

SAMPLE: SEND YOUR STATE EXTENSION OFFICE NAME AND LOGO TO THE NC SOLAR CENTER FOR CUSTOMIZED PDF

BUILD A HIGH PERFORMANCE HOUSE, EARN TAX CREDITS

What is a High Performance Home?

The majority of today's homes are built using construction methods that have been used for decades. Recently there have been dramatic advances in building science, equipment, materials, and construction techniques, due in part to the Department of Energy's Building America Program. Partial implementation of these advances create the potential for quality problems; proper integration throughout the home is key and creates a high performance home. For example, houses can easily be better insulated and built tighter (have less air leakage). This can create a home that uses less energy, but unfortunately when energy efficiency is the only consideration in a home the likelihood of indoor air quality and moisture problems increase. It is important that an energy efficient home integrate fresh air ventilation, reduction of interior moisture, and other high performance strategies. *While this brochure focuses on energy reduction*, to build a high performance home it is critical to integrate low-energy strategies with other strategies that provide safety, durability, and comfort.



Figure 1: Habitat for Humanity framing crew at work

Source: Habitat for Humanity of Catawba Valley

2006-2007 Federal Tax Credits

The Energy Policy Act (EPAct) of 2005 established tax credits for very energy efficient new homes, energy efficient water heating and HVAC (Heating, Ventilation, and Air Conditioning) equipment, energy efficiency improvements to existing homes, and solar energy systems. It is important to note that these are **tax credits and not tax deductions**. This means that the builder or homeowner reduces the amount of federal tax they owe by the full amount of the tax credit they earned. The EPAct established these credits for a period of two years, 2006-2007, **in late 2006 the solar credits were extended to the end of 2008**. New legislation that extends one or more of these tax credits further into the future is being considered. For updates visit www.energytaxincentives.org.

The categories of the building energy tax credits are introduced below. More about earning each credit begins on page two.

- **Energy Efficient New Home:** \$2,000 tax credit to the *homebuilder* of a house that is certified to use 50% less energy for heating and cooling than the same house built to the 2004 International Energy Conservation Code (IECC).
- **Energy Efficient HVAC and Water Heating Equipment:** Up to \$500 (combined between credits #2 and #3 on this list) to a *homeowner* for purchasing qualified energy efficient heating, cooling, and water heating equipment.
- **Energy Efficient Building Shell Retrofits:** Up to \$500 (combined between credits #2 and #3 on this list) to a *homeowner* for improvements to the building shell (windows, insulation, air sealing, etc) of an existing house.
- **Renewable Energy System Installation:** 30% tax credit, up to \$2,000, to a *homeowner* for the purchase and installation of photovoltaic (electricity producing), solar water heating, and fuel cell systems. (2006-2008)

The Climate of the Southeast

Two Building America climate regions dominate the Southeast, shown as Mixed-Humid and Hot-Humid on the map below. As the names indicate, both climate regions **are noted for high humidity levels**. The Hot-Humid region has a short and very mild winter, whereas the Mixed-Humid region has a mix of hot summers and cool to cold winters. In both regions, designers and builders face the challenge of controlling the infiltration of moisture-laden air into the house and keeping moisture away from cold surfaces where condensation may degrade structural materials and contribute to mold growth. Most of the region has a mix of heating and cooling needs, so reaching the new home tax credit standards **requires strategies and equipment efficient for both heating and cooling**.

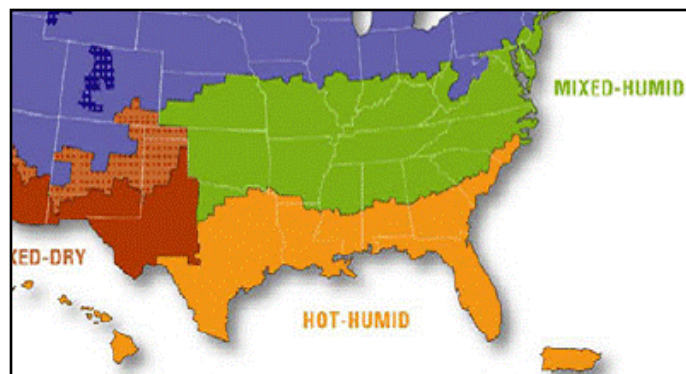


Figure 2: Building America Climate Regions

Source: Building America Program of the US Department of Energy

Build 50% More Energy Efficient Than Code...Earn a \$2,000 Tax Credit!

The EAct of 2005 established a federal tax credit for builders for each home built which uses 50% or less of the energy for heating and cooling as the same home built to the 2004 International Energy Conservation Code. This section will explain what a builder needs to know to build a home in the Southeast which meets this criteria and earn a \$2,000 tax credit per qualifying home. Beyond the benefits of greatly reduced energy costs and a tax credit, many of the improvements discussed provide other significant benefits such as healthier air, less susceptibility to mold/mildew/decay, and more comfort.

Home Energy Raters (HERs) and RESNET

In order to receive the credit a home must have its expected heating and cooling energy use calculated by a qualified **Home Energy Rater (referred to as a HERs rater)**. Fortunately, HERs raters are required for a home to achieve an ENERGY STAR designation, so there may be little to no added expense necessary for the ENERGY STAR builder working to earn the \$2,000 tax credit. For more information see www.RESNET.us

Energy Savings Certified by Computer Program

The predicted certified energy savings of a *tax credit* home must be calculated by a Residential Energy Services Network (RESNET) approved computer program. This is done by a HERs rater, hired by the builder, using one of the approved programs (currently there are two). The program builds an accurate model of a home using inputs such as window location, insulation, HVAC system specifics, blower door test results, and more. The program also builds a *base model* of the home built to just meet the 2004 IECC energy code. It then runs a simulation of the homes' heating and cooling energy use for a typical year which predicts the annual heating and cooling energy savings of the actual home compared to the *base model* home. Additionally, the program calculates the energy savings attributable to the building envelope. **If the total heating and cooling energy savings are 50% or higher and the building envelope savings are 10% or higher**, then a home qualifies for the \$2,000 tax credit.

How to Achieve 50% Energy Savings

There are many ways to achieve the \$2000 tax credit. To start a discussion of how to build homes that use 50% less energy it is critical to begin by understanding the basics of energy use in a home and the concept known as '**The House is a System**'. Resources created by the *Building America Program* or other *Department of Energy* programs are provided and include the details necessary to understand and properly implement each concept or technique. Listed below are

several broad resources on building a high performance energy efficient home in the Southeast.

