Affordable Passive Solar Planbook for North Carolina

State Energy Office,
N.C. Department of Administation

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Introduction

Passive solar homes are designed to take advantage of local climates by maximizing the energy from the sun to heat and cool the home. In North Carolina, as in all of the northern hemisphere, the sun's path passes through the southern sky on its daily trip west. Therefore, a passive solar home has the highest percentage of windows is on the south side. The sun warms the home in the winter, and shading devices, such as overhangs, are designed to block the sun in the summer months to reduce the amount of cooling necessary. Passive solar design creates an energy efficient, comfortable home that reduces energy consumption that save money as well as valuable resources.

Passive solar design can easily be incorporated into any architectural style given you have the proper site. Such design strategies have been used effectively for hundreds of years. There is a small increase in the cost of construction, but the home has lower annual energy and maintenance costs overall.

There are many benefits to passive solar design for the homeowner and the environment. By reducing energy consumption, the homeowner can save money on utility bills and help prevent air pollution from electricity generating plants that burn fossil fuels. Passive solar design elements make a home comfortable year round while bringing in natural light from the increased glass on the southern side. Natural light reduces energy consumption and provides a visual connection to the outdoors.

This book provides the fundamentals and components of passive solar design. A collection of floor plans that work in a variety of sites in North Carolina are also included in this book. The passive solar house plans in this book are affordable homes that are less than 1300 square feet and focus on energy efficiency.

Key Features of Passive Solar Design

Increased south-facing glass area - allows sunlight to help warm the home in winter months. South-facing windows receive close to three times as much sunlight as east and west windows in the winter and a third less sunlight in the summer. Sun-tempered homes have no more than 7% of the floor area as southern glazing. In passive solar homes the area of the south facing glazing is 7-12% of the floor area. This amount of glazing requires the use of thermal mass to temper the heat gain. A home with increased southern glazing up to 7% is considered sun-tempered and can be effective with out the use of thermal mass.

Lower east and west glass areas - reduce summer cooling needs because it prevents unwanted sun from entering the home in the morning and afternoon. Eliminating the windows also lowers construction costs.

Orientation and site selection - are critical in passive solar design. The passive solar windows must face within 15° of due south to maximize solar gain in winter and minimize overheating in summer. Be aware that magnetic south is different than true south. To find how many degrees they vary at your site visit www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp. The house should be designed on an east-west axis so the long side faces south. Trees on the site reduce summer cooling bills, but should not shade south-facing windows in winter. Effective passive solar design is not possible on all sites due to the fact that the site must receive direct sunlight on December 21st between 9 am and 3 pm. Privacy is also a factor, so if the south side is exposed to the street or neighboring houses it may not be conducive to passive solar design.

Energy efficient design - the first step in a successful passive solar home includes proper installation of recommended levels of insulation, air-tight design, and efficient heating and cooling systems. The key energy efficiency steps start on page 13.

Thermal storage mass - materials such as concrete floors, interior brick walls, brick pavers, and tile store heat and regulate interior temperatures both in winter and summer.

Effective window shading - reduces summer cooling needs and glare. Window shades lowered at night can also be used to help trap the heat absorbed by the thermal mass.

Moisture control systems - increases the home's durability, improve indoor air quality, and provide comfort in both summer and winter.

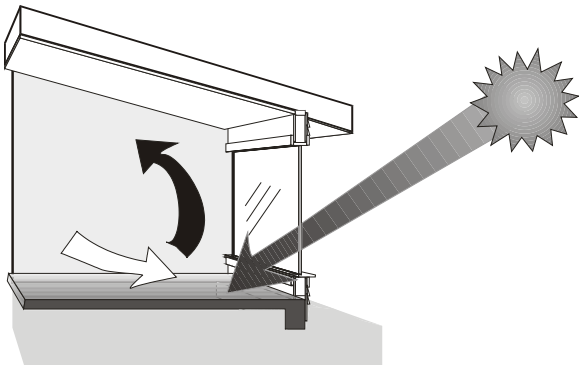
Plan the room layout - to take advantage of the sun's path. Rooms should match solar gain to the time of day the room is used. More on design guidelines on page 5.

Homes in North Carolina need to be equipped to handle both cold winters and hot humid summers. Depending on your climate you may need to reduce the amount of glass on the southern side to prevent high cooling bills due to overheating.

Types of Passive Solar Designs

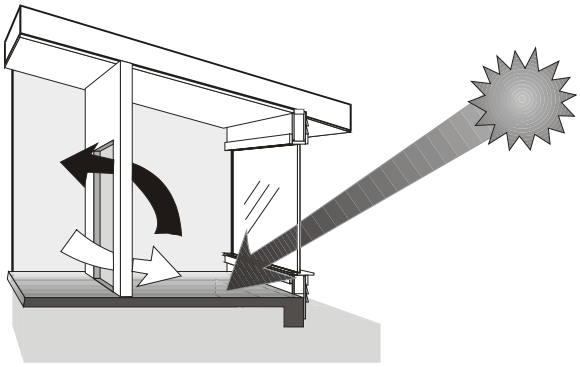
The three main categories of passive solar design are direct, indirect and isolated gain. Within these broad categories there are four primary types of passive solar design. The first type is a basic direct gain system in which the sun's rays directly enter the living area. Thermal storage walls are indirect systems that store and distribute the thermal energy. Sunspaces and solar air collectors are isolated systems which can be closed off or opened to the main living area. Figure 1-1 shows and explains the four primary types of passive solar designs.

Direct Gain



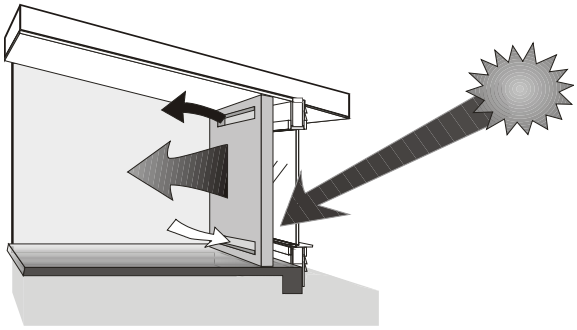
Direct gain system, the most common and simple designs, are houses in which the living areas themselves act as collectors of solar energy by using south-facing windows which allow sunlight directly enter the home. Thermal mass in the form of concrete or masonry walls or floors capture and store the sun's energy.

Passive Solar Sunspaces



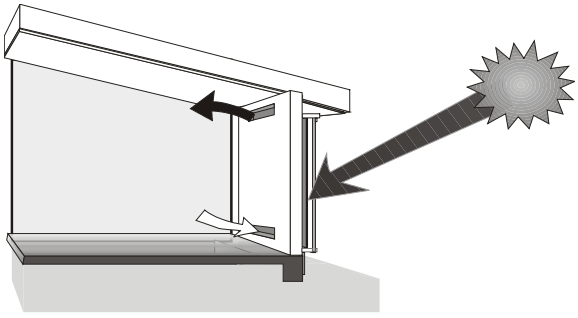
Sunspaces, rooms independent of the home's heating and cooling system, capture the sun's energy and transfer the heat generated to the house. Sunspaces are also used often but are usually not connected to the central heating and cooling system of the rest of the home. They are comfortable during much of the year, but are not intended as living space year round.

Thermal Storage Wall



Thermal storage walls, also know as Trombe wall, require construction of two exterior walls – one made of concrete or concrete-filled block and the other made of glass, are more expensive than other passive solar designs. Thermal storage walls store solar heat and let it radiate into the living area. They also do not provide as much savings on heating bills during the cloudy winters.

Solar Air Collector



Solar air collectors absorb incoming solar energy, vent through the back of the air collector, and transfer heated air into the house. They are similar to thermal storage walls but use a conventionally framed wall and function primarily during the day. Eliminating the mass reduces the cost.

Figure 1-1 Types of passive solar designs

Design Principles of Passive Solar Homes

This section introduces the basic design principles. Current trends in housing, such as expansive glass areas, daylighting, sunrooms, great rooms, tile floors, fireplaces, and open floor plans fit well into passive solar designs. Effective designs reduce heating and cooling bills and provide greater comfort.

Heating Season

In the winter months, three primary elements interact to provide a significant portion of a home's heating needs:

- energy efficiency features including effective insulation, airtight construction, and efficient HVAC systems, minimize the demand for heating;
- increased south-facing windows bring additional sunlight into the home which can be captured as heat energy;
- thermal mass can supply a means to store heat inside the home. Concrete or tile floors; walls made of masonry materials such as brick, stone, concrete; a masonry fireplace; or water-filled containers all provide thermal mass for heat storage and can be incorporated to meet the aesthetic requirements of the space.

Passive Solar Heating Design Components

1. ***Orientaion-*** *long axis facing south.*
2. ***Glazing-*** *South windows let sunlight into the building in winter and can be shaded effectively in summer.*
3. ***Thermal mass-*** *Tile-covered slab floors, masonry walls, and water-filled containers store solar heat and help save energy all year.*
4. ***Heat distribution-*** *Openings and room layouts that aid movement of solar heated air from passive solar rooms to other actively used rooms in the home.*

Cooling Season

In summer months, passive solar homes in North Carolina must compensate for the hot, humid climate and the large amount of heat that can come into the home through windows. The true challenge of passive solar design is to ensure low summer cooling bills compared to those of a similar, standard home.

Many passive solar homes have significantly lower cooling bills because they:

- have energy efficient features – high insulation levels, airtight construction, and effective air conditioning system design and installation;
- have few, if any, windows on the east and west minimizing solar gain in the mornings and afternoons;
- provide shading for south-facing windows;
- incorporate thermal mass to balance temperature extremes;
- can be ventilated during milder outdoor weather with open windows and fans, which help maintain indoor comfort.

Natural Cooling Design Components

1. ***Window shading-*** *Overhangs, shutters, blinds, shade screens, curtains, and landscaping shade unwanted sunlight in summer.*
2. ***Ventilation-*** *natural breezes through windows on opposite sides of the house, ceiling fans, whole house fans, and space fans keep the house more comfortable during non-heating and cooling periods of the year.*

Passive Solar Design Guidelines

In passive solar design it is necessary to be sensible about your expectations of the sun. Do not assume that the sun and the house design will provide all of your heating and cooling needs. The climate in North Carolina can vary from cold, relatively cloudy winters to hot, humid, sunny summers. Well-designed passive solar homes provide their owners with low energy bills and year-round comfort, as well as natural daylight. However, improperly designed passive solar homes may actually have uncomfortable temperature swings both in summer and in winter, thereby reducing potential energy savings. When designing the home remember rooms with large expanses of glass should include thermal storage. It is also important to consider the layout of the rooms in passive solar design. (see figure 1-2) Whether adapting passive solar features to a standard home plan or designing an entirely new plan, consider the following design ideas.

- **Frequently-used rooms** (morning to bedtime)- Family rooms, kitchens, and dens work well on the south side. Be aware of potential problems with glare from sunlight through large expanses of windows.
- **Day-use rooms**- Breakfast rooms, sunrooms, playrooms, and offices work well on the south side of the house. They should adjoin rooms that are used frequently to take full advantage of solar heating.
- **Sunspaces**- These rooms can be isolated from the house if unconditioned. In winter, the doors can be opened to let solar heat move into the home. At night, the doors can be closed, and the sunspace buffers the home against the cold night air. In summer, sunspaces protect the home from outside heat gain. For best performance, they should not be air conditioned.
- **Privacy rooms**- Bathrooms and dressing rooms can be connected to solar-heated areas, but are not usually located on the south side.
- **Night-use rooms**- Bedrooms are usually best on the north side, unless used often during the day. It is often difficult to fit thermal storage mass into bedrooms, and privacy needs may limit opportunities for installing large glass areas. However, some homeowners may prefer bedrooms filled with natural light and can use passive solar features effectively.
- **Seldom-used rooms**- Formal living rooms, dining rooms, and extra bedrooms are best on the north side, out of the traffic pattern and air flow.
- **Buffer rooms**- Unheated spaces such as closets, laundries, workshops, pantries, and garages work best against the north, east, or west exterior walls. They protect the conditioned space from outside temperature extremes.
- **Exterior covered areas**- Porches and carports on the east and west provide summer shading. However, west-facing porches may be uncomfortable in the afternoon. Avoid covered porches on the south side, as they shade winter sunlight.

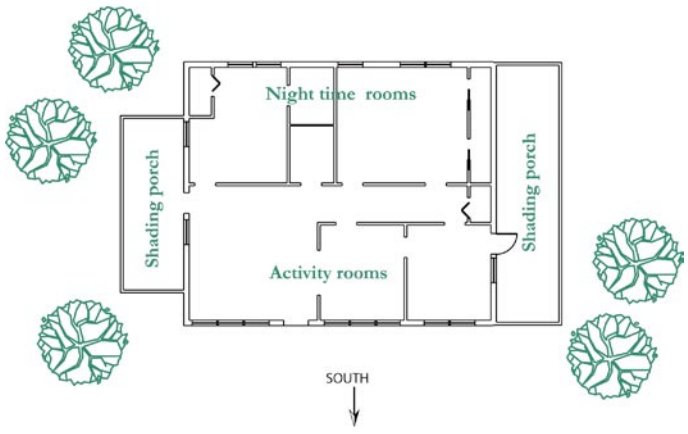


Figure 1-2 Passive Solar Room Planning

Windows

The windows of a home produce benefits such as light, fresh air, ventilation, and good aesthetics. Properly sited windows can provide a significant amount of heat for a home in the winter. In passive solar design, it is important to choose the right windows and place them in the optimum location. Improperly sited windows can lead to unwanted glare from the sun causing deterioration of finishes and fabrics and summer time overheating which could double cooling costs.

When considering a window, you should make good quality a high priority. Double-glazing, solid construction, and effective weatherstripping should be minimum considerations in the choice of windows. To improve performance, consider low-emissivity (low-e), gas filled, and tinted windows, or units with reflective coatings. In passive solar design you want to have a higher solar heat gain coefficient on south facing glazing. A higher solar heat gain coefficient allows more solar energy to enter the home, but the windows are usually non coated, double paned units that are seldom low-e. Shades and shutters should be used to prevent the solar energy gained throughout the day from escaping in the winter and help prevent unwanted gain in summer months. Low-e windows can be used on the south side, but you will lose a small amount of solar gain. On winter evenings low-e windows will more effectively trap gained heat while blocking the sun's heat in summer. Non coated, double paned units or low-e windows can be used on the south side effectively, but it is up to the homeowner if they are willing to actively participate in the conditioning of their home by lowering shades when appropriate. For more information on different types of windows and glazing refer to the North Carolina Builders Guide. The following chart has basic window terminology which will be helpful in shopping for windows.

Basic Window Terminology

NFRC *– the National Fenestration Rating Council, a national nonprofit organization that publishes a directory of windows that have been tested according to their criteria. The NFRC label lists the insulating values and air tightness which has been verified by independent laboratories. See figure 1-3.*

R-value and U-value *– ratings for the insulating values of windows. R-values refer to the resistance to heat flow. U-values measure the ability of the window to conduct heat and are the inverse of the R-value, thus the lower the U-value the better. A typical new window having a low-emissivity coating and an inert gas in the air space might have an R-value of 3.3, or a U-value of about 0.30.*

Solar Heat Gain Coefficient (SHGC) *– the fraction of solar heat that actually penetrates a window and enters the living area of a home. A window with a SHGC of 0.8 lets about 4 times as much sunlight into a home as a window with a SHGC of 0.2. Because they reduce summer cooling bills, windows with lower SHGC save money. However, for heating in passive solar homes, these same windows may not provide the savings in winter months of window units with a higher SHGC.*

Shading Coefficient *– this older method of showing the relative solar transmission through windows assigns a single clear window a Shading Coefficient of 1.0. Double-glazed windows have Shading Coefficients of 0.87. If you know the Shading Coefficient of a window, you can find the SHGC by multiplying the Shading Coefficient by 0.88.*

Visible Light Transmittance *– a measure of the percentage of visible light that penetrates a window.*

National Fenestration Rating Council INCORPORATED

Certified

AAA Window Company

Energy Rating Factors	Ratings Residential	Ratings Nonresidential	Product Description
U-factor Determined in accordance with NFRC 100	0.40	0.38	Model 1000 Casement Low-e Argon Filled
Solar Heat Gain Coefficient Determined in accordance with NFRC 200	0.65	0.66	
Visible Transmittance Determined in accordance with NFRC 200	0.71	0.71	

NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:

Figure 1-3 NFRC label

Infiltration *– the rated tightness of the window usually measured in cubic feet per minute of air leakage per linear foot of crack around the window unit. Double-hung units are typically the leakiest, while fixed are the tightest.*

Thermal Mass

Thermal mass materials, including concrete, tile, masonry, stone and other heavy building materials, absorb water and store heat. These materials are key elements in passive solar homes. Homes with substantial south-facing glass areas and no thermal storage mass do not perform well.

Providing adequate thermal mass is usually the greatest challenge to the passive solar designer. The amount of mass needed is determined by the area of south-facing glazing and the location of the mass. Sun-tempered homes, having less than 7 percent of the floor area in south facing glass, rely on incidental mass in the construction of materials and furniture. The guidelines that follow will help ensure an effective design.

Guideline 1: Locate the thermal mass in direct sunlight.

Thermal mass installed where the sun can reach it directly is more effective than indirect mass placed where the sun's rays do not penetrate. Houses that rely on indirect storage need three to four times more thermal mass than those using direct storage.

Guideline 2: Distribute the thermal mass evenly.

Passive solar homes work better if the thermal mass is thin and spread throughout the living area. The surface area of the thermal mass should be at least 3 times, and preferably 6 times, greater than the area of the south windows. Slab floors and masonry walls that are 3 to 4 inches thick are more cost effective and perform better than those that are 6 to 12 inches thick. See figure 1-4.

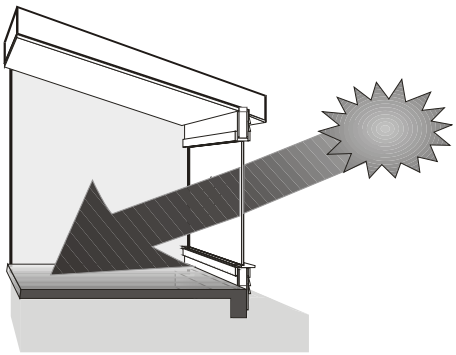


Figure 1-4 Distribute thermal mass evenly

Guideline 3: Do not cover the thermal mass.

Carpeting with a carpet pad substantially reduces the energy savings from the passive solar elements. It is generally acceptable to cover no more than 5 percent of the area with carpet or furniture. Masonry walls can have drywall or plaster finishes, but should not be covered by large wall hangings or lightweight paneling. The drywall should be attached directly to the mass wall, not to purlins fastened to the wall that create an undesirable insulating airspace between the drywall and the mass.

Guideline 4: Select an appropriate mass color.

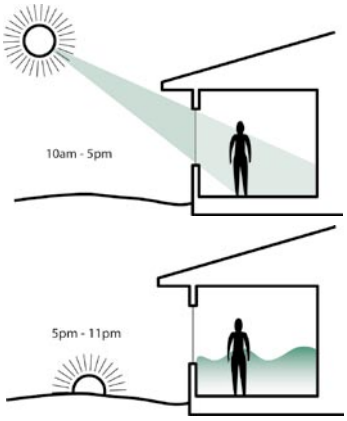
For best performance, thermal mass elements should be a dark color. A medium color, which can store 70 percent as much solar heat as a dark color, may be appropriate in some designs. A matte finish for the floor reduces reflected sunlight, thus increasing the amount of heat captured by the mass and having the additional advantage of reducing glare.

