ENERGY-EFFICIENT NEW CONSTRUCTION

For new homes, there is no single best design or technique for achieving optimal energy efficiency. Builders now have at their disposal a vast array of materials, components, appliances and techniques. Quality work and good materials have always been hallmarks of a well built home but an understanding of how a house operates as a system is essential in building an energy efficient home. Knowing how to properly integrate all of the building components and understanding that they all interact is necessary in order to produce a high performance home. This chapter describes how to identify those features in a new home and presents a few representative examples of each – many of which have already been discussed in previous chapters. The chapter also briefly discusses green building concepts in a special section located at the end of the chapter preceding Energy Tips and Recommendations. Green building emphasizes the importance of environmentally friendly building techniques, which obviously includes energy efficient construction. Green building is essentially an umbrella that encompasses any energy efficient building method or practice and everything discussed in this chapter is a component of the green building approach.

Energy Star Homes

Purchasing or building an Energy Star labeled home means that you will live in a house that is certified to be energy efficient. An Energy Star home will have tight ducts, good ventilation, maximum insulation levels, high performance windows, air tight construction, and energy efficient heating and cooling equipment. This combination of construction gives reduced utility bills, healthy indoor air, and low maintenance. They are site inspected and diagnostic tested by accredited Home Energy Raters.

For more information please visit the Energy Star Web site at www.energystar.gov/homes

High Levels Of Insulation

Insulation (Chapter 3) is one of the most important and most cost-effective ways to improve the energy performance of your home.

High Performance Windows With Proper Solar Control

The windows in an energy-efficient house in Virginia should have overall U-values of at least 0.40 or less. Most commonly they will be double-glazed, low-E windows with wood or vinyl frames. Super insulated windows have a U-vale of 0.22. (See Chapter 4 for a description of how high performance windows work.)

To help control cooling loads, your builder may incorporate solar control glass, which reduces solar heat gain into the house, particularly into south and west facing rooms that have large glass area.

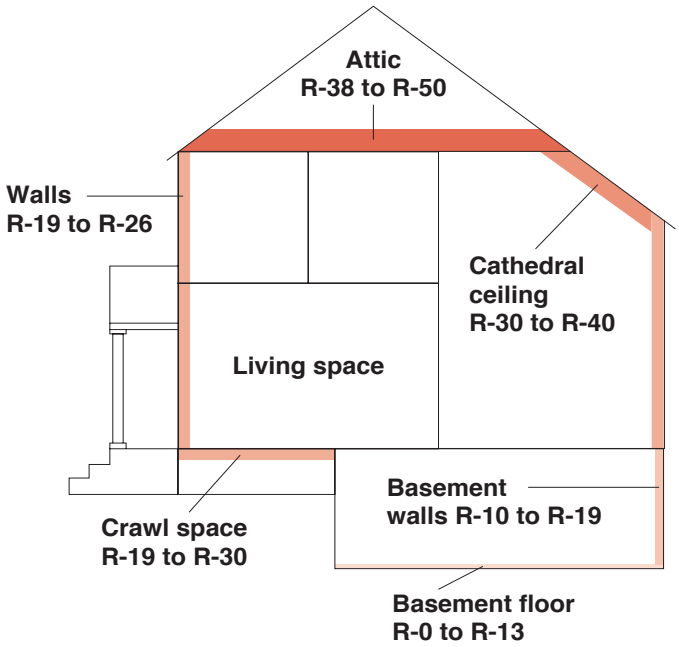


Figure 10-1 - To control heat loss through walls, ceilings and floors, an energy efficient new home has high R-values around the entire thermal envelope. (See Chapter 3 for an explanation of R-values.)

Low Air Leakage Rate

Airtight construction and controlling air leakage is the primary key to the performance of an energy efficient house. It is also one of the most elusive features to identify. As discussed in (Chapter 1), it is an excellent investment to have a professional blower door test done to identify air leakage areas and to determine how tight your house is. All builders should be interested in including blower door testing into their house-as-a-system testing procedures (Chapter 1).

Building for air-tightness entails a variety of materials, techniques, proper testing, and an appropriate design. Air leakage is discussed thoroughly in Chapter 2. In general, all joints, seams and penetrations should be sealed with either caulk, two part foam, gaskets or polyethylene

