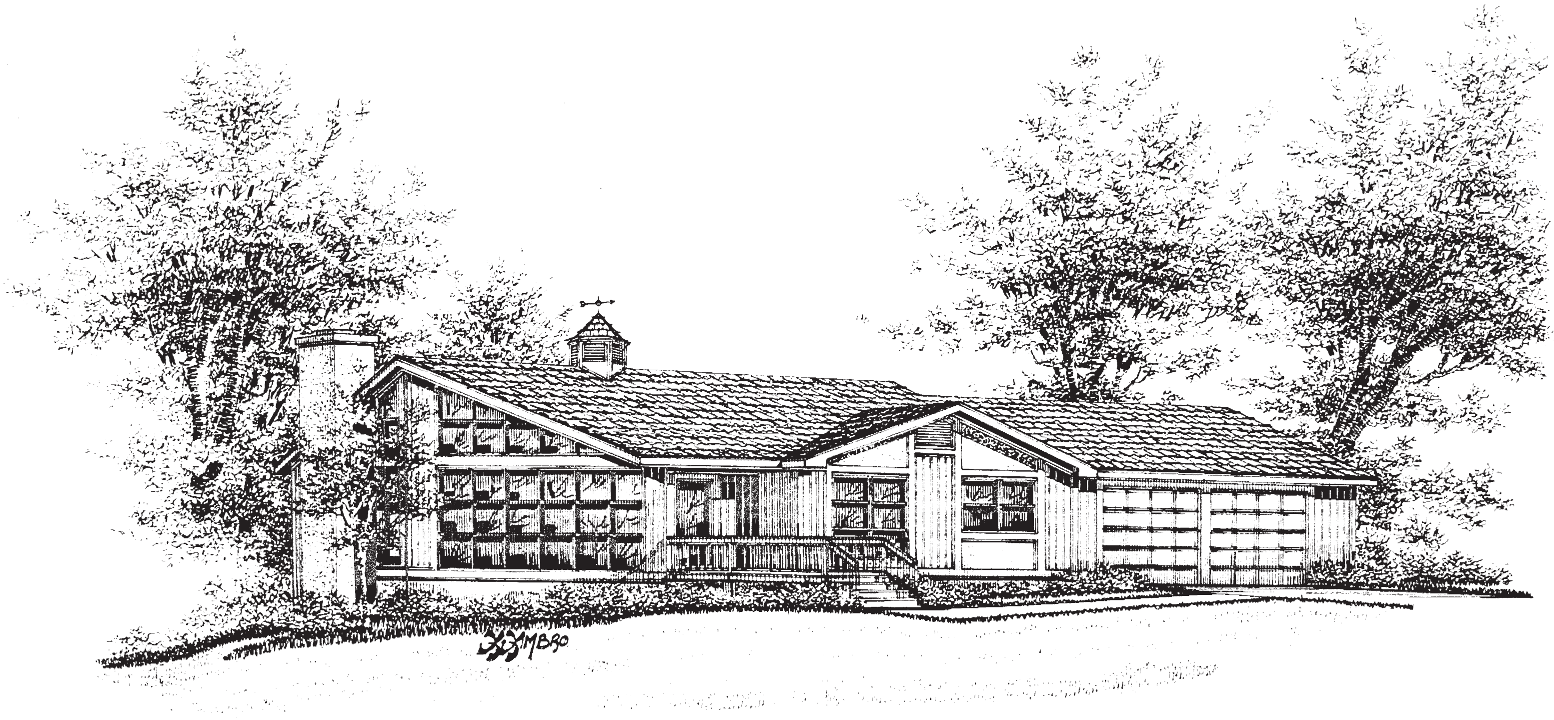
The plan can be built over a crawl space as a sun-tempered home, but better performance will be achieved if built on a concrete slab with tile as a floor finish in the kitchen, living and dining rooms. Carpet is an option for the northern bedrooms. For anyone who has to build over a crawl space but wants a full passive solar design, an innovative alternative to tile and concrete is detailed in the plans. Smooth brick pavers laid on a traditional floor joist and plywood deck system are sealed with a water-based urethane floor finish. This provides a warm, durable and inexpensive solar mass. An alternative galley kitchen and front porch plan also are presented. Energy efficiency details, including a two-foot overhang, western porch, damp-spray cellulose insulation in 2x4 walls, and quality vinyl low-e windows, complete this low-cost gem.

Distribution of this design, as well as three other small home plans, is handled by the N.C. Solar Center. The cost per set is $15.

PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	19,987	33,630	-41
Aux. Heat Performance	15,790	30,839	-49
Cooling Performance	3,638	9,296	-61
Charlotte			
Conservation Performance	15,387	26,302	-42
Auxiliary Heat Performance	12,002	23,856	-50
Cooling Performance	5,646	13,335	-58
Greensboro			
Conservation Performance	18,032	30,489	-41
Auxiliary Heat Performance	14,245	27,958	-49
Cooling Performance	6,146	13,488	-55
Raleigh			
Conservation Performance	16,258	27,789	-41
Auxiliary Heat Performance	12,844	25,205	-49
Cooling Performance	6,609	14,015	-53
Cherry Point			
Conservation Performance	13,661	23,656	-42
Auxiliary Heat Performance	10,382	21,338	-51
Cooling Performance	8,505	17,562	-52

Plan Two



PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	20,410	30,704	-34
Aux. Heat Performance	14,532	28,524	-49
Cooling Performance	4,314	6,077	-29

Charlotte			
Conservation Performance	15,834	24,016	-34
Auxiliary Heat Performance	11,115	22,071	-49
Cooling Performance	5,511	9,350	-41

Greensboro			
Conservation Performance	18,413	27,756	-34
Auxiliary Heat Performance	12,926	25,785	-49
Cooling Performance	6,161	9,589	-36

Raleigh			
Conservation Performance	16,730	25,374	-34
Auxiliary Heat Performance	11,577	23,319	-50
Cooling Performance	6,785	10,131	-33

Cherry Point			
Conservation Performance	14,063	21,558	-35
Auxiliary Heat Performance	9,282	19,790	-53
Cooling Performance	8,086	12,761	-37

J.J. Ewers, NCARB

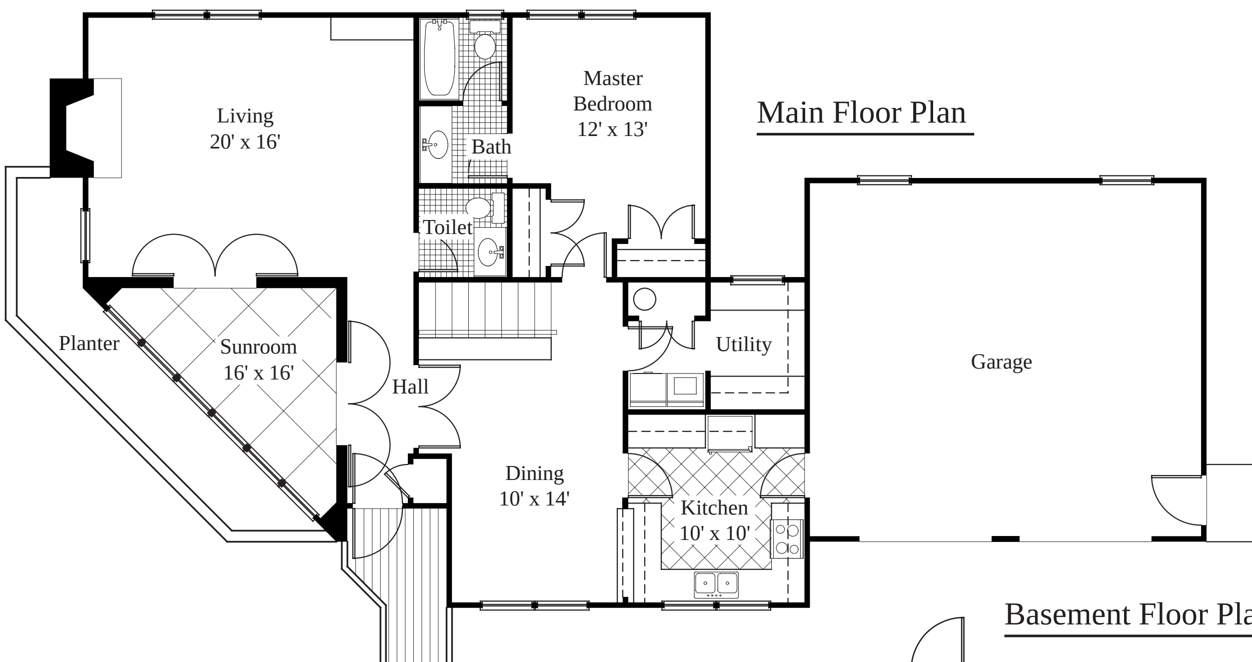
7231 Ridelane Road, Charlotte, N.C. 28262
Tel: (704) 596-5177

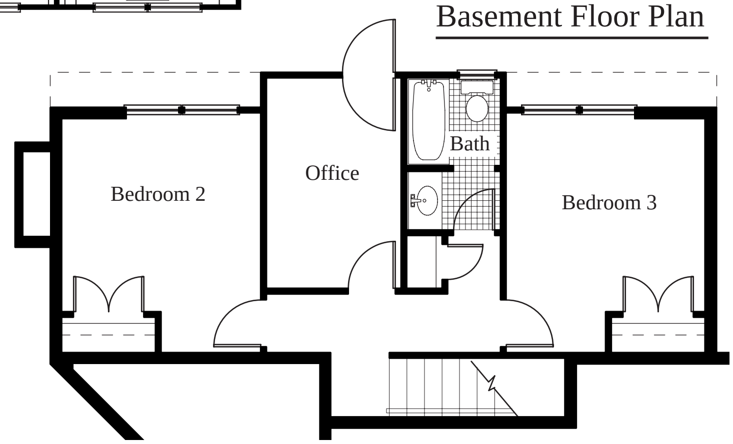
This passive solar design will feel right at home in any residential neighborhood. Its unique blend of traditional and contemporary design offers standard features such as a dining room convenient to the kitchen, office, two-car garage and fireplace. Yet, it also incorporates an excellent passive solar sunspace easily accessible from the living room. The sunspace wall is designed at a 45° angle, making it perfect for those not-so-perfect angled lots. Adding to its flexibility of site placement, this design can be built on a lot with a northwest slope.