Guideline 5: Insulate the thermal mass surfaces.

Insulation levels required by North Carolina code should be viewed as a bare minimum. The slab should be insulated around the perimeter as well as underneath.

Guideline 6: Make thermal mass multipurpose.

For maximum cost effectiveness, thermal mass elements should serve other purposes as well. Tile-covered slab floors store heat and provide a finished floor surface while masonry interior walls provide structural support, divide rooms, and store heat. Thermal storage walls are one type of a passive solar design that is often cost prohibitive because the masonry walls only function as thermal mass.



Thermal Mass in the Heating Season

10:00 am to 5:00 pm

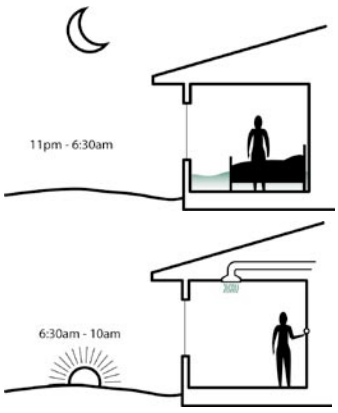
Sunlight enters south-facing windows and strikes the thermal mass inside the home. The sunlight is converted to heat energy, which heats both the air and thermal mass materials. On most sunny days, solar heat maintains comfort during the mid-morning and late afternoon periods.

5:00 pm to 11:00 pm

As the sun sets, it stops supplying heat to the home. However, a substantial amount of heat has been stored in the thermal mass. These materials release the heat slowly into the passive solar rooms, keeping them comfortable on many winter evenings.

11:00 pm to 6:30 am

The homeowner sets back the thermostat at night, so only minimal back-up heating is needed. Energy efficient features minimize heat losses to the outside.



6:30 am to 10:00 am

The cool early morning hours are the toughest for passive solar heating systems to provide comfort. The thermal mass has usually given up most of its heat, and the sun hasn't risen enough to begin heating the home. The homeowner may have to rely on a supplemental heating system.

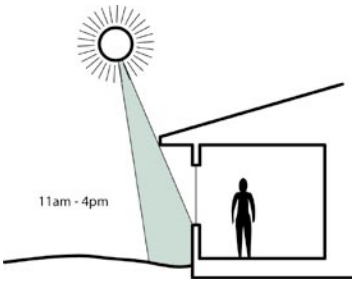
Thermal Mass in the Cooling Season

8:00 am to 10:00 am

The sun's rays strike the outside of the east walls, which have minimal glass area. Thus, the home suffers less heat gain than a comparable standard home.

10:00 am to 4:00 pm

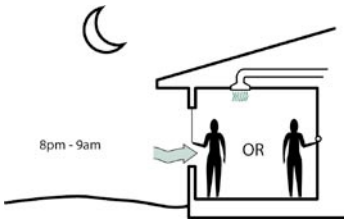
Direct sunlight on the south windows of the home is shaded by roof overhangs. Diffuse sunlight on hazy days is blocked by interior or exterior shades. The energy efficient features minimize heat gain through walls and attics, and stop air leaks which add both heat and humidity to the home.



On warm Spring and Autumn days, natural ventilation or mechanical ventilation, such as that provided by a ceiling fan or whole house fan, helps maintain comfort. On hot summer days, most homeowners prefer the comfort provided by an air conditioning system. The high capacity of the thermal mass to store heat regulates indoor temperatures so that the house is less likely to overheat during the middle of the day.

3:00 pm to 8:00 pm

Sunlight coming from the west is once again deflected because the home has little or no west-facing glass.



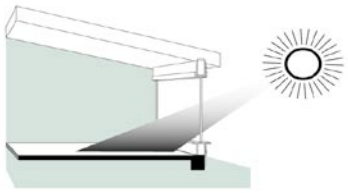
8:00 pm to 9:00 am

On mild nights, the windows can be opened to provide nighttime ventilation. On cool evenings, nighttime ventilation can help flush heat from the thermal mass to the outside. The cooler mass will absorb more heat the following day. On hot, humid evenings, air conditioning may be preferred.

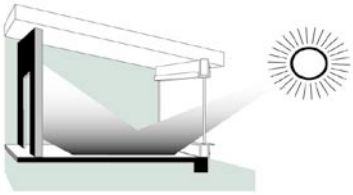
Incorporating Thermal Mass

Thermal mass can be incorporated into a passive solar room in many ways, from tile-covered floors to masonry walls. When selecting thermal mass materials, consider the aesthetics, costs, and energy performance.

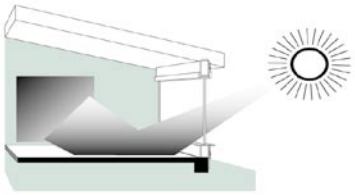
- **Slab-on-grade floor-** used in most passive solar homes. Slab floors can be stained or stamped into a variety of patterns or finished with tile, stone or brick. Concrete floors can be expensive to install on upper stories. Floors made of brick, brick pavers, or tile on a thick bed of mortar also may be used.
- **Interior mass walls**- solid mass walls between interior rooms. Since they have living area on both sides, they can be up to 12 inches thick, although thinner 4- to 8-inch walls deliver heat more quickly. Masonry fireplaces that are several feet thick store heat but are not as effective as thinner mass walls with greater surface area. Since masonry is not a good insulator, keep fireplaces on interior walls.
- **Thermal storage walls**- a solid masonry wall fronted by exterior double-glazed windows. Sometimes known as Trombé walls, these designs are one of the least cost-effective passive solar options for North Carolina. They are expensive to build, and many researchers question whether the mass wall has sufficient time to warm between the periodic spells of cloudy weather experienced by most of the Southeast in the winter.
- **Water-filled containers**- water stores heat twice as effectively as masonry by volume and five times as effectively by weight. However, water containers look unusual in most living areas. Since they store more heat per pound, less weight is required to store the same amount of solar heat; therefore, they are easier to use in upstairs rooms. Commonly used water containers include fiberglass cylinders and 30- or 55-gallon metal drums.
- **Hot tubs, saunas, and indoor pools**- some homeowners have tried to use hot tubs, saunas, and indoor pools as thermal storage mass. In most cases, these forms of water storage do not work well. The desired water temperature for comfortable use of these amenities is hotter than the passive solar contribution can possibly achieve.



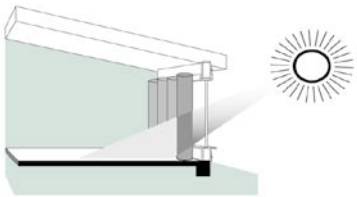
Direct gain- slab floor thermal mass



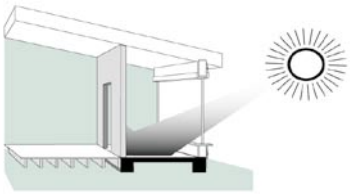
Direct gain- mass floor and rear masonry interior wall



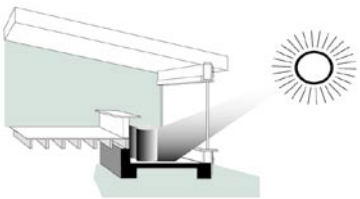
Direct gain- mass floor and masonry walls on sides of rooms



Water Wall



Sunspace- mass floor and wall



Direct gain sunspace (cannot be closed off from conditioned area)- mass floor and water thermal storage

Natural Cooling

Design features known as natural cooling measures can further reduce the air conditioning needs of the house. Natural cooling guidelines are especially important for passive solar homes because their large expanses of south-facing glass can cause overheating if unprotected from the summer sun.

Window Shading Options

The effectiveness of window shading options depends on the position of the incoming sunlight. On a clear day, most sunlight is direct, traveling as a beam from the sun to a home's windows without obstruction. In winter, most of the direct sunlight striking a window is transmitted. However, in summer, the sun strikes south windows at a steep angle, and much of the direct sunlight is reflected. (see figure 1-5) In developing a strategy for effectively shading windows, both direct and indirect sources of sunlight must be considered.

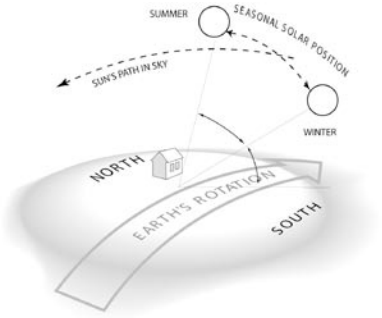


Figure 1-5 Seasonal sun angles

Landscaping and Trees

According to the U.S. Department of Energy report, "Landscaping for Energy Efficiency", careful landscaping can save up to 25% of a household's energy consumption for heating and cooling. Trees and vines are effective means of shading in the summer and combined with a lawn or other ground cover, can reduce air temperatures as much as 9°F in the surrounding area. When located in the front of open windows on the windward side of the house, bushes and other vegetation can cool the air coming in. Trees must be located to provide shade in summer and not block the winter sun. Even deciduous trees that lose their leaves during cold weather block some winter sunlight; a few bare trees can block over 50 percent of the available solar energy.

Overhangs

Overhangs shade direct sunlight on windows facing within 30 degrees of south. Overhangs above south-facing windows should provide complete shade for the glazing in midsummer, yet still allow access to winter sunlight. Overhangs above tall, south-facing windows should generally extend 2 to 2½ feet horizontally from the wall. It is not necessary for south windows to extend vertically all of the way to the overhang because the top one to two feet will be shaded year round.

Shades and Shutters

Exterior window shading treatments are effective cooling measures because they block both direct and indirect sunlight outside of the home. Solar shade screens are an excellent exterior shading product with a thick weave that blocks up to 70 percent of all incoming sunlight. They should be removed in winter to allow full sunlight through the windows.

Shutters and shades located inside the house include curtains, roll-down shades, and Venetian blinds. More sophisticated devices such as shades that slide over the windows on a track, interior movable insulation, and insulated honey comb shades are also available. Interior shutters and shades are generally the least effective shading measures because they try to block sunlight that has already entered the room. However, if passive solar windows do not have exterior shading, interior measures are needed. The most effective interior treatments are solid shades with a reflective surface facing outside.

Reflective Films and Tints

Reflective film, which adheres to glass and is found often in commercial buildings, can block up to 85% of incoming sunlight. The film blocks sunlight all year, so it should not be used on south windows in passive solar homes. These films are also not recommended for windows that experience partial shading because they absorb sunlight and heat the glass unevenly. The uneven heating of windows may break the glass or ruin the seal between double-glazed units.

Ventilation

In spring and fall, ventilation measures can help cool a house and bring in fresh air. Air movement keeps people cooler by evaporating moisture from the skin. Research has shown that people feel as comfortable in rooms at 85°F with air movement as in rooms at 75°F with still air. Both natural ventilation and mechanical ventilation measures are important for low cost cooling.

All houses need ventilation to remove stale interior air and excessive moisture and to provide oxygen for the inhabitants. There has been considerable concern recently about how much ventilation is required to maintain the quality of air in homes. While it is difficult to gauge the severity of indoor air quality problems, most experts agree that the solution is not to build an inefficient, "leaky" home. Research studies show that standard houses are as likely to have indoor air quality problems as energy efficient ones. Most building researchers believe that no house is so leaky that the occupants can be relieved of concern about indoor air quality. They recommend mechanical ventilation systems for all houses

Natural Ventilation

Breezes can generate air movement inside the house. All rooms used frequently should be designed for ventilation; however, natural breezes are unpredictable throughout most of North Carolina. They usually do not blow from any one direction reliably in summer and are not very strong. It is important to place windows on opposite sides of a space to allow for cross ventilation because they can capture cooling, flow-through breezes. However, do not rely on the wind as the only source of air movement.

Another form of natural ventilation, called the *stack effect,* occurs when hot air can exit the house through a high opening. A low opening lets in outside air to replace the exiting air. The stack effect is not a reliable form of ventilation, particularly on hot days when the outside air drawn into the house is uncomfortable.

Mechanical Ventilation

Mechanical ventilation provides an inexpensive means of creating a cooling air flow. In addition, ventilation systems can expel stale air from the home to improve indoor air quality.

Portable fans or *ceiling fans* can provide comfort inexpensively, even when the air conditioner operates. For each degree that the thermostat is raised, air conditioning costs drop 3 to 8 percent. By setting the thermostat between 80° and 85°F and using fans that blow directly on room occupants, homeowners can save 20 to 50 percent on cooling bills.

Whole house fans, also called attic fans, blow hot room air into the attic and pull supply air into the home from outside. They generate substantial air flow within the home. They cost 4 to 6 times less to operate than a central air conditioning system. The primary disadvantage of whole house fans is that they bring in outside air containing dust, moisture, pollen and other allergens. Whole house fans are primarily recommended for houses without air conditioning or for homes whose occupants are committed to saving energy and are willing to control the operation of their home carefully. For most homeowners, they provide an excellent means of cooling a home during warm days in the spring and fall.

Estimating Passive Solar Savings

The following rules of thumb approximate the annual heating energy savings of passive solar homes:

- Each square foot of double-glazed south-facing window that is unshaded in the winter will save 40,000 to 60,000 Btu per year on a home's heating requirement, if sufficient thermal mass exists.
- Low-emissivity glass will increase the savings 15 to 30 percent.

Thus, an energy efficient home with 200 square feet of passive solar windows and sufficient thermal storage mass could save 8 to 12 million Btu of energy on home heating needs each year. Movable insulation or low-e glass would save an additional 2 to 4 million Btu.

The cost of space heating with a standard heat pump or gas furnace in North Carolina is about $10 per million Btu. Thus, the passive solar home described above could save as much as $160 per year on heating bills with movable insulation or low-e windows.

Key Energy Efficiency Steps

Energy features save money, improve indoor air quality, enhance comfort, prevent moisture problems, and increase the long term durability of the building. Keep in mind that investing in energy efficiency not only saves energy and increases comfort over the life of the home, it also decreases the required size of the heating and cooling equipment. Therefore, the added investment in efficiency also reduces the cost of a properly sized heating and cooling system.

Key Feature Checklist

Moisture barrier system

- ✔ drain water away from foundation.
- ✔ install polyethylene ground cover under slabs or on the floor of crawl spaces.
- ✔ install termite shields on top of foundation walls to hinder insect infestations and serve as a capillary break.
- ✔ make interior finish airtight.
- ✔ careful flashing details for roof, around windows and doors, and other roof and wall penetrations through which wind-driven rain may leak.

Air barrier system

- ✔ eliminate leakage between conditioned and unconditioned spaces, in particular between living areas and crawl spaces, unheated basements, and attics.
- ✔ caulk all seams and joints in framing and sheathing before drywall is installed.
- ✔ use drywall, plywood, or other sheet material to seal the tops and bottoms of chases for ductwork or flues. Use the same materials to seal between the attic and dropped soffits above cabinets and shower-tub enclosures.
- ✔ test air tightness using a blower door.

Continuous insulation system

- ✔ install insulation as continuously as possible between conditioned and unconditioned spaces.
- ✔ exterior walls, floors over unconditioned or exterior spaces, ceilings below unconditioned or exterior spaces (including attic access covers).
- ✔ wall areas adjacent to attic spaces or basement spaces — such as knee walls, attic stairways, and high walls between areas with cathedral ceilings and flat attics, and basement stairways.
- ✔ wall areas between conditioned and unconditioned spaces — such as band joists, garage walls, and mechanical room walls.

Design heating and cooling system for efficiency

- ✔ size and properly install high efficiency equipment designed for local climate.
- ✔ eliminate potential for backdrafting of combustion appliances.
- ✔ install fresh air ventilation systems to bring in outside air when needed.

Ductwork design and installation

- ✔ locate ductwork in conditioned spaces.
- ✔ size and lay out ductwork to supply proper airflow; measure airflow to guarantee comfort.
- ✔ seal all duct leaks, except those in removable components, with mastic or mastic plus fiber mesh; seal leaks around removable panel door with rated tape.
- ✔ test ducts for leakage using duct testing blower; leakage (in cfm 25) should not exceed 4% of the floor area.

Minimize hot water costs

- ✔ select efficient equipment; use heat traps to prevent convective loops; install water heater wraps on water heaters five years old or older.
- ✔ use water conserving fixtures and appliances.
- ✔ look for the EnergyGuide label and comparatively shop for hot water heaters.

Choose energy efficient appliances and lighting

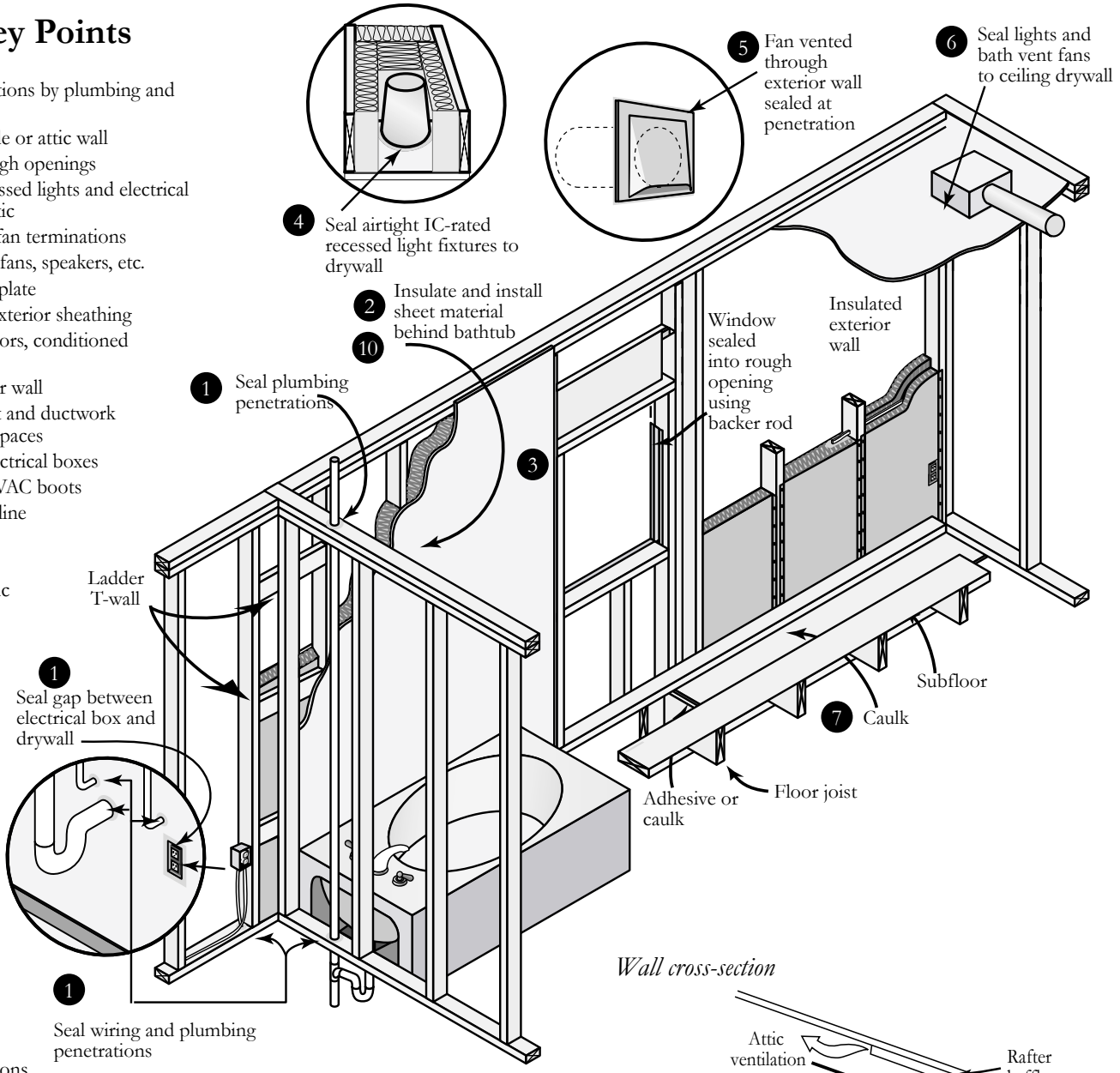
- ✔ install fluorescent fixtures or use compact fluorescent bulbs.
- ✔ use recessed lights selectively, choose only air-tight, I-C (insulation contact) rated lamps.
- ✔ use high-pressure sodium or metal halide lamps for exterior lighting with daylight sensors if used for security lighting.
- ✔ look for the EnergyGuide and Energy Star label and comparatively shop for appliances and fixtures.