GENERAL HIGH PERFORMANCE BUILDING RESOURCES FOR THE SOUTHEAST:

Hot & Humid Best Practices Guide (Building America):

www.nrel.gov/docs/fy05osti/36960.pdf (137 pages)

Mixed & Humid Best Practices Guide (BA):

www.nrel.gov/docs/fy05osti/38448.pdf (139 pages)

Read This Before You Design, Build, or Renovate (BA):

www.eere.energy.gov/buildings/building_america/pdfs/db/32114.pdf (28 pages)

1995-2002 Lessons Learned in Building America projects:

www.nrel.gov/docs/fy03osti/33100.pdf (36 pages)

Whole Building Approach Benefits (BA):

www.nrel.gov/docs/fy01osti/27745.pdf (8 pages)

The House *is* a System

The understanding that 'The House is a System' is one of the foundations of building science. This concept is focused on the reality that every change in construction technique, every new building product, will affect the homes' performance and must be adequately evaluated. Will it affect moisture, heat, or air flow? Will it affect air quality or how the house interacts with the environment? Many times the answer to these questions is yes. Therefore all changes to a building, even improvements, must be carefully considered from all angles to avoid negatively affecting another aspect of the home.

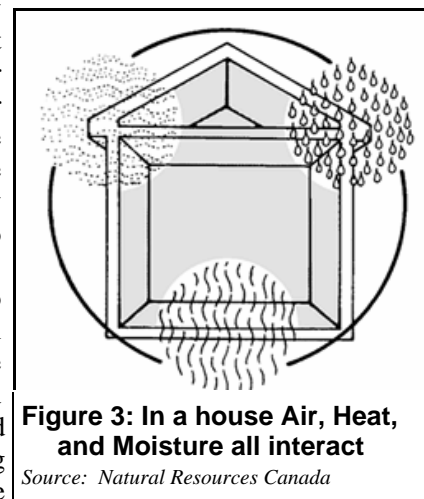


Figure 3: In a house Air, Heat, and Moisture all interact

Source: Natural Resources Canada

How to Use this Brochure:

- Resources are provided at the end of each section. For link updates visit: www.healthybuilt homes.org/docs/Resource_Link_Updates.pdf
- Building Energy Tax Credit category reference guide:
 - Energy Efficient (EE) New Home** (pages 3-10)
 - EE HVAC and Water Heating Equipment** (page 10)
 - EE Building Shell Retrofits** (page 11)
 - Renewable Energy (RE) Systems** (page 11)
- Separate flyers on each construction technique are available. Check with your extension agent for a local version or download from the NC Solar Center website at www.ncsc.ncsu.edu.

Energy Use and Savings in a Home

The graph below shows energy use in the average Southeastern US home. Clearly, heating and cooling account for a very large portion of the energy use in a home. Happily, the builder can have a significant impact on heating and cooling energy use. Let's begin by *building it tight*.

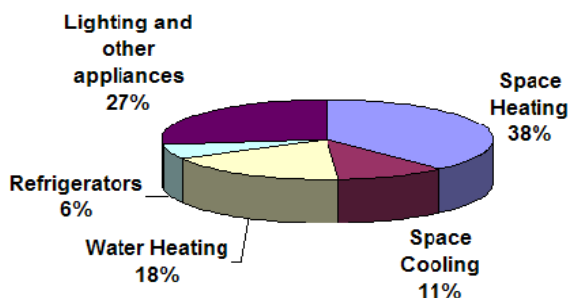


Figure 3: Average total energy use for homes in Mixed-Humid and Hot-Humid climates

Source: Energy Information Administration, Table CE1-1c. Total Energy Consumption in U.S. Households by Climate Zone, 2001

Reduce Air Leakage, Build it Tight

Air infiltration often accounts for 30% or more of a home's heating and cooling costs, and contributes to problems with moisture, noise, dust, and the entry of pollutants, insects, and rodents. *Reducing air infiltration can significantly cut annual heating and cooling costs, improve building durability, and create a healthier indoor environment.* Building tight may decrease the required size of HVAC equipment, saving additional dollars. Reducing air leakage in new homes has a low material cost and does not require specialized labor.

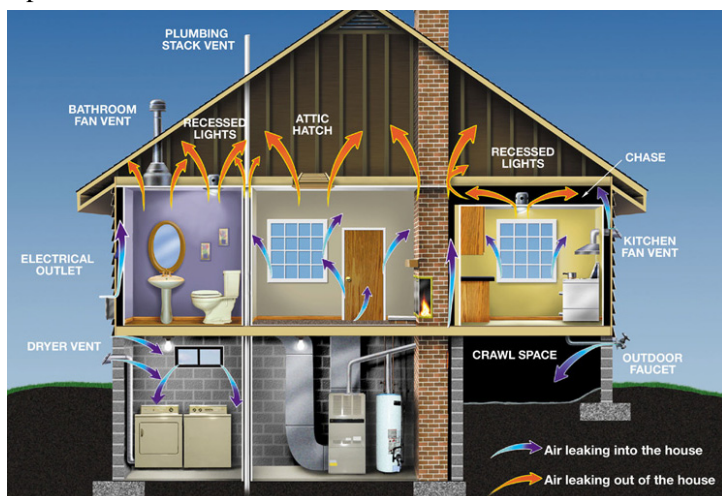


Figure 4: Common building envelope air leakage sites

Source: EPA ENERGY STAR Program

The image above diagrams some of the most common locations of air leaks. Creating a *continuous* air barrier around the conditioned portion of the home is necessary to reduce air leakage. The more continuous the air barrier, the tighter the

home. Air barriers are systems of materials used to control airflow in building enclosures; they keep outside air out and inside air in. Rigid materials such as gypsum board, exterior sheathing materials like plywood or OSB, and supported flexible barriers are typically effective air barrier systems, *if joints and seams are sealed*. Air barriers can be located anywhere in the building enclosure—at the exterior surface, the interior surface, or at any location in between. Wherever they are, air barriers should withstand construction abuse and remain durable over the expected lifetime of a building.

An air barrier is not necessarily a vapor barrier. A vapor barrier is a material that does not allow water vapor to pass through it. Breathability is the term used to refer to the ability of a material to allow vapor to pass through it and is measured in perms. A material with a perm rating of less than 0.1 perms is considered a vapor barrier. OSB, plywood, most house wraps, and building paper can all act as air barriers yet allow some water vapor to pass through, thus allowing drying.