Figure 10-2a

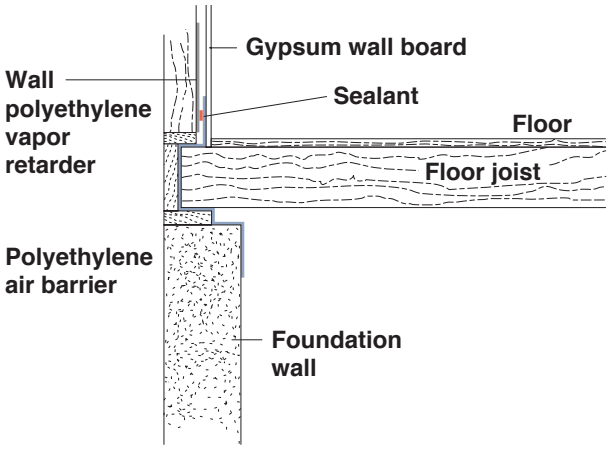


Figure 10-2b

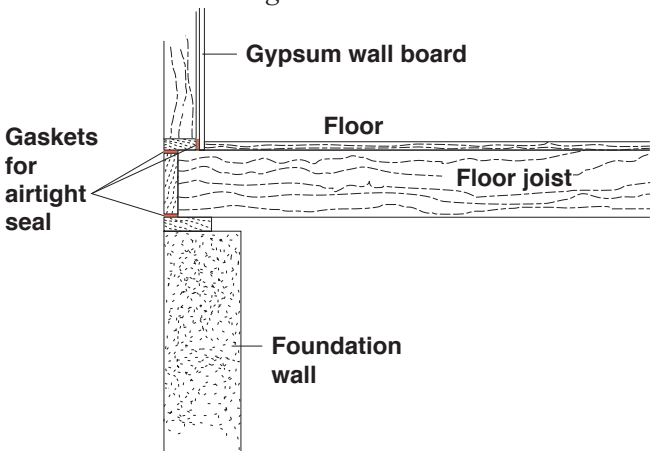


Figure 10-2 - The area around floors is the single most important area to seal for air leakage control. One common approach for controlling air leakage around floors is to wrap a plastic sheet around the edge of the floor system and seal it to the wall above and foundation below (a). Another common approach is to place gaskets between the various framing members (b). Both methods have been tested and proven effective.

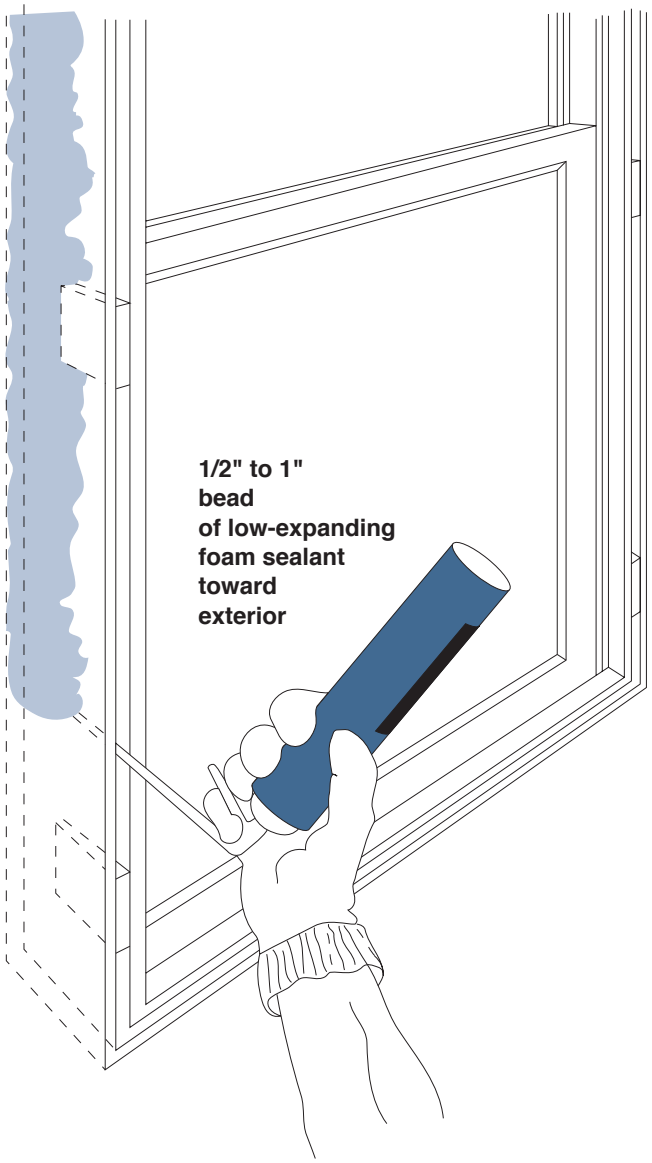


Figure 10-3 - Although most modern windows are very airtight, the gap between the installed window and the rough framing into which it is installed can be a major air leakage pathway if not properly sealed. One common and simple technique is to fill the gap with expanding foam sealant.