Provide intentional ventilation

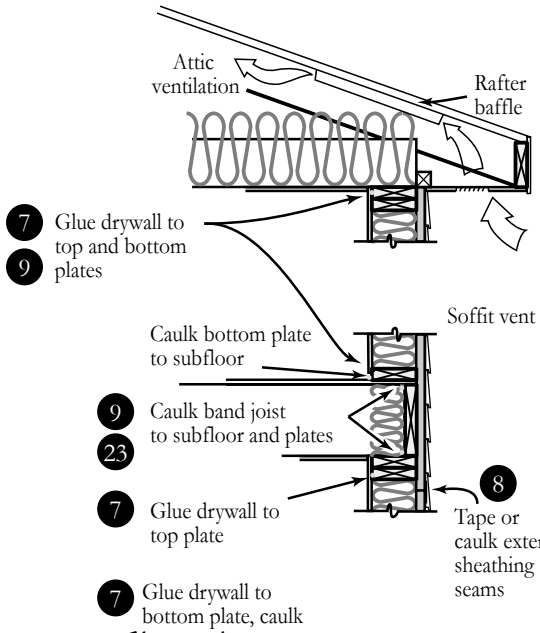
- ✔ provide quiet (low sone) exhaust fans in bathrooms and the kitchen combined with a source of outside air.
- ✔ consider upgrading to a whole house ventilation system using a central exhaust fan or a heat recovery ventilation system.

Air Sealing Key Points

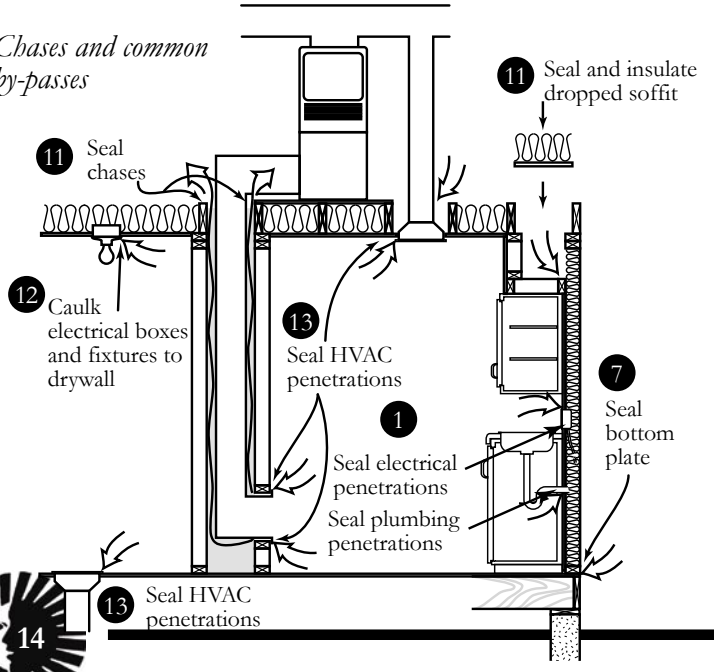
1. Plate and wall penetrations by plumbing and electrical
2. Tub/shower on outside or attic wall
3. Window and door rough openings
4. Airtight, IC-rated recessed lights and electrical fixtures exposed to attic
5. Exterior wall exhaust fan terminations
6. Ceiling mounted bath fans, speakers, etc.
7. Bottom plate and top plate
8. Seams between rigid exterior sheathing
9. Band area between floors, conditioned space and attic
10. Garden tub on exterior wall
11. Mechanical equipment and ductwork chases in attics, crawlspaces
12. Ceiling/crawlspace electrical boxes
13. Ceiling/crawlspace HVAC boots
14. Shower and tub drain line
15. Fireplace inserts
16. Attic kneewall doorsa
17. Joist cavities under attic kneewalls
18. Transition between ceiling heights
19. Attic scuttle hole
20. Attic pull-down stairs
21. Wall penetrations of mechanical combustion closets
22. Thresholds at mechanical combustion closet doors
23. Band joist exposed to exterior
24. Band area exposed to unconditioned space (such as basement or garage)
25. Exterior wall penetrations for refrigeration lines, condensate line, etc.

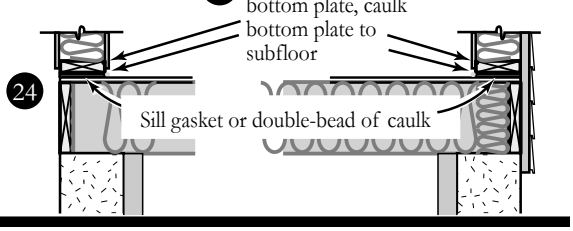


Wall cross-section

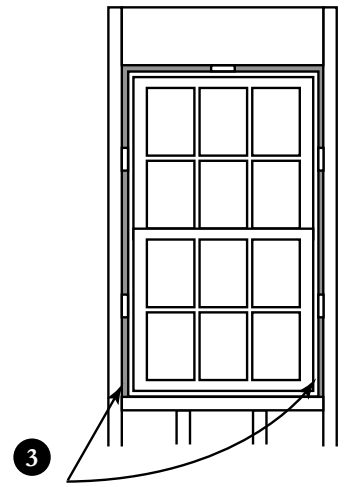


Chases and common by-passes



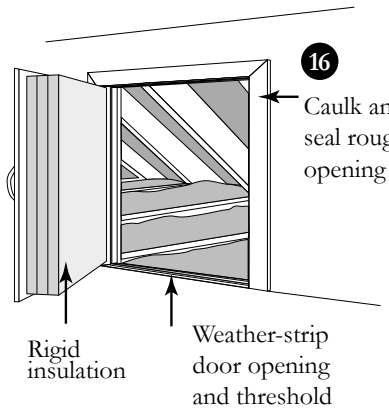


Window rough opening

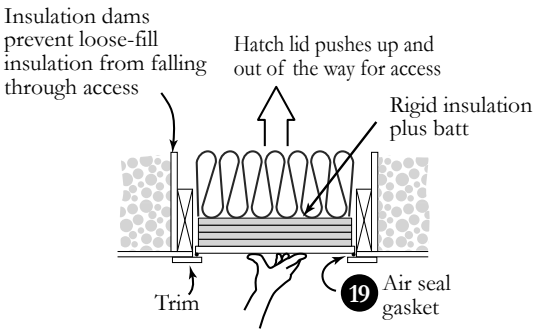


3 Use backer rod or spray foam (appropriate for windows) to fill gaps between window/door and rough opening

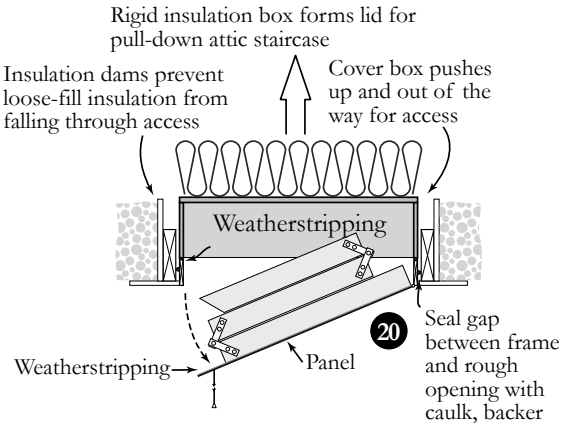
Attic knee-walls

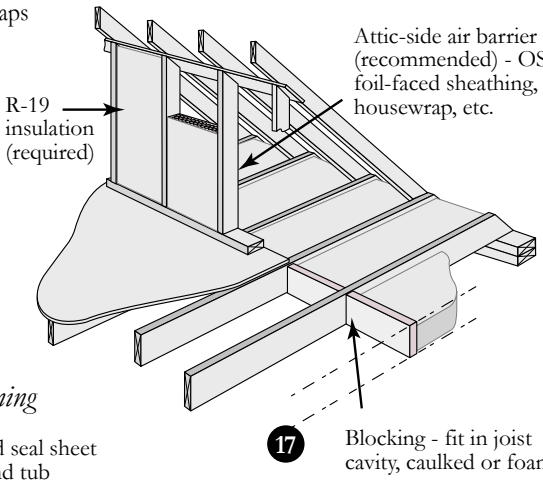


Attic scuttle

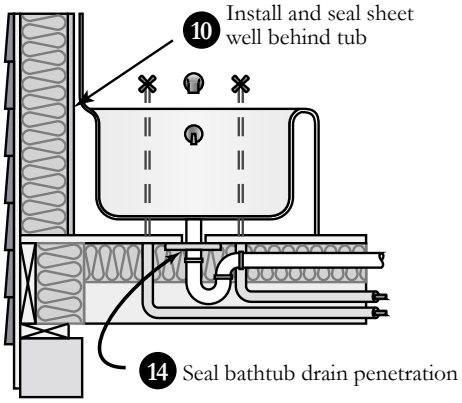


Attic pull-down stairs

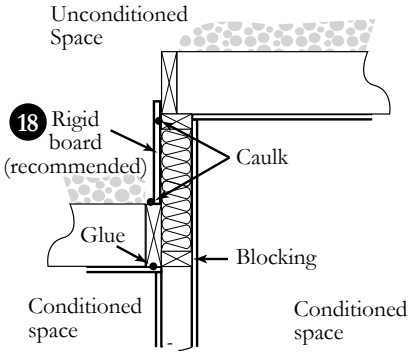




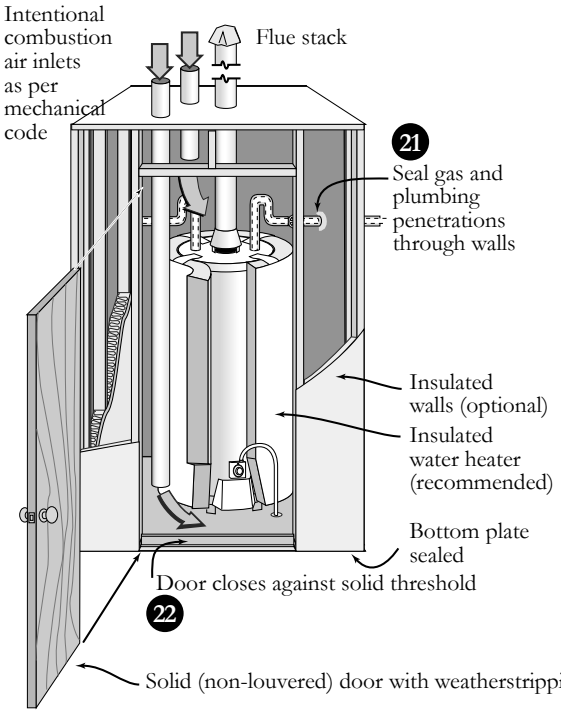
Shower/tub drain rough opening



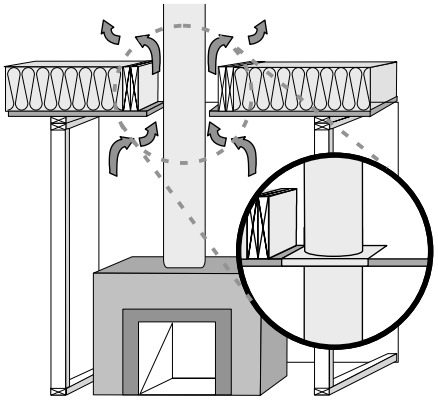
Two-level attic



Combustion closet



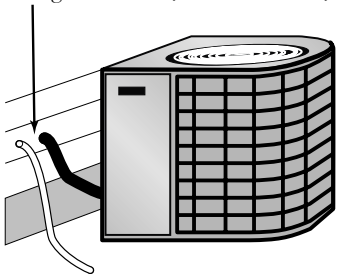
Combustion chase penetrations



15 Seal around chimney flues with sheet metal and high temperature caulk

Exterior penetrations

25 Caulk exterior wall penetrations for refrigeration lines, condensate line, etc.



Disclaimer:
This document is intended solely to help graphically demonstrate the air leakage provisions of section 502.1.4 of the 2000 IECC. It does not cover all airsealing locations or techniques. Other code provisions may be applicable as well.

Southface Energy Institute

High Performance Building Programs

ENERGY STAR Home Program:

ENERGY STAR , an innovative energy efficiency program sponsored by the U.S. Environmental Protection Agency (EPA), is a voluntary partnership that includes more than 2,400 builders, developers, retailers, and product manufacturers nationwide who are working to build homes that use energy more efficiently.

ENERGY STAR qualified homes are independently verified to be at least 30% more energy efficient than homes built to the national Model Energy Code or 15% more efficient than state energy code, whichever is more rigorous. These savings are based on heating, cooling, and hot water energy use and are typically achieved through a combination of:

- building envelope upgrades
- high performance windows
- tight construction
- controlled air infiltration
- upgraded heating and air conditioning systems
- tight duct systems
- upgraded water-heating equipment

To have a home certified ENERGY STAR, an independent contractor must verify that there is minimal air leakage and duct leakage by testing homes with special equipment. The contractor, called a Home Energy Rating Service (HERS) rater, then evaluates the overall efficiency of the insulation, windows, and heating and cooling systems to make sure the home meets ENERGY STAR guidelines. The HERS rater provides the certification and label for the home if it meets ENERGY STAR. ENERGY STAR certification can also be achieved through a Builder Option Package (BOP), which is a set of construction specifications for a particular climate. After certification, the home has the many benefits of an ENERGY STAR home, which include:

- increased comfort
- lower utility bills
- an efficiency label that is backed by the government
- improved resale value
- protecting the environment by reducing energy consumption

Some utilities in North Carolina offer a 5% reduction in electricity rates for homes that qualify as ENERGY STAR. Thus, the energy-saving features of the homes will reduce heating, cooling, and hot water bills, and the utility rate reduction will reduce the total cost of all electricity use. In addition to the efficiency requirements, the North Carolina State Energy Office recommends an effective home ventilation system along with other measures that help provide for quality indoor air. Visit www.energystar.gov or www.ncenergystar.org for more information.

What are Builder Option Packages (BOPs)?

Builder Option Packages (BOPs) help to simplify the process of constructing an ENERGY STAR qualified new home. BOPs represent a set of construction specifications for a specific climate zone. They specify performance levels for the thermal envelope, insulation, windows, orientation, HVAC system and water heating efficiency for a specific climate zone that meet the ENERGY STAR standard. Though constructing a home to BOP specifications eliminates the need for a full HERS rating, third-party verification that BOP specifications have been met is still required. Similar to HERS ratings, BOP ratings typically entail at least one on-site inspection of the home to test the leakiness of the envelope and ducts. However, unlike the HERS rating, the scores derived from these tests are compared with the pre-determined specification of the BOP to either pass or fail the house as an ENERGY STAR qualified new home.

What is a HERS rating?

A HERS Rating is an evaluation of the energy efficiency of a home as compared to a reference house (same size and shape as the rated home) that meets the requirements of the national Model Energy Code (MEC). It provides objective, standardized information on the energy performance of a home. A HERS rating evaluates the performance of the thermal envelope, glazing strategies, orientation, HVAC system and other efficiency criteria. Information is obtained either by an on-site inspection or a review of construction plans. HERS rating calculations incorporate estimates of both annual energy performance and of energy costs.

A HERS rating results in a score between 0 and 100. This rating indicates the estimated annual energy use of a rated house relative to a reference house built to the Model Energy Code (MEC). The reference house is assigned a score of 80. A rated home with identical annual energy use would also receive a score of 80. For each five percent reduction in energy use (compared to the reference house) the score increases by one point. Thus, an ENERGY STAR home that is 30% more energy efficient than the reference house has a minimum HERS rating of 86. Annual energy use is based on the heating, cooling and hot water heating requirements.

Advanced Energy- SystemVision:

SystemVision™ by Advanced Energy

The SystemVision initiative was launched by Advanced Energy in 2000. The program now offers its own guarantee for homeowners of more modest means. The SystemVision guarantee lasts for two years and promises that energy used to heat and cool the home will not exceed a specified amount and the temperature in the center of any conditioned room will not vary more than three degrees from the thermostat setting. If those conditions aren't met, Advanced Energy pays for the energy cost overrun and for identifying problems with the original equipment or construction.

The program treats the building as a system. The initiative helps building professionals improve the durability, energy efficiency, and environmental impacts of a house while emphasizing the health, comfort, and safety of the occupants. Advanced Energy's involvement begins with reviews and necessary modifications to house plans and specifications. Also, onsite quality control monitoring and actual performance testing occurs before the guarantee is issued.

Masco Contractor Services- Environments for Living:

The Environments for Living Program includes a Heating & Cooling Energy Use Guarantee that calculates the amount of energy required to heat and cool the new home. While the program has no control over local utility rates, the combination of special framing techniques, improved insulation, and efficient ductwork helps ensure that the energy usage remains at a manageable level. The program also provides built-in advantages such as pressure balancing, moisture management, and fresh air ventilation to help you and your family enjoy a higher level of consistent comfort throughout your new home. Another feature of the program is that it filters and delivers fresh air more efficiently to help create an environment that contains less dust, fewer odors and remarkably comfortable temperatures. Combined with interior moisture management and advanced combustion safety features, this should help reduce potential health risks.

North Carolina Solar Center- NC Healthy Built Home Program:

The NC HealthyBuilt Homes Program provides visibility and certification of homes for residential builders who practice sustainable, high performance building practices. The Healthy Built home is a comfortable, healthy, and affordable house that reduces energy and water usage and helps protect the environment. Building materials and processes are selected to reduce pollution and the waste of natural resources both during the manufacturing and construction phases and throughout the life of the home. Careful attention is given to energy efficiency and indoor air quality. Because the quality, amenities, and energy savings are evident, these homes have a higher value.

The program has been launched in North Carolina with a focus on providing support for small to medium size home builders who may not have the resources to compete in the rapidly emerging field of green building. The program is designed with two tiers. The first is a statewide umbrella organization that administers the overall program, sets statewide guidelines, provides technical support, and coordinates training, marketing and certification. The second tier consists of local partnerships with organizations such as home builder associations that administer and promote the program in their community, tailoring it to local conditions and code requirements.

North Carolina's Renewable Energy Tax Credit

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 located in state. 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. The credit is distributed over five years. The NC Solar Center can provide details and guidelines to determine the income tax credit, or visit www.DSIREUSA.org

Introduction to Plans

The section is a collection of passive solar house plans that are designed to be affordable. Some of the plans are converted and from a variety of sources including Habitat for Humanity, the rest are original designs.