- *The use of a vapor barrier should be avoided in mixed humid climates so that the wall assembly may dry to both the interior and exterior of the home.*
- *In hot humid climates, no vapor barrier should be installed on the interior of the wall to allow for year round drying to the interior of the home.*

Once home construction is complete many of the air sealing details will no longer be visible, but it is still possible to test the quality of the air barrier. This test uses an instrument known as a *blower door* and is conducted by a certified **HERs rater**, often in less than an hour. The result of this test plays a large role in the predicted energy efficiency of a home. A house can not be too tight as long as it is properly ventilated (see Ventilation)

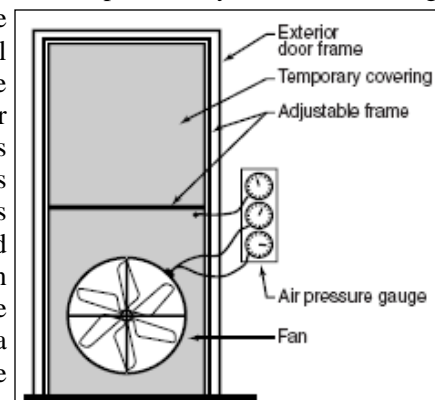


Figure 5: Blower Door equipment

Source: Southface Energy Institute

AIR SEALING RESOURCES:

Air Sealing Overview (Building America):

www.nrel.gov/docs/fy00osti/26446.pdf (4 pages)

Air Sealing Guide (Southface):

www.habitat.org/env/pdf/air_sealing.pdf (4 pages)

Understanding Air Barriers (Building Science Corp.):

www.buildingscience.com/resources/2-Understanding_Air_Barriers.pdf (10 pages)

Air Sealing Example Scope of Work (Comfortwise):

www.eere.energy.gov/buildings/building_america/pdfs/db/35626.pdf (2 pages)

Ventilation

Designers and builders of energy efficient homes work hard to limit uncontrolled air infiltration through the building walls, ceilings, and floors by creating a tight air barrier. The result of this lower energy use is less fresh air naturally finding its way into a home. The rate of this *natural infiltration* is unpredictable and uncontrollable because it depends on pressure differences affected by the home's air tightness as well as outdoor temperatures, wind, and other factors. Natural infiltration can allow contaminated air to enter from a polluted area, such as a garage or crawlspace. The solution to these problems is to install a **designed ventilation system** for providing fresh, clean air.

The most direct strategy is *spot ventilation*, used to expel moisture or pollutant laden air at the source. This includes, at minimum, exhaust fans in bathrooms and above kitchen cook tops ducted to the outside and capable of adequate air movement. In a humid climate, spot ventilation should be a part of every ventilation system.

Whole-house ventilation strategy options are classified as:

- **supply ventilation** (fan(s) force outside air into the home)
- **exhaust ventilation** (fan(s) force inside air out)
- **balanced ventilation** (fan(s) force equal quantities of air in and out).

A common, recommended **supply ventilation** strategy uses the air handler of the HVAC system to provide a small amount of fresh air when the HVAC fan is operating. This strategy can be improved further with a fan cycling device that turns the air handler on using a time schedule to provide adequate ventilation even when no heating or cooling is needed. The energy to run the air handler fan in this manner has been shown to be small, less than \$50 per year, depending primarily on the home's size. An example of supply ventilation coupled with spot ventilation is shown in the diagram below.

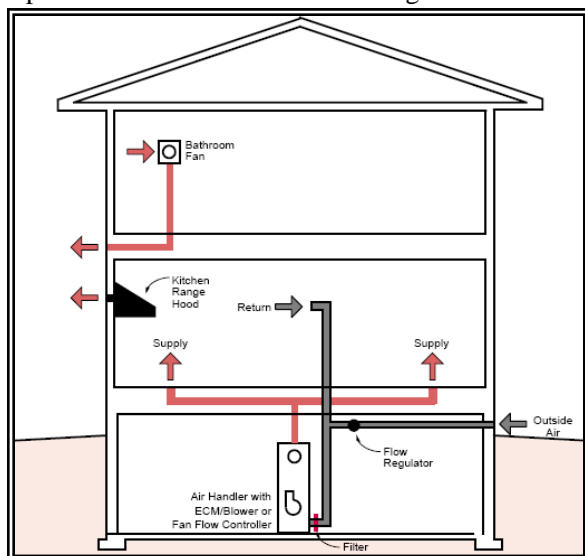


Figure 6: Spot ventilation & HVAC integrated supply

Source: Asthma Regional Coordinating Council of New England

Warm humid climates should **avoid exhaust ventilation** as their sole ventilation strategy. Why? As warm humid air from outside comes inside to replace the exhausted air, it contacts cool surfaces that can create condensation, thereby increasing the potential for mold growth and decay of the structure.

Energy Recovery Ventilators (ERV) are air-to-air heat and moisture exchangers that can reduce the energy needed to heat and cool the fresh air brought into the home via ventilation; however, these systems are costly. ERVs, like other strategies, have merits, shortcomings and cost tradeoffs to be considered.

VENTILATION RESOURCES:

Spot Ventilation (Building America):

www.nrel.gov/docs/fy03osti/26466.pdf (4 pages)

Whole House Ventilation Systems (Building America):

www.nrel.gov/docs/fy03osti/26458.pdf (6 pages)

Ventilation Activities in the Building America Program:

www.nrel.gov/docs/fy01osti/30107.pdf (32 pages)

Air Distribution Systems—DUCTS

The quality of duct system design and installation can vary greatly between a typically constructed home and a high performance home. The differences in *comfort, indoor air quality, and energy efficiency* can be large. The material and labor costs needed to achieve a high performance duct system are rather modest. Additionally, efficient duct system design can reduce equipment size, saving money to immediately offset the cost increases associated with the improved duct design. Duct systems that leak and/or do not distribute air properly throughout the house can create hot and cold rooms. Duct systems that are undersized, pinched, or have numerous bends and turns can lead to low air flow rates and high air velocities. Low air flow rates decrease the efficiency of the heating and cooling system. High air velocities increase noise.

Leaky and unbalanced duct systems often force conditioned air out of the home and bring unconditioned air into the home. This increases energy costs and can draw humidity, dust, mold spores, and other contaminants into a home from the attic, crawlspace, or garage and radon gas from soil below the house. In extreme cases, tight building envelopes coupled with poorly designed and/or installed duct systems can induce **backdrafting**—spillage of flue gases from combustion appliances (e.g., furnace, water heater, fireplace) into the living space. This occurs primarily when using natural-draft flues instead of power-vented flue systems.

Bring Ducts into Conditioned Space

Often, ducts are located in unconditioned spaces such as attics and crawlspaces. *When located in these environments, even well-insulated tight duct systems lose or gain significant unwanted heat and exchange air with these spaces.* This problem can be eliminated by locating the ducts and the air handler in conditioned space. Several ways to accomplish this are covered in detail in the provided resources.