This design received a “Building Value into Housing Program Award” for fostering the use of innovative construction techniques and materials. Since then, passive solar building designs by J.J. Ewers have been published in *The Charlotte Observer* and featured in local Sierra Club solar home tours.

Energy-efficiency features include passive sunspace ventilation through low vent windows up to the functioning cupola, two-foot overhangs, daylight basement, and high quality windows.

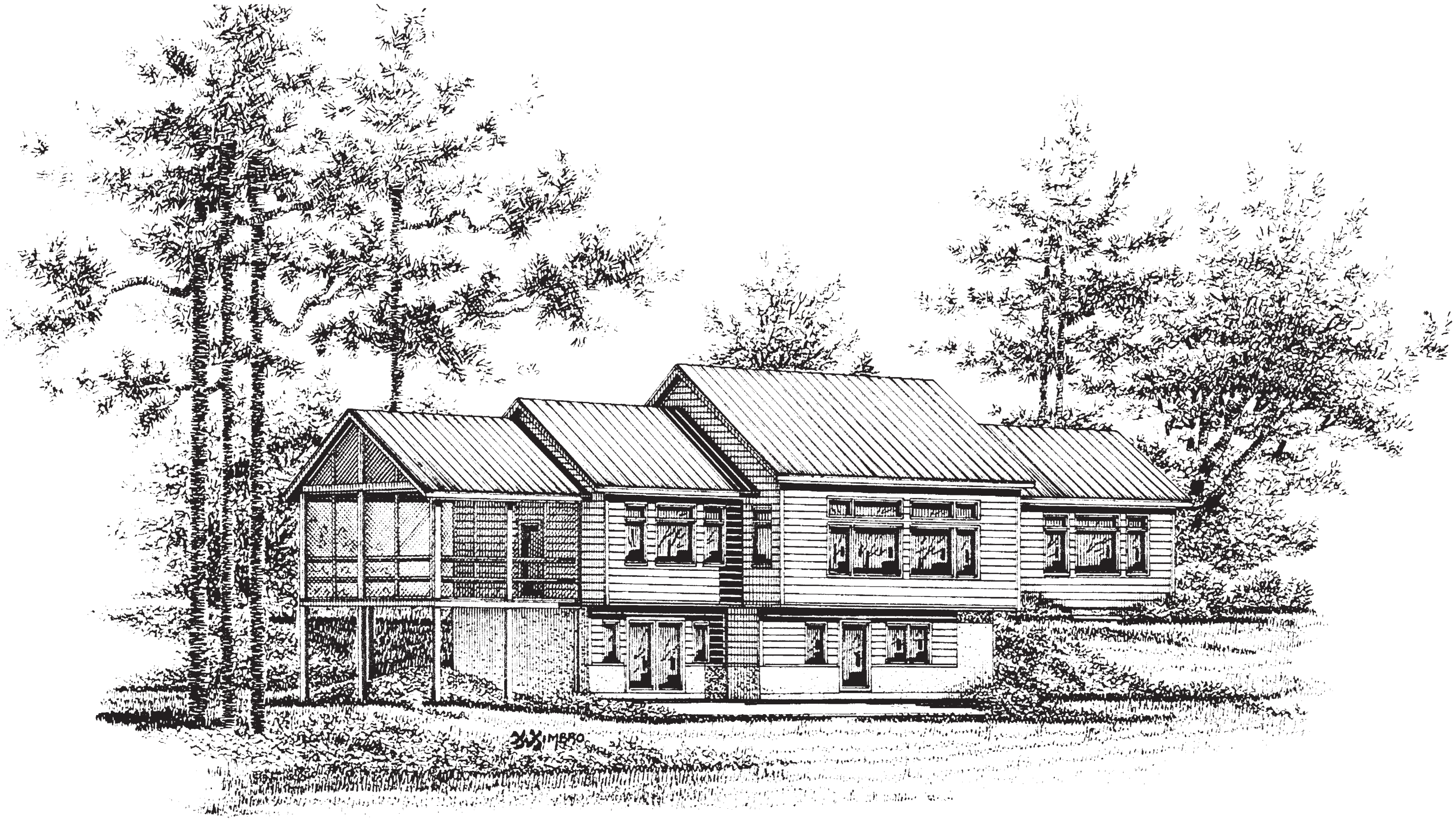
Three sets of this design are available directly from J.J. Ewers for $350.



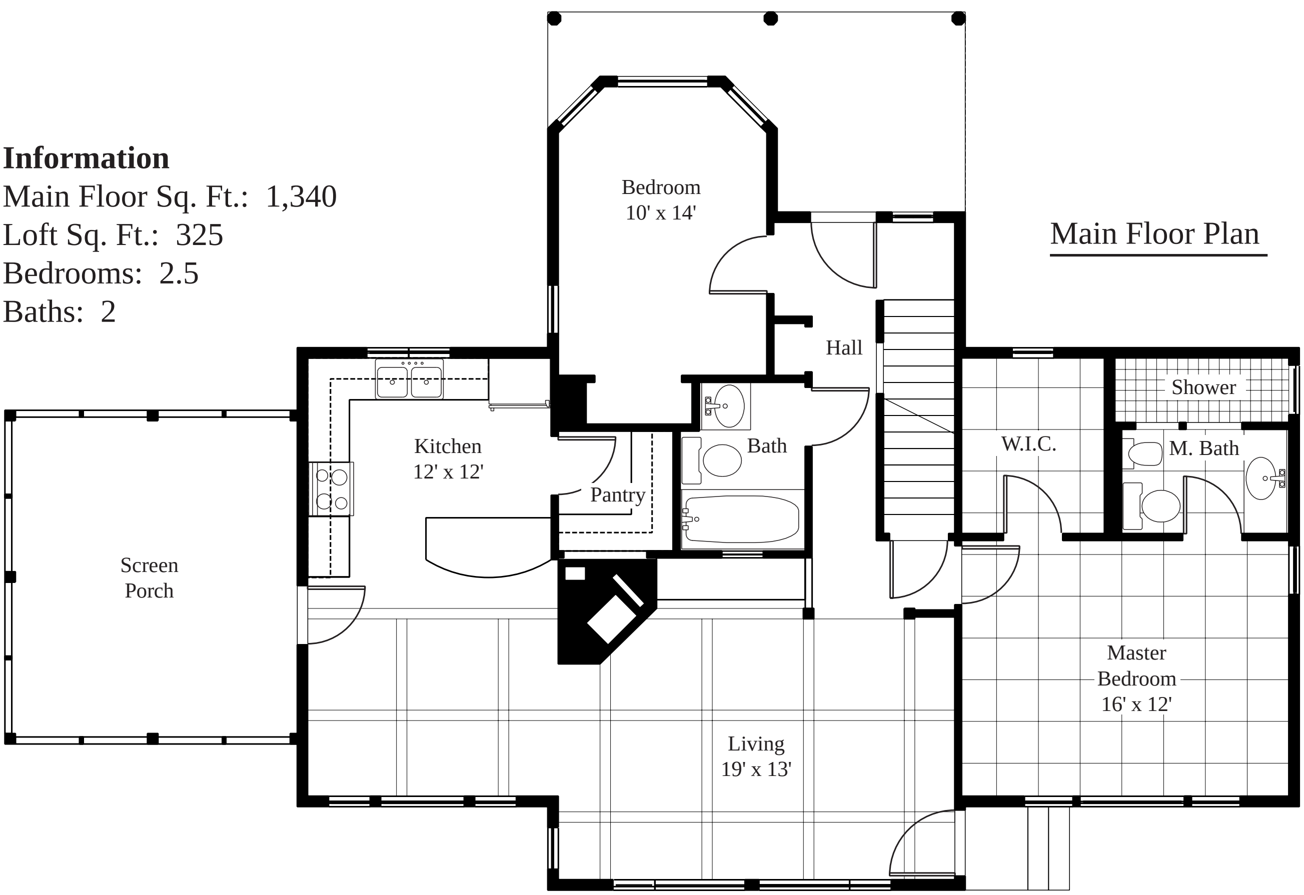


Information
Main Floor Sq. Ft.: 1,132
Basement Floor Sq. Ft.: 616
Bedrooms: 3.5
Baths: 2.5

Plan Three



Information
Main Floor Sq. Ft.: 1,340
Loft Sq. Ft.: 325
Bedrooms: 2.5
Baths: 2



Paul Konove & Alicia Ravetto, AIA

400 West Weaver Street • Carrboro, N.C. 27510
Tel: (919) 933-0999 • Fax: (919) 933-1988

By blending traditional building materials and construction with modern passive solar design, this design by Paul Konove and Alicia Ravetto for their residence fits in well with the local character of the rural Piedmont. Durable materials like cedar siding, aluminum clad windows, standing seam metal roof and colored concrete floors mean you will spend more time enjoying the southern views than maintaining your house.

