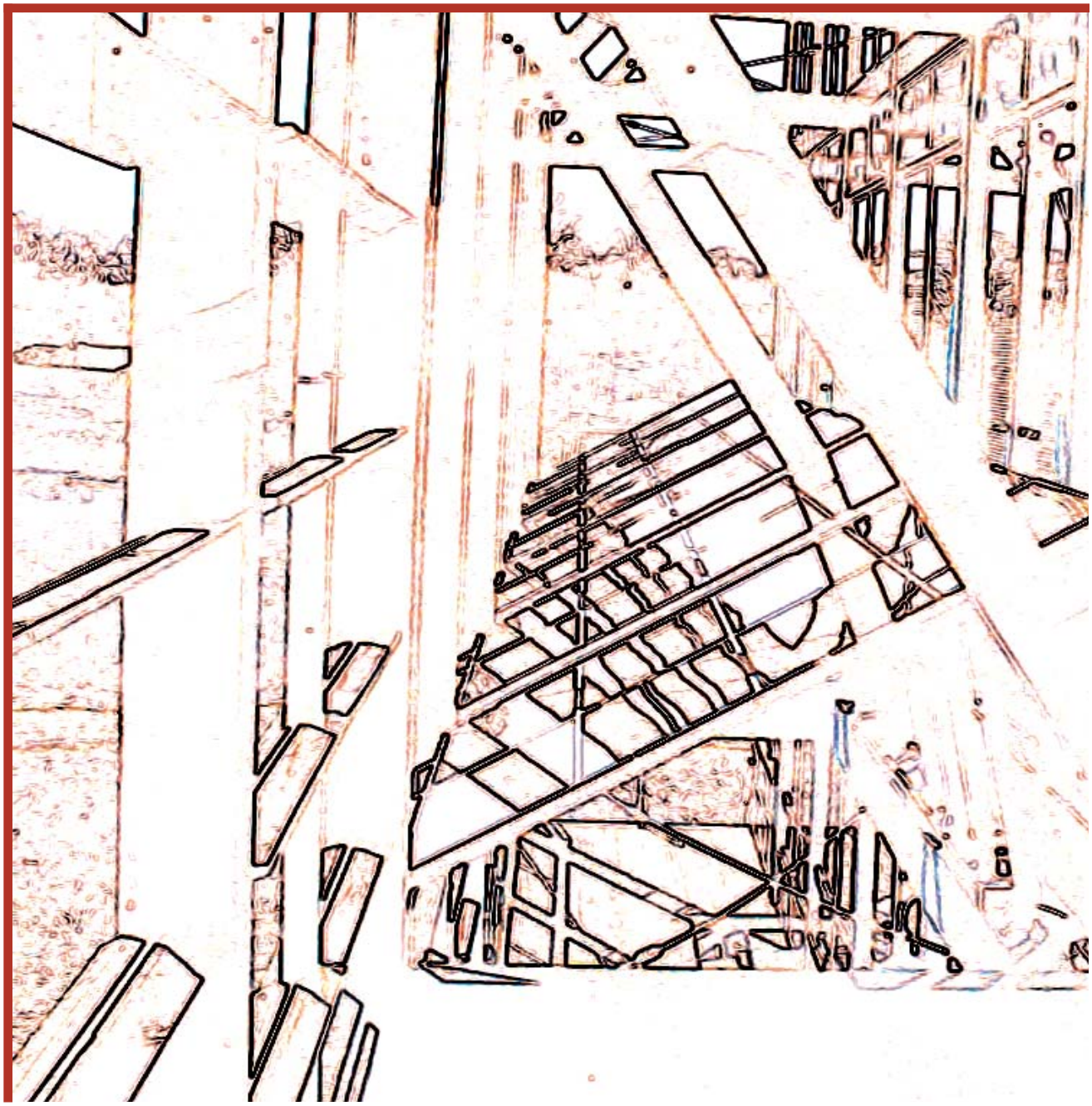

Green Building Sourcebook

Thomas Jefferson Planning District Commission



tjpdc.org

Green Building Sourcebook

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The Green Building Sourcebook is also available at
www.tjpdc.org/housing/Green_building_sourcebook/index.asp

Green Building Sourcebook

Introduction

A new initiative encourages the use of sustainable, green building techniques and materials in the development of affordable housing in the region. As part of this initiative, the HOME Consortium has developed this Green Building Sourcebook to provide information and resources for people interested in learning more about building sustainable, affordable housing.

Meeting our present needs without compromising the needs of future generations is at the heart of sustainable development. The Thomas Jefferson Planning District Commission is committed to regional planning linking land use, affordable housing, the economy and the environment with the goal of developing sustainable communities. A new initiative encourages the use of sustainable, green building techniques and materials in the development of affordable housing in the region. As a part of this Initiative, the HOME Consortium is developing a Green Building Sourcebook to provide information and resources for people interested in learning more about building sustainable, affordable housing. The Sourcebook is designed to be an interactive resource. If you have information that you would like to add, please contact Bill Wanner at wwanner@tjpdc.org.

