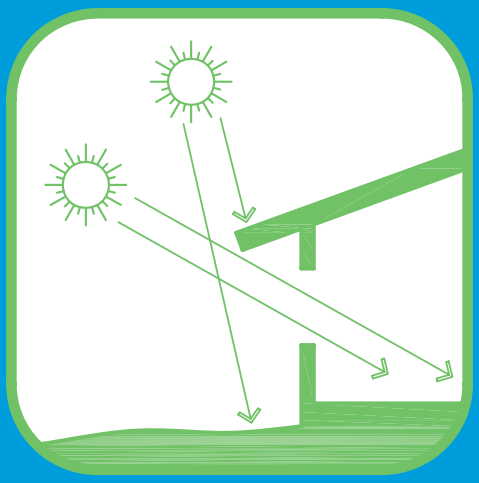
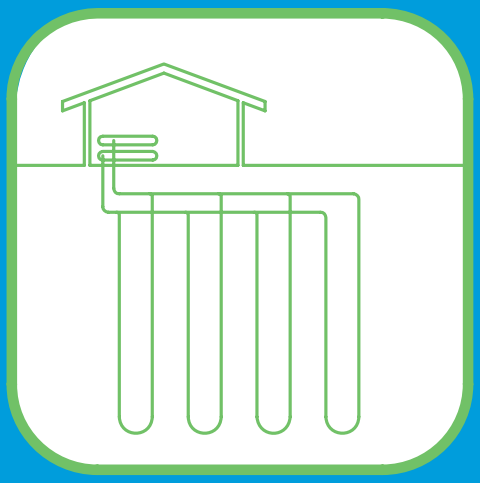
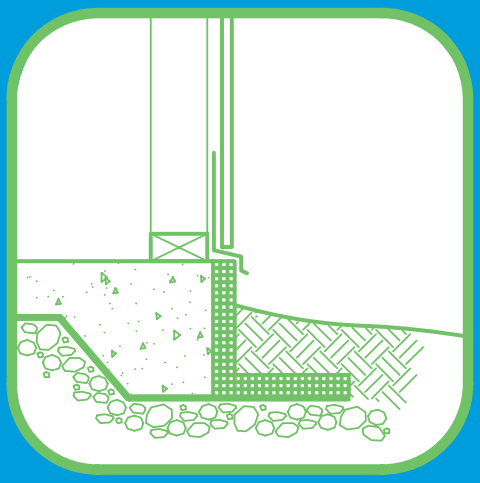
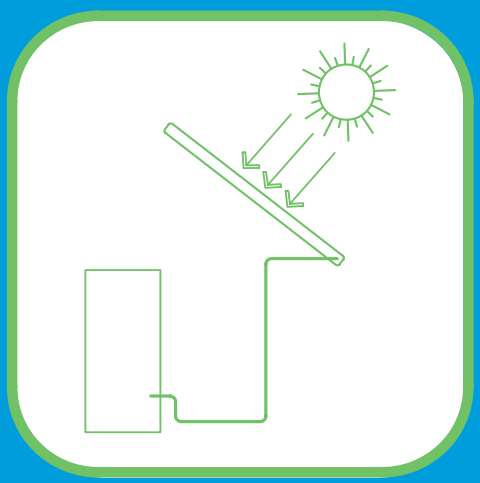
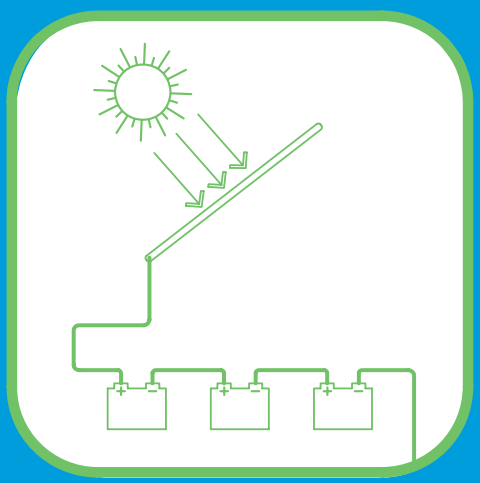
A Homeowner's Guide
to Clean and Efficient Energy in East Tennessee



Southern Alliance for
Clean Energy

"A Homeowner's Guide to Clean and Efficient Energy in East Tennessee"

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ALCOA

Note: This guide is intended as an introduction to energy efficient practices in East Tennessee, Some practices may not be intended for specific buildings, the authors advise consulting building professionals to ensure efficiency practices are appropriate

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Southern Alliance for Clean Energy

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Executive Summary

Here at the Southern Alliance for Clean Energy, we are excited to be provided with the opportunity to write this guide for the citizens of East Tennessee. This guide is written at a time when energy demand is on the rise, and national security is a a top priority. In order to protect our nation, and our environment, there is a desperate need to improve energy efficient practices. Thankfully, you, the citizens of East Tennessee, can answer that initiative now, without sacrificing your economic stability. The Secretary of Energy Samual W. Bodman points out, "While the Department of Energy is working hard to develop new technologies to improve the efficiency of American homes and buildings over the long term, today, there are simple, inexpensive steps families can take to reduce their heating and cooling costs."

This guidebook will help you save money on your electric bill, and help move the United States towards a future relying on American energy, protecting the American environment.

This guide is broken into parts. Part one describes techniques that save energy in current homes. This section will walk through a house and discuss the correct places to seal your home's envelope, ranging from the attic to the basement. Next, an insulation section will demonstrate areas in the home that must be insulated, describe the type of insulation that should be used, and give general tips on how to install this insulation. The importance of ventilation is discussed in the following section. The dynamic relationship between sealing, insulation, and ventilation is a relationship that must be understood, and is given great emphasis in this guide. The current home section will conclude with discussions of landscaping techniques to reduce energy use and types of energy efficient heating and cooling equipment, water heaters, appliances, and lighting.

Part two of the guide will provide an outline for energy efficiency in new home construction. There is an overview of the different type of green building standards and practices that serves as a transition to the green building discussed in this guide, the Zero Energy Home construction practice. An explanation of this building practice is discussed, and the rest of the guide serves to discuss extremely high energy efficient practices incorporated in this building process such as orientation, the use of SIPS technology, centralized heating and cooling, ground source heat pumps, energy efficient roofing, and the liberal application of EnergyStar-rated appliances and lighting.

Zero Energy Home construction includes the use of a renewable energy system installed on the energy efficient home to offset energy use. An introduction to types of systems that apply in East Tennessee is included in the final piece of this guide. These systems include solar photovoltaic (PV) systems and small wind energy systems, that can be connected to the house itself, or the power can be purchased by the TVA Green Power Switch Generation Partner's Program, a program described in this section.

In the Appendix of this guide a list of energy saving tips and financial incentives for clean and efficient energy is included. The Reference section of this guide will direct you to a variety of excellent resources that provide in depth information on the topics covered in this guide. This guide is an introduction to energy efficient practices. When renovating, or building, your home it is important to consult building professionals to ensure the work is done correctly. Producing clean, renewably energy and reducing home energy use is a sustainable living model that we here at the Southern Alliance for Clean Energy promote for not only for citizens of East Tennessee, but all citizens of the United States of America. **We encourage you to use this guide to the fullest extent possible.**

From the Executive Director

We here at the Southern Alliance for Clean Energy want to thank you for reading this guide. **We are excited to make this resource available to the citizens of East Tennessee, helping them to save money in their homes, and to help reduce the growing demand for energy in Tennessee.** As you already know, East Tennessee is one of the most desirable places to live in the United States. Breathtaking Smoky Mountains, recreation, relaxation and low electricity rates make our area ideal. At the same time, higher air pollution has landed several metropolitan areas on the Environmental Protection Agency's list of non-attainment zones for persistently failing to meet national air quality standards. Coal supplies 63 percent of Tennessee's energy. In fact, Tennessee used 23 million tons of coal for electric power in 2003, followed by 25 million tons of coal in 2004 producing millions of tons of harmful air pollutants and greenhouse gases that significantly impact the environment we love.

In Tennessee, residents consume more electricity than either the commercial or industrial sector.

Air pollution amplifies health problems. According to the American Lung Association, air pollution most directly affects people over the age of 65 and under 18. This is 37 percent of the East Tennessee population, more than one out of every three citizens! In Tennessee, residents consume more electricity than either the commercial or industrial sectors. Right now, East Tennessee citizens are poised to make the greatest improvements to their health and their environment all while saving money at home.