The unfinished basement adds another 900 square feet of potential bedroom or workshop space. The second floor is designed as an open loft or study area, but this 325 square feet of space also could be enclosed for an upper bedroom. Designed for a lot that slopes from east to west, this plan can be easily modified to fit a west-to-east or north-to-south slope.

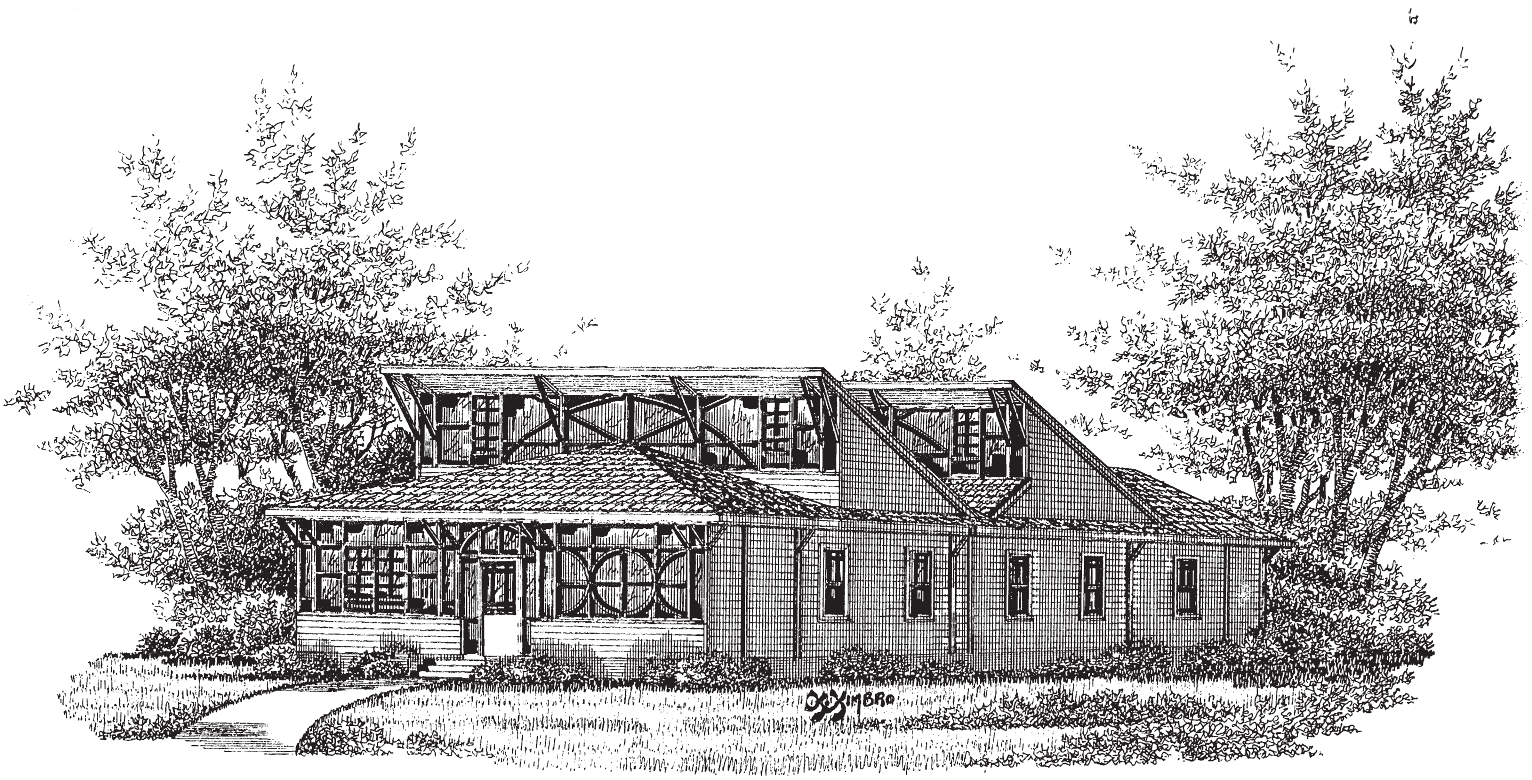
Some of the energy-efficiency features built into this design are generous overhangs, minimum windows on the west and east, a screen porch on the west, 2x6 walls with dense-pack cellulose insulation, a high efficiency “Finish style” masonry stove, R–38 roof insulation with radiant barriers, high quality casement windows and sufficient window area in the daylight basement to keep it warm through most of the winter.

The drawings for this design are available from Alicia Ravetto for $350.

PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	24,034	39,152	-38
Aux. Heat Performance	17,665	36,255	-51
Cooling Performance	3,056	7,080	-56
Charlotte			
Conservation Performance	18,706	30,673	-39
Auxiliary Heat Performance	13,562	28,096	-52
Cooling Performance	5,761	10,987	-48
Greensboro			
Conservation Performance	21,684	35,523	-39
Auxiliary Heat Performance	15,743	32,894	-52
Cooling Performance	5,879	11,107	-47
Raleigh			
Conservation Performance	19,744	32,469	-39
Auxiliary Heat Performance	14,137	29,742	-52
Cooling Performance	6,241	11,559	-46
Cherry Point			
Conservation Performance	16,655	27,767	-40
Auxiliary Heat Performance	11,275	25,407	-55
Cooling Performance	8,113	14,537	-44

Plan Four



PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	22,512	29,441	-24
Aux. Heat Performance	12,224	26,762	-54
Cooling Performance	3,821	6,766	-44

Charlotte			
Conservation Performance	17,609	23,028	-24
Auxiliary Heat Performance	9,280	20,702	-55
Cooling Performance	6,205	10,423	-40

Greensboro			
Conservation Performance	20,330	26,561	-23
Auxiliary Heat Performance	10,917	24,144	-55
Cooling Performance	6,571	10,642	-38

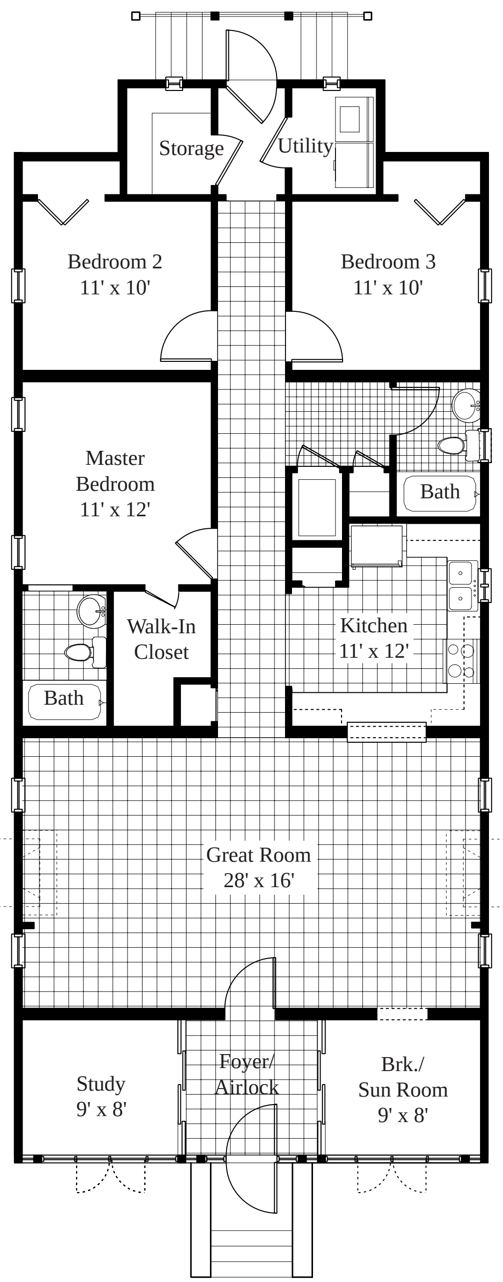
Raleigh			
Conservation Performance	18,530	24,331	-24
Auxiliary Heat Performance	9,580	21,874	-56
Cooling Performance	6,796	11,156	-39

Cherry Point			
Conservation Performance	15,744	20,651	-24
Auxiliary Heat Performance	7,289	18,421	-60
Cooling Performance	8,457	14,020	-40