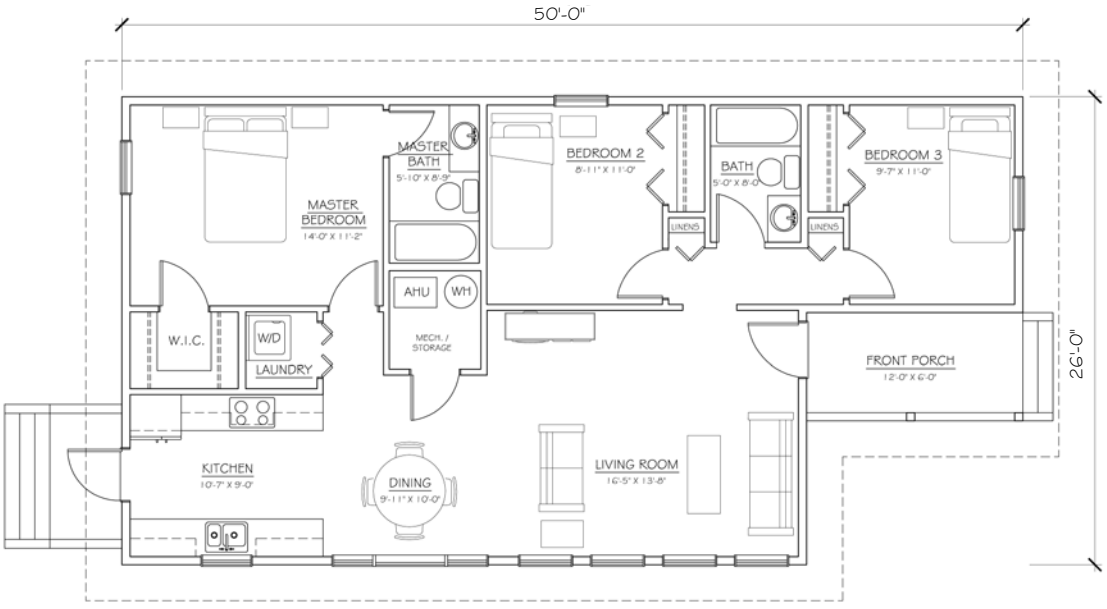
The passive solar features unclude between 6-11% of the floor area as south facing glazing, 2 foot overhangs, and slab on grade construction with incorporated thermal mass. In addition, the main living areas are on the south side of the home.

The plans are affordable because they are simple designs that have even exterior dimensions which reduces construction costs and waste. The plans are all between 900 and 1300 square feet. When windows were added to the south side they are removed from the east and west to further reduce construction costs. The homes also have simple roof lines that can all be built with trusses.

These plans can be adpated or mirrored to suit your site. Use them as a place to get ideas about how to design your passive solar home. Have fun and be creative! Full sets of working drawings are available for free online at www.energync.net or www.ncenergystar.org.

Plan One: The Catawba Valley

3 bedrooms,
2 bathrooms,
1132 total
square feet



FLOOR PLAN
3/32" = 1'-0" 0 2' 4' 8'

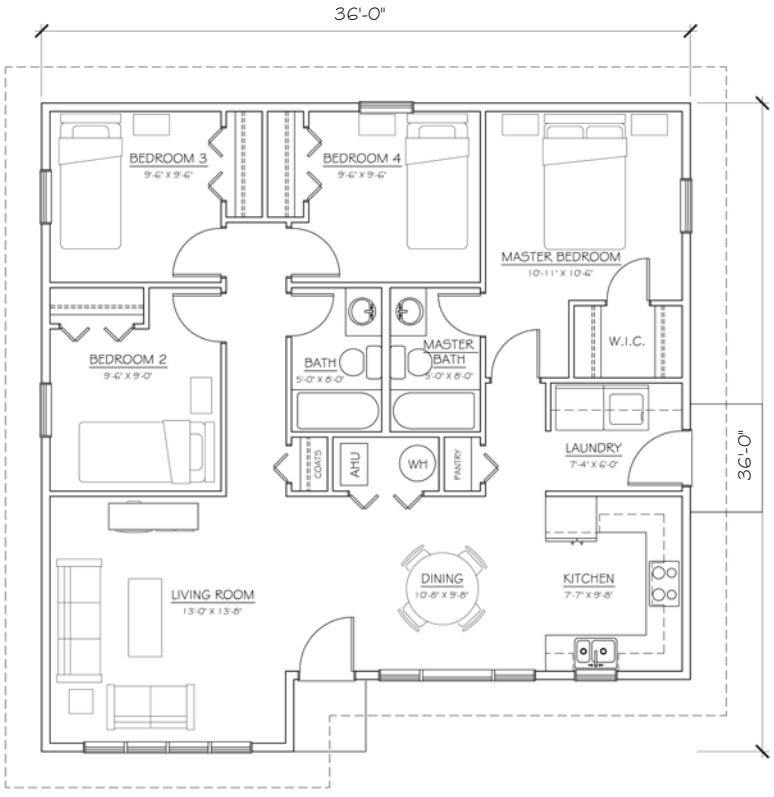
EAST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

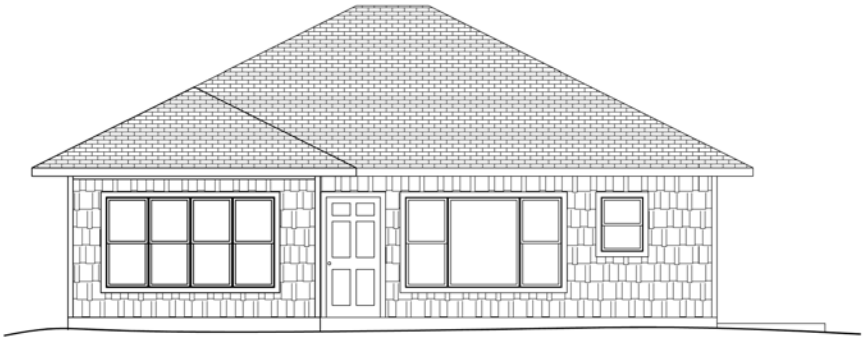
WEST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

Plan Two: The Blue Ridge

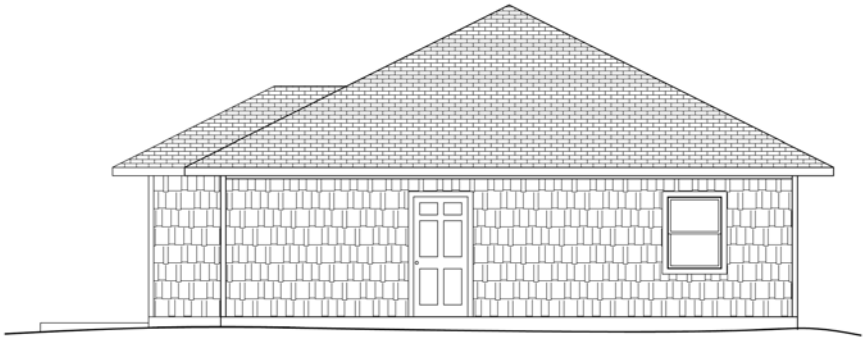
4 bedrooms,
2 bathrooms,
1208 total
square feet



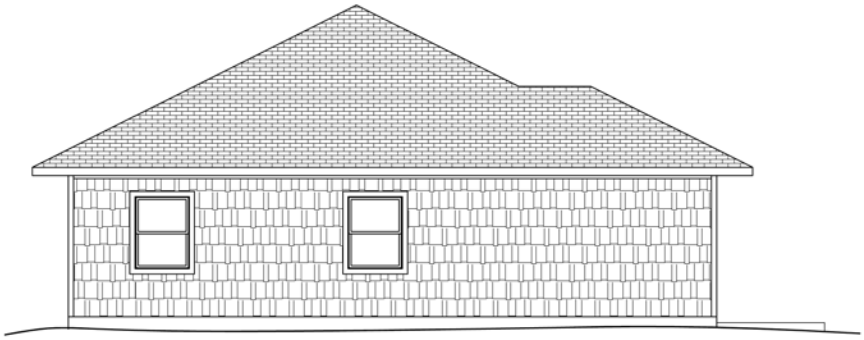
FLOOR PLAN
3/32" = 1'-0" 0 2' 4' 8'



SOUTH (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



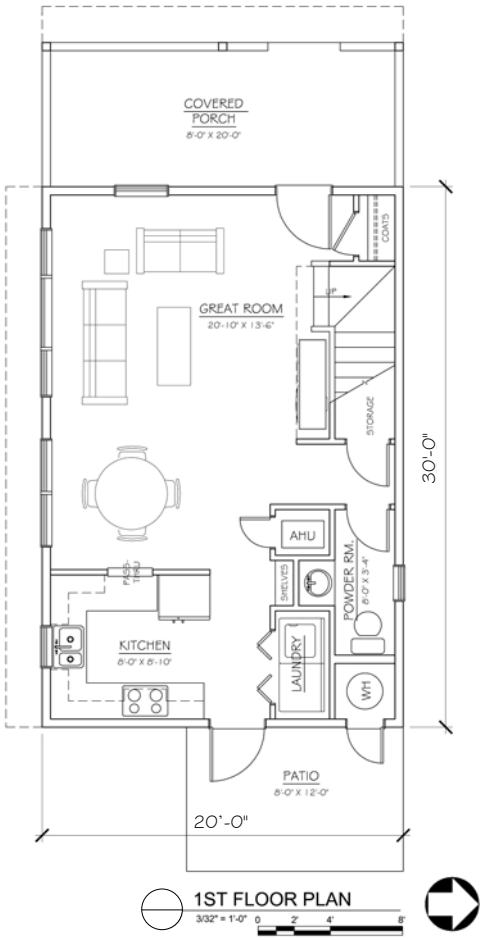
WEST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



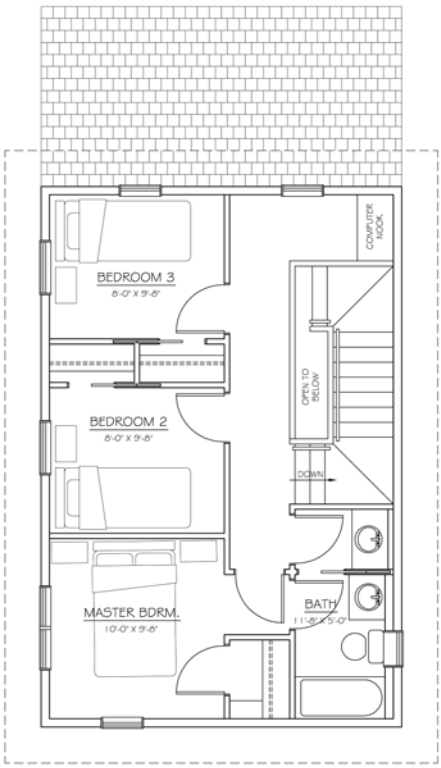
EAST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

Plan Three: The Cardinal

3 bedrooms,
2 bathrooms,
1200 total
square feet

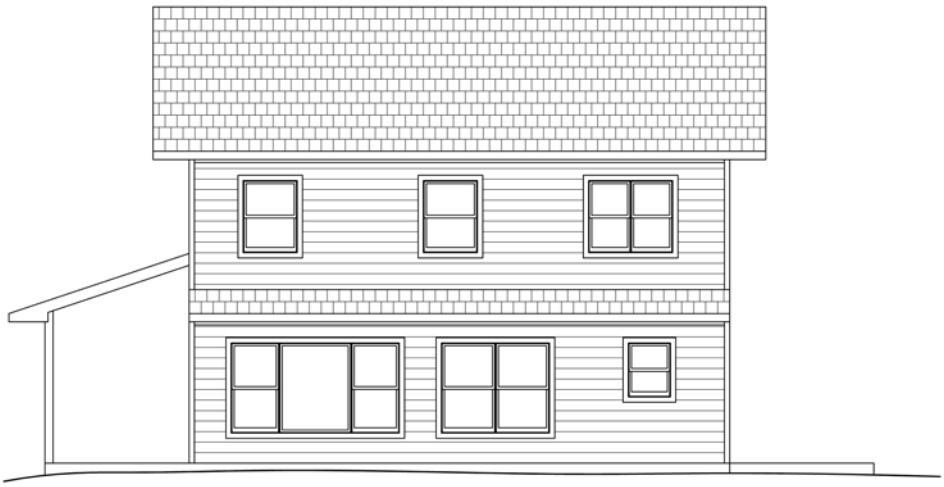


1ST FLOOR PLAN
3/32" = 1'-0"



2ND FLOOR PLAN
3/32" = 1'-0"

WEST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

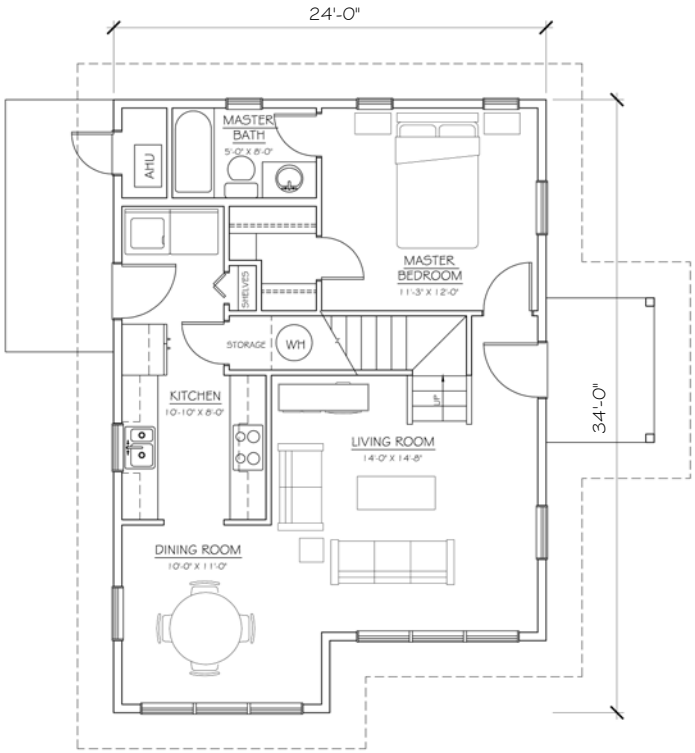


SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

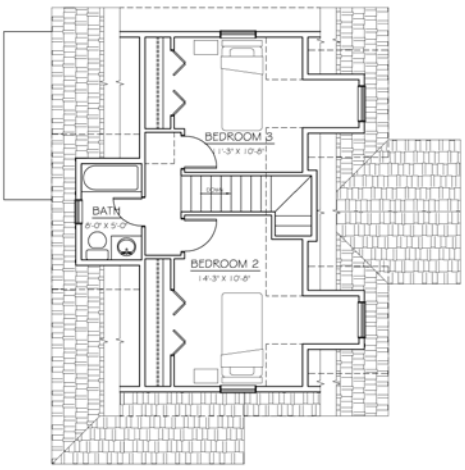
EAST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

Plan Four: The Baby Cape

3 bedrooms,
2 bathrooms,
1286 total
square feet



1ST FLOOR PLAN
3/32" = 1'-0"



2ND FLOOR PLAN
1/16" = 1'-0"

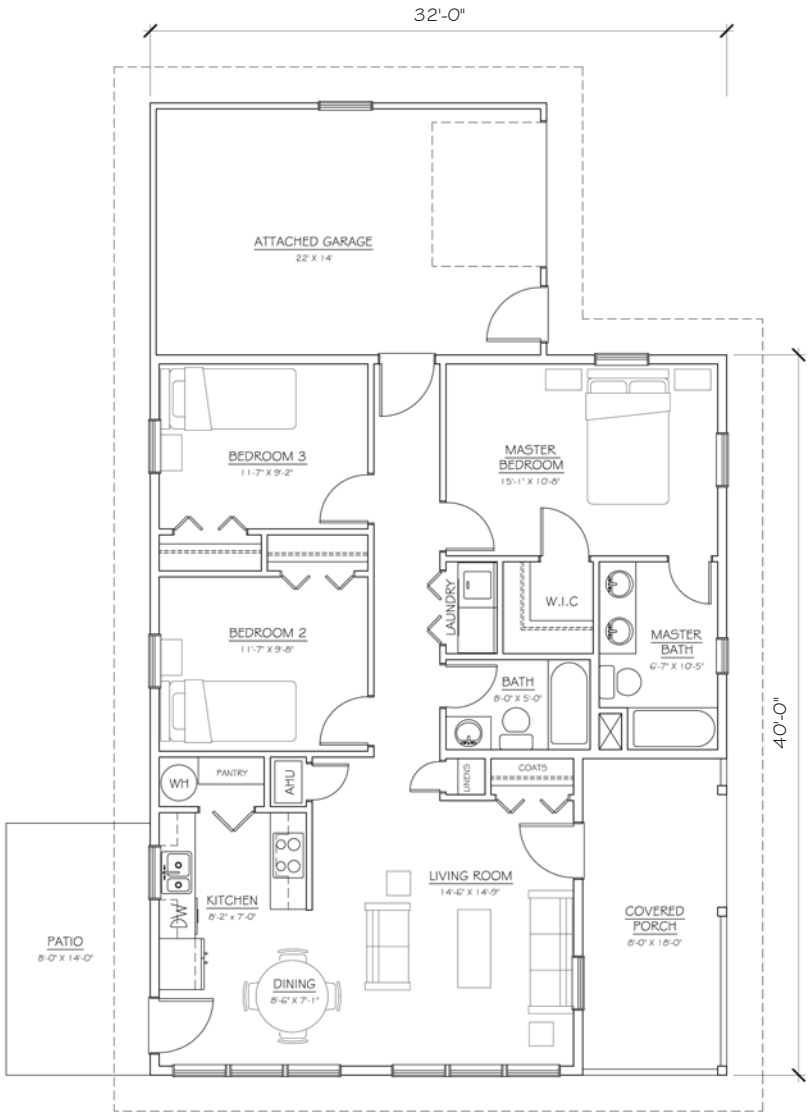
EAST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

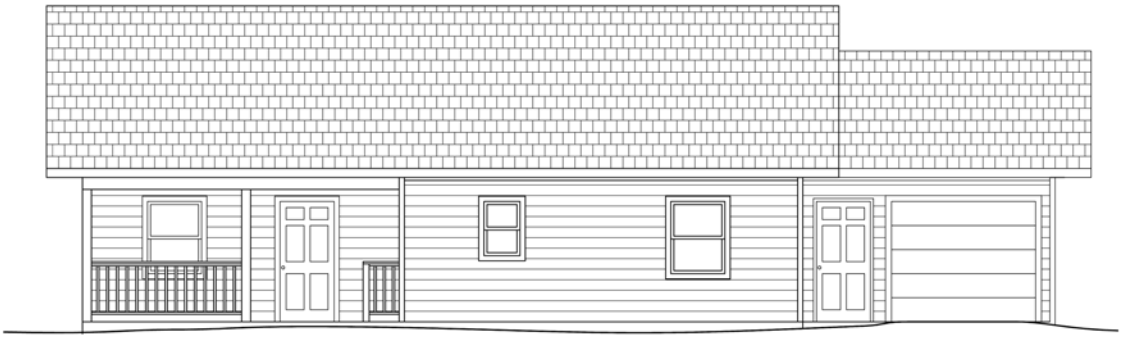
WEST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