When thinking about the cost of energy-efficient practices and improvements, remember there are two price tags: the one you see in the store and the one you see every month on your electricity bill. Savings on your monthly bill accrue over time, which can make upfront costs a worthy investment. Whether you are building new or improving an existing home, consult a local professional on how long it will be before energy savings pay back your upfront costs. Many appliances have a three-to-seven-year payback. If an appliance breaks, consider the cost of fixing an inefficient appliance versus buying an energy-efficient appliance and reducing your energy needs and monthly costs. We hope you use this guide as a reference to improving your home's energy efficiency, improving your health, saving your bank account and your environment.

- Steve Smith, Executive Director, Southern Alliance for Clean Energy

Part 1: Improving Energy Efficiency in an Existing Home

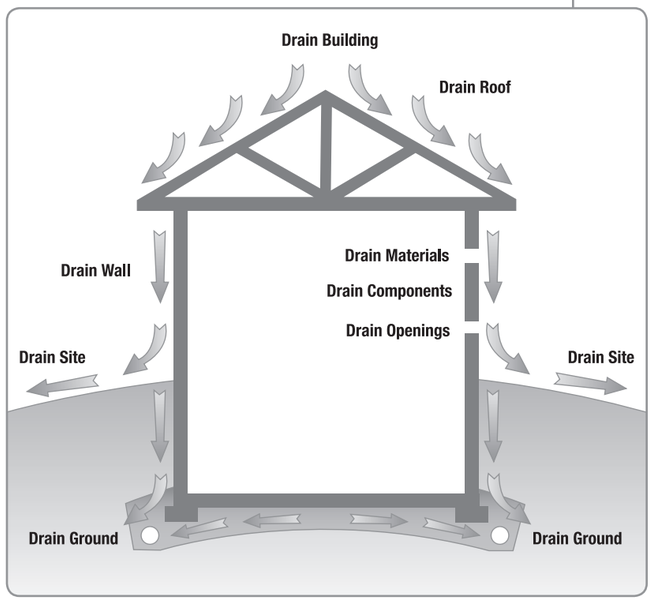
Using a Whole House Approach to Assess Energy Efficiency Needs

To maximize home efficiency it is imperative to view a house and it's subsystems as a dynamic system.

A house uses energy to heat water, to heat, cool and dehumidify air, to cool and freeze food, run appliances and provide lighting. A house wastes energy if it has a leaking building envelope, is under-insulated, or poorly ventilated. The Whole House Approach examines and improves all these aspects of energy demand. Each homeowner will need to consider all options and how systems work with one another to select the best combination of systems, materials, and equipment for each particular circumstance.

Here is an example of the whole house approach:

If a homeowner purchases a state-of-the-art, efficient HVAC unit, but the house has leaky ducts and gaps around windows, energy is being wasted. Furthermore, if the homeowner later improves the sealing and insulation, the new HVAC unit may become too large for the space. An oversized air conditioner does not run long enough to dehumidify air, making the home uncomfortable while wasting energy. It is important that the building envelope be properly sealed and insulated before installing a new HVAC unit. The new unit can be smaller and less expensive because of insulation improvements. This is the advantage of the whole house approach.



A Utility bill with high summer and winter variability is a strong indicator of leaks and improper insulation.

Common sense suggests if there is a draft, there is a leak in the building envelope. Many East Tennessee utilities offer home energy audits to help consumers further diagnose home energy needs, or a professional energy auditor are available.

Assessing Moisture Problems

Sealing the building envelope and increasing insulation will require increased ventilation. East Tennessee's mixed-humid climate creates moisture problems if a home is not properly ventilated. This will cause uncomfortable living conditions and potentially thousands of dollars in material damages. The attic should be the first place you check for moisture damage, followed by crawl spaces, basements, garages, and finally windows and walls. Discovering mold, mildew, paint blisters, stains, or any other signs of water buildup means it is crucial that you take care of these problems first.

To further prevent moisture buildup, check downspouts to be sure they are clear and diverting water away from the house. Clean your gutters regularly. Avoid unnecessary paved surfaces because this increases the amount of stormwater and decreases the amount of landscape area that can absorb a heavy rainfall. The outside ground should slope away from your house in all directions, or you should have a French drain to capture stormwater and direct it away from the base of your home. Any time you make improvements to the exterior envelope of your home, it is very important that flashing is properly installed. A drain space or drain mat behind the siding will allow a path for removing moisture that gets driven behind siding or veneers. This space will also allow siding materials to dry out evenly from both sides.

Sealing the Envelope

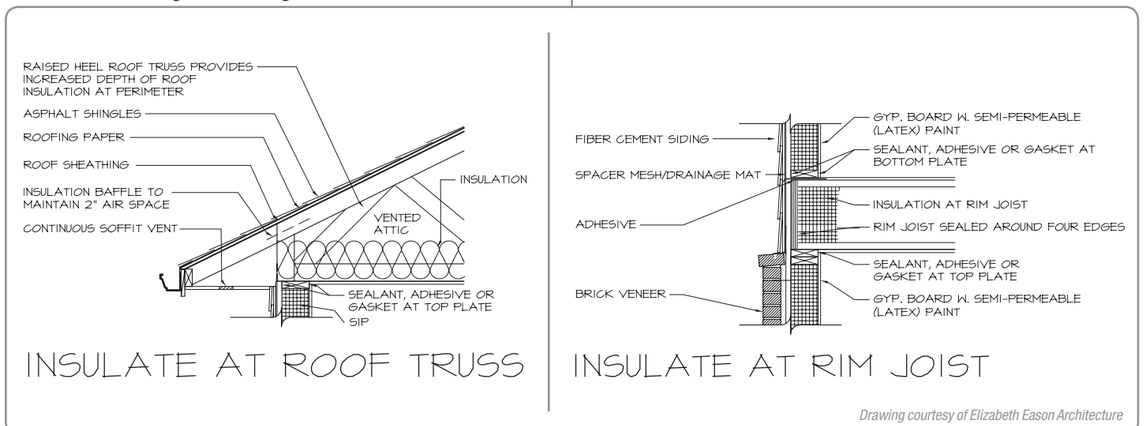
Improperly sealed houses waste 25 to 40 percent of the energy used to heat and cool air, creating uncomfortable temperature and humidity levels. Areas in a house that are cold during winter and warm during summer indicate a nearby leak in the envelope. The building envelope includes the attic, exterior walls, crawl spaces, basement, garage, windows and doors. Envelope sealing is the first step to reducing energy needs in your home.

Sealing your Attic

Attics have the most direct interface with outside conditions and can be vented if unconditioned, or could be insulated and semi-conditioned. Uninsulated attics are subject to wild temperature fluctuations, making them a primary area to seal off from the rest of the house. Sealing prevents air leaks between and attic and conditioned space in the home.

A dirt streak in attic insulation identifies an air leak and requires sealing. Other places to seal are duct penetrations into the attic, around ceiling fans and light fixtures, and where electric conduits enter the attic. Exhaust fans and light fixtures not rated for contact with insulation can become fire hazards if not sealed and insulated properly. Check with a building code inspector or a professional before insulating or sealing near electrified fixtures.

Lastly, seal the attic hatch with weather stripping. Depending on the shape of the attic, there may be additional joints and interfaces that require caulking. When caulking, use a backer rod, a foam strip placed in the crack before caulking, to ensure a tight seal. For cracks too large for caulk, use spray foam. Ducts and windows in the attic should be sealed following procedures described later in this section.



Drawing courtesy of Elizabeth Eason Architecture

Sealing Windows and Doors

Windows and doors can be a significant source of drafts and leaks. In an existing home, it is imperative to reduce leaks around the edges of windows and doors. The efficiency rating of windows needs to be high unless you have a historic home where storm windows may be added. Some doors and windows may require caulking or foam sealants in hard-to-reach places between the frame and siding. Always use foam that is low expanding and made especially for doors and windows. High expanding foam can put pressure on the frame and prevent proper operation, and in extreme cases can break the glass. Some types of windows will be more airtight than others, for example, latched windows are more airtight than sliding windows. Should your siding need to be replaced, you will have an excellent opportunity to replace windows or seal them while the siding is off.

Doors function similarly to windows with cracks and tightness being common problems. Weather stripping placed around the door frame, and an airtight door sweep, will reduce air leaks around the door. Uneven cracks around a door signal improper installation. A professional should be hired to replace doors, if needed, and a new door should be EnergyStar-rated to ensure energy efficiency. Interfaces between doors and siding are another space for potential leaks that can be sealed with caulk.

Correctly Sealing the Duct System

In a home, the duct system transfers conditioned air from the HVAC unit to the rest of the house; therefore, sealing ducts can improve energy efficiency more than almost any other improvement. Older houses tend to have ducts located in unconditioned spaces such as crawl spaces, attics, or basements. According to Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory and EnergyStar, locating ducts in conditioned space greatly reduces energy loss. The Department of Energy found 20 percent monthly savings from sealing ducts, with surveys in East Tennessee showing 35 percent savings on heating and cooling. Duct sealing adds comfort to the home and should be practiced with unconditioned and conditioned ducts alike.