Michael Connor, AIA

318 Pine Cliff Drive • Wilmington, N.C. 28409
Tel: (910) 397-0491

Main Floor Plan

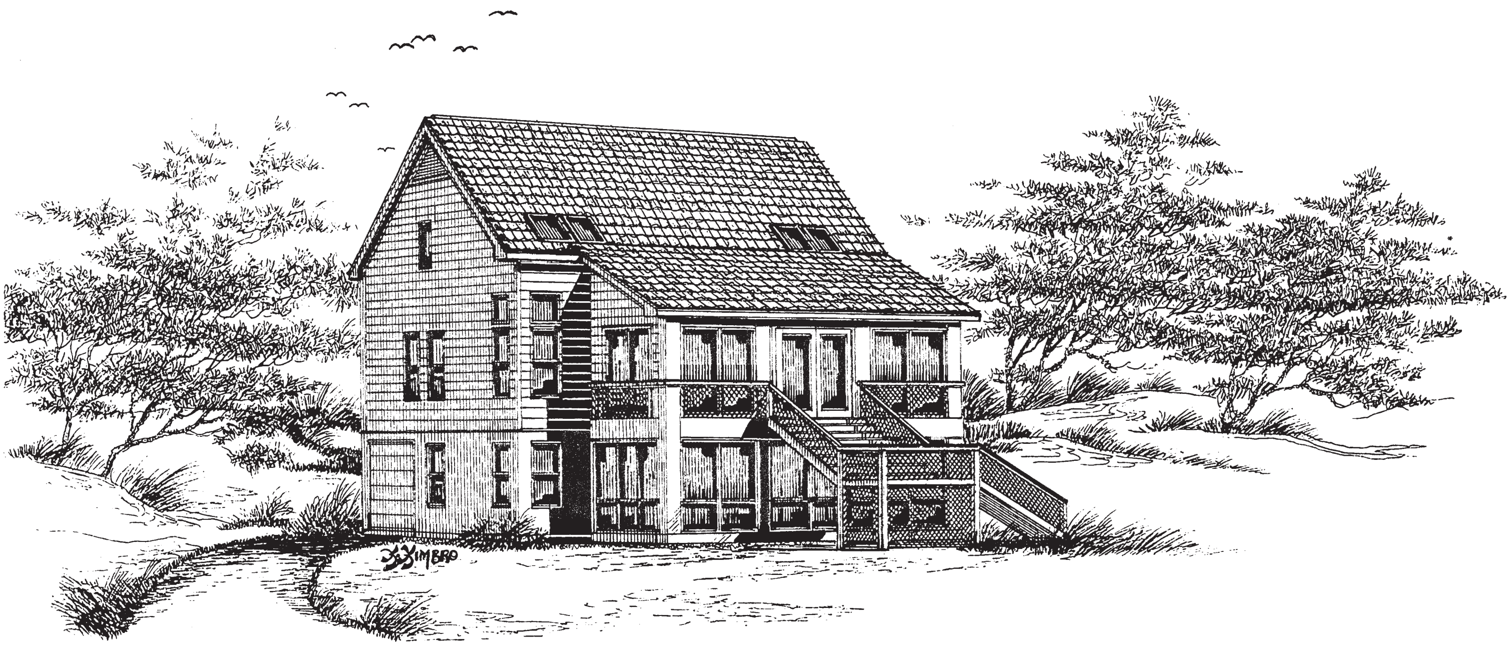


This solar bungalow design by Michael Connor (a.k.a Les Izzmo) of Wilmington, N.C., is an excellent solution to a common problem encountered when designing for an urban infill lot. Although the most efficient shape for a passive solar home is one that is elongated along the east-west axis, not all homeowners or builders have the luxury of owning a lot with these ideal proportions. In fact, every city in North Carolina has at least one neighborhood that consists of lots that are elongated perpendicular to the street, with 14 feet or less of clearance to the adjacent homes. The craftsman bungalow is the dominant house form in many of these neighborhoods.

This design seeks to provide an urban infill solar home that can be located in one of these older neighborhoods, on a south-facing lot, with the building being elongated in the north-south axis. The challenge of providing enough south-facing glazing is met through the use of clerestories, which create some very dramatic interior spaces. The design of this home respects the

Information
Floor Sq. Ft.: 1,752
Bedrooms: 3
Baths: 2

Plan Five



PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	19,804	27,874	-29
Aux. Heat Performance	16,120	25,700	-37
Cooling Performance	3,870	6,230	-38
Charlotte			
Conservation Performance	15,246	21,695	-30
Auxiliary Heat Performance	12,258	19,786	-38
Cooling Performance	5,100	9,687	-47
Greensboro			
Conservation Performance	17,867	25,148	-29
Auxiliary Heat Performance	14,365	23,186	-38
Cooling Performance	5,754	9,907	-42
Raleigh			
Conservation Performance	16,108	22,921	-30
Auxiliary Heat Performance	12,951	20,904	-38
Cooling Performance	6,326	10,457	-40
Cherry Point			
Conservation Performance	13,535	19,396	-30
Auxiliary Heat Performance	10,490	17,650	-40
Cooling Performance	7,417	13,203	-44

Larry Vickers, AIBD

L. Vickers & Associates • 704 Arendell Street • Morehead City, N.C. 28557
Tel/Fax: (919) 247-7740

If a passive solar *second* home is what you are looking for, then this Solar Cottage design by Larry Vickers will be a perfect fit. Three floors of flexible living space provide multiple arrangements for room use — tall as shown, or on a slab without a ground-level family room, garage, and workshop.

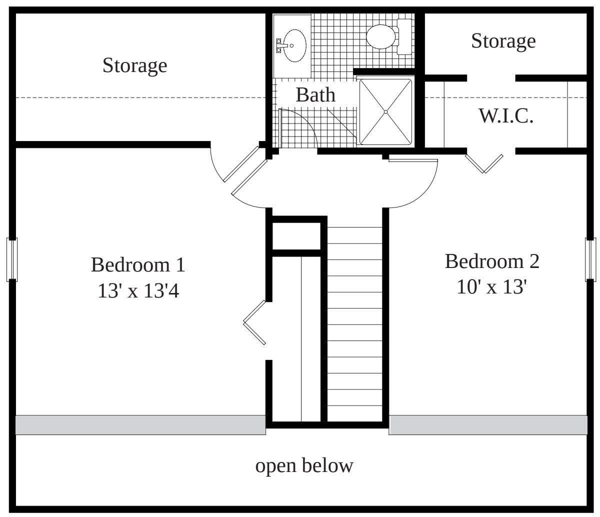
As for solar features, the Solar Cottage has many. The primary solar feature, the large sun porch, can be fully ventilated in the summer and gives consistent and even heat in the winter. Off the main floor, this sun porch offers excellent views to the south and is high enough to catch a breeze — an appealing feature on the coast or in the mountains.

On the upper floor are two bedrooms with their own high performance thermal storage water walls that are sunlit by four operable skylights. Ceiling fans and floor registers assist the passive convection of solar heat throughout the house in the winter. Along with the high ceilings, well placed windows and operable skylights promote ventilation in the summer.

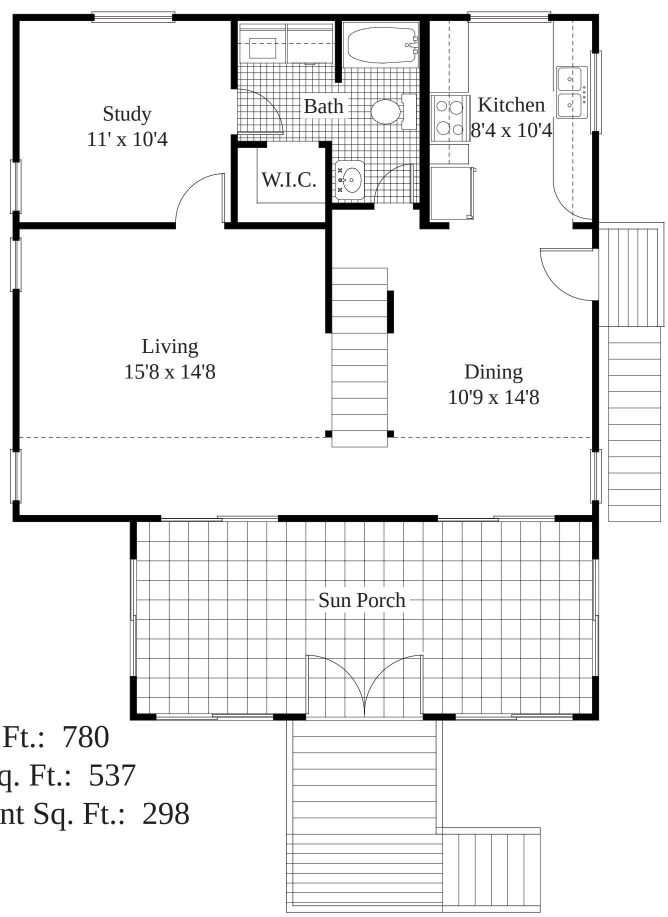
The idea behind Larry Vicker's designs has always been to create maximum comfort with minimum environmental load, while appearing classically conventional.

Construction plans for the Solar Cottage are available from L. Vickers & Associates for $250 for five sets. Modifications can be done for an additional fee.