HOME Consortium

TJPDC operates the Thomas Jefferson Regional HOME Consortium, the only regional consortium in the Commonwealth. This program provides approximately $800,000-1,050,000 per year for housing rehabilitation or new construction for qualifying families in the region. The TJPDC staff prepares the Annual Consolidated Plan for housing in cooperation with City of Charlottesville staff and administers funding to six non-profit corporations and the City Housing and Redevelopment Authority HOME-funded projects.

The Consortium was established in 1993 through a Cooperation Agreement among our six member localities. The six member jurisdictions of the Consortium are the counties of Albemarle, Fluvanna, Greene, Louisa, Nelson, and the city of Charlottesville. We are an entitlement Consortium for federal HOME funds aimed at assisting low and moderate-income citizens with housing needs. The chief implementing agency for each locality is as follows:

- Albemarle County: Albemarle Housing Improvement Program (AHIP);
- City of Charlottesville: Charlottesville Housing and Redevelopment Authority (CRHA) and Albemarle Housing Improvement Program (AHIP);;
- Fluvanna County: Fluvanna Louisa Housing Foundation;
- Greene County: Skyline Community Action Program;
- Louisa County: Fluvanna Louisa Housing Foundation
- Nelson County: Nelson County Community Development Foundation

Components of Green Buildings

Green building is good for the environment, promotes health and safety, and is often more affordable than conventional building over the long-term. "Green building" implies using environmentally sound building materials and techniques, using energy and other resources efficiently (recycling and reusing materials, when possible) and fostering a sense of community in the design of buildings. Encouraging the use of environmentally friendly green building materials and techniques contributes to the long-term health, vitality, and sustainability of the region.

Siting and Landscape

- Building oriented to utilize natural heating and cooling features
- Building near public transportation and bike/walking paths
- Retention of natural habitat areas for wildlife
- Retention of native plants/replanting with native plants
- Low pesticide and herbicide use for landscape maintenance
- Rainwater or graywater retention for landscape use

Building Design

- Increased natural lighting
- Use of renewable energy sources
- Energy-efficient building systems
- High indoor air quality goals
- Energy and water-efficient appliances
- Less-toxic building materials
- Recycled-content building materials

Construction Practices

- Water pollution impact reduced during construction
- Protection of trees and topsoil during sitework
- Construction waste reduction and recycling
- Exposure to toxic materials reduced
- Water and electricity-conserving practices used on construction site

Building Use

- Built-in recycling systems
- Less toxic cleaning products
- Less toxic pest control products
- Adequate maintenance of appliances and heating/cooling systems
- Building reuse/remolding instead of demolition

Source: Virginia Housing and the Environment Network, Regenerations, Vol.2, Issue No. 1.

Benefits of Green Building

In addition to the environmental, health, and safety benefits of green building, residents benefit from increased affordability through lower energy costs from heating and air conditioning, less water consumption, lower costs from waste disposal, and reduced long-term maintenance.

Affordability

- Lower energy costs from heating and air conditioning
- Less water consumption
- Lower costs from waste disposal
- Reduces long-term maintenance

Reduces impacts on the environment

- Decreased consumption (use of recycled or reused materials)
- Decreased reliance on toxic materials
- Efficient use of energy
- Efficient use of water

Improves health and safety

- Improves air quality
- Reduces the use of toxic materials and processes
- Minimizes the use of vinyl and pressure treated lumber

Promotes sustainability by design

- Improves energy efficiency
- Encourages quality construction and design
- Lessens the stigma often attached to low income housing
- Promotes a cohesive sense of community

Simple Ways to Green Your Home

There are many things you can do to Green Your Home including replacing thermostats, choosing energy efficient appliances, and replacing windows and doors. These simple steps can help you increase energy efficiency, decrease utility bills, and provide healthier indoor air quality in your home.

1. **Replacing outdated thermostats**. New programmable thermostats can reduce energy wasted heating or cooling a house when no one is home or everyone's asleep. This will save you money and reduce the amount of energy your home uses.
2. **Install ceiling fans**. Since moving air tends to feel cooler, you can set your thermostat at a higher temperature in the summer months.
3. **Replacing regular light bulbs with compact fluorescent lamps (CFL's).** CFL's use up to 75% less energy than standard incandescent bulbs and last up to 10 times longer, according to Home Energy Saver.
4. **Choosing energy-efficient appliances when buying new home appliances.** Look for the EPA's Energy Star designation.
5. **Installing hot water jackets on your water heater.** This will maintain the temperature in the water heater longer and reduce the cost of water heating dramatically.
6. **Installing low-flow faucets and showerheads**. This will reduce the amount of water used in both the bathroom and kitchen, and can save you a bundle on your monthly water bill.
7. **Adding a skylight or light tubes.** Skylights and light tubes increase internal light without the need for electricity.
8. **Installing natural floor coverings**. Choose floor coverings that are made of renewable materials such as sisal, seagrass, bamboo, pure wool or coir (coconut). Nylon and acrylic carpets are petroleum based.
9. **Installing motion sensors outside.** With motion sensors turning lights on when they detected movement, you don't have to waste power by leaving lights on constantly.
10. **Replacing your windows and doors.** Older windows and doors let out both heat and a/c. By upgrading windows and doors you can save a lot of money on your utility bills.
11. **Choosing green paints.** When decorating avoid standard acrylic paints or wallpaper, as they are PVC (polyvinyl chloride) based. Instead, opt for a natural plant-based paint or a low volatile organic compound (VOC) paint.
12. **Using potted plants.** Indoor potted plants add atmosphere, generate oxygen and help to eliminate potentially harmful volatile organic compounds.