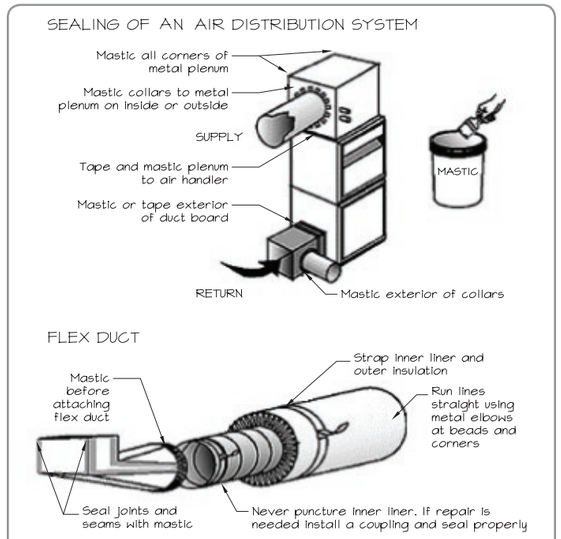


Image courtesy of Reliant Energy

Heating and cooling contractors will conduct professional tests to calculate duct system efficiency. These contractors can repair leaky ducts by applying wet mastic around joints and connections in the duct system; standard duct tape should not be used. Standard duct tape will only stay in place a year or two. Correct sealants will be labeled UL 181A for rigid ducts and UL 181B for flexible ducts. There are also professional sealants that last longer than UL 181-rated duct tapes.

Where else should I seal?

Outlets on outer walls provide a path through which air can pass. To seal them, turn off the room's power, remove the faceplate and caulk around the outlet box edges. High-quality caulk seals holes and keep air from flowing into conditioned space. Remodeling a bathroom is a perfect time to seal plumbing fixtures. Plumbing fixtures and pipes go through floors and walls, creating air gaps. Unconditioned spaces such as basements and crawl spaces should be caulked or sealed with spray foam to ensure no exchange of conditioned and unconditioned air. Crawl spaces may need a plastic sheet on the floor with lapped seams, taped to prevent ground moisture from rising into the crawl space. This ground cover should run up the walls and be fastened with masonry nails through a pressure-treated 1" X 4" board on top of the sheet, or be taped and sealed to the wall.

Insulation

The house is sealed, now it is time for insulation. Whereas sealing prevents air flow, insulation prevents heat loss and heat gain. How much insulation you need depends on your climate. This part of the guide explains how to properly install insulation in East Tennessee. It is based on years of research at the Oak Ridge Building Envelope Program and other research institutions.

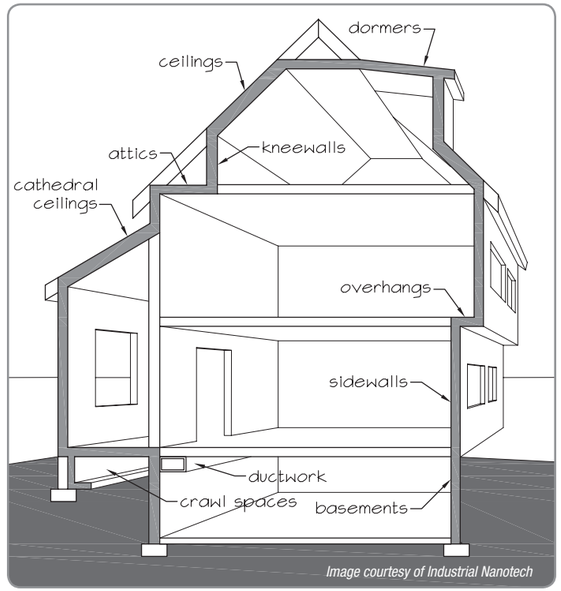


Image courtesy of Industrial Nanotech

Important: when installing insulation, it is important to never cover or hand pack insulation around stovepipes, electrical fixtures or any heat producing element. Building code inspectors can explain fire-prevention guidelines.

Insulation comes in a variety of styles:

Blanket insulation: Rolls between wall studs.
Blown-in insulation: Loose insulation that can be used in hard to reach places.
Foamed-in insulation: A very effective insulation that is widely used. There are high-density, closed-cell foams and low-density, open-cell foams available with a range of insulating values. A professional should install foamed-in insulation.
Rigid-board insulation: A common insulation for basement walls, crawl spaces and flat areas. It is attached with nails or adhesives. The proper adhesives should be available at the same store where the insulation is purchased. Rigid-board insulation requires a ½ inch gypsum board barrier to meet fire safety codes.

Attic Insulation

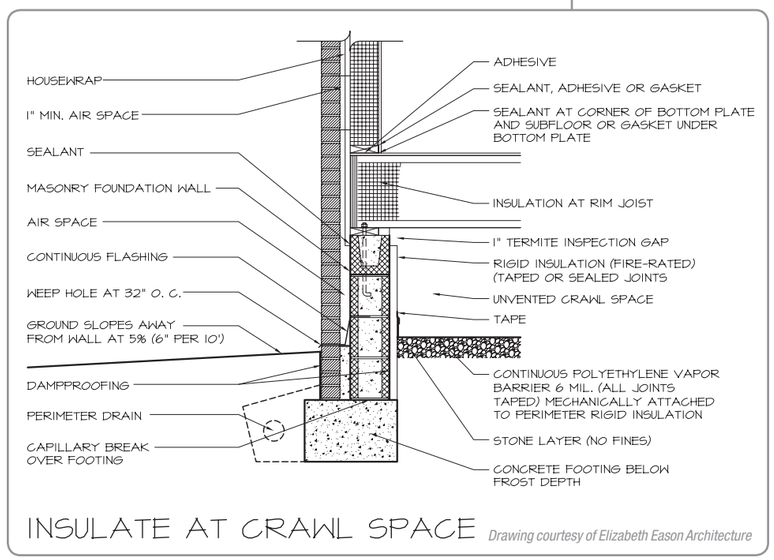
The attic is most vulnerable to heat exchange. Summer sun will heat the attic while money is spent cooling the house. Similarly, conditioned heat will attempt to escape the house through the attic in the winter. Sufficient insulation and an airtight ceiling plane, will minimize heat exchange between the ceiling and attic, adding comfort and saving money.

East Tennessee attics are recommended to have a minimum of R-38 insulation. **The R-value is a measure of how well insulation works and is calculated by thickness of the insulation in inches multiply R-value per inch.** If your attic is already insulated but has an R-value less than R-19, you need to insulation until R-38 is reached. Higher elevations need more than R-38 in order to keep the home energy efficient.

Insulating Unconditioned Spaces

Once the attic is insulated, the next priority is unconditioned spaces such as crawl spaces, basements, or any other unconditioned space in the house. Insulation of R-19 or greater is recommended for East Tennessee basements and crawl spaces.

Rigid insulation board is good for crawl spaces, if you can fit it into the space. Be careful; moisture control is a concern in East Tennessee but is often misunderstood. **When the summer air is hot and humid, do not ventilate a cool basement or crawl space.** This will only bring in the warm moist air that will condense when it reaches a cooler space or a cold pipe. Opening and closing vents seasonally is suggested for vented crawl spaces. Remember, a crawl space can remain unvented.



INSULATE AT CRAWL SPACE *Drawing courtesy of Elizabeth Eason Architecture*

In unfinished basements, blanket insulation can be rolled between the studs. Along concrete-block walls, special fiberglass boards with a laminated coating work well, providing a heat barrier with high air permeability. These boards snap on and off the wall, allowing access to the wall if problems occur.

Exterior Wall Insulation

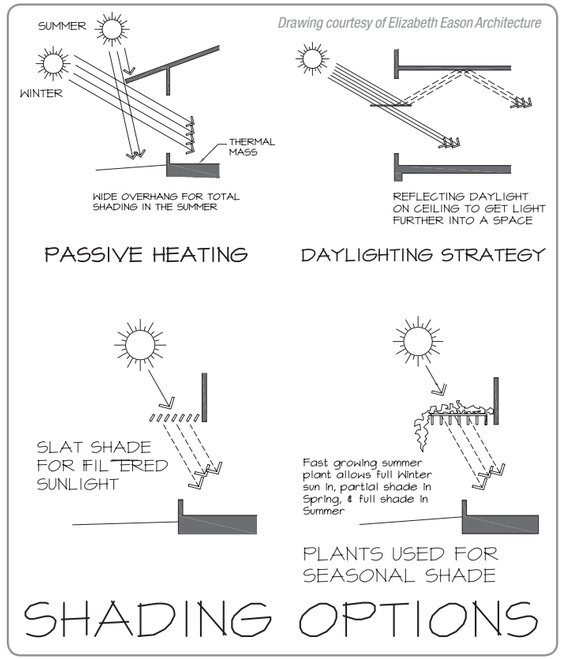
Building codes have required better insulation as time has passed so older houses tend to have less insulation in the wall cavity. However, the walls may have been built with materials such as brick and plaster that have higher insulation ratings than studs and sheet rock. Older homes may also be designed with wide overhangs and porches that shade exterior walls from summer sun. Consult a professional when insulating a wall. Wall insulation is often difficult to add to existing homes unless replacing siding or paneling. In some cases, small holes can be made in the plaster or in wood siding and insulation blown in. Once again, a building professional should be consulted.