Some of the more common methods of bringing ducts into conditioned space are:

- *leave the ducts in the crawlspace, but seal, insulate, and condition the crawlspace*
- *use open web trusses for the floor assembly so ducts can run in the floor*
- *add a dropped ceiling in which to run ducts*

No matter how the duct system is brought into conditioned space, the energy efficiency benefits will be rather large, at potentially little to no net cost increase. The home's indoor air quality and the house's durability are also likely to improve by moving the ducts inside. **Of note: It is difficult to achieve the \$2,000 tax credit without bringing the ducts inside conditioned space.**



Figure 7: Duct in floor

Source: US Department of Energy

air from outside, the attic, or the crawlspace into the home. Potential solutions are to either provide a return in each area/room of the home with a supply or to install other air pathways (such as a jumper duct) to give the air an easy route back to the HVAC return. Several of the Building America resources listed below provide detailed descriptions of the various methods available to create a home without air pressure balancing problems.

DUCT RESOURCES:

Better Ducts for Heating and Cooling (Building America):

www.nrel.gov/docs/fy05osti/30506.pdf (12 pages)

Air Distribution System Design (DOE):

www.toolbase.org/PDF/DesignGuides/doe_airstributionsystemdesign.pdf (6 pages)

Duct Installation and Sealing Guide (DOE):

www.eere.energy.gov/buildings/info/documents/pdfs/air_dist_sys_install_seal-0783.pdf (6 pages)

Interior Duct Systems (in conditioned space) (FSEC, BA):

www.eere.energy.gov/buildings/building_america/pdfs/db/34803.pdf (18 pages)

Heating and Cooling Systems

Regions with primarily cooling climates should focus more design attention as well as expenditures on a home's cooling system than on its heating system; for mixed climates with fairly similar heating and cooling needs, attention to both heating and cooling needs is essential. Some common HVAC system options are introduced below.

Heat Pump (SEER & HSPF are efficiency ratings)

There are many types of heating and cooling systems. most of these can be used in a home that earns the energy efficiency tax credit. See the Sample 'Tax Credit Homes' on pages 9-10 of this brochure for a few examples.

A heat pump is an electrical device that efficiently extracts heat or coolness from outside air to provide both heating and cooling, depending on the season. Cooling mode efficiency is most often reported in **SEER**, Seasonal Energy Efficiency Rating; SEER 13 is the federally mandated minimum for equipment manufactured after January 1st, 2006. The higher the SEER, the more energy efficient the unit, assuming it is installed as the manufacturer specifies. *Often heating and cooling systems, such as heat pumps, are improperly installed. **Poor installation causes the in-use SEER to be up to 40% lower than the homeowner purchased.***

The heating efficiency of a heat pump is measured in **HSPF**, Heating Season Performance Factor, and the current federally mandated manufacturable minimum is 7.7. Like SEER, a higher HSPF indicates a unit with a higher heating efficiency. Also similar to SEER, achieving the rated HPSF of a unit is contingent on proper installation.

Test Duct System Air Tightness

Proper design and installation of ducts, including tightly air sealing the ducts with mastic (a plaster-like material that is painted on), provides the homeowner with quiet, comfortable, and energy efficient delivery of conditioned air. The tightness of the ducts is tested with a **duct blaster**, which operates similarly to the blower door. The duct blaster test is administered by a HERs rater and the test

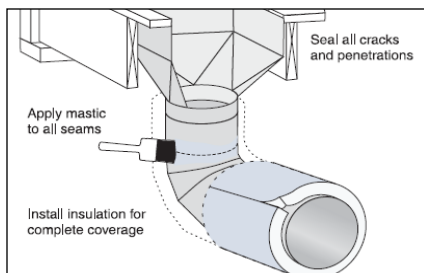


Figure 8: Proper Duct Sealing

Source: Building America, US DOE

results have a dramatic affect on the home's modeled and actual energy use.

Balancing Air Pressure Between Rooms

A tight home that is safe and comfortable must include a well designed HVAC system which creates rooms that are at similar air pressures; a much higher or lower air pressure in one room compared to other regions of the home can cause safety concerns, such as backdrafting. This can happen when a room has a supply duct, but the room's air does not have easy access to a return duct. An example of this is when a door to a bedroom with a supply vent in it is closed. The closed door can cause the bedroom to become pressurized and leak conditioned air to the home's exterior. The room where the return is located is starved of air and is depressurized, causing it to suck unconditioned (possibly hot, cold, dirty, or humid)

Geothermal Heat Pumps (Ground-Source)

Geothermal heat pumps, also known as **ground-source** or **water-source** heat pumps, operate as a typical heat pump with one exception: they *extract heat and coolness from the ground (or groundwater) instead of the outside air*. This greatly increases the heating and cooling energy efficiency of these units compared to an air-source heat pumps. Why? This is due to the fact that the range of temperatures below ground in the Southeast is narrow and close to human comfort levels. Depending on location, the ground temperature is 60° to 75° and fairly constant year round, while the air temperature can range from 0° to 100°! *This allows geothermal heat pumps to be significantly more energy efficient, typically 1.5 to 2 times more efficient, than air-source heat pumps.* The downside to geothermal systems is their high first cost, largely due to the installation of the below ground pipes used to exchange heat with the ground.



Figure 9: Geothermal heat pump with vertical loop

Source: US Department of Energy

Air Conditioner with a Gas Furnace

This is a common heating and cooling package that uses a central air conditioner, which is essentially a heat pump with only a cooling mode, and a natural gas furnace. This combination system is often referred to as a ‘gas pack’. Gas furnaces come in a range of efficiencies and can be a very cost effective method of heating, especially in colder climates that limit the performance of heat pumps. Efficient operation depends on proper installation and maintenance. As heat pump performance increases, gas packs grow less popular.

Hydronic Heating, including Radiant Floors

Hydronic heating uses hot water to supply heat to the home. This can be done by passing air over a coil of hot water pipe and distributing this heat using the central air conditioner’s fan and ducts, or it can be done by imbedding special plastic pipes into the floor of the home and running warm water through these pipes. This second option is known as **radiant floor heating**, which is an extremely comfortable and increasing popular way to provide heat. The water in a hydronic heating system can be heated by a dedicated boiler or combined with the home’s hot water system. In many instances, a solar hot water system can work well in conjunction with a radiant floor system, affordably heating the home with solar energy. The solar aspect of the system can not be counted toward the new home energy efficiency tax credit, however, it is eligible for a federal renewable energy personal tax credit (see page 11).