Second Floor Plan

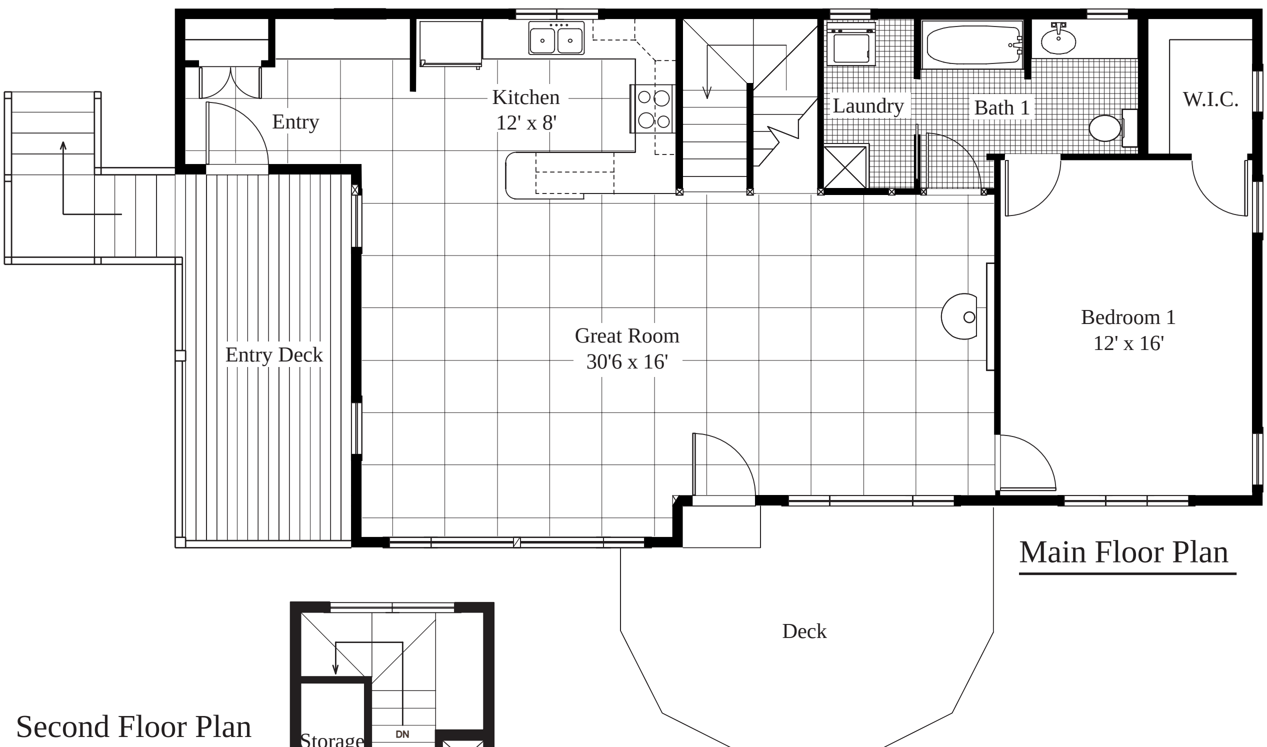


Main Floor Plan

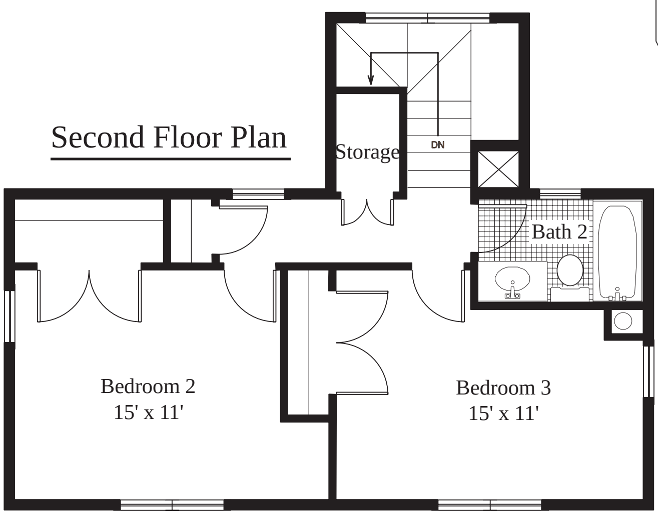


Information
Main Floor Sq. Ft.: 780
Second Floor Sq. Ft.: 537
Heated Basement Sq. Ft.: 298
Bedrooms: 2.5
Baths: 2

Plan Six



Main Floor Plan



Second Floor Plan

Information
Main Floor Sq. Ft.: 1,160
Second Floor Sq. Ft.: 530
Bedrooms: 3
Baths: 2

Paul Konove & Lynn Maguire

Carolina Country Builders of Chatham County
1459 Redbud Road • Pittsboro, N.C. 27312
Tel/Fax: (919) 542-5361

This design by passive solar builder Paul Konove was developed in partnership with its first owner, Lynn Maguire. The fruit of this partnership is an attractive and modest plan with its roots in functionality and energy efficiency. From the open-floor plan in the main living area, to the maximum use of southern windows, this design is an excellent example of direct passive solar strategies. The large, scored, colored concrete floor provides plenty of thermal storage day to day, while a wood stove in the interior can carry the house through extended periods of cloudy weather. The home is equally appealing when placed on a lot with either southern or western road frontage.

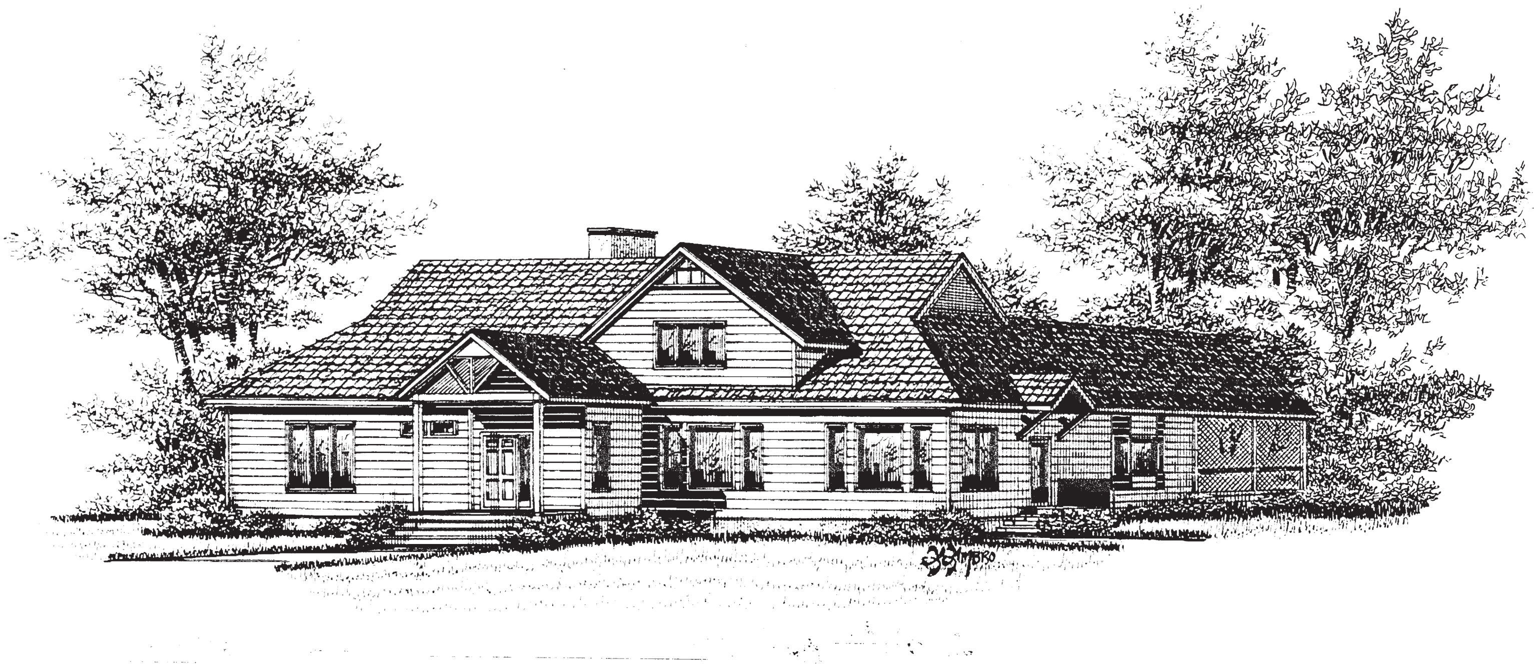
Some of the energy-efficiency details called for in the plans are 2x6 exterior stud walls at 24" O.C. with R–19 insulation, framing details with continuous insulation in mind, air infiltration barriers, casement windows placed for cross ventilation, and quiet exhaust fans. Specifications for using recycled and resource efficient building materials are also included.

The construction drawings for this design are available from Carolina Country Builders for $350 for five sets.

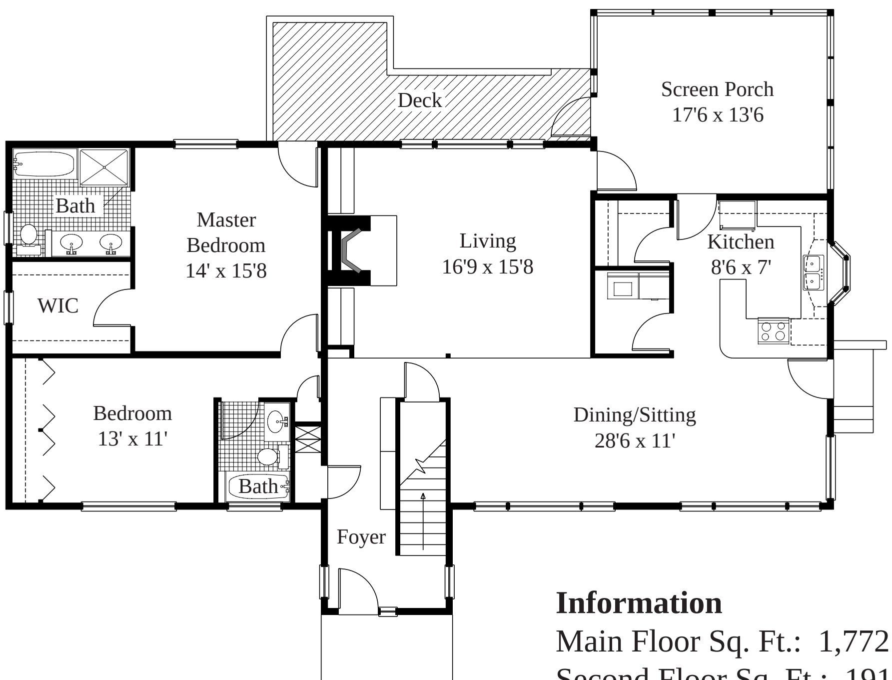
PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	22,744	31,615	-28
Aux. Heat Performance	15,238	28,864	-47
Cooling Performance	2,992	7,343	-59
Charlotte			
Conservation Performance	17,701	24,751	-28
Auxiliary Heat Performance	11,683	22,350	-48
Cooling Performance	5,413	11,198	-52
Greensboro			
Conservation Performance	20,519	28,607	-28
Auxiliary Heat Performance	13,625	26,118	-48
Cooling Performance	5,701	11,332	-50
Raleigh			
Conservation Performance	18,702	26,151	-28
Auxiliary Heat Performance	12,156	23,614	-49
Cooling Performance	6,128	11,833	-48
Cherry Point			
Conservation Performance	15,727	22,218	-29
Auxiliary Heat Performance	9,593	19,930	-52
Cooling Performance	7,864	14,860	-47