Correctly Insulating the Duct System

It is best to install ductwork in conditioned space; however, many existing homes have ducts in unconditioned spaces such as attics, basements and garages. Ducts in unconditioned space must be insulated. Hardware stores sell a special wrap for insulating ducts. Experts recommend duct-wrap insulation be R-6, with the vapor retardant layer on the outside. Where sections of insulation meet, the wrap should be overlapped then sealed with fiberglass tape, but not so tight it deforms the insulation. The wrap should be fastened every three feet to ensure it stays snug on the ducts. Water pipes running through unconditioned space near ductwork should be wrapped with electric heating tape, because unconditioned spaces can cause pipes to freeze and burst in the winter.

Using Windows and Shading as Insulation

Windows made today can be exceptional insulators. The most efficient windows are double paned windows with a non-reactive gas filling to reduce heat conduction between the panes. Argon-filled windows are typically less expensive than krypton-filled windows, but krypton is more efficient. Low emissive windows (low-E) windows cost 10 to 15 percent more than regular windows; however, they can reduce heat exchange by 30 to 50 percent by reflecting UV rays, but allowing visible light through.



Double-paned windows are more efficient than single-paned windows. If your home has single-paned windows, new EnergyStar-rated windows can pay for themselves. **Replacing single-paned windows with EnergyStar-rated windows saves up to $260/yr and replacing a double-paned window with EnergyStar windows saves up to $45/yr.**

An exception should be made for historic homes. Original windows in historic homes should be preserved. In a historic home, seal around the frames and have wood storm windows made to match the original window style. Wood is a better insulator than metal, and more appropriate for a historic home.

To insulate your home from the heat of the sun, you can create shade. An awning over south or west-facing windows can greatly reduce heat transmission during the summer, but the awning should be removed in the winter to allow solar heating or be designed so that the lower winter sun angle allows the sun into the house. Blinds can be used to block sunlight in the summer and be left open in the winter. Properly sized overhangs can also help as shown in the figure.

Ventilation

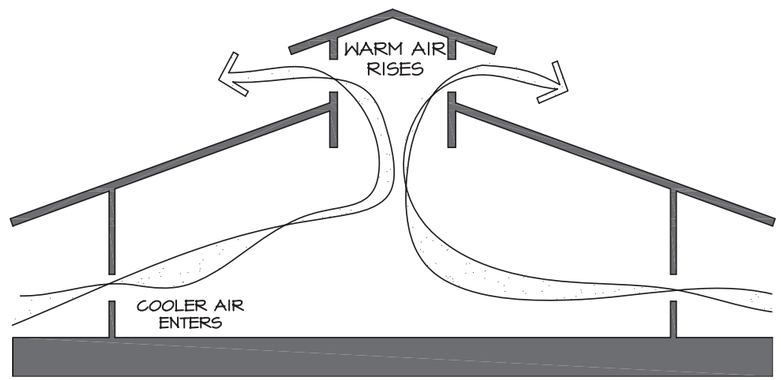
The house is sealed and insulated; energy can now be controlled. Now it is crucial the house be properly ventilated to avoid moisture problems and stagnant air. How does moisture get into a sealed and insulated house? You create water vapor every time you cook, breathe, take a shower, open the door or take care of a plant. Your house always has some amount of moisture in it, but ventilation moves moisture out. The air inside a home can be more polluted than exterior air due to chemicals and pollutants in many furnishings and building products. Be sure to bring in plenty of fresh air through a mechanical system, or use open windows when the heating and cooling system is not running. Mechanical systems can be designed to mix the needed amount of fresh air with the return air.

The golden rule of ventilation is to never exhaust ducts and vents into the attic.

The attic invariably heats and cools faster than the rest of the house, which can condense moisture from the exhausted air.

Unconditioned attics must be ventilated. The easiest way to ventilate an attic is by obeying the laws of physics. Warm air rises and will be exhausted through a vent near the roofline. Cool air will be drawn in through soffit vents, creating natural airflow. The size of the exhaust vent depends on the size and shape of the attic. A licensed contractor can perform this calculation

A leaky house may be pulling outside air through cracks in the building envelope in order to ventilate the house. This allows humid air to enter the home, raising the potential for moisture problems. For maximum comfort, ventilate all enclosed spaces with fresh air introduced through the mechanical system or by opening windows when the temperature and humidity are pleasant.



Landscaping for Energy Savings

Homeowners across East Tennessee plant shrubs, trees and flowers to beautify their yard. Such plantings can provide more than just aesthetics. Landscaping can reduce a home's energy demands with shade, wind breaks and buffers. A clever landscaper can maximize the sun's warming effect in winter and reduce it warming in summer.

Trees with high crowns on south-facing slopes will shade the house from the high summer sun. During winter when the sun is low, sunlight can pass under and through the crown to warm the house. East Tennessee has plenty of trees that are deciduous, meaning they lose their leaves in winter, exactly what is needed for summer cooling and winter warmth.

Evergreen trees and shrubs on the northwest side of the house can protect the house from cold winds and storms. Windbreaks can reduce wind for a distance of up to 30 times the height of the vegetation. Low, deciduous shading on the west side can stop the afternoon sun from heating the house in summer. Shrubs near the house shade the exterior wall.

Energy Efficient Heating and Cooling Systems

After sealing, insulating and ventilating the house, it is time to assess your heating and cooling system, or HVAC. On average, 45percent of a utility bill spent on the heating and cooling of the home. For maximum efficiency, a professional contractor will need to correctly size the home's HVAC system. A building professional will size the HVAC system using a Manual J calculation; a calculation that takes into account square footage, ceiling height, windows, insulation and how air tight the house is.

warm air is extracted from the house, pumped outside, and air is then conditioned and returned to the house, keeping the house cool and dry.

Replace heat pump filters once a month to ensure optimal performance. In the winter, a heat pump that is too large will turn on and off repeatedly, creating discomfort and wasting energy. If a heat pump is too small it will switch into the more expensive electric resistance mode of heating. Properly sized heat pumps run almost constantly.

There are other heating and cooling options that use other fuels, natural ventilation and sunlight. Natural gas and oil heating are common in East Tennessee. An efficient furnace is sealed and has insulated ducts to minimize heat. Carbon monoxide detectors should be installed in homes heated by natural gas, propane or wood. In a tightly sealed house, caution must be taken to avoid back drafting of gas appliances, water heaters, and mechanical systems.

When using a fireplace, remember to close the damper when no fire is burning. Leaving the damper open is similar to leaving a window open, but with worse consequences. Warm air rises up a chimney faster than it flows through an open window. When using the fireplace, open the dampers at the bottom of the fireplace and crack a nearby window to feed the fire unconditioned air. Doors leading into the room should be closed.

Lower the thermostat when using the fireplace to avoid using two sources of heat. The flue should be properly sealed and the hearth caulked to prevent air loss. A fireplace that is never used should have a plugged and sealed flue and chimney.

Room air conditioning units are also popular forms of conditioning air, and like heat pumps must be sized according to the room's energy needs. An oversized air conditioner reduces

Heat pumps use 30 to 40 percent less electricity than other heating and cooling systems.

A programmable thermostat is an excellent investment. Set the temperature higher in the summer when you are not at home and cooler when desired. In winter, let the house cool down while you sleep. When using a programmable thermostat in the winter, be careful not to let the house cool too much, or the heat pump will kick into resistance heating when it first comes on. Since the heat and air will still be on when needed, the only time this change will be noticed will be on the monthly utility bill!

The U.S. Department of Energy's Energy Efficiency and Renewable Energy Office deemed heat pumps the most efficient electric heating system in mixed-humid climates like East Tennessee's. Heat pumps use 30 to 40 percent less electricity than other heating and cooling systems. Air-source heat pumps collect heat from the outside air and distribute warm, conditioned air throughout the house during winter months. In summer, comfort while wasting energy. EnergyStar-rated air conditioners reduce cooling costs by up to 50 percent. Shading a room air conditioning unit decreases energy use by up to 10 percent. Be sure not to restrict airflow around the outdoor coils or the unit will overheat. Turning the thermostat to the coldest temperature can also cause overheating, and contrary to popular belief, this cools the room no faster.