Plan Five: The Garden Window

3 bedrooms,
2 bathrooms,
1140 total
square feet

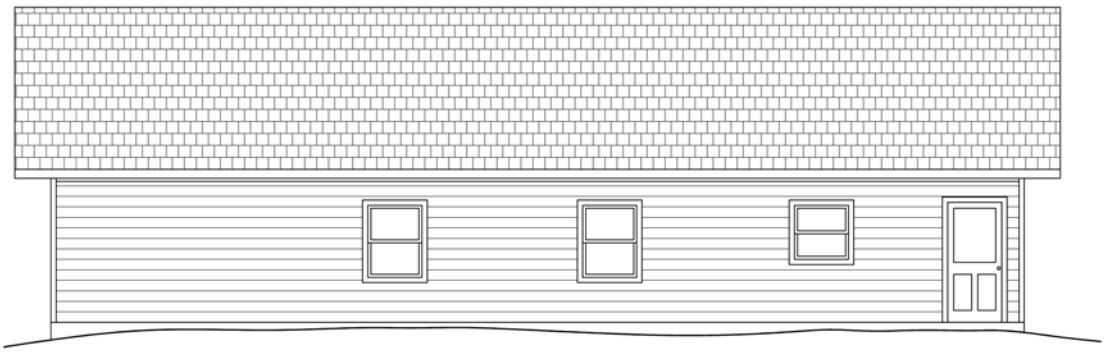


FLOOR PLAN
3/32" = 1'-0"



EAST(FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

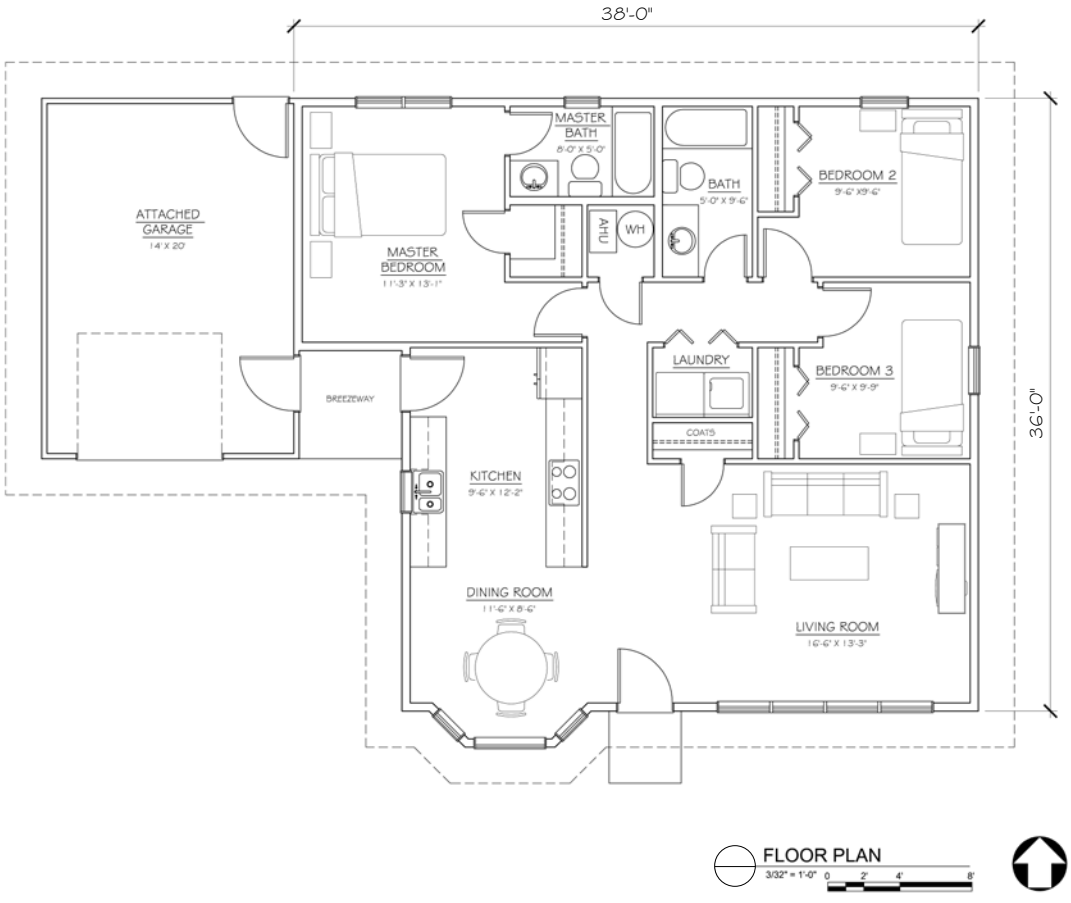
SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



WEST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

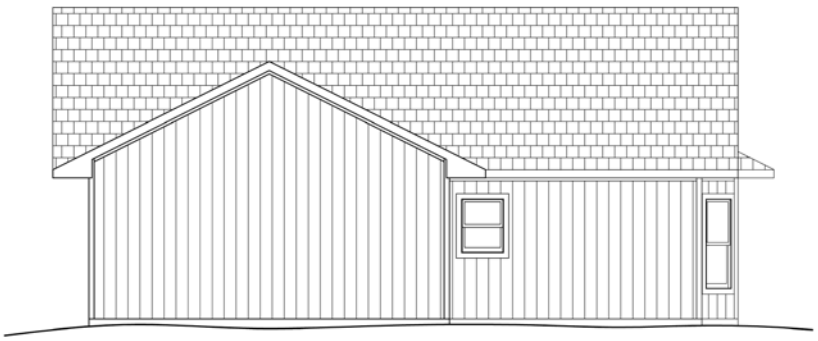
Plan Six: The Bay Breeze

3 bedrooms,
2 bathrooms,
1166 total
square feet

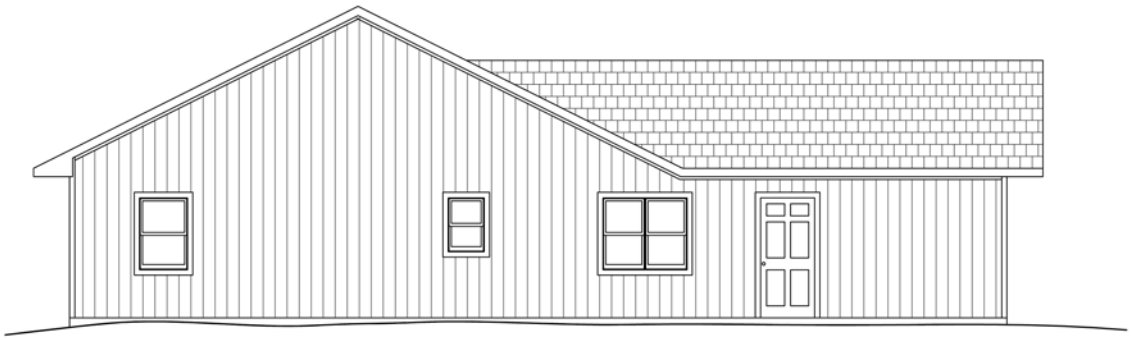


FLOOR PLAN
3/32" = 1'-0"

SOUTH (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



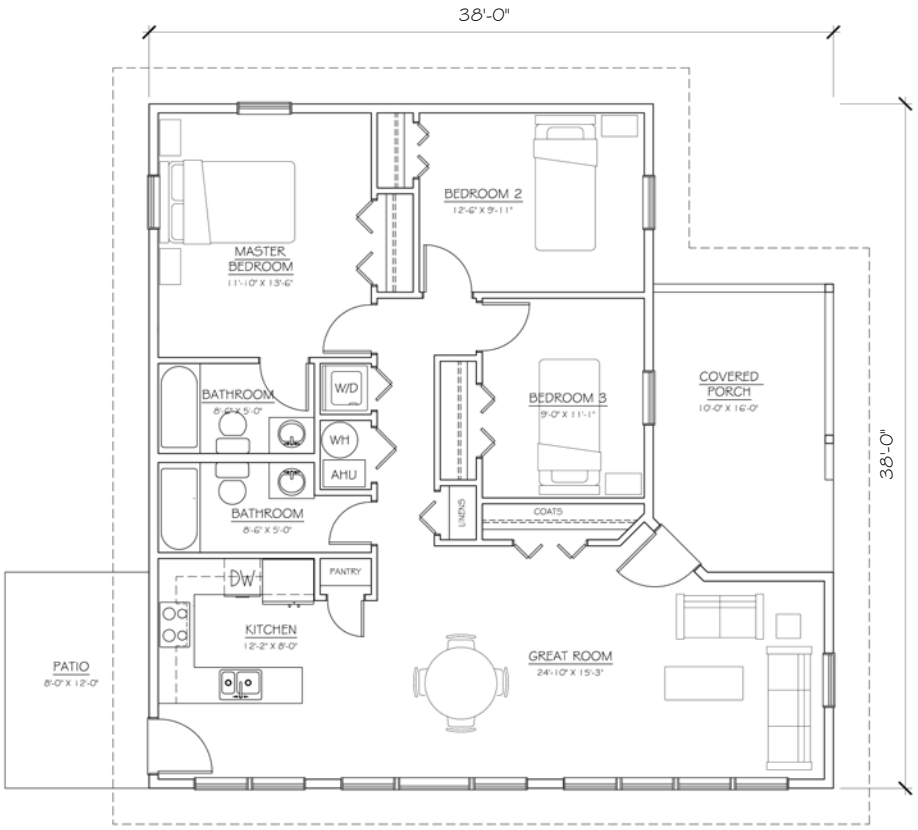
WEST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



NORTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

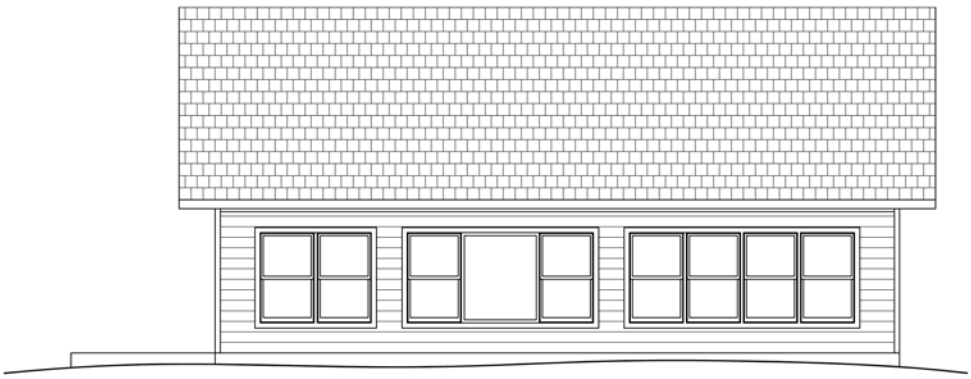
Plan Seven: The Sun Ray

3 bedrooms,
2 bathrooms,
1188 total
square feet

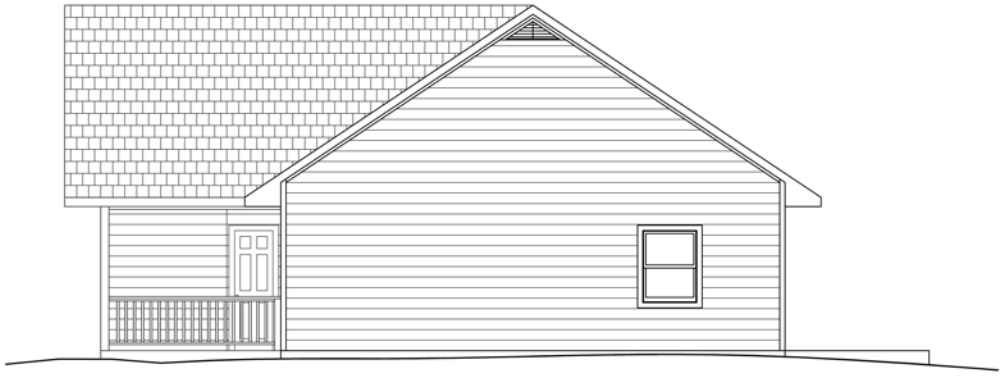


FLOOR PLAN
3/32" = 1'-0"

EAST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



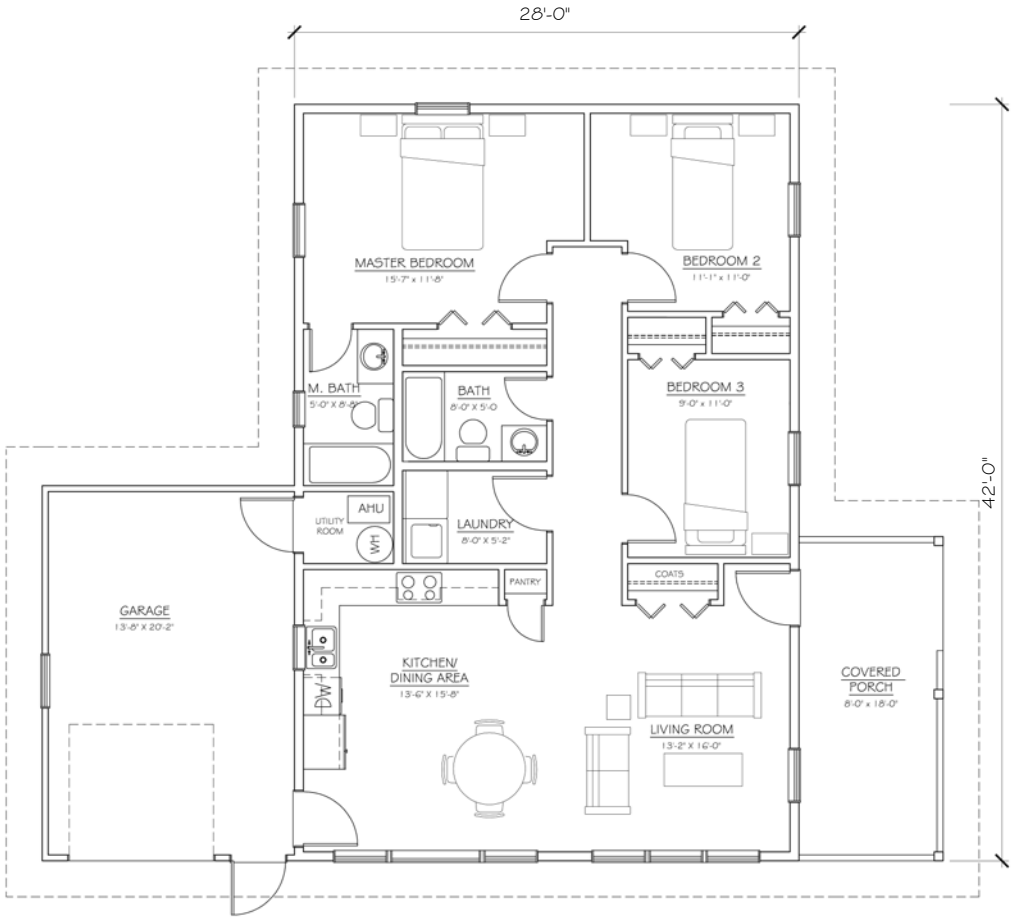
SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



NORTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

Plan Eight: The Orion

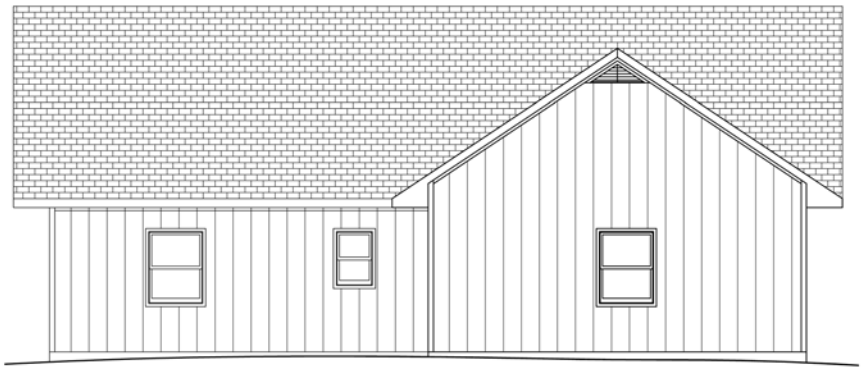
3 bedrooms,
2 bathrooms,
1176 total
square feet



FLOOR PLAN
3/32" = 1'-0"

EAST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

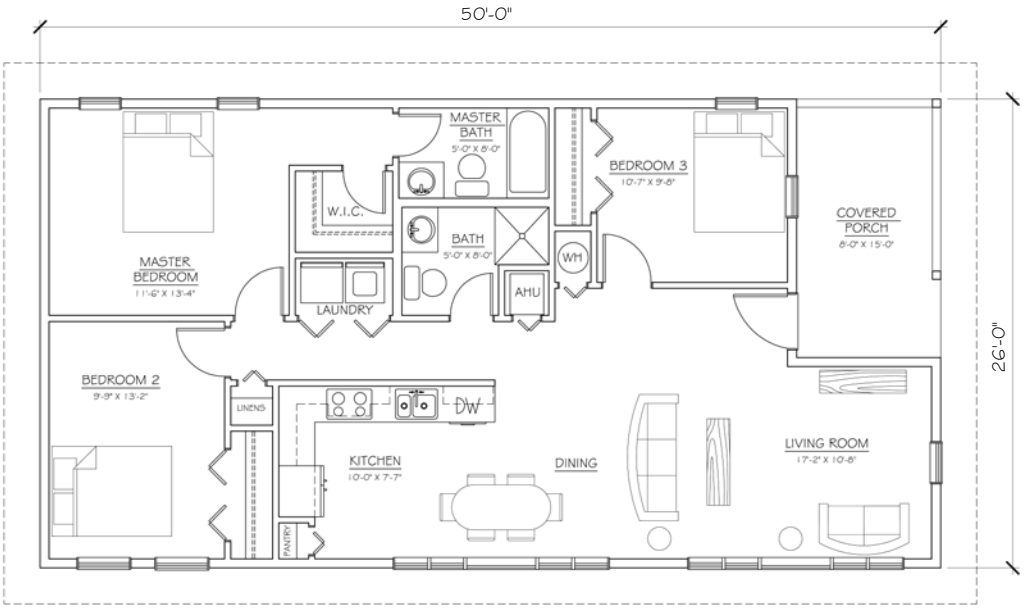
SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



WEST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

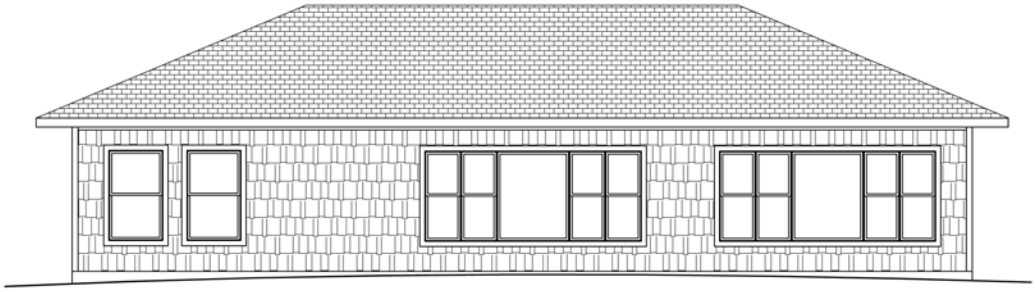
Plan Nine: The Cottage

3 bedrooms,
2 bathrooms,
1186 total
square feet

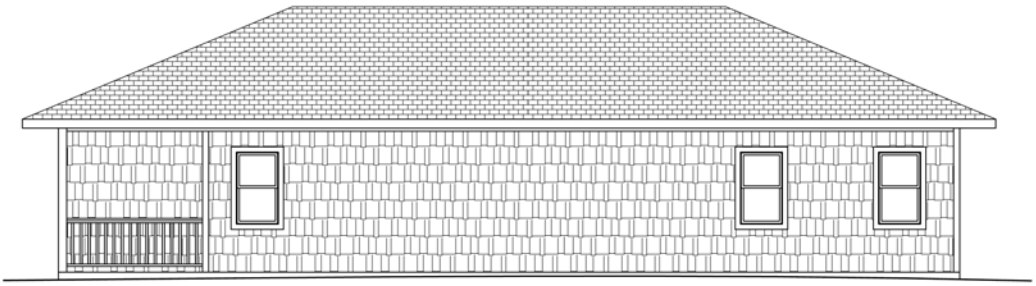


FLOOR PLAN
3/32" = 1'-0"