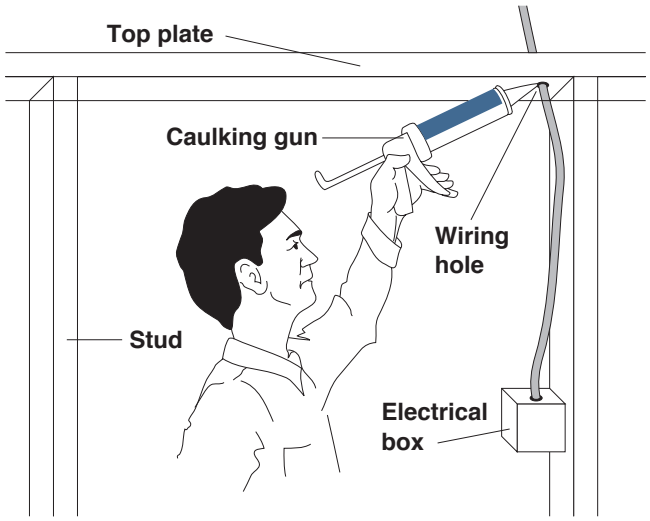


Figure 10-4 - All wiring holes in the top plate of interior partitions are caulked to prevent air leakage up into the attic.

film with special attention being made to avoiding the creation of any thermal bypasses when constructing the home. The result is a continuous "air barrier" that surrounds the entire conditioned space of the house.

Fresh Air Ventilation For Indoor Air Quality Control

Energy efficiency goes hand in hand with indoor comfort and health and a key component for providing all three is a mechanical ventilation system that exhausts stale air and brings in fresh outdoor air in a controlled fashion. Adequate air exchange is essential in a tight house in order to create a healthy indoor air quality environment (Chapter 2). Some contractors go further by installing a fully ducted system. In a ducted system, a central ventilator exhausts stale air from bathrooms and kitchen while distributing fresh air to each part of the house. The most sophisticated residential ventilation systems include a "heat recovery ventilator" which extracts waste heat from the exhaust air and uses it to preheat the incoming fresh air (reverse in summer) (Figure 6). Typical installed costs for these systems are listed in Table 1.

A typical "exhaust only" ventilation system (see Figure 10-5) includes a fan that extracts stale air from bathrooms and kitchens and exhausts it to the outdoors. The fan creates a slight negative pressure in the house, which causes fresh outdoor air to be drawn in through a "passive" inlet duct that is connected to the return plenum of the forced air distribution system or through window or wall ventilators. Many varieties of timers and controls are available and most fans now operate very quietly. Keep in mind that ventilation fans can cause combustion appliances to back draft because they do create a negative pressure within the house.

Table 10-1 - Typical ventilation system installed costs.

Central exhaust fan with passive outdoor air inlets	$300 to $600
Balanced ventilation system with heat recovery ventilator	
Rotary wheel	$400 to $800
Flat plate core	$600 to $2000

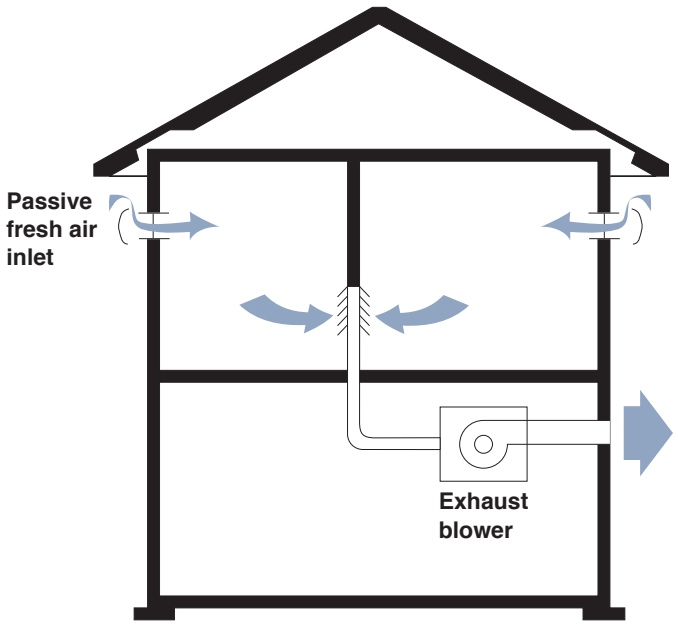


Figure 10-5 - A typical "exhaust-only" ventilation system.