Right-Sizing HVAC Systems

Individual heating and cooling system sizes should be selected based on the building design loads for the house. **Simplistic sizing rules of thumb (e.g., Btu per square foot of conditioned floor area) are unacceptable.** The Air Conditioning Contractors of America (ACCA) Manual J calculation procedures are the industry standard (www.acca.org). ACCA’s Manual J Residential Load Calculation estimates design heating and cooling loads by considering climate and house-specific variables such as: insulation level(s); window size(s), tint, and orientation; shading/exposure; air infiltration; duct location; and number of occupants. Sufficient safety factors are built into ACCA’s methodologies, so there is no need to deviate from ACCA recommendations and/or add margins of safety.

The problem of A/C oversizing is of particular concern in the humid Southeast because it greatly limits the air conditioner’s ability to dehumidify the air. This leads to high humidity levels in the home which can be uncomfortable and lead to mold, mildew, and rot. When an A/C system is oversized it often provides adequate cooling while operating short periods of time, however air conditioners do not remove much moisture from the air until they have been running for at least several minutes and have fully cooled and wetted the coil. Therefore, when an oversized A/C starts and stops often, only running briefly each time, it does not operate long enough each cycle to remove much moisture from the air. This short cycling also uses more energy (i.e. operates at a lower-than-purchased SEER) and causes greater equipment wear and tear than a right-sized unit running for long periods of time.

Programmable Thermostat

Programmable thermostats automatically adjust temperature settings during the day and week to save energy. For example, in the winter programmable thermostats set the temperature lower during weekly work hours when the home’s occupants are out of the house. Temperature setbacks can be performed manually using standard thermostat models, but a consistent pattern is usually not achieved in practice. *A programmable thermostat is a relatively inexpensive way to increase the energy efficiency of your home.*



Figure 10: Programmable Thermostat

Source: ENERGY STAR Program

HVAC RESOURCES:

Heating & Cooling Equipment Selection (BA):

www.nrel.gov/docs/fy02osti/26459.pdf (4 pages)

Central Heat Pump and Air Conditioner Installation (BA):

www.eere.energy.gov/buildings/info/documents/pdfs/central_heat_pump_ac_install-0781.pdf (6 pages)

HVAC RESOURCES, continued**Right-Size Your Equipment (BA):**www.nrel.gov/docs/fy02osti/31318.pdf (6 pages)**Combustion Equipment Safety (BA):**www.nrel.gov/docs/fy01osti/26464.pdf (4 page)**Dehumidification System Research—Hot-Humid (BA):**www.nrel.gov/docs/fy05osti/36643.pdf (32 pages)**The How and Why of Your High Performance HVAC (BA):**www.eere.energy.gov/buildings/building_america/pdfs/db/35009.pdf (1 page)

Windows and Doors

Windows and doors add immensely to the beauty, comfort, and style of a home, however they also provide easy pathways for heat, air, and moisture which can lead to higher energy use and moisture problems. It is important to keep both of these in mind when designing and building a high performance home.

Limit Unwanted Heat Gain/Loss

Quality, well-installed windows are a must in an energy efficient home, however, even highly insulated windows offer only one quarter or less of the insulation value of a typical wall and collect unwanted solar heat in the summer. This means that the total area of windows should be considered and limited where appropriate. **Double pane Low-E windows offer affordable high performance.** The U-Factor of a window is a measure of how easily it allows heat to pass through it, smaller numbers indicate a better ability to insulate.

Limit Unwanted Solar Heat Gain

Much of the Southeast has warm or hot summers that require months of air conditioning. Unlike in the winter when the

temperature difference between inside and outside is as much 60 degrees or more, the outside summer air is often only 10 to 20 degrees higher than the desired indoor temperature. This means that heat gain due to outside air temperatures is not very dramatic. What is dramatic is the summer sun that can stream into windows, glass doors, or skylights. The first

Figure 11: National Fenestration Rating Council Example Label

Source: National Fenestration Rating Council

ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	0.32
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./I-P)
0.51	0.2
Condensation Resistance	
51	—

sunshine that can be hard to stop with typical roof overhangs. So, the area of East and West facing windows in regions with hot summers should be limited. Porches or other structures on the East and West can do a wonderful job of blocking summer sun before it can reach windows. Shade trees also do a good job of this. South facing windows with adequate overhangs do a great job of shading out summer sun, yet allowing in winter sun (see Passive Solar Design). North facing windows receive almost no direct sun in the summer or winter, so they collect little solar heat, but provide nice daylighting.

The second line of defense against summer sun is a type window glass that limits the amount of solar heat that passes through it. The portion of solar energy that any given window allows to pass through is indicated by the window's Solar Heat Gain Coefficient (SHGC).

- *Climates with significant cooling seasons should generally strive for windows with a SHGC of 0.40 or less*

WINDOWS AND DOORS RESOURCES:**Window Selection (Building America):**

www.eere.energy.gov/buildings/info/documents/pdfs/window_selection-777.pdf (6 pages)

Passive Solar Design

Windows can also be positioned and designed to allow use of the winter sun to provide heat to the home. This is known as passive solar heating. **The winter sun travels rather low across the southern sky, while the summer sun takes a much higher path.** This allows ample South facing glass to be unshaded all winter long and collect the sun's heat.

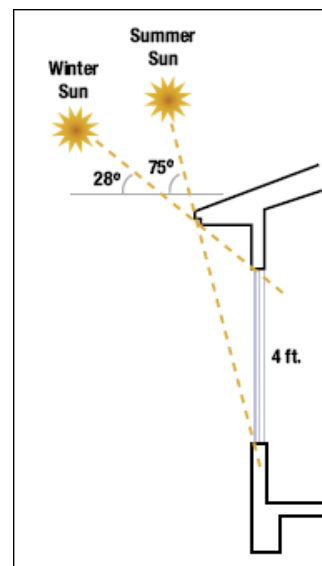


Figure 12: Overhangs key to passive solar design

Source: US Department of Energy

In the summer, the higher sun is blocked from entering these same South facing windows by a properly sized and positioned overhang. Homes with a large amount of south facing windows may need additional thermal mass (a material to collect and hold solar heat in the day for release at night) in order to avoid daytime overheating in the winter. Passive solar design is most useful in the cooler areas of the Southeast, which have substantial winter heating needs.

PASSIVE SOLAR RESOURCES:**Passive Solar Factsheet (EERE):**

www.nrel.gov/docs/fy01osti/29236.pdf (4 pages)

line of defense against this costly solar heat is thoughtful placement of windows and overhangs. The path of the summer sun causes the East and West ends of the home to receive several hours each of intense

Insulation

Properly installed insulation keeps heat where it's wanted for maximum energy efficiency. Any insulation type that has vapor permeability (breathability) is acceptable in an energy efficient high performance home. Common insulation types include cellulose, fiberglass, and foam. Blown foam can serve as an air barrier as well as insulation, but air sealing must be accomplished by a separate component or system when cellulose or fiberglass is used.