EAST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



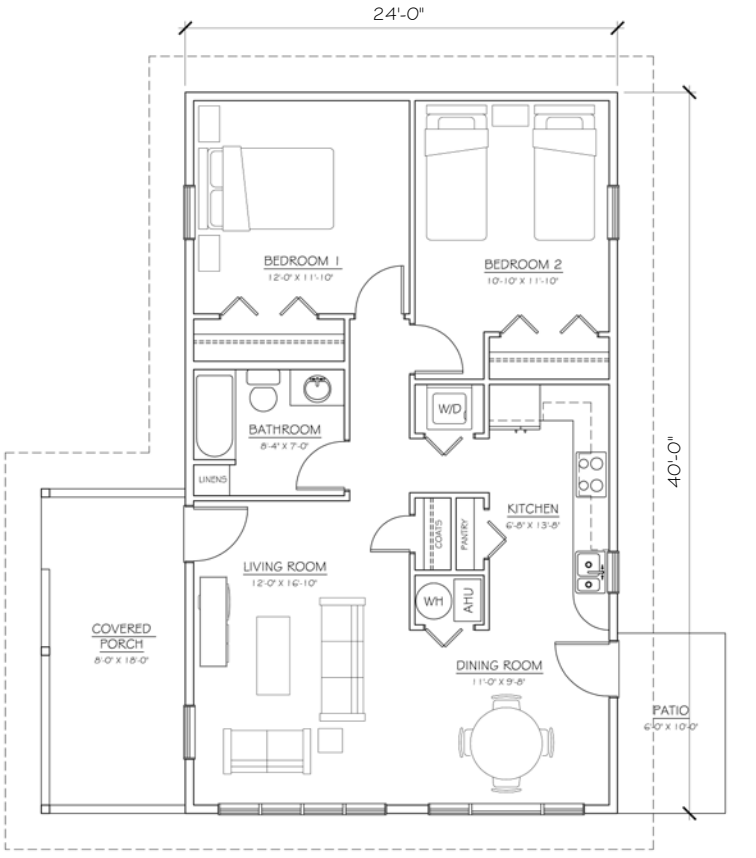
SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



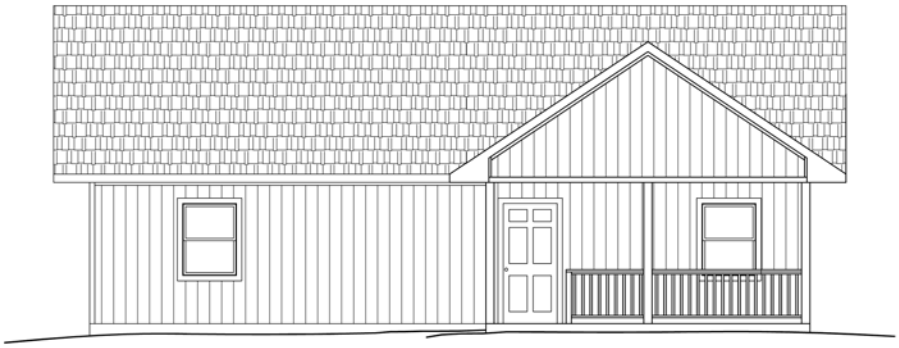
NORTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

Plan Ten: The Hide Away

2 bedrooms,
1 bathrooms,
960 total
square feet

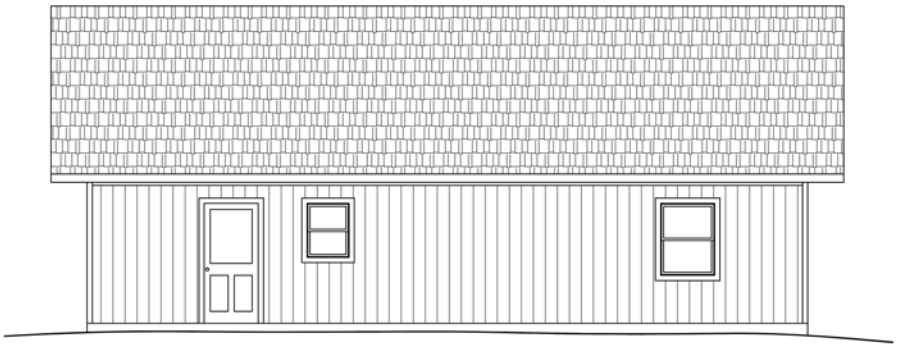


FLOOR PLAN
3/32" = 1'-0" 0 2' 4' 8'



WEST (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

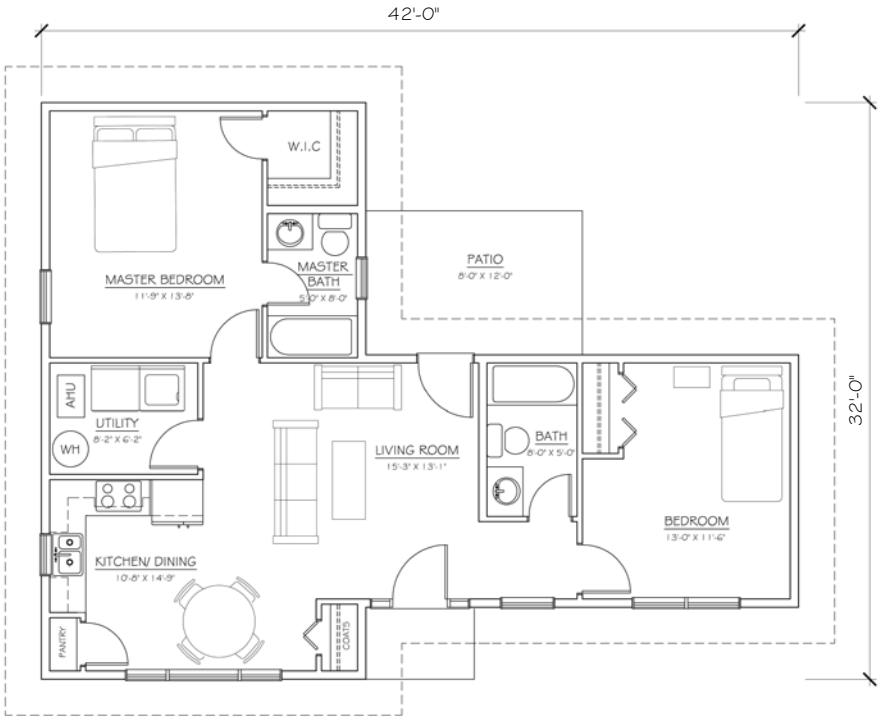
SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

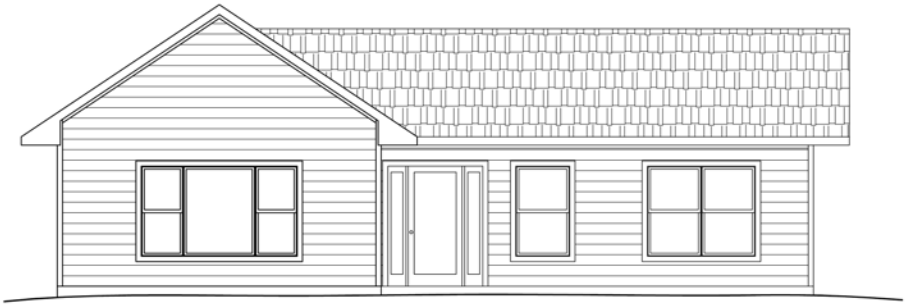


EAST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

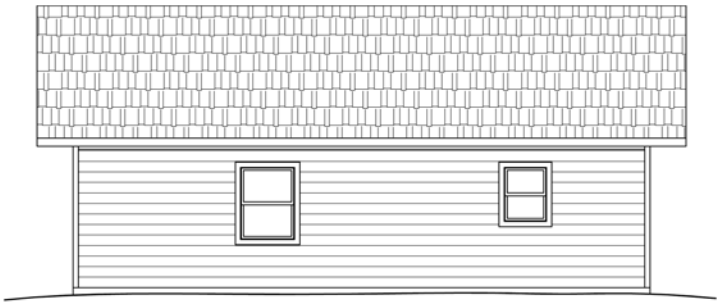
Plan Eleven: The Dogwood

3 bedrooms,
2 bathrooms,
916 total
square feet

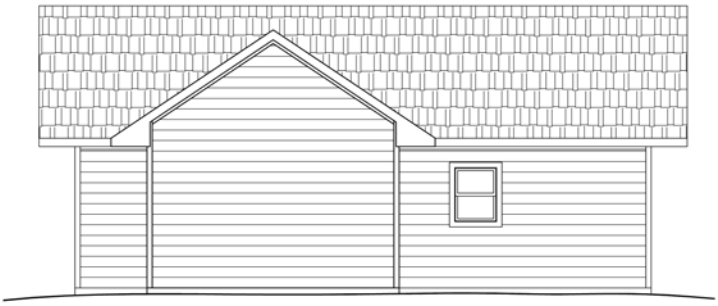




SOUTH (FRONT) ELEVATION
3/32" = 1'-0"



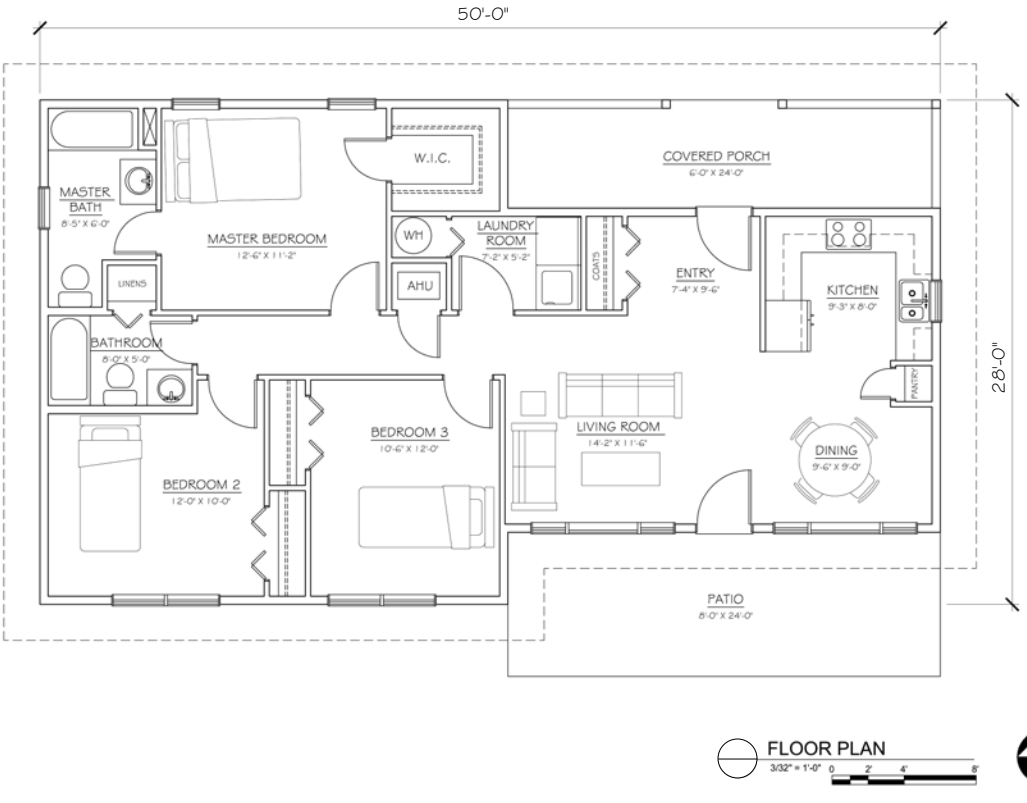
WEST ELEVATION
3/32" = 1'-0"



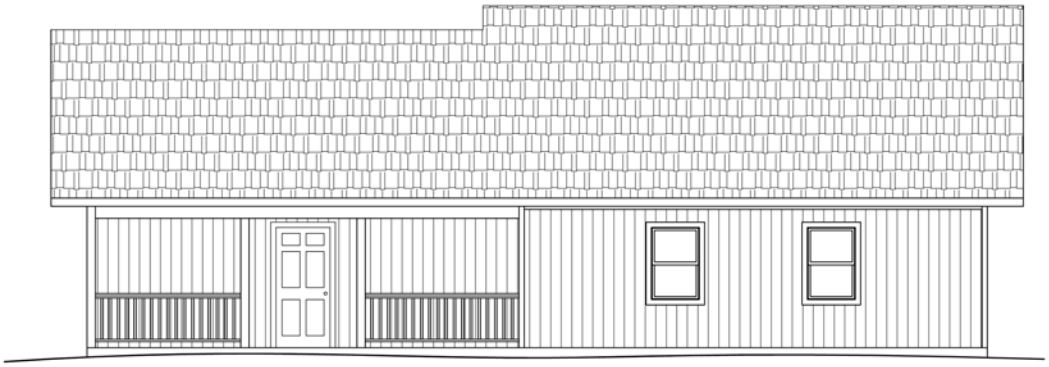
EAST ELEVATION
3/32" = 1'-0"

Plan Twelve: The Mountain Laurel

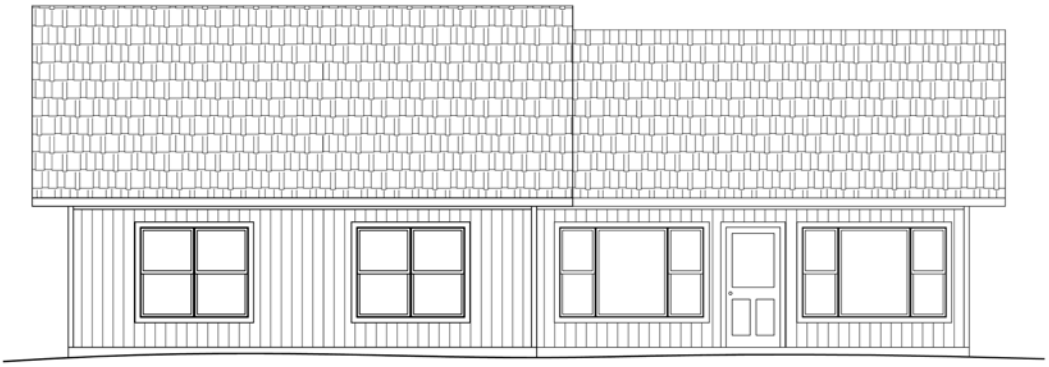
3 bedrooms,
2 bathrooms,
1150 total
square feet



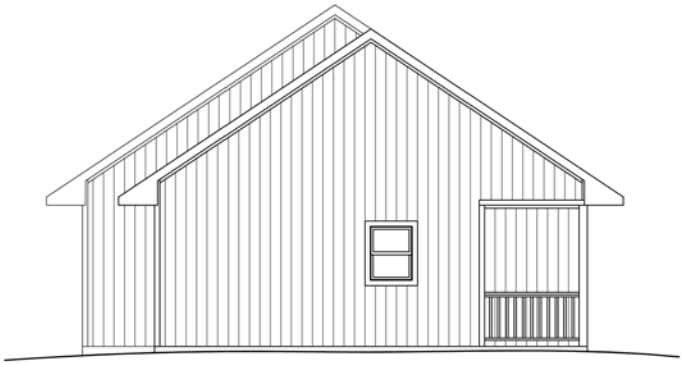
FLOOR PLAN
3/32" = 1'-0"



NORTH (FRONT) ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



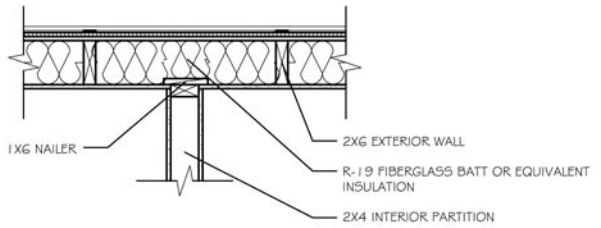
SOUTH ELEVATION
3/32" = 1'-0" 0 2' 4' 8'



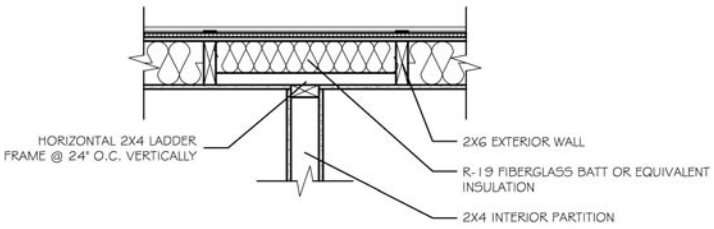
EAST ELEVATION
3/32" = 1'-0" 0 2' 4' 8'