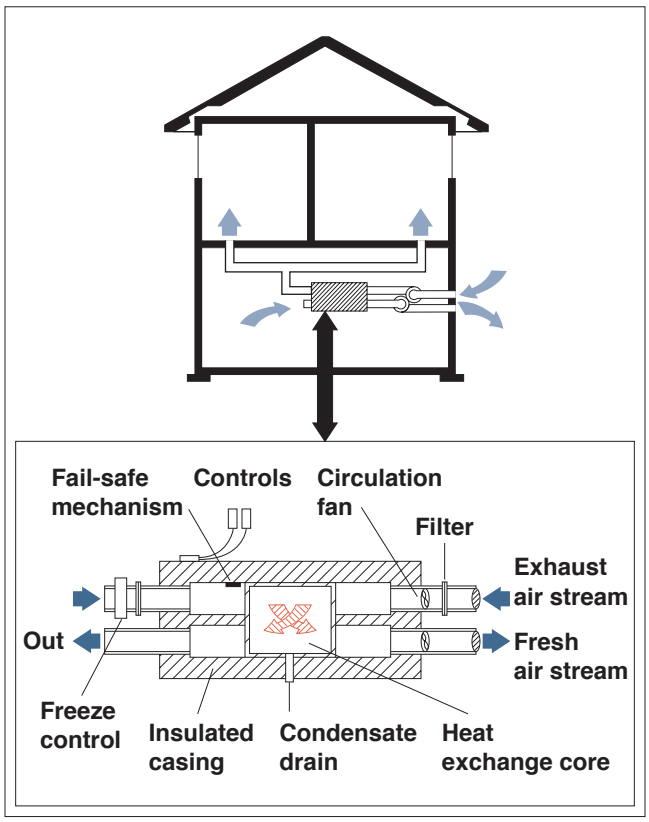


Figure 10-6 - The most sophisticated type of residential ventilation system includes a central heat recovery ventilator that has two separate blowers -- one for exhausting stale air and a second for bringing in fresh outdoor air. A system of ducts carries both airstreams to and from the ventilator.

The core of the heat recovery ventilator extracts heat (in winter) or coolness (in summer) from the exhaust air stream before expelling it from the house.

High Performance Mechanical Systems

In a tightly built, well insulated home, the efficiency of the heating and cooling systems is not as important as in a less energy efficient home but it is still an important investment. The reason is because the heating and cooling loads will be so much lower that a 5% or 10% improvement in efficiency may translate into only a small decrease in energy costs. (10% savings of an already small load is only a small savings.) Nonetheless, energy efficient homes should have appliances with reasonably efficient heating and cooling equipment. More efficient combustion appliance equipment will also burn cleaner and produce less harmful pollutants that are released into the atmosphere.

For fuel-burning heating appliances, look for an Annual Fuel Utilization Efficiency (AFUE) of 90% or better. For central air conditioners, look for a Seasonal Energy Efficiency Ratio (SEER) of at least 12.0. For heat pumps look for cooling SEER between 11 and 12 and Heating Seasonal Performance Factor (HSPF) of 8.0 or better. (See Chapter 5 for explanation of heating and cooling system efficiencies.) Remember to study the Energy Guide labels and look for the most efficient models available and always try to purchase Energy Star certified equipment, which represent those products that exceed the minimum government efficiency standards (Chapter 7).

Perhaps the most important appliance to check for efficiency is the water heater (Chapter 6). Since the water heating energy consumption is unaffected by how energy efficient the house is, water heating is sometimes the biggest energy load in an energy efficient house. In a gas-fired water heater, look for an Energy Factor (EF) of 0.61 or more. In an electric water heater, look for an EF of 0.92 or more.

Power-vented or sealed combustion appliances

In a tightly sealed house, there are few leaks to bring in air for combustion appliances. To prevent any chance of flue gases spilling into the house, all fuel-burning appliances should be either power vented or have completely sealed combustion. This includes gas and oil-fired furnaces, boilers and water heaters as well as kerosene and gas space heaters. (See Chapter 2 for discussion of combustion safety.)

Duct Systems

New construction is the perfect opportunity to properly install, size, and seal duct systems. Leaky and improperly installed duct systems can account for significant heating and cooling loss, increased energy bills, and serious health and safety problems within a household. Duct systems should be tested for leaks by a professional contractor and properly sealed using mastic. Ducts are discussed in Chapter 5.

Advantageous Use Of Available Solar Energy

A properly designed and built energy efficient home requires so little space heating energy, that it rarely can benefit from extensive solar heating systems. That is not to say, however, that it cannot benefit at all from solar heating. On the contrary, because the heat load is so small, it is easy to provide a good portion of your heating needs using simple "passive solar" principles. In most cases, this will mean concentrating a higher percentage of your window area on south-facing or east-facing walls to maximize winter sun.

Conversely, to control excessive summer cooling loads, an energy efficient house, should, if possible, minimize west-facing windows. It may also have solar control glass for year-round solar heat gain control (see Chapter 4).

Other Features For Energy Efficiency And Comfort

Solar water heater

Solar water heaters are discussed in Chapter 6. Though expensive to install, solar water heaters may produce hot water at a lower cost than fuel fired water heaters when analyzed on a life cycle cost basis (see analysis in Chapter 6).

Zoned heating and cooling

A zoned heating and cooling system allows you to control various "zones" of your house independently. There are two advantages to zoning. From a comfort perspective, it allows you to control the indoor environment according to the needs of the people and/or functions of a particular space. A workshop, for example, can be kept cooler than the living room. A bedroom for an elderly person can be kept warmer than one for a child.