How much insulation a home needs depends on the local climate, the home design, and other building features. Using a systems approach, insulation should be integrated with other building features to reach the desired energy use. Building codes require more insulation in colder climates.

To reach the required 50% heating and cooling energy savings of the tax credit, more insulation than required by code will likely be necessary for an economical design.

Proper Insulation Installation

The performance of insulation is measured in R-value; the higher the value the better the insulation. *An insulation's rated R-value assumes that it has been installed to manufacturer's specifications.* Any imperfections in the installation such as missing insulation, compressed batts, or space for air to bypass the insulation reduces the performance of the insulation. HERs raters are trained to rate insulation installations from acceptable (Grade III) to best (Grade I). Any installation graded below Grade I will have the R-value of the insulation down-graded in the certifying software.



Figure 13: Proper insulation installation

Source: Advanced Energy

Advanced Framing

Advanced framing, or optimum value engineered (OVE) framing, is a collection of wood-stud construction techniques that increase the amount of insulation in walls by removing wood, without compromising the strength of the wall. Several common strategies include:

- **2-Stud or California Corners**
Typical stud corner framing leaves no room for insulation; 2-stud corners leave room for some insulation.
- **Ladder Framing**
Framing that looks like a ladder where an interior partition attachment meets an insulated exterior wall.
- **Raised Heel or Energy Heel Trusses**
Trusses provide adequate vertical clearance at the attic perimeter for the full desired thickness of ceiling insulation.

Sealed Crawlspace

In the south vented crawlspaces are common, unfortunately, vented crawl-spaces in humid climates can lead to serious moisture and energy problems. A sealed crawlspace blocks entry of moisture from both the soil and humid outside air. *This keeps the crawlspace drier. Because it is difficult to completely seal a house off from a crawlspace, a dry crawlspace often results in a dry home.* A sealed crawlspace can be insulated either on the interior of the foundation walls (leaving a termite view strip at the top) or under the first floor. The construction of sealed crawlspaces is not recommended in areas prone to flooding or standing water. In these cases a raised slab or foundation piers may be considered.

Properly Insulate Slab Foundation

Slab foundations can be difficult to properly insulate, but proper slab insulation is important for a tax credit home. See Insulation Resources below for acceptable insulation options.

Attic Radiant Barrier

Anyone who has been into an attic in the summer in the South knows the huge effect the sun can have on the temperature of an attic. Much of the heat that enters an attic in the summer gets there as thermal radiation coming off the underside of the hot roof deck. A radiant barrier is a highly reflective material that greatly reduces the roof deck's ability to radiate its heat into the attic. This inexpensive simple product can create very meaningful savings.



Fig. 14: Radiant Barrier

Source: Southface

INSULATION RESOURCES

Advanced Framing (DOE):

www.nrel.gov/docs/fy01osti/26449.pdf (6 pages)

Insulation Fact Sheet (DOE):

www.ornl.gov/sci/roofs+walls/insulation/insulation.pdf (24 pp)

Wall Insulation (DOE):

www.nrel.gov/docs/fy01osti/26451.pdf (4pages)

Ceiling and Attic Insulation (DOE):

www.nrel.gov/docs/fy00osti/26450.pdf (4 pages)

Attic Access (DOE):

www.nrel.gov/docs/fy00osti/26447.pdf (4 pages)

Guide to Insulation Sheathing (BSC):

www.buildingscience.com/resources/walls/Guide_to_Insulation_Sheathing.pdf (30 Pages)

Slab Insulation (DOE):

www.nrel.gov/docs/fy01osti/29237.pdf (4 Pages)

Basement Insulation (DOE):

www.nrel.gov/docs/fy02osti/26455.pdf (4 Pages)

Crawlspace Insulation (DOE):

www.nrel.gov/docs/fy01osti/29238.pdf (4 Pages)

Closed Crawlspaces (Southeast focus) (Advanced Energy):

www.crawlspaces.org (84 Pages)

Sample 'Tax Credit Homes'

RESNET has published some examples of homes that have qualified for the \$2,000 tax credit. Also, EnergyGauge (one of the two approved software packages) provides some example tax credit homes with its latest edition. A 15-day free trial of this program with these sample homes can be downloaded from www.energygauge.com. The examples below are a Florida home from the RESNET website and a Georgia example home calculated with Energy Gauge and based on the Atlanta tax credit example provided with Energy Gauge software. These examples are shown to give builders a better idea of what it will take to build a super energy efficient tax credit home in the Southeast, but should not be taken as the only combination of features and equipment that will earn the tax credit.



Figure 15: Photo of tax credit home in Gainesville, FL
Source: RESNET

Gainesville, FL Tax Credit Example from RESNET

- **Location:** Gainesville, FL
- **Home Size:** 1,858 Sq/ft
- **Foundation:** Slab on grade
- **Duct Location:** Air handler in conditioned space, ducts in attic
- **Duct Insulation:** R-6
- **Duct Testing:** results not provided on website
- **Air Leakage:** 3.5 ACH50
- **Ventilation:** Whole house mechanical
- **Windows:** U: 0.36 - SHGC: 0.30
- **Air Conditioner:** 15 SEER heat pump
- **Heater:** 8.6 HSPF heat pump
- **Walls:** R-13
- **Ceiling:** R-30
- **Floor:** Slab on grade

50% Minimum Savings of Heating and Cooling Energy

Atlanta, GA Tax Credit Example from EnergyGauge

- **Location:** Atlanta, GA
 - **Home Size:** 2,400 Sq/ft
 - **3 Bedrooms, 2 Stories**
 - **No shade** from trees or buildings
 - **Foundation:** Sealed Crawlspace
 - **Gable Roof:** Full attic, dark roof
 - **Radiant Barrier** on interior of roof deck
 - **Duct Location:** All ducts and Air handler in conditioned space
 - **Duct Insulation:** R-4.2
 - **Duct Testing:** 72 CFM25
 - **Air Leakage:** 4.5 ACH50
 - **Ventilation:** (Home is not very tight, no additional ventilation supplied)
 - **Windows:** 8 windows, 2 on each side of home, smaller windows on E and W, 428 ft² area, Overhangs on half of windows, U: 0.47, SHGC: 0.40, Vinyl frames
 - **Air Conditioner:** 14 SEER heat pump
 - **Heater:** 8.0 HSPF heat pump
 - **Walls:** R-19 in 2"x6" framing with R-3 exterior sheathing—R-22 wall
 - **Ceiling:** R-38 blown
 - **Floor:** R-19 batts
 - **Insulation installations** all Grade I
 - **Doors:** two exterior R-5 doors
- Energy Savings:**
50.8%
- Envelope Savings:**
38.0%