High Performance Building Sections

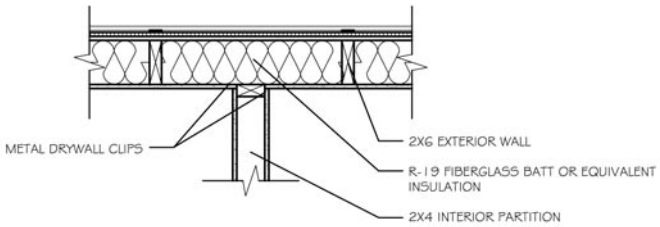
T-wall Details



1X6 NAILER

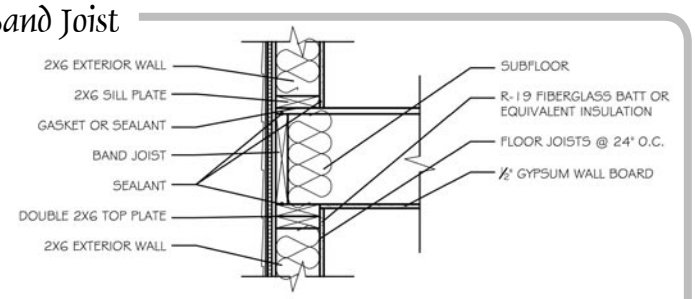


2X4 LADDER FRAME



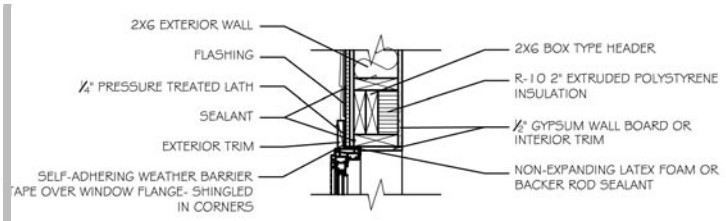
DRYWALL CLIPS

Band Joist



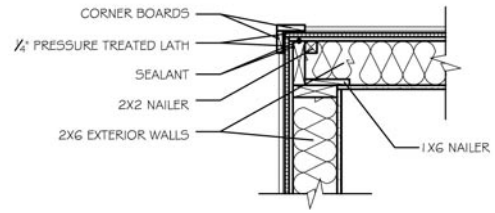
BAND JOIST DETAIL

Window Door Header

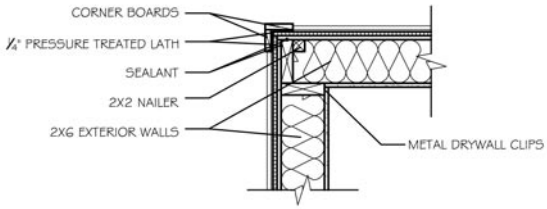


WINDOW AND DOOR HEADER

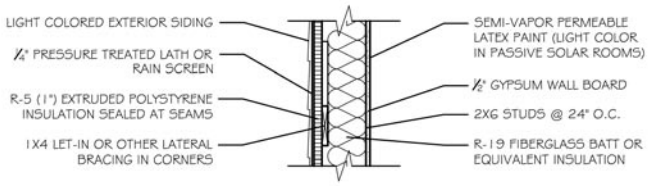
Corner Details



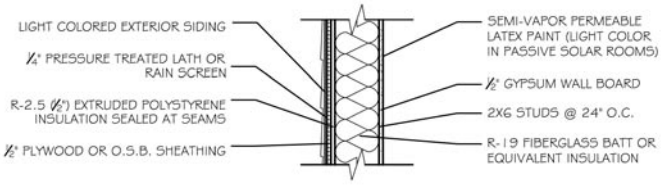
3-STUD CORNER



DRYWALL CLIPS

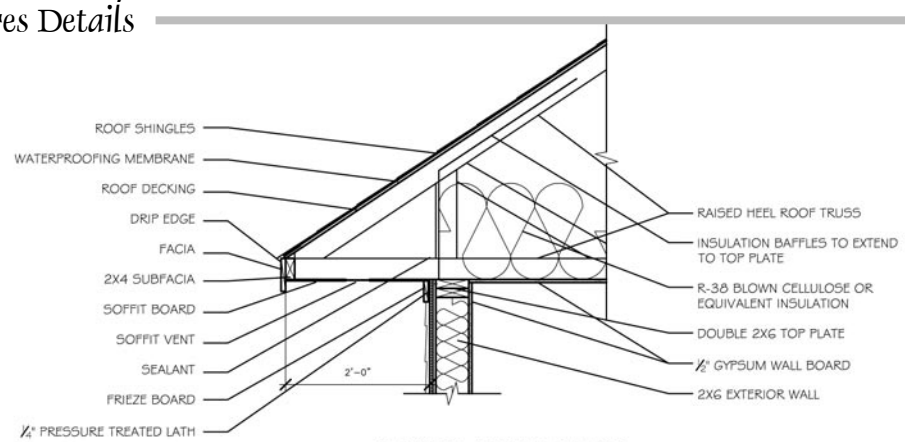


R-24 W/ LET-IN BRACING

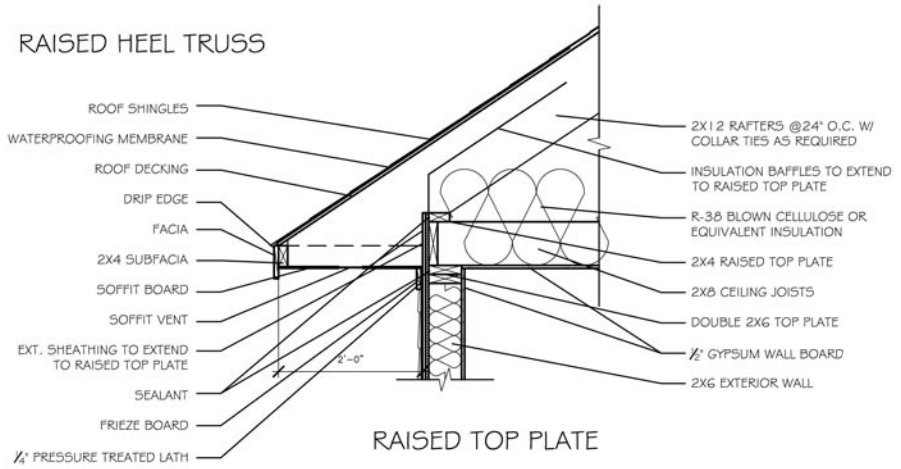


R-21.5 W/ PLYWOOD OR O.S.B. SHEATHING

Eaves Details

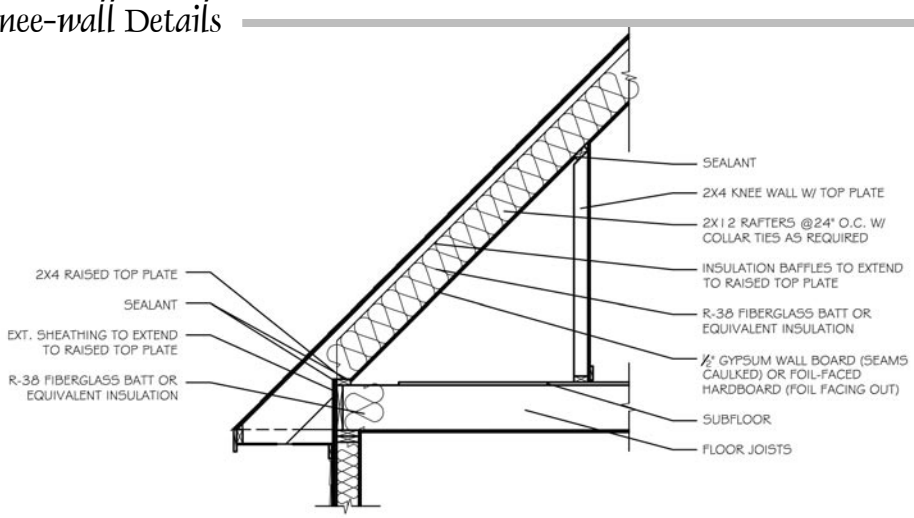


RAISED HEEL TRUSS

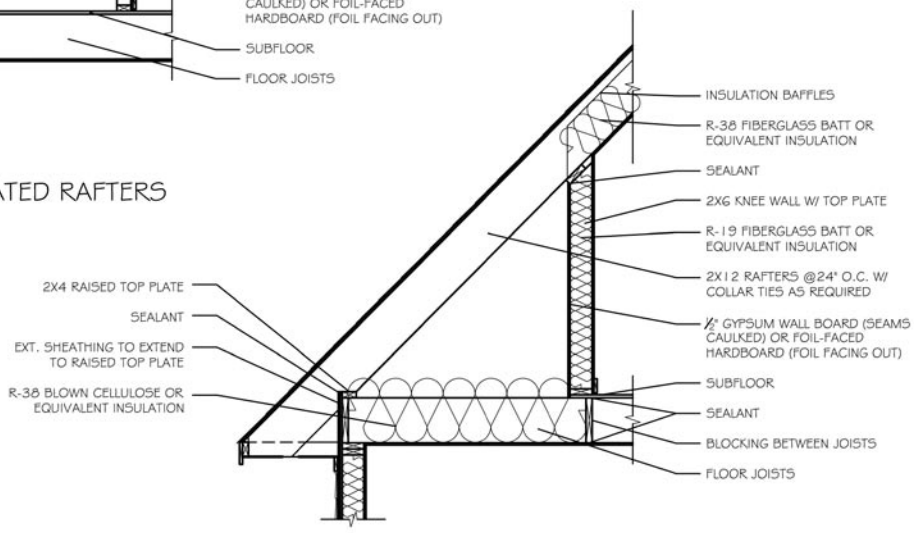


RAISED TOP PLATE

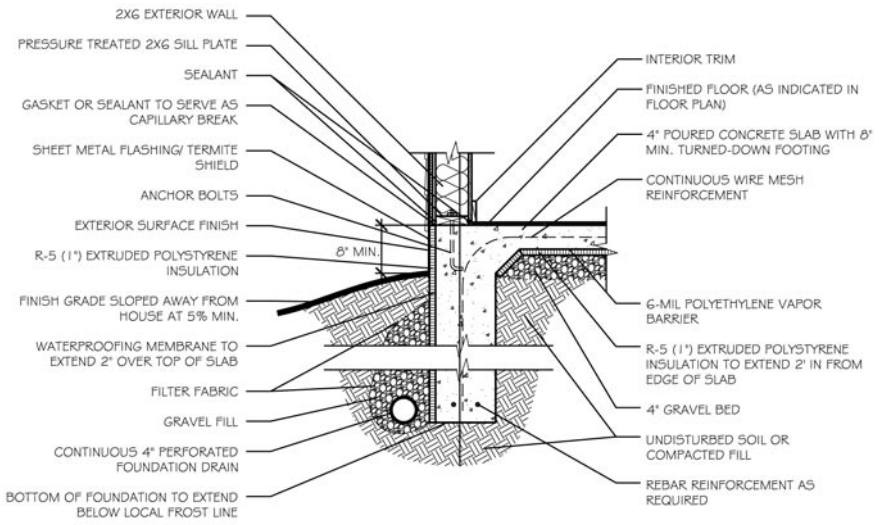
Knee-wall Details



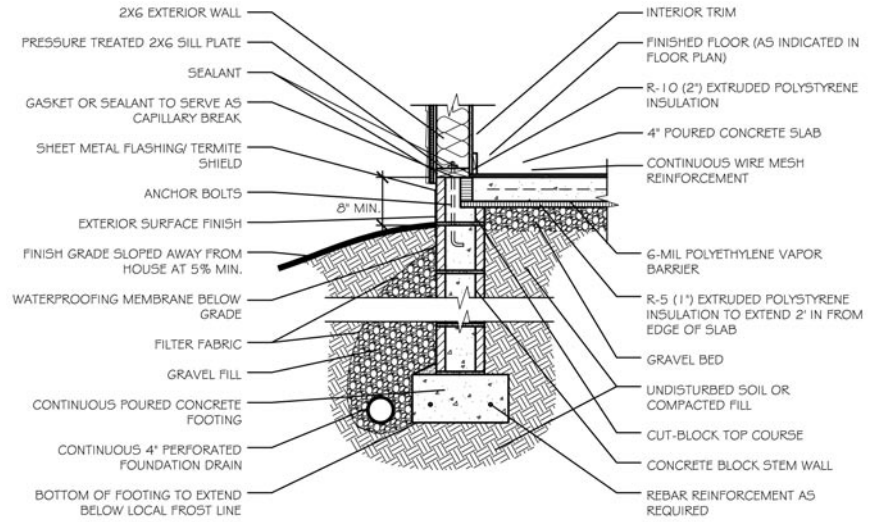
INSULATED RAFTERS



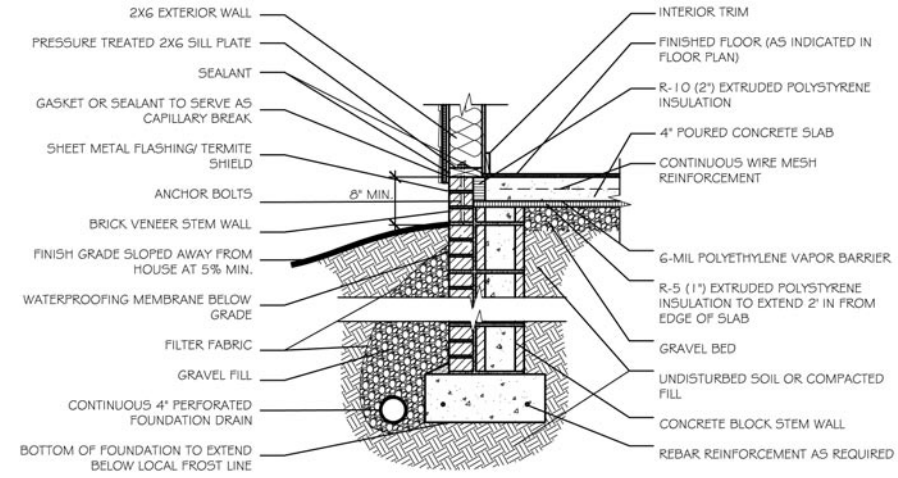
INSULATED FLOOR AND WALL



MONOLITHIC SLAB W/ TURNED-DOWN FOOTING



CONTAINED SLAB W/ CONCRETE BLOCK STEM WALL



CONTAINED SLAB W/ BRICK VENEER STEM WALL

A Zero Energy Home Case Study

The North Carolina State Energy Office, Appalachian State University, and Catawba Valley Habitat for Humanity collaborated and constructed a Zero Energy Home based on the Catawba Valley plan featured in this book. The U.S. Department of Energy's Zero Energy Homes research initiative is bringing a new concept to homebuilders across the United States. A Zero Energy Home (ZEH) combines state-of-the-art, energy-efficient construction and appliances with commercially available renewable energy systems such as solar water heating and solar electricity. This combination can result in net zero energy consumption from the utility provider. Zero Energy Homes are connected to the utility grid but can be designed and constructed to produce as much energy as they consume annually. The home is participating the System Vision program as well as North Carolina's green building program, NC HealthyBuilt Homes. The house will be used for demonstration purposes for the first year and tours will be given.

Features

Insulation and Air Sealing Systems

The additional air sealing and insulation creates an energy saving thermal barrier for the home. The home has an insulated slab floor on both the perimeter and underneath. The walls are insulated with spray foam insulation which also provides air sealing. The attic has an blown in insulation that is R-52.

Passive Solar Design

Passive solar design incorporates a high percentage of glass on the south side to take advantage of the heat from the sun in the winter. This home has 11 percent of the floor area as south facing glazing. The main living areas are on the south side of the home. Recylced tile in the living room, kitchen and dining room provides thermal mass to store the heat. The overhangs are 2 feet and block the sun in the summer to reduce the cooling load.

Renewable Energy Systems

The renewable energy systems provide the Zero Energy Home distinction by generating electricity and hot water, greatly reducing energy consumption. The home has a solar hot water heating system which can provide all of the hot water needed by the homeowners. A standard hot water heater will also be installed for back up. The roof will boast 4500 kilowatts of photovoltiac panels.

Appliances and Lighting

The appliances all have the ENERGY STAR certification and all of the light bulbs will be compact flouresents.

Heating, Cooling and Ventilation

The home has a geothermal heat pump, which uses the temperature of the earth to heat and cool the home. The duct runs are inside the home's insulation and are well sealed. An energy recovery ventilation system provides fresh air with minimal energy cost. The home also has quiet low-sone exhaust fans in the bathrooms.

Directions For Using This Worksheet

PLEASE NOTE: Many items have been abbreviated for convenience;
Please see the Documentation Guide for full item description.
To request a copy of the Documentation Guide, email the HBH Coordinator at jamie_hager@ncsu.edu.

To determine the climate zone to use with your building, locate your county on the **NC Climate Zone map**
(downloadable from the NCSC website: www.ncsc.ncsu.edu , click on "Homes" then "NC HealthyBuilt Homes")

If you would like the worksheet to calculate your score as you select items, **Type "x" in the columns** beside each item as appropriate for your project:

Y = Yes, item is applicable **?**= Item may be applicable **N** = No, item not applicable to this project

Y	?	N	Prerequisites		Points	Score
			Prereq 1	*Comply with all erosion control and tree protection as required by your local area.*	required	0
			Prereq 2	*Plumbing fixtures meet National Energy Policy Act low flow standards*	required	0
			Prereq 3	*Home must be certified by EPA Energy Star program*	required	0
			Prereq 4	*Perform blower door test to meet 0.35 CFM50/sf or 3.5 ach50 standard.*	required	0
			Prereq 5	*All ducted systems, sealed (mastic)and leakage tested not to exceed 5% of sf at CFM25.*	required	0
			Prereq 6	*Size all HVAC equipment to meet ANSI / ACCA Manual J 8th Edition calculations.*	required	0
			Prereq 7	*No combustion equipment in conditioned space--see full checklist item for specifics.*	required	0
			Prereq 8	*Provide clean source ventilation equal to 7.5 CFM per bedroom plus 7.5 plus .01/sf.*	required	0
			Prereq 9	*Enroll in NC HBH program*	required	0

Y	?	N	Site Opportunities--minimum 7 points		Points	Score
			Soil/Amendments			
			1	Provide an erosion control site plan	2	0
			2	Use of redundant mulch, compost, or straw bales for erosion control.	3	0
			3	Save, protect and reuse 75% or more of all valuable site topsoil.	4	0
			Vegetation			
			4	Trees and natural features on site protected during construction (min 25%)	3	0
			5	Tree planting (min. 12 trees per acre of developed land)	4	0
			6	Provide tree preservation plan.	3	0
			7	Individual trees fenced at drip line (1 point per tree, max. 5 trees)	enter points	0
			8	Grind stumps and limbs for mulch.	2	0
			9	Mill cleared logs.	2	0
			Development			0
			10	Sidewalk connects house to business district (max 2 miles)	5	0
			11	Use B20 blend bio-diesel for 90% of all diesel fueled construction equipment.	5	0
Subtotal of points for this section					**0**	

Y	?	N	Water Opportunities--minimum 9 points		Points	Score
			Outdoor			
			1	Drought resistant guidebook given to homeowner.	1	0
			2	Provide a drought resistant planting plan to homeowner.	3	0
			3	Permeable materials comprise 40% of areas for all walkways, patios and driveways.	3	0
			4	Installed landscape is drought resistant for at least 50% of non-paved area.	7	0
			5	Rainwater harvested and directed toward landscaping needs .	4	0
			6	Installed irrigation system is zoned separately for turf and bedding areas.	2	0
			7	Installed irrigation system includes rain sensor, soil moisture, or other efficiency device.	2	0
			8	Greywater irrigation system is installed where allowed by code .	7	0
			Indoor			
			9	Kitchen faucet fitted with aerator restricting flow to 2.0 gpm .	1	0
			10	Bathroom faucets fitted with aerator restricting flow to 1.8 gpm.	1	0
			11	All toilets are high efficiency toilets (max 1.45 gpf) or dual flush (1.6/0.8 gpf).	1	0
			12	High efficiency showerheads (max 2.25 gal/min).	1	0
			13	Install whole house water filter system (NSF certified).	1	0
			14	Clothes washer is an Energy Star labeled product .	5	0
Subtotal of points for this section					**0**	