From an energy standpoint, zoning allows you to turn down the heating or air conditioning for spaces that are not in use. Bedroom temperatures can be set back during the day, for example. Field studies have shown that when properly operated, zoning systems can save up to 25% of total utility bills in moderate climates like ours. (Ironically, if not properly operated, zoning can actually increase energy use by maintaining full temperature in all parts of the house.)

Thermal storage heating and cooling

Some electric utility companies offer special low "off-peak" electric rates during nights and weekends. To take advantage of those rates, manufacturers now sell special "thermal storage" heaters that store heat during off peak periods for use the following day while rates are high.

The use of a heat pump requires a different approach to thermal storage. Since outdoor temperatures are lower at night, heat pump performance drops. The decreased heat pump performance may waste more money than the off-peak electric rate saves. For heat pump systems in areas without off-peak rates it can sometimes be worthwhile to store heat during the day (when outdoor temperatures are high) for use during the night.

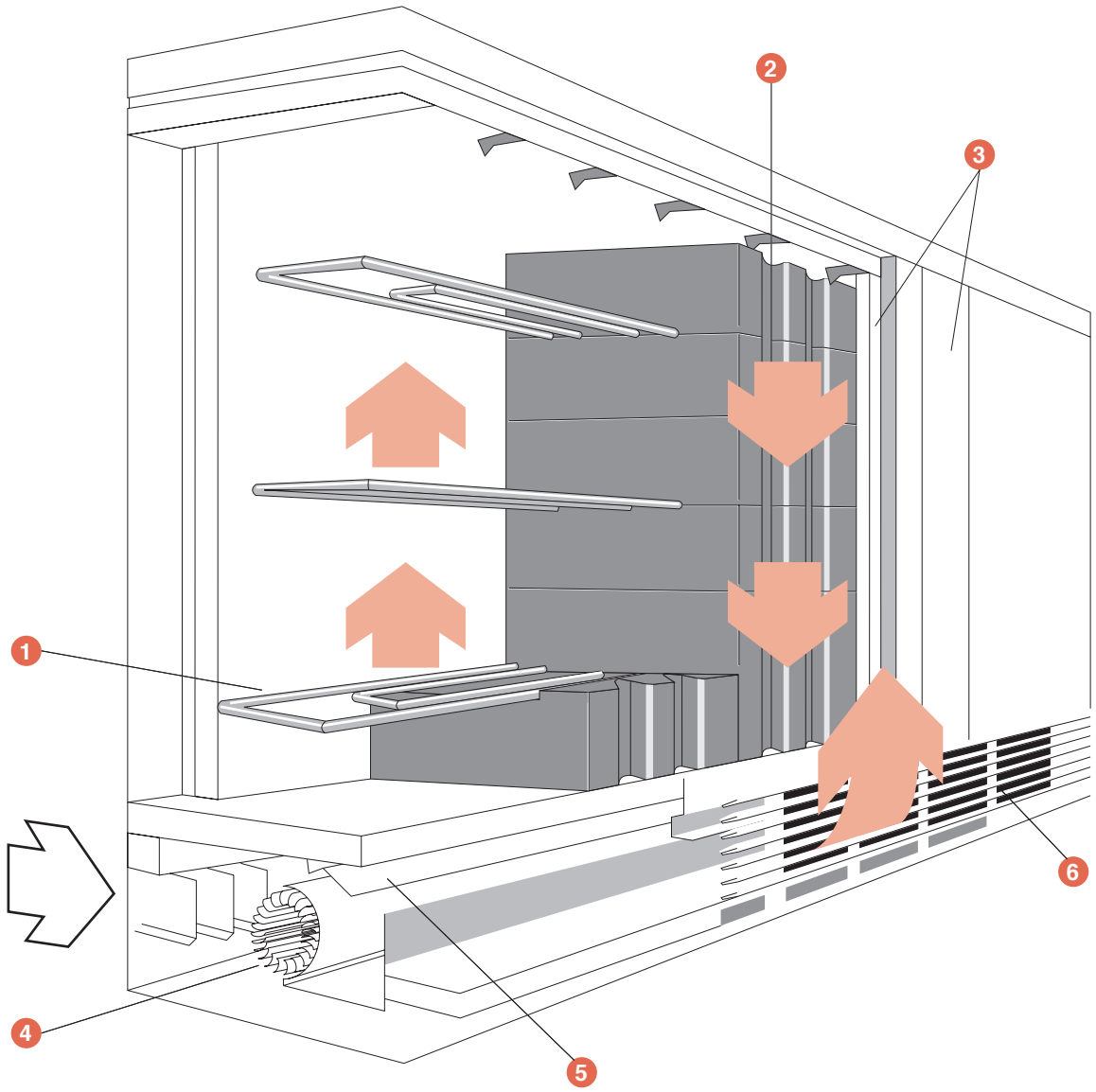
Various wood-fueled heaters (such as soapstone stoves) also incorporate thermal storage, allowing them to run more efficiently and heat the house for a long time on a single load of wood.