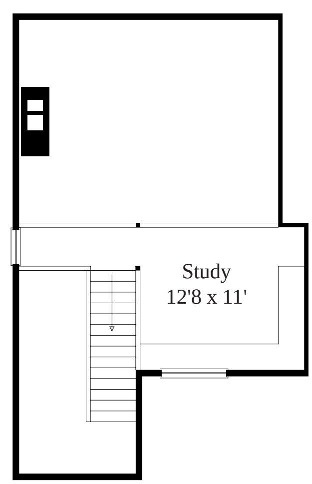
Plan Eight



Main Floor Plan



Second Floor Plan



Information

Main Floor Sq. Ft.: 1,772

Second Floor Sq. Ft.: 191

Bedrooms: 2.5

Baths: 2

Alicia Ravetto, AIA

400 West Weaver Street • Carrboro, N.C. 27510
Tel: (919) 933-0999 • Fax: (919) 933-1988

For a design in the traditional-contemporary style, this plan is hard to beat. The floor plan is laid out for logical flow from room to room, the screened porch adjacent to the kitchen offers a second dining area, and the working Rumford design fireplace is both efficient and attractive. Practical amenities like large closets, walk-in laundry, private foyer, shower and tub in master bath, and side entry next to the kitchen are welcome additions. Features like the wood deck, nine foot ceilings, bay window above the kitchen sink, and a large study looking down from the vaulted ceiling into the living room make this home attractive and functional.

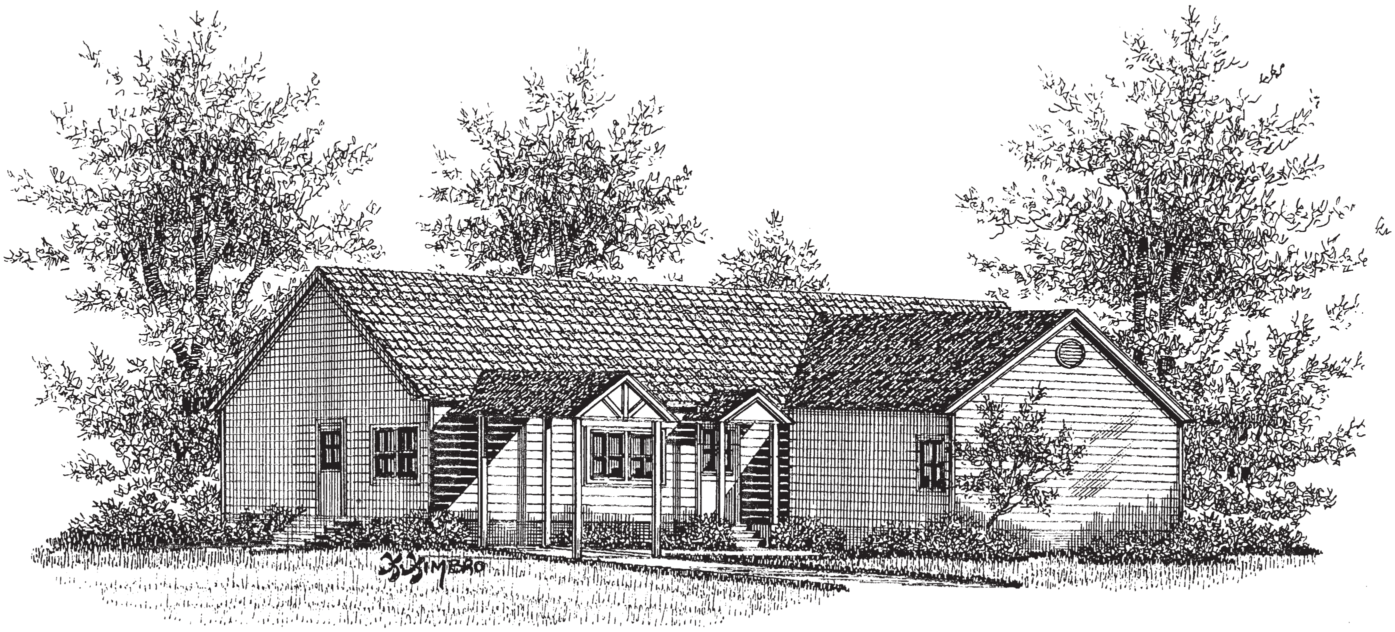
Some of the other energy-efficiency features built into this design are generous overhangs, minimum windows on the west and east, a screen porch on the east, 2x6 walls with dense-pack cellulose insulation, R–38 roof insulation with radiant barriers, and high quality casement windows.

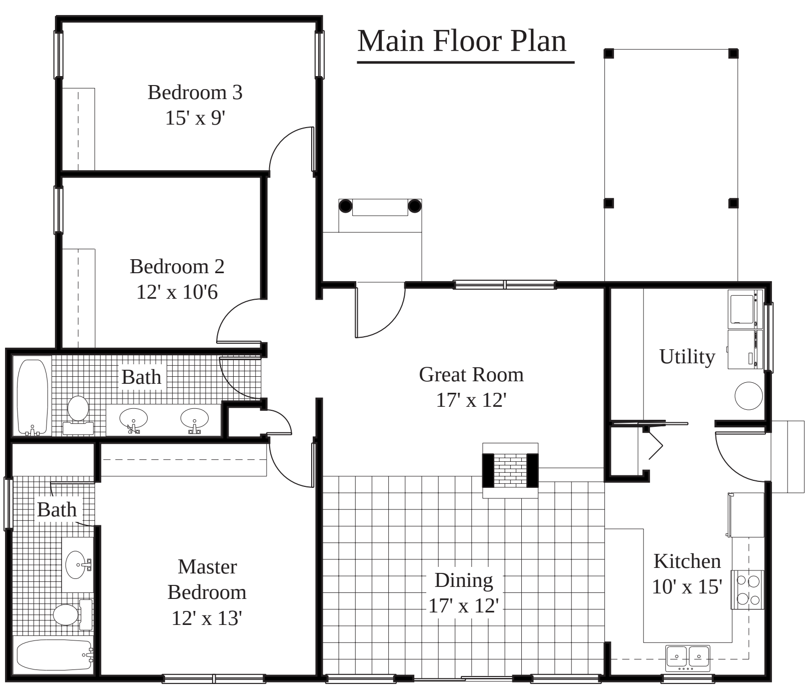
Alicia Ravetto's strategy for direct solar gain in this design is to equally distribute the modest window area across the entire southern wall. With generous northern windows, the entire house will be comfortably daylit, while colored concrete floors quickly store any excess solar energy and provide year-round comfort.

Five sets of construction drawings can be purchased from Alicia Ravetto for $350.

PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	22,804	36,414	-37
Aux. Heat Performance	16,419	33,537	-51
Cooling Performance	1,902	6,775	-72
Charlotte			
Conservation Performance	17,749	28,395	-37
Auxiliary Heat Performance	12,602	25,868	-51
Cooling Performance	3,994	10,662	-63
Greensboro			
Conservation Performance	20,574	32,915	-37
Auxiliary Heat Performance	14,710	30,315	-51
Cooling Performance	4,498	10,778	-58
Raleigh			
Conservation Performance	18,675	30,001	-38
Auxiliary Heat Performance	13,166	27,331	-52
Cooling Performance	4,809	11,210	-57
Cherry Point			
Conservation Performance	15,702	25,733	-39
Auxiliary Heat Performance	10,520	23,366	-55
Cooling Performance	6,327	14,121	-55





Information

Floor Sq. Ft.: 1,348

Bedrooms: 3

Baths: 2

Chris Rea & Robert Wagner

School of Design • N.C. State University
Raleigh, N.C.

This design developed by Chris and Robert has a number of interesting features. The large dining area can act as the natural gathering space that will be warm and full of light in the winter because of the ample southern glass. This area also will be cool and shady in the summer with the help of the tile floor over concrete slab and generous overhangs. The open circulation between living room, dining area and kitchen helps to distribute solar heat and promotes good ventilation. The northern courtyard makes possible some outdoor living during the summer, especially if properly shaded. A minimum amount of windows on the east and west and the centrally located fireplace are also positive features.