Saving Energy with Water Heating Systems

Hot water heating is typically the third largest energy expense in a home, accounting for 13 to 20 percent of an average utility bill. The tried and true way to save energy on hot water is to conserve it. New technologies do this for you without reducing the luxury of hot water. For example, low-flow shower and sink heads (< 1.5 gal/min) are cheap and effective

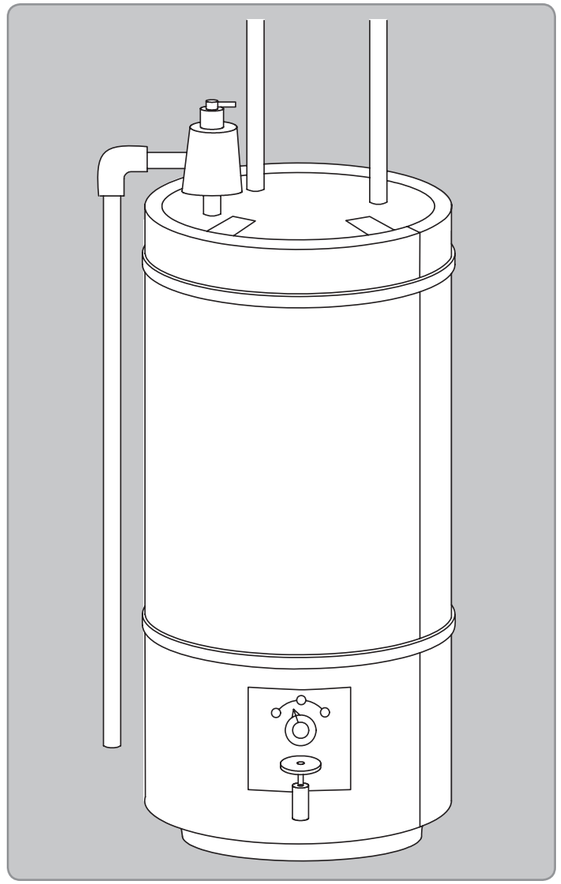
ways to conserve hot water without decreasing the duration of showers or hand washing. Of the hot water used in a house, 70 percent is for showers and baths, which is approximately 40 gallons of water and 3.5 kilowatt-hours of energy per day.

Another simple way to save energy on water heating is to turn the thermostat down to 120°F. This is sufficiently hot for comfort, but easier on the heater. Insulating your hot water tank is an inexpensive way to improve efficiency. This requires a few simple steps. First, insulate the pipes within six feet of the water heater to at least R-6 insulation. Second, install a water heater blanket, which cost around $15 and is easy to install.

3 Cheap and Easy ways to Save Money on Water Heating

1. **Install low-flow shower and sink heads**
2. **Set water heater thermostat to 120 F**
3. **Insulate your water heater and pipes**

Image courtesy of US Department of Energy



A timer for a hot water heater can yield savings of 5 to 12 percent, and at a cost of around $60, it will pay itself off within a year. Simply set the timer so water is only heated just before it will be required. Timers are simple to install, easy to use, and a great way to save money.

There are alternatives to electric water heaters, such as tankless water heaters that heat water only when the water is flowing, making the heater much more efficient.

Solar Hot Water Heaters

The most efficient water heater is a solar powered system. There are excellent incentives for a solar water heater installation listed in the appendix. There are different types of solar hot water heaters and according to the North Carolina Solar Center in Raleigh, NC, two types are best suited for the East Tennessee climate. Drain-back and mixed-refrigerant solar hot water systems are the most efficient hot water heaters for East Tennessee. Drain-back solar water heaters allow water to drain into an insulated collector when the system is not in use. This keeps water from sitting in the tubes during cold winter months, preventing tubing ruptures due to freezing. Refrigerant systems heat a mixture of water and antifreeze in the sun and then circulate the heated fluid through coils in the hot water tank to transferring heat to the water. Both systems provide ample hot water at almost no cost.

Purchasing Energy Efficient Appliances and Lighting

Collectively, appliances can use more energy than water heaters and HVAC units. Consider all the appliances and prioritize which to replace first with more efficient models. Consider how often the appliance is used and its age. Larger appliances usually require more energy. EnergyStar-rated products should be used.

Lighting is one of the most practical ways to save energy, and money! The average American home can save $60 per year by changing five high-use incandescent light bulbs with EnergyStar-rated florescent bulbs. If every home in America did this it would eliminate 1 trillion pounds of greenhouse gases, equivalent to the emissions of 8 million cars. Investing in efficient lighting saves money in several other ways. Lights waste energy by releasing heat, adding to home cooling costs. Compact fluorescent bulbs produce less heat and last up to 10 times longer than incandescent light bulbs.

The average American home can save $60 per year by changing five high-use incandescent light bulbs with EnergyStar-rated florescent bulbs.

Combining renewable energy and energy efficiency is the only way we can ensure a sustainable future.

Part 2: Building an Energy Efficient House

The first part of this guide covers energy-saving concepts that apply to both existing and new homes. This portion of the guide discusses green building standards and techniques for attaining them. There are many energy saving techniques that are best employed when designing and building a new home. How a new house is designed and constructed dictates how much energy it will require.

House orientation, advanced insulation, integrated heating and cooling systems, integrated hot water systems, reflective roof design, mechanical ventilation and appliances and lighting are energy saving techniques when constructing a new home. The sealing, insulating, and ventilating techniques presented in Part 1 are relevant to all homes, but this section discusses advanced techniques unique to new home construction.

Green Building Standards

The myth that energy efficiency is difficult to achieve has been completely dispelled in the past several years. Surprisingly, many builders remain unfamiliar with innovations in home energy efficiency. Building codes have evolved since 1993 to encourage improved home energy ratings (HERS); however, several green standards have been developed that go beyond code requirements. There are two widely accepted benchmarks in green building standards, the Leadership in Energy and Environmental Design (LEED) certification from the United States Green Building Council, and EnergyStar certification from the Environmental Protection Agency and Department of Energy.

These standards are further enhanced by programs such as the EarthCraft House program, conducted by the Greater Atlanta Home Builders Association and Southface Energy Institute, as well as the greatest challenge to energy efficiency, the Department of Energy's Zero Energy Homes Program. Working with Habitat for Humanity, Oak Ridge National Laboratory has already built five near-zero energy homes in East Tennessee. Houses built following these standards and practices maintain their value longer, create more comfortable living, and are easier to finance.

EnergyStar-qualified homes are at least 30 percent more efficient than homes built to 1993 National Model Energy Code standards and 15 percent more efficient than homes meeting more strict state energy codes. These savings are achieved by integrating energy-efficient building strategies into a home during construction. EnergyStar houses must be independently verified, and the guidelines are available at the EnergyStar website listed in References.

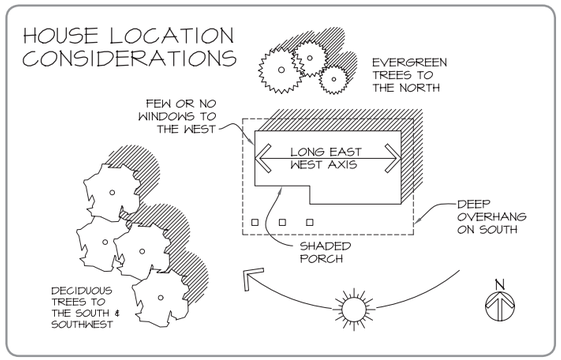
EarthCraft is a program created by Greater Atlanta Home Builders Association and Southface Energy Institute. The EarthCraft program focuses on environmentally responsible practices from pre-construction through post-construction. The program covers everything from how to correctly dig trenches around tree roots before construction, to properly sealing a house during construction, to disposing of excess logs after construction is complete. Correctly sealing the building envelope is emphasized, and at least half of the 150 points needed to meet the Earthcraft rating must come from sealing practices. The rating system can be viewed at the Southface website, listed in the references.

Oak Ridge National Laboratory's Building Envelopes Program has been researching climate and home design for years. The lab's Large Scale Climate Simulator allows design and building techniques to be tested and tailored specifically to the East Tennessee climate. Adding solar panels to a high-efficiency home allows it to produce as much energy as it consumes, thus the term Zero Energy Housing aptly describes their own building practices. In 2004 and 2005 the ORNL program helped lead a Habitat for Humanity project that built five near-zero-energy homes for local families. The last house operated on a meager $0.61 per day. Zero Energy Housing is cutting-edge technology being developed here in East Tennessee, and it is the model followed in this guide.