SUGGESTED HOT-HUMID AND MIXED-HUMID DESIGNS, CASE STUDIES, AND COST AND PROFIT INFORMATION:

Builder System Performance Packages by Climate for 30 to 40% Energy Savings (Building America):

www.nrel.gov/docs/fy04osti/34560.pdf (165 pages)

Builder System Performance Packages by Climate (BA):

www.nrel.gov/docs/fy04osti/34007.pdf (42 pages)

Houses that Work II—2003 (Building America):

www.nrel.gov/docs/fy04osti/34585.pdf (169 pages)

Habitat Congress, Mixed-Humid, Case Study (BA):

www.buildingscience.com/designthatwork/mixedhumid/DTW_MixedHumid.pdf (74 pages)

Hot & Humid Cost Savings Tradeoff Case Study (BA):

www.nrel.gov/docs/fy99osti/26884.pdf (2 pages)

Mixed & Humid Cost Savings Tradeoff Case Study (BA):

www.nrel.gov/docs/fy99osti/26536.pdf (2 pages)

Home Energy Efficiency Checklist (BA):

www.eere.energy.gov/buildings/info/documents/pdfs/whole_house_energy_checklist-766.pdf (6 pages)

Energy Efficiency Pays (Building America):

www.nrel.gov/docs/fy99osti/26290.pdf (4 pages)

Build and Profit with Energy Efficiency (BA):

www.nrel.gov/docs/fy01osti/28996.pdf (89 pages)

Federal Energy Efficient HVAC and Water Heating Equipment Tax Credit

Homeowners are eligible for up to \$500 (combined with the building shell retrofit tax credit) during the two year period of the tax credit for the purchase of qualified energy efficient heating, cooling, and water heating equipment. These credits must serve a dwelling in the United States owned and used by the taxpayer as a primary residence. This implies that equipment in new homes is generally not eligible since equipment in new homes is generally installed prior to occupancy. These credits are not based on a percentage of initial cost, but are a set amount for various qualified equipment, ranging from \$50 to \$300. The specifics of the credit are given below; updated information may be found at www.energytaxincentives.org.

- **Furnaces and boilers (gas, oil, propane) - \$150:**
Annual Fuel Use Efficiency (AFUE) 95 or higher
- **Central air conditioning units - \$300:**
 - Central air conditioning units must meet the highest tier standards set by the Consortium for Energy Efficiency, which require a Seasonal Energy Efficiency Ratio (SEER) of 15 and an Energy Efficiency Ratio (EER) of 12.5 for split systems (those with separate indoor and outdoor units) and SEER 14 and EER 12 for single-package systems (typically located on a roof).
 - Air-source heat pumps must have a Heating Seasonal Performance Factor (HSPF) 9 or greater, SEER 15 or higher, and EER 13 or higher
 - Ground-source heat pumps must meet the following criteria (the same criteria as for Energy Star):
 - Closed-loop systems—14.1 cooling EER and 3.3 heating Coefficient of Performance (COP)
 - Open-loop systems—16.2 EER and 3.6 COP
 - Direct-expansion systems—15 EER and 3.5 COP
 - In addition, ground-source heat pumps must include a desuperheater (which preheats water for a water heater) or an integrated water heating system.
- **Fans for heating and cooling systems - \$50:**
Fan must use no more than 2% of total heating system energy. More info at www.gamanet.org
- **Water heaters - \$300:**
 - Gas or propane water heaters—Energy Factor of at least 0.8. This includes both typical tank-based water heaters as well as tankless, or instantaneous, water heaters.
 - Heat pump water heaters—Energy Factor of at least 2.0

SEE HVAC RESOURCES ON PAGE 7

Earlier in this publication

Federal Energy Efficient Building Shell Retrofits

The energy efficiency of existing homes is often much worse than the energy efficiency of the typical new home. However, because many existing homes are so energy inefficient, significant improvements can be made very economically. Homeowners of existing homes can receive tax credits of up to 10% of the cost of materials to upgrade the efficiency of the building's envelope. Note that the expense eligible for the 10% tax credit does not include the installation/labor costs of the upgrades. Each taxpayer is eligible for up to \$500 (combined with the Energy Efficient HVAC tax credit) over the two years of the tax credits. Components eligible for the credit are:

Note: Only materials (insulation, windows, sealants, etc.) are eligible for the retrofit tax credit, and not the labor to install these materials.

- **Added insulation in walls, ceilings, or other part of the building envelope.**
Added insulation to bring R-value to or above R-values specified in *either* the 2001 or 2004 IECC energy code.
- **Replacement windows and skylights (credit capped at \$200).**
Replacement windows meeting the requirements in the *either* the 2001 or 2004 IECC model energy code. *Energy Star windows will always qualify.* In addition, storm windows are eligible if the existing window plus the new storm window meet the window requirements in either IECC model energy code.
- **External doors**
Replacement doors to bring doors to R-values specified in *either* the 2001 or 2004 IECC model energy code.
- **Sealing cracks in the building shell**
Sealing cracks in the building shell and ducts to reduce infiltration and heat loss is eligible. All improvements must be expected to remain in service at least 5 years.
- **Pigmented metal roofs.**
Metal roofs that have appropriate pigmented coatings that are specifically and primarily designed to reduce the heat gain of a dwelling unit when installed. Also pigmented coatings must meet Energy Star requirements.

View IECC Climate Zones by state and county, and IECC 2004 Supplement Edition R-values and U-factors for insulation, windows, and doors. www.energytaxincentives.org/IECC04.pdf

EXISTING BUILDING SHELL RETROFIT RESOURCES

reHABITAT Guide for Energy Retrofits

www.nrel.gov/docs/fy04osti/36057.pdf (76 pages)

Federal Renewable Energy Tax Credits (1-1-2006 to 12-31-2008)

The other federal energy tax credits reward a reduction in energy demand via improved energy efficiency. This tax credit rewards the production of useful energy from solar energy. **A 30% tax credit, up to \$2,000, is available for the purchase and installation of residential photovoltaic and solar water heating systems.** A taxpayer may take the full credit (\$2,000) on both a photovoltaic and a solar water heating system.

- **Photovoltaic System**

- Includes the cost of all components *and installation*.