PROJECTED ANNUAL ENERGY PERFORMANCE (Btu/yr-sf)

Asheville	Current Design	Reference Design	% Difference
Conservation Performance	23,782	34,970	-32
Aux. Heat Performance	17,551	32,137	-45
Cooling Performance	3,864	8,416	-54
Charlotte			
Conservation Performance	18,509	27,270	-32
Auxiliary Heat Performance	13,475	24,788	-46
Cooling Performance	6,452	12,491	-48
Greensboro			
Conservation Performance	21,455	31,611	-32
Auxiliary Heat Performance	15,791	29,051	-46
Cooling Performance	6,675	12,619	-47
Raleigh			
Conservation Performance	19,495	28,812	-32
Auxiliary Heat Performance	14,153	26,190	-46
Cooling Performance	7,062	13,065	-46
Cherry Point			
Conservation Performance	16,427	24,644	-33
Auxiliary Heat Performance	11,400	22,303	-49
Cooling Performance	9,099	16,406	-45

Assessment of Solar Energy Technologies. *Dennis A. Andrejko, AIA, editor. Boulder, CO: American Solar Energy Society, 1989.*
Available from N.C. Solar Center for $8, this soft cover publication presents each solar technology in depth.

Alternative Energy Sourcebook. *John Schaeffer. Ukiah, CA: Real Goods Trading Corporation, 1992.*
Essentially an expanded catalog, this book has excellent chapters on resource-efficient living and renewable energy. Cost is $23 from Real Goods at 1-800-762-7325.

A Builder's Guide to Energy Efficient Homes in North Carolina. *Jeffrey S. Tiller & Dennis B. Creech. Raleigh, N.C.: N.C. Department of Commerce, Energy Division, 1992.*
This book was written by Southface Energy Institute for the Energy Division and is a good manual on energy efficiency for the homeowner and homebuilder. The cost is $7 from the Energy Division at (919) 733-2230.

The Builder's Guide to Solar Construction. *Rick Schwolsky and James I. Williams. New York, NY: McGraw-Hill Book Co., 1982.*
A practical guide to solar home construction for all. Many photographs and drawings illustrate construction techniques.

Design with Nature. *Ian L. McHarg. Garden City, NY: Doubleday & Company, Inc., 1969.*
A well-known book that deals with climatic design and site planning, particularly as it pertains to urban planning and development.

A Golden Thread. *Ken Butti & John Perlin. Palo Alto, CA: Cheshire Books, 1980.*
This is an entertaining and informative book on the history and lore of solar energy.

More Other Homes and Garbage. *Jim Leckie, Gil Masters, Harry Whitehouse, & Lily Young. San Francisco, CA: Sierra Club Books, 1981.*
Very useful for those looking to develop a self-sufficient lifestyle, it covers topics ranging from aquaculture to active solar collectors. $14.95 postpaid, (415) 923-5600.

Resource-Efficient Housing: an Annotated Bibliography and Directory of Helpful Organizations. *Robert Sardinsky. Snowmass, CO: Rocky Mountain Institute, 1991.*
This resource book will guide you to the organizations or information you need on renewable energy. Order from Rocky Mountain Institute for $15 at (970) 927-3128.

Science Projects in Renewable Energy and Energy Efficiency. *NREL & DOE. Boulder, CO: American Solar Energy Society, 1991.*
A great source for science projects in the classroom or for science fairs. The material is primarily short project outlines with some background information. Excellent bibliography and resource guide. $10 from the Solar Center.

Passive Solar

Climatic Design. *Donald Watson, FAIA and Kenneth Labs. New York, NY: McGraw-Hill Book Company, 1983.*
A well-written guide to architectural considerations of passive solar design with many useful formula and indices.

Designing & Building a Solar House. *Donald Watson. Pownal, VT: Garden Way Publishing, 1985.*
More conceptual than Climatic Design, this book is a complete guide to active and passive solar energy in home design.

Design with Climate: Bioclimatic Approach to Architectural Regionalism. *Victor Olgyay. Princeton, NJ: Princeton University Press, 1963.*
One of the seminal works of passive solar design. An excellent source of information for professionals and the general public.

Energy Conserving Site Design. *E. Gregory McPherson, editor. Washington, DC: American Society of Landscape Architects, 1984.*

Landscape Planning for Energy Conservation. *Gary O. Robinette, editor. Reston, VA: Environmental Design Press, 1977.*

The New Solar Home Book. *Bruce Anderson. Andover, MA: Brick House Publishing Company, 1987.*
An updated version of a solar classic. Anderson covers the basics of active and passive solar design. $16.95 postpaid, from the N.C. Solar Center.

The Passive Solar Energy Book (Expanded Professional Edition). *Edward Mazria. Emmaus, PA: Rodale Press, 1979.*
No longer in print but worth looking for in your local library. This is a very easy to use guide for designing passive solar homes.

Passive Solar Energy: The Homeowner's Guide to Natural Heating and Cooling. *Bruce Anderson and Malcolm Wells. Amherst, NH: Brick House Publishing Company, 1994.*
A well-illustrated and informative how-to book that describes solar principles in simple terms, with a minimum of technical jargon. $16.95 postpaid, from the N.C. Solar Center.

Passive Solar Retrofit Handbook. *Thompson, Hancock, White Architects and Planners. Atlanta, GA: Southern Solar Energy Center, 1980.* Available from N.C. Solar Center for $8.

Sun, Wind, and Light: Architectural Design Strategies. *G.Z. Brown. New York, NY: John Wiley and Sons, 1985.*
Written for architects, this book presents solar design concepts for buildings and town planning with many illustrations.

Solar House Plans

Affordable Passive Solar Homes. *Richard L. Crowther, FAIA. Denver, CO: SciTech, 1984.*
Many home designs by a well-known solar architect. Large and small, this is a good place to start for the prospective home builder. Available from ASES for $20 at (303) 443-3130.

Planbook for Low-Cost Energy Efficient Homes. *Southface Energy Institute. Atlanta, GA: 1988.*
This planbook includes five solar and energy efficient low-cost designs, each about 1,000 square feet in size, and has been used by affiliates of Habitat for Humanity in the construction of many homes. One copy may be obtained at no cost from Southface at (404) 872-3549.

Solar Homes for North Carolina. *Energy Division, N.C. Department of Commerce. Raleigh, NC, 1984.*
A booklet containing 12 passive solar house plans designed specifically for the North Carolina climate. Available at no cost from the N.C. Solar Center.

Sun-Inspired Home Plans. *Debbie Rucker, AIA. Greensboro, NC: Energetic Design, Inc., 1991.*
This book includes four sets of designs, each with numerous options for changing size, facade, number of rooms, etc. It also contains an excellent section on energy considerations for those building their own home. To order this planbook, send $12 to: Energetic Design, 6158 Marina Dr. South, #39, Mobile, AL 36605.

Photovoltaics

A Guide to the Photovoltaic Revolution. *Paul D. Maycock and Edward N. Stirewalt. Emmaus, PA: Rodale Press, 1985.*
An introductory overview of the photovoltaic industry and its impacts on society and the economy. Available from the Solar Center for $8.

The New Solar Electric Home. *Joel Davidson & Richard J. Komp. Ann Arbor, MI: Aatec Publications, 1990.*
One of the best overall books on photovoltaics for the homeowner with complete information and many examples. $18.95 postpaid from the N.C. Solar Center.

Practical Photovoltaics: Electricity from Solar Cells. *Richard J. Komp. Ann Arbor, MI: Aatec Publications, 1995.*
A recently published guide to the practical applications of photovoltaics.

The Solar Electric House: Energy for the Environmentally-Responsive, Energy-Independent House. *Steven Strong with William G. Scheller. Emmaus, PA: Rodale Press, 1993.*
Written by one of the nation's most knowledgeable photovoltaic designers, this book is a wealth of practical information. Order from the N.C. Solar Center, $19.95.

The Solar Electric Independent Home. *Paul Jeffrey Fowler. Worthington, MA: Fowler Solar Electric, Inc., 1991.*
A hands-on book with valuable details for electricians and homeowners, written by a photovoltaic supplier, designer and installer. $17.95 postpaid from the N.C. Solar Center.

Solar Water Heaters

Active Solar Heating Systems Design Manual. *Atlanta, GA: ASHRAE, 1988.*
A technical evaluation of different systems and a guide to systems sizing. Available from ASHRAE for $76 at (404)636-8400.

Active Solar Thermal Design Manual. *Theodore D. Swanson, P.E., project manager. Baltimore, MD: Mueller Associates, 1985.*
A very technical manual on solar DHW system sizing and design. Available from ASHRAE.

Design and Installation of Solar Heating and Hot Water Systems. *J.R. Williams. Woburn, MA: Butterworth Publishers, 1983.*

Installation Guidelines for Solar DHW Systems in One & Two Family Dwellings. *HUD-DOE Publication. Philadelphia, PA: Franklin Research Center, 1979.*
Very useful and accessible nuts-and-bolts information on installing Solar DHW. Available from N.C. Solar Center for $10.

Solar Water and Pool Heating Design and Installation Manual, *Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703, 1992.*
An installation guide for solar contractors and plumbers, with good diagrams and descriptions of water heating systems and materials. Available from FSEC at (407) 638-1000.

Solar Water Heater Handbook: A Guide to Residential Solar Water Heaters. *R. Montgomery and J.H. Livingston, editors. New York, NY: John Wiley & Sons, 1986.*

Low-Cost & DIY Solar Heating

The Food and Heat Producing Solar Greenhouse. *Rick Fisher and Bill Yanda. Santa Fe, NM: John Muir Publications, 1980.*
Authoritative and friendly with all the how-to's for greenhouses and vegetable growing. $8 from John Muir Publications, (505) 982-4078.