Zero Energy Home Building Practices

Orientation is a major factor in designing a low-energy home. How a house is situated impacts heating, cooling and most major subsystems. Passive solar heating works well in East Tennessee, but using the sun effectively requires proper home orientation. Solar water heaters and photovoltaic panels work optimally on south-facing, sloped roofs.

The winter sun stays lower in the sky than the summer sun and therefore shines more directly into a home. Orienting windows and walls toward the sun adds natural heat to your home in winter. Passive heating works best if the sun shines on a thermal mass that can hold heat and radiate it into the house. A stone floor or hearth makes a good thermal mass. Windbreaks to the north and northwest, whether landscaped in or part of the natural topography, make passive solar heating more effective by reducing heat loss due to winds and storms.

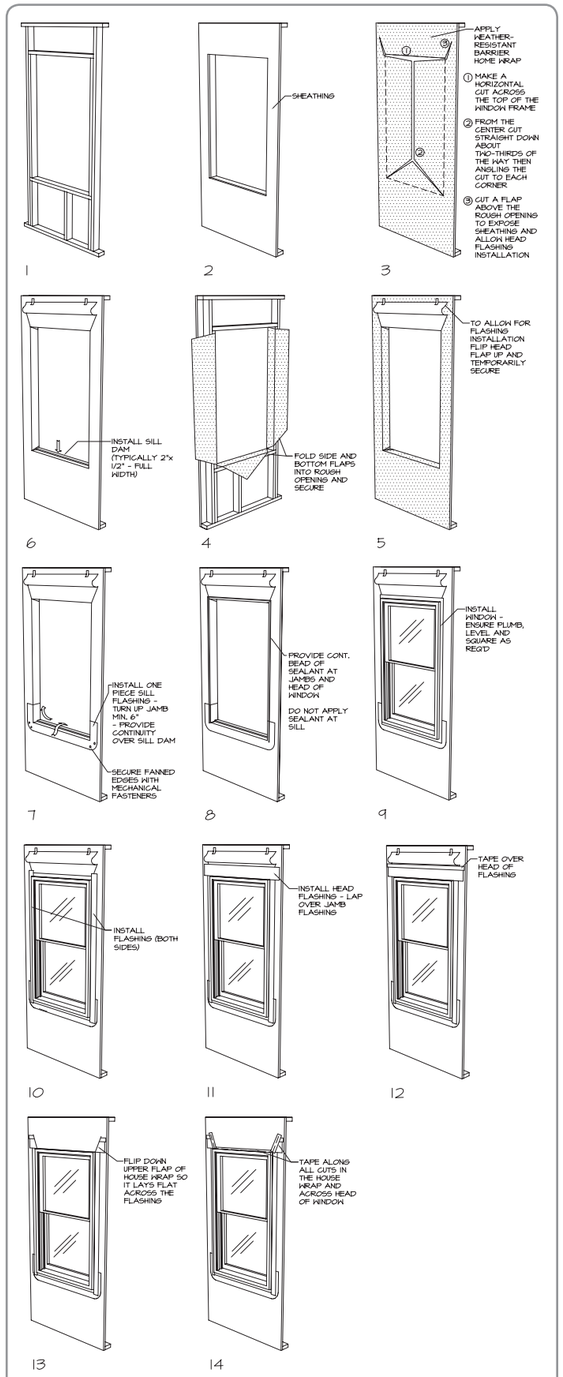


A roof overhang or tall, deciduous trees on the south side of your yard will block incoming sunlight in the summer, when the sun is higher in the sky. Because the sun is lower in the sky in the afternoon, sun from the west is very difficult to control. Windows should be avoided or minimal on the western face of a house. Passive solar heating is usually not enough to provide all your heating needs during the coldest months in our region, but it can greatly reduce the amount of heating needed from a mechanical system, lowering your energy use. Orientating spaces to take advantage of natural light will also save money by reducing the need for electric lights.

Constructing a High Efficiency Building Envelope

During construction is the best time to seal a home, perhaps the only time you can be sure it is completely sealed. After the house is framed, stud cavities should be sealed at changes in ceiling height to decrease airflow through wall cavities. Joist cavities under attic knee walls should be blocked and sealed, as should any location where attic air might penetrate. Bottom plates should be properly sealed to the floor or the foundation. Penetrations through band joists should be sealed.

Wrapping the house is critical step toward sealing a new home. It is important to attach the housewrap below the bottom plate, seal all overlaps with tape and seal the wrap to window and doorframes. Use plastic-capped nails to hold housewrap in place. You can seal the house wrap at the top plate or fold it over the top and attach it with roofing nails. Any holes or penetrations in the housewrap should be sealed.



WINDOW FLASHING AND WEATHER BARRIER

SIPs Construction

Structural insulation panels (SIPs) are now being used in residential construction. SIPs are composed of rigid foam sandwiched between orientated-strand boards. By decreasing the number of seams in the exterior wall and roof, you have fewer locations for air leaks or insulation gaps in the envelope. When the same contractor builds and seals a typical frame house with SIPs, airflow through the envelope shrinks from the equivalent of a hole larger than a volleyball to a hole smaller than a softball.

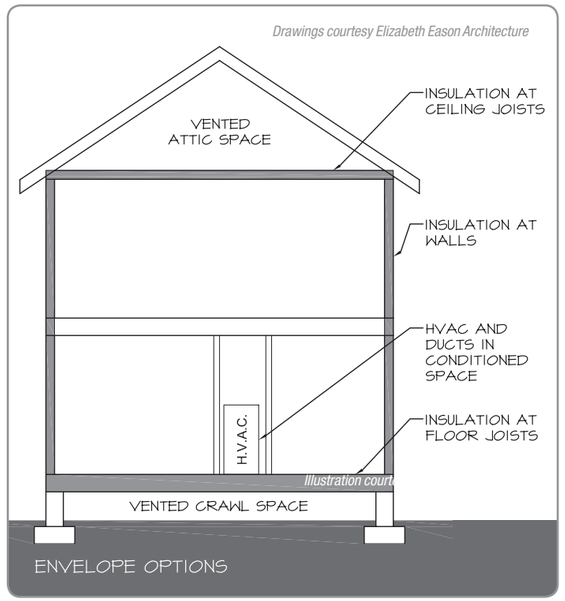
Structural insulation panels also reduce the time it takes to install roofs and walls. Roofs and walls can now be built in one day for a small house. One near-zero energy house with SIP walls needed only five hours for the walls and three hours for the roof to be installed. Panels can come to the job site uncut or with custom-cut openings for windows, doors, electrical conduits and the like. When installing SIPs, it is recommended that panels be joined with splines and sealed with caulk, tape, or foam at every edge as per the manufacturer's recommendations. Zero Energy Homes in East Tennessee should have 4.5- or 6.5-inch SIP walls and 6.5-, 8-, or 10-inch SIP roofs.

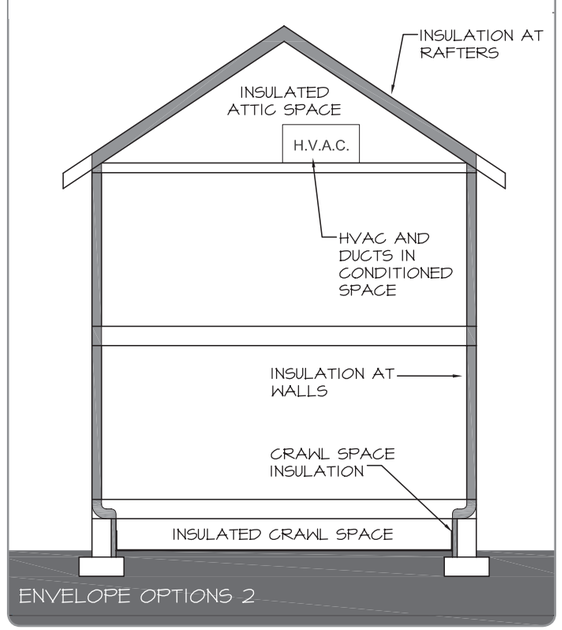
An alternative to SIPs is to frame with 2" x 6" studs instead of the standard 2" x 4". This allows more insulation inside the wall. Advanced framing techniques can reduce the number of wall connections and air passages.

Mechanical Ventilation

Zero Energy Homes must have increased ventilation. If a well-sealed house is not well ventilated, it will not be protected from problems such as moisture, water damage, mold, mildew, and indoor air pollution. East Tennessee receives ample rainfall throughout the year, so controlling moisture is a high priority, especially in SIP-constructed houses.

Mechanical ventilation is the primary way to keep the air fresh and dry in an energy-efficient house. Sensors detecting moisture levels and CO^2 levels can determine when a ventilation system should be turned on to bring fresh air in. It is a good idea to have an energy-efficient dehumidifier on hand in case humidity remains high for an extended period of time.





When the same contractor builds and seals a typical frame house with SIPs, airflow through the envelope shrinks from the equivalent of a hole larger than a volleyball to a hole smaller than a softball.

Heating and Cooling

An energy-efficient home needs a highly efficient HVAC unit that is correctly sized and more importantly, strategically located. Placing an HVAC unit in conditioned space reduces the temperature gradient between the unit and the surrounding air, saving energy. Placing the HVAC unit in a central location will shorten the total amount of ducts you will need to purchase and reduce the distance air needs to travel, saving you money. Ducts should be located in conditioned space for the same reason. Running ducts through conditioned space can save you 35 percent on HVAC energy consumption, $200 per year on average.

Ground-Source Heat Pumps

Did you know that while it is 90 degrees outside, the soil inches below your feet maintains a cool 70 degrees? During winter, the ground stays a warm 55 degrees even when the air temperature drops below freezing. Ground-source heat pumps take advantage of the stable temperature underground. A series of closed coils buried five feet below the surface, ground-source heat pumps are significantly more efficient than air-source heat pumps. Ground-source heat pumps circulate refrigerant or water through the coils, exchanging heat with the surrounding earth. During summer, the fluid is cooled by the soil; in winter the fluid is warmed by the soil, both of these greatly reduce the energy required to heat or cool the air in the heat pump.

Ground-source heat pumps are best installed when the foundation is being dug. The heat pump should be located inside the house in conditioned space. It operates similarly to an air-source heat pump, the main difference being that it requires less energy to produce the same results. Ground-source heat pumps are quiet, efficient, and an excellent addition for an energy efficient house.

Heat-Pump Water Heaters

Heat-pump water heaters are twice as efficient as conventional water heaters. In summer, they draw warm air through a vent near the back of the refrigerator, transfer heat from the air to the water then pump cool, dehumidified air back into the house. During winter, warm air is drawn from insulated crawl spaces to heat the water, and the unneeded cool air is exhausted outside the house.

Heat-pump water heaters are an excellent investment and an outstanding way to save money on hot water and cooling.

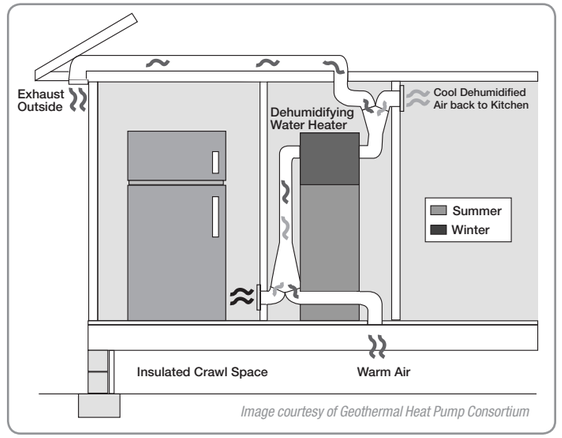


Image courtesy of Geothermal Heat Pump Consortium

If a heat pump water heater is not chosen, purchase an EnergyStar-rated water heater and properly insulate it using techniques mentioned in the first part of this guide. If a water heater is in the garage or basement, place a rigid foam board underneath when you install it. This can prevent 6 to 9 percent of the energy from conducting into the floor.

Roofing for Energy Savings

The greatest solar exposure a house has is on the roof. Cool roofs are more popular in hotter climates, but still make a good investment in East Tennessee. Cool roofs use special reflective paints to keep solar radiation from being absorbed so heat is not conducted into a home's living space. Researchers have been perfecting cool roof paints since the mid-1980s. To the untrained eye, it is impossible to differentiate between a cool roof and a normal roof. The variety of colors includes shades of blue, green, red, brown, gray, and white. Reflective roofs along with proper attic sealing and insulation will ensure cooling costs are kept to a minimum under the hottest summer sun.

CRRC COOL ROOF RATING COUNCIL

Appliances and Lighting

Not using energy efficient appliances will cost hundreds of dollars more per year. Save money and remember there are two price tags to every appliance. EnergyStar ratings will help you find the most efficient appliances. Zero Energy Houses should be equipped with nearly 100 percent florescent lighting.

...ground-source heat pumps are significantly more efficient than air-source heat pumps.

Part 3: Clean, Renewable Energy at Home

TVA Green Power Switch Generation Partners Program

To create a Zero Energy House clean, renewable energy is needed to offset the power consumed. This can be achieved with any house, new or old, that is highly efficient. In East Tennessee we can integrate photovoltaic panels or small wind turbines, into our electrical system. TVA created a program known as the TVA Green Power Switch Generation Partners program, which pays 15 cents for every kilowatt-hour of green energy produced by a resident. This rate is well above the price residents pay for electricity, making it possible to install a wind or solar system and live in a home that never has an electric bill.

Green Power Switch®

Harnessing the Sun's Energy: Solar Power

Tennessee is blessed with good solar potential and many initiatives for investing in solar. Solar systems should be installed on south roof faces in clean, shade free locations. The characteristic of a good site for solar panels is a site that receives sunlight throughout the day, as the sun moves from east to west. Avoiding placing dormers that can shade the southerly roof is a recommended technique for optimizing PV performance as well.

A photovoltaic (PV) system operating at 12 percent efficiency (average for current PV panels) requires 1 ft² of roof space for every 10 watts produced. More efficient panels need less roof space. Solar panel installation is a must for building a Zero Energy House.

Solar power has become increasingly cheaper in recent years, and current incentives make solar a great deal. Solar incentives are located in the appendix of this guide. The main solar incentives in Tennessee are the TVA Green Power Switch Generation Partners Program and the federal tax credit. Businesses can take advantage of the TN-CET grant from the TN State Energy Office. Rural businesses can take advantage of the USDA Section 9006 grant.

Powering a Home with Wind Energy

Tennessee's famous landforms, the Cumberland Plateau and Great Smoky Mountains give us high perches with views. Those views are often hazy thanks to coal-fired power plants, but those who enjoy the views will likely have high wind potential as well. Wind power is the fastest growing renewable energy technology in the United States and worldwide. Wind turbines are sized for commercial energy production or for homes, neighborhoods and schools.

Turbine blades spin in oncoming wind, rotating a generator and producing electricity. High East Tennessee elevations are a great place for wind power. Current technology allows electricity production at wind speeds as low as 10 miles per hour. Some locations in the valley and foothills experience 10 mph winds too infrequently to justify installing small turbines. Small wind turbines can directly power the house, and excess energy either be purchased by TVA or be stored in a battery bank for later use. There are also great incentives for wind power in Tennessee, and with enough land and a high wind resource, a commercial wind farm may be located on the land.

TVA Green Power Switch Program

If you are unable to generate renewable energy due to natural or financial restraints, you can still purchase renewable energy. In 2000, TVA kicked off their Green Power Switch program, allowing customers to buy 150 kilowatt-hour blocks of green energy for $4 per month. Purchasing two blocks for $8 a month saves the same amount of carbon dioxide as if you planted one acre of trees. Purchases of green power blocks help support the Generation Partners program.

TVA's Green Power Switch Generation Partners Program pays 15 cents for every kilowatt-hour of green energy produced by a resident.

Appendix

Appendix A: 15 Energy Saving Tips and Tricks

If you cannot make every improvement your home might need to become energy efficient, the great news is there are countless simple ways to live an environmentally responsible life! The general idea is to use as little energy as possible. Here are 15 easy tips for reducing your energy consumption:

1: If you are leaving for more than 3 days, turn off your hot water heater. In the summer, turn off your air conditioner or turn the thermostat up to 83 degrees.

2. Keep air vents clear of obstructions.

3. Close drapes and blinds on the sunny side of the house during summer and open them in winter.

4. Only wash full loads of dishes and clothes to conserve water.

5. Plug appliances into power strips so you can switch them all off at once. Appliances you operate briefly or infrequently can consume more energy waiting in standby mode than they consume while in use and are better left unplugged or fully off. You can now buy power strips with motion detectors that switch on when you pass by. This is great for home office and entertainment centers.

6. Vacuuming your refrigerator coils every three months keeps the condenser running efficiently and energy costs down.

7. Locate your refrigerator away from the stove, dishwasher, heat vents, direct sunlight or any heat source.

8. Keep your refrigerator full so it retains its temperature when you open and close the door.

9. Thawing food before cooking it saves a third of the energy it would take to heat it from a frozen state.

10. Do all your laundry at one time so the dryer needs to heat up just once.

11. Don't run water the entire time you brush your teeth or shave.

12. Repair any leaks in your pipes or plumbing fixtures, especially in hot water lines.

13. Install timers on thermostats and hot water heaters so they shut off while you are asleep or at work.

14. Always set thermostats to the minimal level that affords comfort. Even a one degree change can make a difference over time.

15. During mild spells in spring and fall, shut off your central air and ventilate the house with open windows and fans.

Appendix B: Financial Incentives

Federal Tax Incentives for Energy Efficient Builders and Homeowners

The US Department of Energy provides financial incentives to both the builder, and homeowner, of energy efficient homes. These incentives change from year to year . To find out what incentives your home could qualify for, please contact your local tax office, or visit www.energy.gov/taxbreaks

TVA Energy Right Program

Energy Efficiency program that provides financial assistance to customers in TVA owned utilities for purchases of various energy efficient products. Products vary by energy demand season. To find out which appliances qualify for financial assistance please visit www.energyright.com

Solar Incentives

TVA Generation Partners: $0.15 per kWh produced by residence and small businesses, with $0.20 per kWh compensated to large business solar production, maximum 50kW solar system www.tva.gov/greenpowerswitch/partners/index.htm

2002 USDA Farm Bill Section 9006: Grants compensate up to 25 percent of installation costs, up to $500,000; small, rural businesses only. Further information can be found at www.rurdev.usda.gov/rbs/farmbill/index.html

TN-CET Grant: State grant provides financing for up to 40 percent of installation costs; businesses only, maximum $40,000. For more information visit www.state.tn.us/ecd/

Federal Tax Credits: Tax credit for up to 30 percent of installation costs, up to $2,000; residences and businesses. Incentives for both PV and thermal hot water systems. Visit www.SEIA.org for free guide on applying for solar tax credit.

DSIREUSA: A web page of all renewable incentives available to Tennessee residents. www.dsireusa.org

Wind Incentives

TVA Generation Partners: $0.15 per kWh produced by a residence, maximum 50 kW turbines. Specific information can be found at www.tva.gov/greenpowerswitch/partners/index.htm

2002 USDA Farm Bill Section 9006: Grants compensate up to 25 percent of installation costs, up to $500,000; small, rural businesses only. Further information at: www.rurdev.usda.gov/rbs/farmbill/index.html

Tenn. Code § 67-5-601 (2005): A 67 percent property tax exemption for commercial wind farms located in the state of Tennessee.

Federal Production Tax Credit: A 1.9-cent tax credit for every 1 kWh of commercial wind energy produced.

Reference Sources

Publications

Closed Crawl Spaces: An Introduction for the Southeast
Advanced Energy
909 Capability Drive, Suite 2100
Raleigh, NC 27606
www.crawlspaces.org

EarthCraft House Guidelines
Southface
241 Pine Street, NE
Atlanta, GA 30308
www.southface.org

Energy Efficient Residential Construction Guide: Climate Zone 4
Cleveland State Community College
Prepared by Brett Dillon, Dillon Consulting
Chattanooga, Tennessee

Energy Information Administration: State Energy Data 2001
Energy Information Administration
1000 Independence Avenue, SW
Washington, DC 20585
www.eia.doe.gov

Energy Savings from Small Near-Zero-Energy Houses: Integration of whole-house construction technologies in small, affordable, super-efficient houses
Jeff Christian, ORNL Buildings Technology Center
Building Envelopes Program
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
www.ornl.gov/btc

Energy Savers: Tips on Saving Energy & Money at Home
U.S. Department of Energy
Energy Efficiency and Renewable Energy
PO Box 3048
Merrifield, VA 22116
www.eere.energy.gov

Heat Island Group: Cool Roofs
Lawrence Berkeley National Laboratory
Building 90, Room 2000 Berkeley Lab
Berkeley, California 94720
www.eetd.lbl.gov/HeatIsland/CoolRoofs

How to Build a Zero Electric Utility Cost House
Jeff Christian, ORNL Buildings Technology Center
Building Envelopes Program
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
www.ornl.gov/roofs+walls

Insulation Fact Sheet
Building Envelopes Program
Oak Ridge National Laboratory
P.O. Box 2008, Mail Stop 6070
Oak Ridge, Tennessee 37831
www.ornl.gov/btc

ORNL Fact Sheet for DOE and TVA with Habitat for Humanity and ORNL to Design, Build, and Monitor five Near-Zero Energy Homes in Lenior City, Tennessee: April 2006
Building Envelopes Program
Oak Ridge National Laboratory
P.O. Box 2008, Mail Stop 6070
Oak Ridge, Tennessee 37831
www.ornl.gov/btc

Passive and Active Solar Domestic Hot Water Systems
North Carolina Solar Center
Box 7401
North Carolina State University
Raleigh, NC 27695
www.nscs.ncsu.edu

Photovoltaics: Electricity from the Sun
North Carolina Solar Center
Box 7401
North Carolina State University
Raleigh, NC 27695
www.nscs.ncsu.edu

Pushing the Envelope: ORNL Review
Building Envelopes Program
Oak Ridge National Laboratory
P.O. Box 2008, Mail Stop 6070
Oak Ridge, Tennessee 37831-6070
www.ornl.gov/btc

Residential Load Calculation: Manual J, 7th edition
Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206
www.acca.org

Retrofit Best Practices Guide
Building Envelopes Program
Oak Ridge National Laboratory
P.O. Box 2008, Mail Stop 6070
Oak Ridge, Tennessee 37831-6070
www.ornl.gov/btc

Siting of Active Solar Collectors and Photovoltaic Module
North Carolina Solar Center
Box 7401
North Carolina State University
Raleigh, NC 27695
www.ncsc.ncsu.edu

State of Tennessee 2000 Age and Sex
US Census Bureau
4700 Silver Hill Road
Washington DC 20233-000
www.census.gov

Websites

In addition to those websites already listed in this reference, these websites were used and/or recommended for further study:

ASHRAE
www.ashrae.org
Explains heating, ventilation, air conditioning and refrigeration standards in the United States, made mainly for builders to abide by codes.

Clear the Air
www.cleartheair.org
Explains how air pollution affects the nation, including a state by state breakdown.

Cool Roofs Rating Council
www.coolroofs.org
Website discussing the latest innovation in cool roofs technology.

Database of State Incentives for Renewable Energy
www.dsireusa.org
Website that explains and lists financial incentives for all 50 states regarding renewable-energy products.

East Tennessee Clean Fuel Coalition
www.etcfc.org
Explanation and location of the East Tennessee biodiesel infrastructure, excellent website for anyone in East Tennessee interested in biodiesel.

Efficient Windows Coalition
www.efficientwindows.org
Allows homeowners and builders to gather enough information to make educated decisions about proper window rating and orientation in the home. Excellent resource for energy-efficient window questions.

EnergyStar Program
www.energystar.gov
EnergyStar appliance listings, programs and explanation of the need for energy efficiency.

Environmental Protection Agency – Non Attainment Zone
www.epa.gov/oar/oaqps/greenbk/
Lists the various types of non attainment zones, the standards and the counties that fall into these zones

Gas Appliance Manufacturers Association (GAMA)
www.gamanet.org
Listing of efficiencies for gas and oil-fueled furnaces and boiler efficiencies. Also lists gas, oil and electric hot water heater efficiencies.

Geothermal Heat Pump Consortium
www.geoexchange.org
Excellent website providing information and explanation for geothermal systems, including technical information, financial incentives, installation types and placement locations.

Lawrence Berkeley National Laboratory
www.ducts.lbl.gov
Shares information on numerous studies on home duct systems.

NABCEP Solar Certification
www.nabcep.org
Official website of NABCEP certification, the official certification for solar installers, gives information about how to become a certified installer.

Solar Installers
www.findsolar.com
Dedicated to locating a solar installer in your area.

Structural Insulation Panel Association
www.sips.org
Official webpage of SIPA describing use of SIPS for builders and consumers.

TVA Energy Right Program
www.energyright.gov
Tennessee Valley Authority program giving financial incentives to residents interested in investing in energy-efficient products. Updated seasonally.

TVA Generation Partners Program
www.tva.gov/greenpowerswitch/partners/index.htm
Provides information regarding TVA purchasing power from installed renewable energy systems.

TVA Green Power Switch
www.tva.gov/greenpowerswitch/index.htm
This website provides information regarding Green Power for TVA consumers, a great way to use green energy in the home.

U.S. Department of Energy
Energy Efficiency and Renewable Energy Program Office
www.eere.energy.gov
Studies and statistics involving energy efficiency in the home. Provides insightful, easy-to-read instructions for practicing energy efficiency.

US Green Building Council
www.usgbc.org
Excellent resource for builders to understand how to construct green buildings.

Wind Powering America
www.windpoweringamerica.gov
Department of Energy program providing information on wind energy and its application to residences, businesses and schools

For more information, please visit www.cleanenergy.org

www.cleanenergy.org