Another new technology is "cool storage", which uses the same principle to store coolness either as ice, as chilled liquid, or as chilled solid material. Cool storage allows the air conditioner to build up coolness at night, when electric rates may be lower and outside air is cooler, for use the next day. It is now widely used in commercial applications, while residential applications are small but growing.

The cost-effective use of thermal storage heating and cooling depends in part on the willingness of your electric service provider to sell energy at lower cost during off-peal periods. Utility restructuring (see Chapter 13) may increase consumer access to different rate structures.

Geothermal Heat Pumps

Geothermal heat pumps (also referred to as ground source heat pumps and discussed in Chapter 5) use the constant temperature of the earth to heat and cool your home. They are typically more efficient than the more



1 Special alloy heating elements use off-peak electricity to heat...

2 ...magnesite bricks which efficiently store the heat until it is needed.

3 Glass fiber and microtherm insulation keep the heat inside of the unit.

4 A quiet, low velocity fan is activated when the room thermostat calls for heat. Room temperature air is drawn into the unit and heated as it is circulated around the hot bricks.

5 A bimetallic damper mixes additional room air with the hot air inside to provide an even, comfortable flow of warm air into the room through...

6 ...the air discharge grille at the bottom of the unit.

Figure 10-7 - This thermal storage space heater contains high density bricks that are heated at night electrically and store the heat until the following day.

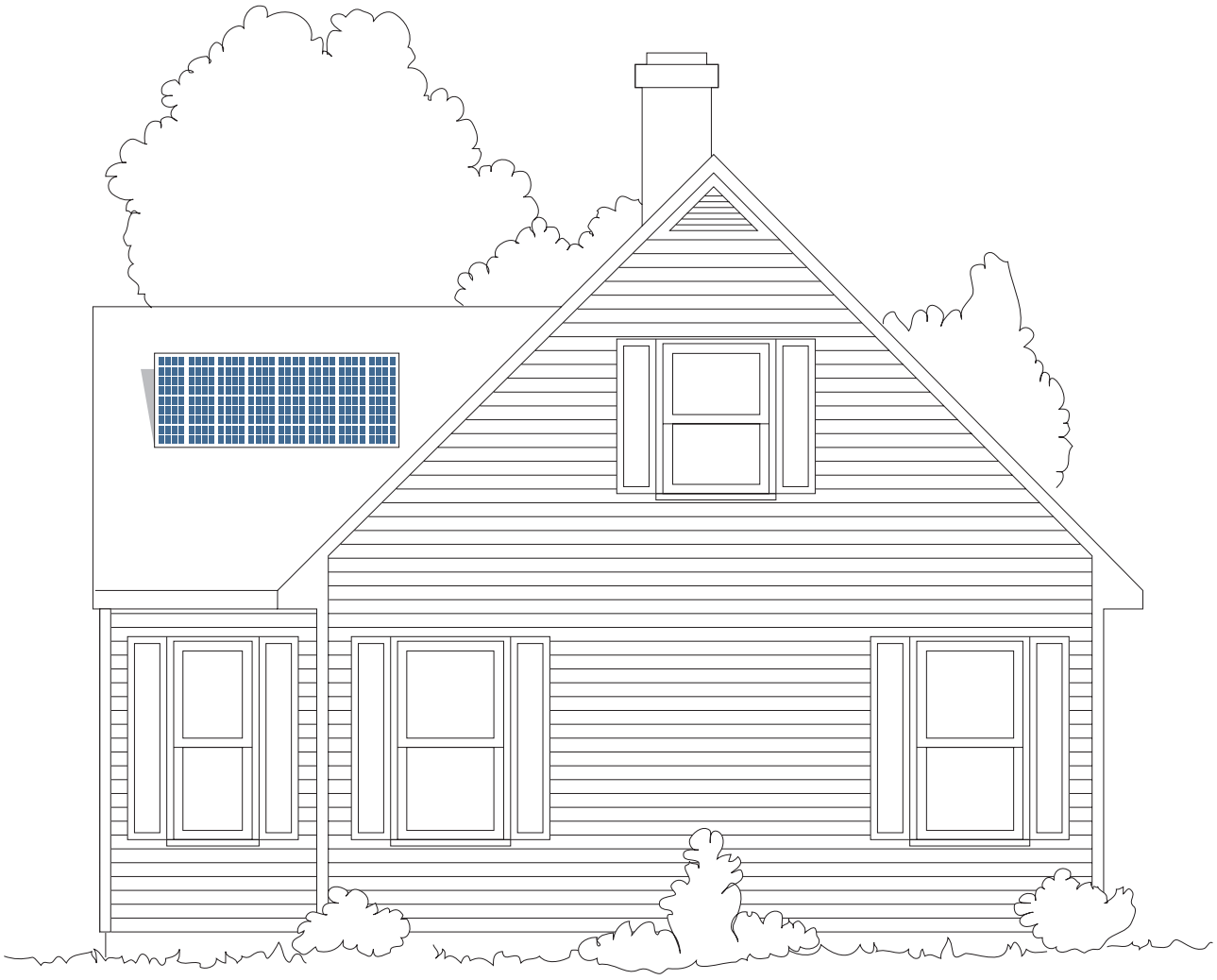


Figure 10-8 - Photovoltaic panels, mounted on the roof of a home, produce 12-volt electricity for use by specially equipped appliances.