Y	?	N	Building Envelope--minimum 15 points		Points	Score
			1	Builder must certify house as ENERGY STAR.	required	0
			2	Exceeds Energy Star (1 point for each 1%) max 5 points.	enter points	0
			3	Enrolled in Energy Bill Guarantee program.	5	0
			4	Provide Insulation/ HVAC inspection	5	0
			Air Infiltration			
			5	Perform a blower door test and meet minimum standard of 0.25 cfm50/sf or 2.5 ach50	5	0
			6	Perform a blower door test and meet minimum standard of 0.15 cfm50/sf or 1.5 ach50	10	0
			Insulation			
			Slab/Foundation Wall/Floor			
			7	Slab insulation (min R5).	2	0
			8	Slab insulation (min R8)	3	0
			9	Insulated concrete or masonry basement walls (continuous floor to ceiling R13).	2	0
			10	Insulated foundation walls with rigid R-10 foam insulation from footer to top of wall.	3	0
			11	Sealed, insulated crawl space walls (R10).	5	0
			12	Cantilevered floor insulated. (R30).	2	0
			13	Band joist insulated (R19).	2	0
			14	Insulate framed floor over unconditioned space (R21 Zones 6-7; R25 Zones 8-9, 11).	2	0
			Walls			
			15	Framing Efficiency Package for wood stud construction (see Doc Guide for details).	5	0
			16	R-2.5 to 4.9 insulated exterior wall sheathing on 75% or more exterior wall area.	3	0
			17	R-5 or better insulated exterior wall sheathing on 75% or more exterior wall area.	4	0
			18	Chases air sealed and insulated in addition to any required insulation value. (R5)	2	0
			19	Insulate fireplace chase. (R5)	1	0
			20	Exterior wall stud cavities insulated (R19 Zones 6-7; R21 Zones 8-9, 11).	3	0
			21	Pre-cast Autoclaved Aerated Concrete used as exterior wall material. (R10, min)	5	0
			22	Insulated Concrete Form wall system. (R20, min.)	5	0
			23	Structural Insulated Panels (exterior walls) (R14, min.)	2	0
			24	Structural Insulated Panels (exterior walls) (R20, min.)	5	0
			Roof/Ceiling/Attic			
			25	Energy (raised) heels of 6" or more on trusses.	2	0
			26	Structural Insulated Panels (roof) (R30, min.)	3	0
			27	Insulate flat ceilings (R38-Zones 6-7; R42 Zones7-8; R48 Zones 9,11).	2	0
			28	Insulate vaulted and tray ceilings (R38-Zones 6-7; R42 Zones7-8; R48 Zones 9,11).	2	0
			29	Attic pull-down or scuttle hole (R10).	1	0
			30	Attic pull-down or scuttle hole (R19).	2	0
			31	Insulate attic kneewall stud cavities (see Doc Guide for specifics).	3	0
			32	Attic kneewall stud cavities insulated with R13 with R5 sheathing towards attic.	4	0
			33	Attic kneewall doors insulated (R10).	1	0
			34	Attic kneewall doors insulated (R19).	2	0
			35	Install ceiling radiant heat barrier facing air space.	2	0
			Miscellaneous			
			36	Insulate hot water pipes to R-6 in unconditioned spaces.	2	0
			37	Loose-fill attic insulation card and rulers facing main attic access.	1	0
			38	Water heater with insulating blanket installed to manufacturer's specifications.	3	0
			39	House Insulation Package exceeds code by 20% (using RESCheck software)	8	0
			40	House Insulation Package exceeds code by 40% (using RESCheck software)	16	0
			41	House Insulation Package exceeds code by 60% (using RESCheck software)	24	0
			Window and Doors			
			42	Low-e windows (NFRC rated) w/ following U-values: *Zone 6 ≤ 0.46; Zone 7 ≤ 0.45; Zone 8 ≤ 0.41; Zone 9 ≤ 0.37; Zone 11 ≤ 0.29;*	3	0
			43	No metal-frame windows in house, including basements	1	0
			44	Inert gas-filled double glazed units. (e.g. argon gas filled)	1	0
			45	Exterior doors (includes door to garage) insulated to R5, or greater.	3	0
			46	10 year warranty on all insulated glazing.	1	0
Subtotal of points for this section					**0**	

Y	?	N	Comfort Systems--minimum 20 points		Points	Score
			Passive Solar Heating and Cooling Strategies			
			1	Ceiling fans (minimum of 3 fans) sized appropriately for space.	1	0
			2	Provide overhang (b/w 1 - 2 ft) above south windows as indicated in Doc Guide	3	0
			3	External strategies to reduce heat gain and/or heat loss through windows	5	0
			4	Orientation allows solar heating (long dimension w/in 15º East or West of solar south)	7	0
			5	East facing glazing less than 3% of floor area.	2	0
			6	West facing glazing less than 2% of floor area.	2	0
			7	South glass area is between 6-7% of total finished floor area.	5	0
			8	Home designed for passive solar heating (>20% per standards provided).	10	0
			9	Home designed for passive solar heating (>35% per standards provided).	20	0
			10	Home designed for passive solar heating (>50% per standards provided).	30	0
			Mechanical Comfort Systems			
			Ductwork			0
			11	Duct blaster test results indicate a leakage rate of 3% or lower of conditioned floor area.	6	0
			12	Ducts located within conditioned space (min 95%).	5	0
			13	Ducts sized and installed in accordance with ACCA Manual D.	3	0
			14	No panned joist space or unsealed cavities used as return air.	2	0
			15	Airflow for each room measured & balanced w/in 10% of ACCA manual J specifications.	3	0
			16	No ducts in exterior walls or vaulted ceilings.	3	0
			17	Ducts outside conditioned space sealed w/ mastic, insulated to R-8(supply), R-4(return).	2	0
			18	Transfer air grills or insulated jump-ducts or return-air ducts provided in every bedroom.	2	0
			19	Rigid supply trunk.	2	0
			20	Design Heating/Cooling system to function without ductwork.	5	0
			Controls			
			21	Programmable thermostat with “fan-only” switch.	1	0
			22	Zoning using 2 or more thermostats for single system, or zoning using separate systems.	5	0
			Equipment			
			23	87% or higher efficiency boiler with sealed combustion air.	6	0
			24	90% or higher energy efficiency furnace with sealed combustion air.	8	0
			25	90% or higher energy efficiency furnace w/ sealed combustion air+ modulating gas valve.	9	0
			26	SEER 12 cooling equipment (minimum of 75% total load).	4	0
			27	SEER 14 cooling equipment (minimum of 75% total load)	6	0
			28	HSPF 8.0 heat pump (75% total capacity). Provide outdoor thermostat for heat pump.	6	0
			29	HSPF 7.5 heat pump (75% total capacity). Provide outdoor thermostat for heat pump.	4	0
			30	Air handler located within conditioned space (all units).	5	0
			31	Cooling equipment has non-CFC and non-HCFC refrigerant.	3	0
			32	Enthalpy recovery ventilator (ERV) or air-to-air heat exchanger	9	0
			33	Drain waste heat recovery system installed (AIR HANDLER)	3	0
			34	Geothermal (ground source) heating and cooling system installed.	15	0
			35	In-floor heating system installed per requirements listed in Reference Manual.	10	0
			36	Responsible 3rd Party performs or reviews and approves Manual J Calculations	2	0
Subtotal of points for this section					**0**	

Y	?	N	Appliances, Lighting, Renewables--minimum 10 points		Points	Score
			Appliances			
			1	Refrigerator is an Energy Star labeled product or exceeds Energy Star criteria.	2	0
			2	Refrigerator is a super energy efficient product, rated to use less than 360 kWh.	4	0
			3	Dishwasher is an Energy Star labeled product or exceeds Energy Star criteria.	1	0
			4	Gas clothes dryer with electronic ignition.	2	0
			5	Gas cook top with electronic ignition.	3	0
			6	Provide list of energy efficient appliances to homebuyer if appliances are not included.	2	0
			7	High efficiency or tankless water heater (min Energy Factor: gas 0.62 electric 0.92).	1	0
			8	Geothermal or waste heat recovery water heating.	3	0
			9	Shower drain heat recovery device.	1	0
			10	Heat pump water heater installed.	5	0
			Lighting			
			11	Recessed light fixtures are compact fluorescents (1 per light, max. 3).	enter points	0
			12	50 % of light fixtures are fluorescent or have compact fluorescent light bulbs installed.	2	0
			13	75 % of light fixtures are fluorescent or have compact fluorescent light bulbs installed.	3	0
			14	100 % of light fixtures are fluorescent or have compact fluorescent light bulbs installed.	4	0
			15	Switchable automatic outdoor lighting controls. (e.g. motion/photo sensor).	1	0
			16	High efficiency exterior lighting (metal halide or high pressure sodium) with on/off switch.	1	0
			Renewables			
			17	Solar water heating system.	10	0
			18	Rough-in for future solar hot water heating (includes insulating pipes, wiring for controls).	3	0
			19	Provide solar electric (photovoltaic) panel for powering pump for solar hot water system.	3	0
			20	Solar electric (photovoltaic) system provides 25% or more of the home's electricity.	30	0
			21	Solar electric (photovoltaic) system provides 50% or more of the home's electricity.	50	0
			22	Solar electric (photovoltaic) system provides 75% or more of the home's electricity.	75	0
			23	Solar electric (photovoltaic) system provides 100% of the home's electricity.	100	0
			24	Provide battery back-up system for solar electric (photovoltaic) system.	10	0
			25	Provide solar electric (photovoltaic) powered well water pumping system	8	0
			26	Active Solar thermal heating system provides 40% or more of home's heating needs	12	0
			27	Active Solar thermal heating system provides 70% or more of home's heating needs.	24	0
			28	Active Solar thermal heating system provides 100% or more of home's heating needs.	36	0
			29	South roof area designed for future solar hot water/PV collectors w/in 30° of solar south	2	0
			30	Provide at least 25% of the power for a home using wind turbine technology.	30	0
			31	Provide at least 50% of the power for a home using wind turbine technology.	50	0
			32	Provide at least 20% of the electricity for the home using micro-hydro power generation.	20	0
			33	Provide at least 40% of the electricity for the home using micro-hydro power generation.	40	0
			34	Buyer enrolls for 1 year in NC GreenPower (see Doc Guide)	5	0
Subtotal of points for this section					**0**	

Y	?	N	Indoor Air Quality Opportunities--minimum 20 points		Points	Score
			1	House meets American Lung Association Health House standards.	8	0
			Structural Air Quality			
			2	Attached garage is isolated from house by extensive air-sealing.	3	0
			3	Detached garage in lieu of attached garage.	5	0
			4	Capillary break between foundation and framing.	1	0
			5	Drainage board for below grade walls.	4	0
			6	Continuous foundation drain at outside perimeter edge of footing.	2	0
			7	Vapor barrier placed in crawl space and/or beneath slab, above drainable substrate.	2	0
			Appliance Air Quality			
			8	Sealed-combustion solid fuel (ground bio-mass) burning stove w/ outside combustion air.	3	0
			9	Sealed-combustion gas or sealed wood-burning fireplace/stove w/ outside combustion air.	2	0
			10	Provide filters rated MERV 9 or greater on forced air systems.	2	0
			11	Install one hardwired carbon monoxide detector in mechanical equipment area.	1	0
			12	Low sone (1.5 or less) bath exhaust fan able to exhaust 50 cfm to the outside (all units).	3	0
			13	Ducts protected from dirt and debris until construction is completed.	2	0
			14	Automatic tub/shower room fan controls (e.g. timer/humidistat).	1	0
			15	Attached garage - exhaust fan controlled by motion sensor or timer.	2	0
			16	Radon/soil gas vent system.	3	0
			17	Whole house fan installed.	2	0
			18	Dehumidification system installed.	3	0
			19	Outside air intake with dampers.	3	0
			20	Radon test of home prior to occupancy.	2	0
			21	Kitchen range hood or downdraft vented to exterior (max. 200 cfm).	3	0
			22	Install a whole house HEPA filter.	6	0
			IAQ Material Use			
			23	Zero formaldehyde OSB (PMDI binder only) used in subfloor.	2	0
			24	Formaldehyde-free particle board/MDF used for cabinets.	2	0
			25	Formaldehyde-free particle board/MDF used for shelving/countertops.	2	0
			26	All surfaces of any particle board product painted w/ water-based sealer See Doc Guide	1	0
			27	Use paints and finishes that have minimal VOC content (max 150 g/L for light colors; max 250 g/L for dark colors) See Doc Guide for standards.	2	0
			28	Use non-toxic paints and allow VOC's to dissipate prior to occupation of dwelling.	4	0
			29	Only low toxicity, solvent free adhesives used throughout. See Doc Guide for standards.	2	0
			30	Use low VOC stains and finishes on wood floors and wood work.	2	0
			31	Use water-based urethane finishes on wood floors.	3	0
			32	Use low VOC carpet certified by the Carpet & Rug Institute.	1	0
			33	Ceramic tile installed with low toxic adhesives and plasticizer-free grout.	1	0
			34	100% Formaldehyde-free insulation throughout house.	1	0
			35	Environmentally safe spray foam or formaldehyde free, low VOC, low toxic insulation.	3	0
			36	Zero formaldehyde OSB (PMDI binder only) sheathing.	3	0
			37	Alternative termite treatment approved by the NC Dept of Agriculture. See Doc Guide	2	0
Subtotal of points for this section					**0**	

Y	?	N	Materials Opportunities--minimum 22 points		Points	Score
			1	House does not exceed 2500 square feet of conditioned area (excluding crawl space).	10	0
			2	House does not exceed 2000 square feet of conditioned area (excluding crawl space).	20	0
			3	House does not exceed 1500 square feet of conditioned area (excluding crawl space).	30	0
			Construction Material Waste			
			4	Prohibit burying construction waste and recycle job site waste (>25%).	3	0
			5	Prohibit burying construction waste and recycle job site waste (>50%).	5	0
			6	Prohibit burying construction waste and recycle job site waste (>75%).	7	0
			7	Central, organized cutting area for project site.	2	0
			8	Donation of excess materials or re-use of materials (min $500/job).	3	0
			9	Job site framing plan with locations of studs, joists, and roof structure with cut list.	3	0
			10	Drywall (recycle or grind and spread on site) (100%).	1	0
			11	Recycle wood waste (recycle or grind and spread on site) (100%).	3	0
			12	Recycle metal waste (100%).	1	0
			13	Recycle cardboard waste (100%).	1	0
			14	Recycle plastic(s) waste (100%).	1	0
			15	Recycle shingle waste (100%).	1	0
			Exterior/Structural System Materials			
			Slab/Foundation/Floor			
			16	Concrete with fly ash (min 25% fly ash).	3	0
			17	Recycled concrete or glass cullet used for aggregate in concrete.	2	0
			18	Floor framing lumber from third-party certified sustainably harvested sources.	4	0
			19	Engineered alternative replaces solid lumber (2x10 or greater) in 90% of floor framing.	3	0
			20	Oriented strand board (OSB) made from fast growth material.	1	0
			21	Continuous foundation termite flashing.	1	0
			22	Use non-solvent based damp proofing	1	0
			Wall			
			23	Wall framing lumber from third-party certified sustainably harvested sources.	3	0
			24	Engineered alternatives to wood framing for 80% of structure.	4	0
			25	Engineered wall framing (25% of studs).	1	0
			26	Finger-jointed studs for 100% of stud wall framing.	2	0
			27	All headers are steel (with thermal break) or engineered wood.	1	0
			28	Install window and door flashing per diagrams in the Reference Manual.	2	0
			29	Natural stucco, with drainage plane, on 50% or more of exterior wall area.	3	0
			30	Exterior cladding (min 3 sides with 40-year warranty or masonry).	1	0
			31	Back and edge-primed siding and trim.	2	0
			32	Indigenous stone on 50% or more of exterior wall area.	4	0
			33	100% of wood siding is certified as sustainably harvested, 50% of exterior wall area.	2	0
			34	Fiber cement siding on 50% or more of exterior wall area.	2	0
			35	Recycled/recovered-content siding on 50% or more of exterior wall area. See Doc Guide	1	0
			Roof/Ceiling/Attic			
			36	Roof framing lumber from third-party certified sustainably harvested sources.	3	0
			37	Engineered alternative replaces solid lumber (2x10 or greater) in 90% of roof structure.	2	0
			38	All beams are steel, engineered wood, or trusses.	1	0
			39	Fiber cement fascia and soffit.	2	0
			40	Use OSB roof decking.	1	0
			41	Engineered exterior trim including soffit, fascia, and trim.	1	0
			42	Recycled-content roofing material.	3	0
			43	Light roof color (tile or metal).	2	0
			44	Provide roof drip edge.	1	0
			45	Roof gutters/downspouts that discharge water 5 feet away from foundation.	1	0
			46	Covered entry ways (all doors; min. 2'-0" deep, max. 2'-0" above door).	2	0
			Miscellaneous			
			47	Recycled-content (minimum 25%) insulation.	1	0
			48	Recycled-content (minimum 75%) insulation.	2	0
			49	HCFC-free rigid foam insulation.	1	0
			50	40% of outdoor structures and landscaping materials made from recycled materials.	2	0
			51	Outdoor structures made from 3rd-party certified sustainably harvested lumber.	3	0

Y	?	N		*Materials Opportunities Continued… (min 22 points)*	Points	Score
			52	Floor plan adheres to 2-ft dimensions.	2	0
			53	Use of any additional appropriate engineered wood products not already specified	3	0
			54	Specify salvaged, reclaimed or refurbished materials for 10% of structural materials	5	0
			55	Finger-jointed plate materials used.	2	0
			56	Engineered plate materials used	2	0
			57	Recycled-content sheathing used. (minimum 50% pre or post-consumer)	1	0
			58	Provide 34" doors to all habitable rooms, all hallways shall be at least 42" clear, finished.	2	0
			59	One accessible bathroom on main floor with blocking for future accessory installations.	2	0
			Interior Materials			
			Floor			
			60	Install min. 25% regionally obtained salvaged materials for 25% of floors & interior trim	4	0
			61	Natural cork or 100% recycled or recovered content underlayment used (no Luan)	3	0
			62	Soft or hard flooring/padding containing 50-100% recycled-content.	2	0
			63	No use of permanently installed carpeting in the home.	3	0
			64	Natural fiber carpet made with natural latex rather than SB latex backing.	2	0
			65	Natural linoleum in place of any vinyl sheet flooring or vinyl composition tile	3	0
			66	25% of flooring made from rapidly renewable resource material (engineered product ok).	2	0
			67	25% wood flooring-interior trim regionally obtained and certified as sustainably harvested	3	0
			Walls/Trim/Ceiling			
			68	Paints or finishes with recycled-content.	1	0
			69	Engineered interior trim--Finger-jointed and/or MDF trim.	1	0
			70	Recycled and/or recovered content gypsum wallboard.	2	0
			Miscellaneous			
			71	No Luan doors (tropical hardwood).	2	0
			72	Doors made from third-party certified sustainably harvested wood.	2	0
			73	Recycled and/or recovered content doors.	2	0
			74	100% agricultural waste or 100% recycled wood particleboard/MDF for shelving/countertops.	3	0
			75	Interior living space adheres to 2-ft dimensions.	3	0
Subtotal of points for this section					**0**	

Y	?	N		**Bonus Opportunities--minimum 2 points**	Points	Score
			1	Built-in kitchen recycling center with two or more bins.	3	0
			2	Provide local recycling contact.	1	0
			3	Provide household hazardous waste resources.	1	0
			4	Environmental checklists provided subcontractors as applicable. See Doc Guide	4	0
			5	Markets NC HealthyBuilt Homes program.	2	0
			6	Provides environmental features checklist for walk through to owner.	3	0
			7	Home safety certification.	1	0
			8	Accessibility certification. (provided by the Center for Universal Design @ NCSU)	5	0
			9	Include back up generator using Fuel Cell technology of 1 kW or larger size.	6	0
			10	Innovation points - Builder submits specifications for innovative products or design (1-10)	enter points	0
			11	Builder is enrolled in Community HealthyBuilt Homes Program	2	0
Subtotal of points for this section					**0**	

Total Overal Score for Program	**0**

RATING SCALE
125-150 points: Certified
151-200 points: Bronze certified
201-250 points: Silver certified
251+ points: Gold certified

Resources

Advanced Energy- *www.advancedenergy.org*

American Solar Energy Society- *www.ases.org*

Department of Energy- *www.energy.gov*

Florida Solar Energy Center- *www.fsec.ucf.edu*

Oak Ridge National Laboratory- *www.ornl.gov*

National Renewable Energy Laboratory- *www.nrel.gov/buildings_thermal*

North Carolina Solar Center- *www.ncsc.ncsu.edu*

North Carolina State Energy Office- *www.energync.net*

North Carolina Sustainable Energy Asscociation- *www.ncsustainableenergy.org*

Southface- *www.southface.org*

Sustainable Buildings Industry Council- w*ww.sbicouncil.org*

Western North Carolina Green Building Council- *www.wncgbc.org*