The Homeowner's Complete Handbook for Add-On Solar Greenhouses & Sunspaces. *Andrew M. Shapiro. Emmaus, PA: Rodale Press, 1985.*
An excellent reference for do-it-yourself building. Focused more on actual construction techniques than the Muir book. Contact Rodale Press at 1-800-441-7761 for ordering, $19.95.

Solar Air Collectors - A Design and Construction Guide for Low-Cost Systems. *Alamosa, CA: San Luis Valley Solar Energy Association.*

Solar Retrofit. *Daniel K. Reif. Andover, MA: Brick House Publishing Company, 1981*. Includes descriptions and plans for retrofitting a direct gain system, solar greenhouse, thermosiphoning air panel, and active solar wall collector. Call (508) 635-9800 for ordering, $11.95.

Solar Wall Collector Plans Review. *Don Malloy and Ambrose Spencer. Brattleboro, VT: Northeast Solar Energy Association, 1987*. A comprehensive source and evaluation of wall collector plans. Good general information on all styles and materials. Available from NESEA, (413) 774-6051.

Periodicals

Carolina Sun
North Carolina Solar Energy Association
P.O. Box 19473
Raleigh, NC 27619
(919) 832-7601, Fax: (919) 785-1881
Free with membership in NCSEA. This magazine/newsletter will keep you up to date on solar and energy information and events.

Energy Design Update
Cutter Information Corporation
37 Broadway
Arlington, MA 02174
1-800-964-5118
$297 per year. $197 discounted price for contractors and educators. A very thorough reporting of national energy news relating to building products and techniques.

Home Energy
2124 Kittredge, Suite 95
Berkeley, CA 94704
(510) 524-5405
$49 for six issues. Geared toward energy professionals and contractors, this magazine is a reliable source for information, issues and construction techniques.

Home Power Magazine
P.O. Box 520
Ashland, OR 97520
(800) 707-6585
$22.50 for six issues. The source for do-it-yourself information on all types of solar energy with an emphasis on electric power. This popular magazine is informative and enjoyable.

Solar Industry Journal
122 C Street, NW, 4th Floor
Washington, DC 20001
(202) 383-2600
$25/year, free to SEIA members. A trade journal for U.S. solar equipment manufacturers, installers and institutions, it covers current solar events worldwide.

Solar Today
American Solar Energy Society
2400 Central Avenue, Unit G-1
Boulder, CO 80301
(303) 443-3130
$29/year, free to ASES members. This broad-based current events magazine is an excellent source for information on recent developments in all types of solar energy.

Sun World
International Solar Energy Society
192 Franklin Road
Birmingham B30 2HE
United Kingdom
+44 21 459 4826
$20/ 4 issues. Similar to Solar Today but with an international focus.

Fact Sheets

These fact sheets are provided free of charge by the North Carolina Solar Center. Call toll free: 1-800-33-NC SUN, inside North Carolina, or (919) 515-3480 to request a copy of the following:

Cost of Photovoltaic-Generated Electricity
Decorating Your Passive Solar Home
Energy Education Resources for Teachers and Students
Energy-Saving Landscaping for Your Passive Solar Home
Heating Your Swimming Pool with Solar Energy
Information Resources for Conservation and Renewable Energy
Low-Cost Solar Applications for Retrofit and Affordable Housing
North Carolina Consumer's Guide to Buying a Solar Electric System
Passive and Active Solar Domestic Hot Water Systems
Passive Cooling for Your North Carolina Home
Passive Solar Design Checklist
Passive Solar Options for North Carolina Homes
Passive Solar Retrofit for North Carolina Homes
Photovoltaic Applications
Photovoltaic Power System of the NCSU Solar House
Photovoltaics: Electricity from the Sun
Selecting a Site for Your Passive Solar Home
Siting of Flat Plate Solar Thermal Collectors and Photovoltaic Modules
Solar Activities for Students
Solar Energy and You
Solar Energy: An Overview
Solar Tax Credits for North Carolina
Sources of Solar Home Plans
Space Heating with Active Solar Energy Systems
Summer Shading and Exterior Insulation for North Carolina Windows
Sunspace Design Basics
Troubleshooting Your Solar DHW System
Tax Credit Guidelines
A Word to the Wise

State Organizations

North Carolina Solar Center
Box 7401
North Carolina State University
Raleigh, NC 27695-7401
Phone: (919) 515-3480 or
1-800-33 NC SUN (toll-free in NC)
Fax: (919) 515-5778

Sponsored by the Energy Division of the N.C. Department of Commerce, in cooperation with North Carolina State University, the N.C. Solar Center serves as the lead state organization for solar energy programs and resources in North Carolina.

Headquartered at the NCSU Solar House, a demonstration facility that is open daily and Sundays for public tour, the Solar Center conducts workshops for consumers and building professionals, operates a toll-free hot-line for solar-related inquires, publishes and distributes solar publications, operates a videotape lending service and reference library, provides design assistance, offers a referral service to a network of 250 professionals, and offers tours and educational materials for teachers and students.

Energy Division, N.C. Department of Commerce
1830A Tillery Place
Raleigh, NC 27604
Phone: (919) 733-2230 or
1-800-622-7131 (toll-free in N. C.)
Fax: (919) 733-2953

As North Carolina's state energy office, the Energy Division conducts seminars and workshops, administers federal programs related to energy conservation, renewable resources and emergency planning, and offers free publications on a wide range of energy topics. The Energy Division has projects under way in the residential, commercial, industrial, agricultural, institutional and transportation sectors.

North Carolina Solar Energy Association
P.O. Box 6465
Raleigh, NC 27628-6465
Phone: (919) 832-7601
Fax: (919) 468-8632

As the principal nonprofit membership association working to advance the use of solar energy in North Carolina, NCSEA publishes "Carolina Sun," a quarterly newsletter/magazine covering solar developments in the state and holds conferences and workshops periodically on solar topics. Membership is open to the public. NCSEA is the state chapter of the American Solar Energy Society.

Advanced Energy
909 Capability Drive
Raleigh, NC 27606
Phone: (919) 857-9000 or
1-800-869-8001 (toll free in NC)
Fax: (919) 832-2696

Advanced Energy is a private nonprofit corporation established by the N.C. Utilities Commission to reduce electrical demand and peak loads through research, education, demonstration, and commercialization of energy-efficiency technologies. Funds are contributed by electric utilities serving North Carolina. Advanced Energy provides consulting, testing and training to utility, commercial and industrial customers.

Industrial Extension Service
College of Engineering
Box 7902
1600 Research IV Building
North Carolina State University
Raleigh, NC 27695-7902
Phone: (919) 515-2358
Fax: (919) 515-6159

The Industrial Extension Service links business, industry, government and the engineering profession with the College of Engineering. The Industrial Extension Service focuses on bringing many of the engineering faculty and laboratories to bear on industrial, economic and societal problems and opportunities.

N.C. Cooperative Extension Service
Box 7602
104 Ricks Hall
North Carolina State University
Raleigh, NC 27695-7602
Phone: (919) 515-2811

The N.C. Cooperative Extension Service provides educational opportunities to the citizens of North Carolina through county extension offices in each of the 100 counties and the Cherokee Indian Reservation.

Brick Association of North Carolina
P. O. Box 13290
Greensboro, NC 27415
Phone: (919) 273-5566
Fax: (919) 273-3463

The Brick Association supports the use of passive solar as a viable energy alternative. It encourages the use of passive solar guidelines for builders and architects developed by the Passive Solar Industries Council and National Renewable Energy Laboratory.

Carolinas Concrete Masonry Association
1 Centerview Drive, #112
Greensboro, NC 27407
Phone: (336) 852-2074
Fax: (336) 299-7346

The CCMA supports the implementation of passive solar applications. They promote the use of concrete masonry in exterior and interior residential applications as thermal storage mass.

National Organizations

American Council for An Energy Efficient Economy
1001 Connecticut Avenue, NW, Suite 801
Washington, DC 20002
Phone: (202) 429-8873
Fax: (202) 429-2248

American Solar Energy Society
2400 Central Avenue, Unit G-1
Boulder, CO 80301
Phone: (303) 443-3130
Fax: (303) 443-3212

Center for Resourceful Building Technology
P.O. Box 100
Missoula, MT 59806
Phone: (406) 549-7678
Fax: (406) 549-4100

Energy Efficient Building Association
P.O. Box 3048
Merrifield, VA 22116
Phone: (800) 363-3732
Fax: (703) 893-0400

Energy Efficiency and Renewable Energy Clearinghouse (EREC)
U.S. Department of Energy
P.O. Box 3048
Merrifield, VA 22116
Toll-free: (800) 363-3732

Florida Solar Energy Center
1679 Clearlake Road
Univeristy of Central Florida
Cocoa, FL 32922-5703
Phone: (407) 638-1000
Fax: (407) 638-1010

National Association of Home Builders Research Center
400 Prince George's Boulevard
Upper Marlboro, MD 20772
Phone: (301) 249-4000
Toll-free: (800) 638-8556
Fax: (301) 249-3035

Sustainable Buildings Industries Council
1331 H Street, NW, Suite 1000
Washington, DC 20005
Phone: (202) 628-7400
Fax: (202) 393-5043

Solar Energy Industries Association
1616 H. Street, NW
Washington, DC 20006-4999
Phone: (202) 628-7745
Fax: (202) 628-7779

Southface Energy Institute
241 Pine Street
Atlanta, GA 30308
Phone: (404) 872-3549
Fax: (404) 872-5009