common air-source heat pumps, they tend to last longer, and they can provide hot water more efficiently than standard electric water heaters.

Radiant Floor Heating

Hydronic radiant floor heating systems (Chapter 5) represent a quiet and efficient heat source. They use water filled tubing that is situated under the floor and delivered by a boiler that provides a very even distribution of heat.

Gas heat pumps and air conditioners

Air conditioners and heat pumps that use natural gas instead of electricity have been available for years and are constantly being improved. The newest generation of gas heat pumps and air conditioners use a natural gas-fired internal combustion engine to drive the compressor. As the efficiency of these systems improves, they could provide an economical alternative to electric air conditioning.

Energy Efficient Lighting

New construction is an ideal time to effectively design lighting strategies for your home. Utilizing energy efficient lighting sources such as compact fluorescent lamps (Chapter 8) can save money by using less electricity while also reducing harmful emissions from power plant generation.

Daylighting

Daylighting (discussed in Chapter 8) is using natural light in appropriate ways to minimize the need for turning on electric lights. Daylighting should always be considered when designing an energy efficient home.

Energy Star Appliances

The house is a system of interactive parts and an energy efficient home that is well insulated, air tight with proper ventilation, and installed with high performance windows should also include energy efficient appliances and equipment. Always study the black and yellow Energy Guide that is displayed on most appliances and be sure to look for those appliances that are Energy Star qualified (Chapter 7). Appliances can account for up to 20% of your household energy consumption

Photovoltaics

Electricity from sunlight contains the promise of reduced utility costs and independence from the power grid. Although photovoltaic electricity is still quite a bit more expensive than utility electricity, the technology is constantly being improved with respect to efficiency, reliability and cost. And even with today's hardware, photovoltaic electricity may be a practical option in remote locations where utility hookup is very expensive or otherwise impractical.

For many users, the high purchase and installation costs of photovoltaic systems is easily balanced by the reduced environmental cost. Electricity produced by photovoltaic systems is clean and produces no harmful emissions. This in itself is a reason to explore the potential of including solar powered equipment in any new home design.

Low Flow Water Fixtures

Install low flow water appliances, faucet aerators and low flow showerheads (Chapter 9 in combination with an energy efficient water heater (Chapter 6) and you will save significant money and energy as well as conserving a very valuable natural resource – water.

Cogeneration

Another technology just on the horizon is residential "cogeneration." Cogeneration is based on using both the shaft power output of an engine and the "waste heat" from the radiator or cooling fins and from the hot exhaust. A natural gas-fueled engine drives a generator that produces electricity, while the engine waste heat is used for space and water heating. The electricity is used for household appliances. Any excess electricity is fed back into the utility power grid and credited to the homeowner by the utility company.

Cogeneration technology is available today although its practicality is limited by cost. Further improvements in effectiveness may make it an attractive option, particularly in remote areas.

Another new technology, similar to cogeneration, is the engine-driven heat pump. A natural gas-fueled engine drives a heat pump compressor. The compressor pumps heat from the outdoors into the house, while the engine waste heat is also used. Gas engine-driven heat pumps can perform like gas-fueled furnaces with efficiency higher than 100%!

Energy Efficient Landscaping

Taking advantage of "nature's heating and cooling system" through the effective use of landscaping is an important way to cut energy costs by as much as 10-25%. Landscaping is a natural and beautiful way to block the sun and provide protection from winter winds. A well-placed tree, bush, or vine can deliver effective shade and add to the aesthetic value of your property.

The main idea behind landscaping is to plant trees and shrubs so they shade your home in hot weather and block the chilling winds of winter. When designing your landscaping, first take a good look at your home and yard. It is important to make the landscape work for you, and you must know how your house is oriented (north, south, east, west) so you can minimize heat gain in the summer and maximize it in the winter. Strategically planted or preserved trees around your home can reduce solar heat gains during the summer by 40-80% depending on the density of the trees. It is important to use plants native to your area that survive with minimal care and (once they are established) without watering. Evergreens can greatly

Green Building Technology

Green Building technology is an alternative to current building methods that strives to:

- Minimize the environmental impact of living in your house by saving energy, saving water, and reducing pollution emissions.
- Minimize the environmental impact of building your house by using building materials and construction practices that do not damage the environment.