- **Solar Hot Water System**

- Includes the cost of all components *and installation*.
- System must be designed to provide at least 50% of annual hot water needs of the home.
- Pool and hot tub heating are not covered by this credit.
- Must be certified for performance by the Solar Rating Certification Corporation (SRCC) or a comparable entity endorsed by the local state government. At the time of publication, the IRS has not made a ruling on if the entire system (OG-300) or just the collectors (OG-100) require certification.
- *The credit is calculated based on the individual's expenditures excluding subsidized energy financing, defined as "financing provided under a Federal, State, or local program a principal purpose of which is to provide subsidized financing for projects designed to conserve or produce energy."*
- If the federal tax credit exceeds tax liability the excess amount may be carried forward to future taxable years.

Solar Hot Water Systems for Hot Water and Space Heating

Solar heating harnesses the power of the sun to provide thermal energy for hot water and space heating. A solar heating system saves energy, reduces utility costs, and produces clean energy. Other than passive solar design, solar hot water heating is the most economical route to producing your own renewable energy.

The efficiency and reliability of solar heating systems have increased dramatically over the last two decades, making them attractive options in homes and businesses. Domestic solar hot water systems provide base load heating for home hot water. In most of the Southeast one or two 4'x8' or 4'x10' collectors can provide over half of the annual hot water for a family, saving \$150 to \$350 per year depending on hot water use and the cost of back-up heating fuel (electricity or gas). The solar hot water panels connect to a storage water heater in the house, basement, or garage. Throughout most of the US, and much of the Southeast, the solar hot water system must be

freeze tolerant to avoid damage to the collectors or plumbing. This is accomplished by either running a non-toxic antifreeze through the collectors or using a 'drainback' system design that automatically empties the collectors of fluid when the solar circulation pump is not running.

Solar space heating can be easily accomplished, either with a hot water coil in the air handler unit or with a series of radiant floor pipes installed just under the floor. Either system can be integrated into an expanded solar domestic hot water system and affordably, cleanly, and renewably, provide a large portion of a home's space heating.



Figure 16: Solar hot water collectors

Source: National Renewable Energy Laboratory

Photovoltaics (PV) (Solar Electric)

Photovoltaic panels convert solar energy into direct current (DC) electricity. A typical residential sized PV system may be able to produce over 3,000 Watts under peak sunlight and cost \$20,000 to \$30,000. In order for this electricity to be useable in the home it must be inverted from direct current electricity

into alternating current (AC) electricity. This is accomplished with a piece of equipment known as an inverter. Most modern inverters are capable of connecting to the electric grid and sending any solar produced electricity not immediately needed in the home out onto the electricity grid. Depending on a home's location (state) or utility and the availability of a green power program, this solar electricity may be sold



Figure 17: PV Shingle Installation

Source: National Renewable Energy Laboratory

from much less than retail per kWh (3¢) to more than double the retail price (20+¢). Many states and utilities have enacted net metering laws, which allow electricity produced by a residential PV system and not used in a home to return to the electric grid. This turns the utility electric meter backwards, reducing or eliminating the monthly electric bill of the home.

Southeastern States Energy Efficient Building and Renewable Energy Incentives and Resources

DSIRE: DSIRE (Database of State Incentives for Renewables and Efficiency) is a comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency. This database is easy to use and is kept up to date. DSIRE should be a primary source when researching energy related incentives. www.dsireusa.org

Local Utilities: Many utilities offer incentives for energy conservation and/or investment in renewable energy systems. Utility incentives are usually in the form of a cash rebate to a customer who purchases or installs qualifying products or equipment, such as a solar hot water system or having the home's ducts properly sealed. A few utilities offer a 5% discount on the electric bill of ENERGY STAR homes. Check with your local utility to find out what incentives they offer. DSIRE lists some, but not all, utility incentives.

State Energy Office: Each state has a State Energy Office that may act as a clearinghouse of information on state and local energy related incentives. Contact information for each state's energy office may be found through the National Association of State Energy Officials website: www.naseo.org.

State by State Overview of State Incentives and Related Resources

Alabama:

- **TVA Green Power Switch Generation Partners Program** in their Alabama territory (See Tennessee)
- **Numerous Utility rebate and loan programs**

Arkansas:

- **Net Metering:** currently net excess generation will be credited to the utility at the end of each billing cycle.

Florida:

- **1-Week Sales Tax Exemption** for energy efficient products
- **Solar Energy System Rebates:** PV - \$4 per peak DC Watt, Solar hot water residential - \$500, solar pool heaters - \$100
- **Numerous Utility rebate programs**
- **JEA and New Smyrna Beach Utilities: Net Metering**
- **JEA- Clean Power Program: Renewable Portfolio Standard**
- **Renewable Energy Access Law**

Georgia:

- **3-day sales tax holiday** for energy efficient products
- **Net Metering**
- **Solar access law/guideline**

Kentucky:

- **Kentucky Solar Partnership:** www.kysolar.org
- **Statewide Net Metering** for PV Systems up to 15 kW
- **Solar Access Law/Guideline**

Louisiana:

- **Home Energy Rebate Option (HERO):** 20% of energy efficiency construction premium, up to \$2,000, for existing homes with a 30% energy efficiency improvement.
- **Home Energy Loan Program (HELP):** 2% interest loan for energy improvements, including solar systems
- **Net Metering** for various technologies up to 25kW

Mississippi:

- **Mississippi Power** offers incentives for purchase of energy efficient electric water and space heaters.
- **TVA Green Power Switch Generation Partners Program** in their Mississippi territory (See Tennessee)

North Carolina:

- **35% personal tax credit** for passive solar, solar thermal, photovoltaics, wind, biomass, hydroelectric, biofuels, solar pool heating, and daylighting.
- **NC Green Power:** Production payments for renewable electricity supplied to grid: www.ncgreenpower.org
- **Progress Energy & Duke power:** 5% discount on ENERGY STAR homes
- **Net Metering:** requires Time Of Use rate schedule

Oklahoma:

- **\$2,000 to \$4,000 Tax Credit** to the builder of an energy efficient home
- **Net Metering** for various technologies up to 100kW

South Carolina:

- **25% personal tax credit** on system cost of solar hot water, solar space, or solar cooling systems
- **\$1000 rebate** for EarthCraft Homes that install solar hot water system
- **Progress Energy:** 5% discount to ENERGY STAR homes

Tennessee:

- **TVA - Green Power Switch Generation Partners Program:** Production incentive for PV and Wind from Tennessee Valley Authority electric utility
- **Solar Easement**

Texas:

- **Numerous Utility rebate and loan programs**
- **Net Metering** for various technologies up to 50kW
- **Renewable Portfolio Standard (RPS):** 5,880 MW (~5%) by January 2015

Virginia:

- **Several Utilities offer low interest loans for energy improvements**
- **Solar Access Law/Guideline**
- **Net Metering** for various technologies up to 10kW

This Project was Supported by:

