Elements of an Energy-Efficient House

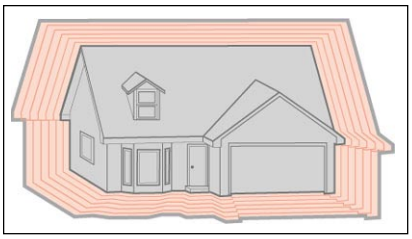
Summary

This fact sheet will provide you with an overview of some basic elements to consider when designing and building an energy-efficient house.

You have much to consider when designing and building a new energy-efficient house and it can be a challenge. However, recent technological improvements in building elements and construction techniques also allow most modern energy-saving ideas to be seamlessly integrated into house designs while improving comfort, health or aesthetics. And even though some energy-efficient features are expensive, there are others that many home buyers can afford.

While design costs, options and styles vary, most energy-efficient homes have some basic elements in common: a well-constructed and tightly sealed thermal envelope; controlled ventilation; properly sized, high-efficiency heating and cooling systems; and energy-efficient doors, windows and appliances.

Thermal Envelope



A thermal envelope is everything about the house that serves to shield the living space from the outdoors. It includes the wall and roof assemblies, insulation, air/vapor retarders, windows and weatherstripping and caulking.

Wall and Roof Assemblies

Most builders use traditional wood frame construction. Wood framing is a "tried and true" construction technique that uses a potentially renewable resource — wood — to provide a structurally sound, long-lasting house. With proper construction and attention to details, the conventional wood-framed home can be very energy-efficient. It is now even possible to purchase a sustainably harvested wood.

Some of the available and popular energy-efficient construction methods include the following:

Optimum Value Engineering. This method uses wood only where it is most effective, thus reducing costly wood use and saving space for insulation. The amount of lumber has been determined to be structurally sound through both laboratory and field tests. However, the builder must be familiar with this type of construction to ensure a structurally sound house.

Structural Insulated Panels. These sheets are generally made of plywood or oriented-strand board that is laminated to foam board. The foam may be 4 to 8 inches thick.

Because the structural insulated panels act as both the framing and the insulation, construction is much faster than optimum value engineering or stick framing. The quality of construction is often superior because there are fewer places for workers to make mistakes.

Insulating Concrete Forms. Houses constructed in this manner consist of two layers of extruded foam board (one inside the house and one outside the house) that act as the form for a steel-reinforced concrete center. It's the fastest technique and least likely to have construction mistakes. Such buildings are also very strong and easily exceed code requirements for areas prone to tornadoes or hurricanes.

Insulation

An energy-efficient house has much higher insulation R-values than required by most local building codes. An R-value is the ability of a material to resist heat transfer and the lower the value, the faster the heat loss. For example, a typical house in New York might have insulation of R-11 in the exterior walls and R-19 in the ceiling, while the floors and foundation walls may not be insulated. A similar, but well-designed and constructed house will have insulation levels that range from R-20 to R-30 in the walls and from R-50 to R-70 in the ceilings. Carefully applied fiberglass batt or rolls, wet-spray cellulose or foam insulation will fill wall cavities completely.

Foundation walls and slabs should be as well insulated as the living space walls. Poorly insulated foundations have a negative impact on home energy use and comfort, especially if the family uses the lower parts of the house as a living space. Also, appliances — such as domestic hot water heaters, washers, dryers and freezers — that supply heat as a byproduct are often located in the basement. By carefully insulating the foundation walls and floor of the basement, these appliances can assist in heating the house.

While most new houses have good insulation levels, it is often poorly installed. In general, gaps and compaction of insulation reduce its effectiveness.

Air/Vapor Retarders

Water vapor condensation is a major threat to the structure of a house, no matter what the climate. In cold climates, pressure differences can drive warm, moist indoor air into exterior walls and attics. The air condenses as it

cools. The same can be said for southern climates, just in reverse. As the humid outdoor air enters the walls and encounters cooler wall cavities, it condenses into liquid water. This is the main reason why some buildings in the South have problems with mold and rotten wood after they're retrofitted with air conditioners.

A vapor retarder is a material or structural element that can be used to inhibit the movement of water vapor, while an air retarder can inhibit airflow, into and out of a house's envelope. How to design and install vapor retarders depends a great deal on the climate and on the chosen construction method. However, any water vapor that does manage to get into the walls or attics must be allowed to escape.

Regardless of climate, water vapor migration should be minimized by using a carefully designed thermal envelope and sound construction practices. Systems that control air and water vapor movement in homes rely on the nearly airtight installation of sheet materials on the interior as the main barrier.

The Airtight Drywall Approach uses the drywall already being installed along caulking to create a continuous air retarder. In addition, seams where foundation, sill plate, floor joist header and subfloor meet are also carefully sealed with appropriate caulk or gasket material.

Consult your local building codes official on the best vapor retarder method to use in your area.

Windows

The typical home loses more than 25 percent of its heat through windows. Even modern windows insulate less than a wall. Therefore, an energy-efficient house in a heating-dominated climate should, in general, have few windows on its northern, eastern and western sides. Total window area should also not exceed 8 to 9 percent of the floor area for those rooms, unless the designer is experienced in passive solar techniques. If this is the case, then increasing window area on the southern side of the house to about 12 percent of the floor area is recommended. This is often called solar tempering.

A properly designed roof overhang for south-facing windows will help prevent overheating in the summer. North, east and west windows should have low Solar Heat Gain Coefficients. South windows with properly sized overhangs should have a high coefficient to allow winter sun (and heat) to enter the house. The overhang blocks the high summer sun (and heat). If properly sized overhangs are not possible, a low Solar Heat Gain Coefficient glass should be selected for the south windows.

At the very least, you should use windows and doors with an Energy Star® label, which are twice as energy efficient as those produced ten years ago, according to regional, climatic guidelines (note: houses with any kind of solar tempering have other guidelines). The best windows are awning and casement styles because these often close tighter than sliding types. In all climates, window glass facing south without overhangs can cause a problem on the cooling side that far exceeds the benefit from the winter solar gains.

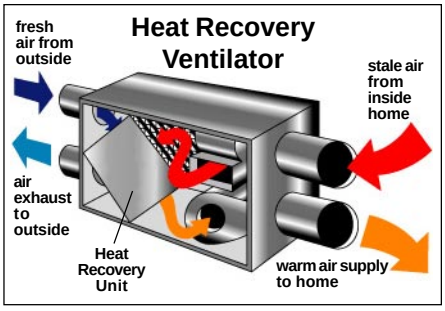
Weatherstripping and Caulking

You should seal air leaks everywhere in a home's thermal envelope to reduce energy loss. Good air sealing alone may reduce utility costs by as much as 50 percent when compared to other houses of the same type and age. You can accomplish most air sealing by using two materials: caulking and weatherstripping. Caulking can be used to seal areas of potential air leakage into or out of a house. And weatherstripping can be used to seal gaps around windows and exterior doors.

Controlled Ventilation

Since an energy-efficient house is tightly sealed, it needs to be ventilated in a controlled manner. Controlled, mechanical ventilation prevents health risks from indoor air pollution, promotes a more comfortable atmosphere and reduces air moisture infiltration, thus reducing the likelihood of structural damage.

Furnaces, water heaters, clothes dryers and bathroom and kitchen exhaust fans expel air from the house, making it easier to depressurize an airtight house if all else is ignored. But natural-draft appliances may be back-drafted by exhaust fans, which can lead to a lethal buildup of toxic gases in the house. For this reason, sealed-combustion heating appliances, which use only outside air for combustion and vent combustion gases directly to the outdoors, are very important for ventilation energy efficiency and safety.



Heat recovery ventilators or energy recovery ventilators are growing in use for controlled ventilation in airtight homes. These ventilators can salvage about 70 percent of the energy from the stale exhaust air and transfer that energy to the fresh

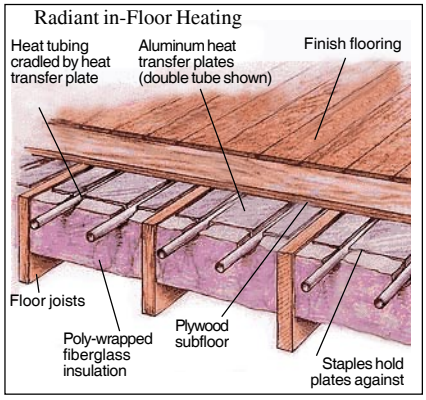
air entering by way of a heat exchanger inside the device. They can be attached to the central forced air system or may have their own duct system.

Other ventilation devices, such as through-the-wall or "trickle" vents, may be used in conjunction with an exhaust fan. They are, however, more expensive to operate and possibly more uncomfortable to use because they have no energy recovery features to precondition the incoming air. Uncomfortable incoming air can be a serious problem in northern climates and can create moisture problems in humid climates. Therefore, this ventilation strategy is only for arid climates. Other systems pull outside air in with a small outside duct on the return side of the furnace.

Heating and Cooling Systems

Specifying the correct sizes for heating and cooling systems in airtight, energy-efficient homes can be tricky. Rule-of-thumb sizing is often inaccurate, resulting in wasteful operation. Conscientious builders and heating, ventilation and air-conditioning contractors size heating and cooling equipment based on careful consideration of the thermal envelope characteristics.

Generally, energy-efficient homes require relatively small heating systems, typically less than 50,000 Btu/hour even for very cold climates. Some require nothing more than sunshine as the primary source of heat along with auxiliary heat from radiant in-floor heating, a standard gas-fired water heater, a small boiler, a furnace or electric heat pump. Any common appliance that gives off "waste" heat can also contribute significantly to the heating requirements for such houses.



If an air conditioner is required, it's often a small unit and sufficient for all but the warmest climates. Sometimes only a large fan and the cooler evening air are needed to make the house comfortable. The house is closed up in the morning and stays cool until the next evening.

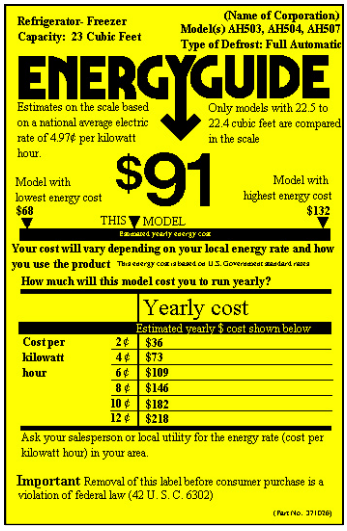
Smaller-capacity heating and cooling systems are usually less expensive to buy and operate. This helps recover the costs of purchasing more insulation and other energy-efficient products, such as windows and appliances. Always look for the EnergyGuide label on heating and cooling equipment. The label will rate how efficient it is as compared to others available on the market.

In climates where summer cooling requirements dominate, light-colored materials and coatings, such as paint, on the exterior siding and roof can help reduce cooling requirements by up to 15 percent. Carefully selected and placed vegetation in any climate also contributes to reduced cooling and heating loads.

Energy-Efficient Appliances

Appliances with relatively high operating efficiencies are usually more expensive to purchase. However, higher efficiency appliances provide a measure of insurance against increases in energy prices, emit less air pollution and are attractive selling points when the home is resold.

Home buyers should invest in high-efficiency appliances — such as refrigerators, clothes washers and dryers, dishwashers and water heaters — especially if these appliances will be used a great deal. Because all major appliances must have an EnergyGuide label, read the label carefully to make sure you buy the most efficient appliance. To help you choose wisely, major appliances with an Energy Star® label exceed the federal government's minimum efficiency standards by a large percentage.



Refrigerator- Freezer
Capacity: 23 Cubic Feet
(Name of Corporation)
Model(s) AH503, AH504, AH507
Type of Defrost: Full Automatic

ENERGYGUIDE

Estimates on the scale based on a national average electric rate of 4.97¢ per kilowatt hour.

Only models with 22.5 to 22.4 cubic feet are compared in the scale

Model with lowest energy cost $68

$91

Model with highest energy cost $132

THIS MODEL

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. The energy cost is based on U.S. Government standard rates

How much will this model cost you to run yearly?

Cost per kilowatt hour	Yearly cost (Estimated yearly $ cost shown below)
2¢	$36
4¢	$73
6¢	$109
8¢	$146
10¢	$182
12¢	$218

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area.

Important Removal of this label before consumer purchase is a violation of federal law (42 U. S. C. 6302)

(Part No. 371036)

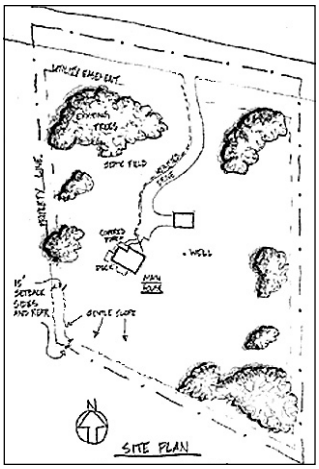
Energy-efficient lighting helps keep energy bills down by producing less heat and reducing cooling requirements. Fluorescent lighting, both conventional tube and compact, is generally the most energy-efficient for most home applications.

Advantages and Disadvantages

Houses that incorporate all of the above elements of energy efficiency have many advantages. They feel more comfortable because the additional insulation keeps the interior wall at a more comfortable and stable temperature. The indoor humidity is also better controlled and drafts are reduced. A tightly sealed air/vapor retarder reduces the likelihood of moisture and air seeping through the walls. They are also very quiet because the extra insulation and tight construction helps to keep exterior noise out better.

But these houses also have some potential disadvantages. They may cost more and take longer to build than a conventional home if there's a lack of builder familiarity with new construction techniques and products available on the market. Even though the house's structure may differ only slightly from conventional homes, the builder and contractors may be unwilling to deviate from what they've always done before. They may need more training if they have no experience with these systems.

Building and Buying



Before you start a home-building project, the building site and its climate should be carefully evaluated to determine the optimum design and orientation for the house. There are energy-related computer software programs that can help with these evaluations. The design should accommodate appropriate insulation levels, moisture dynamics and aesthetics. Decisions regarding appropriate windows, doors and heating, cooling and ventilating appliances are central to an efficient design. Also the cost, ease of construction, the builder's limitations and local building code compliance should be competently evaluated. Some plans are relatively simple and inexpensive to construct, while others can be extremely complex and, thus, expensive.

An increasing number of builders are participating in the federal government's Building America and Energy Star® Homes programs, as well as local home energy rating programs, all of which promote the construction of energy-efficient houses. Many of these builders construct energy-efficient homes to differentiate themselves from their competitors. Construction costs can vary significantly depending on the materials, construction techniques, contractor profit margin, experience and the type of heating, cooling and ventilation system chosen.

In the end, your energy-efficient house will provide you with superior comfort and lower operating costs, not to mention a higher real estate market value.

Resources

Ask an Energy Expert

DOE Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
Phone: 1-800-DOE-EREC 1-800-363-3732
Fax: 703-893-0400
E-mail: doe.erec@nciinc.com
Web Site: **http://www.eere.energy.gov/consumerinfo/**

Energy experts at EREC provide free general and technical information to the public on many topics and technologies pertaining to energy efficiency and renewable energy.

Produced by the
Nebraska Energy Office
1111 "O" Street, Suite 223
P.O. Box 95085, Lincoln, NE 68509
Phone 402-471-2867, Fax 402-471-3064
email: energy@mail.state.ne.us
www.nol.org/home/NEO

This document was produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory, a DOE national laboratory and modified by staff from the Nebraska Energy Office. DOE/GO 10200-1070 FS104, produced October 2000.

Other factsheets and additional information can also be found at: www.nol.org/home/NEO/home_const/design_build.htm

This factsheet was partially financed through the Nebraska Department of Environmental Quality Litter Reduction and Recycling Program.