Green building technology uses a systems approach to the overall environmental impact of a home. For instance, a green home design would avoid a building material, which saves energy once it is installed but which results in pollution during its manufacturing process.

Listed below are some basic green building principles that should be considered when building an energy efficient home:

- Use durable products and materials that require low maintenance.
- Choose low-embodied energy materials (Chapter 14).
- Use locally produced materials to minimize unnecessary transportation costs.
- Consider using recycled building products and salvaged materials if possible.
- Try not to use materials that offgas pollutants (Chapter 2).
- Reduce waste generated on site by inefficient construction practices.
- Incorporate all of the energy efficient technology that is discussed throughout this handbook.
- Utilize renewable energy (Chapter 12).
- Don't overbuild. Design and build a house that meets your needs but uses space and building materials efficiently.
- Utilize energy efficient landscaping.
- Consider responsible water management principles when designing your house. Absorb storm water rather than allowing it to run off. Collect rainwater (Chapter 9) and use it for household needs and irrigation.
- Protect the environment when you build. Protect trees, existing vegetation, and sensitive natural areas. Let the natural area guide the house design.
- Select a home location that allows you and your family to work, shop, attend school, etc. without excessive driving. Ideally, many trips should be possible by walking or using public transportation.

Green Building Materials

Green building materials are materials that are produced using environmentally friendly processes and can include salvaged products, recycled materials, certified wood products, products from renewable materials, materials that don't release harmful pollutants, and especially durable building materials.

The best available resource for identifying and locating green building materials is the GreenSpec Directory and GreenSpec Binder both of which are published by the Environmental Building News (EBN) – a leading newsletter on environmentally responsible design and construction. Over 1,200 green building products are selected by the editors of EBN who provide descriptions, environmental considerations, and manufacturer contact information. For more information, go to EBN's website at www.BuildingGreen.com.

Green Site Selection and Planning

Proper site selection and planning is essential in order to make optimum use of existing situations and to create new opportunities for an energy efficient dwell-

ing. Considering how the house will be situated allows the home-builder to take advantage of:

- Solar access
- Natural areas
- Prevailing wind
- Water resources
- Existing landscaping

Studying site development procedures and determining the lowest environmental impact will enable the home-owner to:

- Minimize the potential impact of improper excavation
- Protect existing trees
- Provide efficient storm water drainage and management
- Avoid contamination of the soil through disposal of construction waste
- Take advantage of summer shading and winter wind protection

Incorporating green building technology, materials and site planning will produce homes that don't create problems, but rather help to solve environmental, energy and economic issues that confront a community.

An aspect of green building that is often overlooked is the selection of a location with access to schools, shopping, and work. Living in a green design, energy efficient house where you must drive 75 miles to work probably doesn't help the environment. In selecting sites, many homebuilders fail to consider future development. They build homes out in the country with a commute that is long in distance, but short in time over rural roads with little traffic. Five or ten years later, they are inundated with development and have a long commute through heavy stop-and-go traffic.

slow cold winter winds, which for the most part come from the west, north, and northwest. Large deciduous trees can provide shade and summer cooling and then allow the sun's warm rays to enter the house during winter months. Deciduous trees are most effective on the east, west, and south sides of the house.

A well planned landscape can reduce an un-shaded home's air conditioning costs in summer by 15-50%. In the winter, a house with windbreaks on the windward side can average 25% less fuel consumption.

Trees not only help conserve energy but also help the environment in other ways. They absorb carbon dioxide, release oxygen, moderate storm water runoff and soil erosion, provide wildlife food and shelter, lessen local temperature extremes, buffer against noise and dust, and mitigate the glare of urban and suburban lighting.

Xeriscaping

Xeriscaping landscape designs focus on water conservation by using native plants and avoiding exotic plants that may not be as well suited to the local climate. This means that native grasses, plants, and trees when used will require less maintenance and less water to survive.

Energy Tips and Recommendations

1. Energy efficient new construction must include quality materials and workmanship as well as a whole house or house as a system approach. Proper integration of all building components is necessary for a high energy performing home.
2. An energy efficient house must include maximum levels of insulation, high performance windows, low air leakage rates and adequate ventilation, tight ducts, energy efficient heating and cooling equipment as well as Energy Star appliances.
3. Utilize renewable energy opportunities in constructing an energy efficient home such as solar water heaters, passive solar applications, and photovoltaic panels to produce clean electricity.
4. Consider building an Energy Star labeled home. Over 100,000 homes in 2003 qualified for the Energy Star

certification.

5. Use green building technology, green building materials, and green site planning to produce a sustainable home that will solve economic, environmental, and energy problems rather than creating them.
6. When constructing an energy efficient home, make use of the energy efficient technology that has been discussed in the Handbook.