Affordable Green Building Design

Why build "green"? To improve energy efficiency, conserve resources, and improve indoor air quality.

Energy Efficiency

- **Tight "Building Envelope"** means insulation, windows and doors are as air tight as possible. Since there isn't the typical influx of outdoor air, this does require additional ventilation to create air circulation and fresh air.
- **On-Demand Hot Water Heaters** heat water only when needed. There is no tank with a constant supply of hot water. Instead, the water passes through a heater that quickly heats the water as it passes through. On-Demand Hot Water Heaters do limit the number of concurrent uses to just one. (Can't take a shower and run the dishwasher.)
- **Efficient Wall Systems** include a reduction of the amount of wood needed to frame the house. Wood does not insulate well so putting studs 24 inches apart rather than 16 inches allows for more insulation. Insulated Concrete Forms, or ICFs, are a complete wall system made of concrete and Styrofoam insulation. The walls are 6 inches thick rather that the typical 4 inches. The concrete holds warm air in during the winter and keeps indoor air cool in the summer.
- **Heating and Cooling.** Most houses use a heat pump to provide both heat and air conditioning. The higher the SEER (Seasonal Energy Efficiency Rating) the more efficient the system. A variable speed fan on the heat pump also improves efficiency. A geothermal heat pump takes advantage of the stable temperature of the ground to improve efficiency.
- **EnergyStar Appliances.** Appliances with an EnergyStar rating have a high efficiency and thus reduce costs. EnergyStar is a program of the federal government.
- **Florescent Lighting.** Provides illumination at a lower wattage than incandescent lights and typically last longer. Florescent bulbs are particularly practical in a hard to reach receptacle.

Resource Conservation

- **Water** especially well water can be effectively conserved using low flow fixtures, and in some of the houses developed in the region, a cistern (an underground tank for storing rainwater) collects rainwater from the roof of the house and stores it in the cistern for use in flushing toilets. Additional plumbing is needed but over time more than pays for itself. On demand hot water heaters also conserve resources.
- **Reused and Recycled Materials** include concrete, (demolished concreted can be used in poured concrete structures such as ICFs), wood flooring, flooring tile, carpeting, and insulation (containing recycled newspaper). Recycled plastic is used in the manufacture of roofing shingles and is being used in AHIP's Esmont homes.
- **Exterior Siding.** Vinyl siding is typically used in affordable housing but it is a oil-derived product made with polyvinyl chloride (PVC). HardiPlank siding is a concrete based product and is more durable than vinyl, its manufacture is less

polluting and less wasteful of non-renewable resources. It is more attractive and sturdier as well.

- **Flooring.** More imaginative flooring includes cork and bamboo. Rather than harvesting old growth trees, cork is more plentiful and bamboo grows quickly and can be harvested every 4 years.
- **Minimize Construction Waste.** Wood, cardboard, metals, drywall, plastics, and shingles can all be recycled. Habitat for Humanity manages a store on Preston Avenue, collecting used but serviceable construction materials and architectural artifacts. It is open to the public.

Air Quality

- **Garages** should be completely sealed from living space, preferably with an exhaust fan, which can be powered with a motion-detector.
- **Fuel Burning Fireplaces,** including those using gas are to be properly vented and space heaters are to be avoided.
- **Moisture Control** is important to minimize mold and mildew and primarily involves protecting living space from the home's foundation.
- **Ventilation** is particularly important in airtight homes. Ceiling fans, EnergyStar bath fans, kitchen range hoods vented to the outside, and whole house fans are examples of good ventilation controls.
- **Off-gasing** of carpeting and particle board (containing formaldehyde) is a problem, particularly right after installation, for allergy prone residents. Carpets should be made of natural fibers and particleboard should be formaldehyde free.
- **Fiberglass** insulation has been identified as a potential carcinogen and irritates the skin. Insulation made of cellulose (a paper product) is a better alternative.

Energy and Resource Efficient Products and Materials

Windows

The **U-Factor** measures the rate of heat transfer, or heat loss, of the window. This value reflects the conductivity if the window, as well as the windows ability to absorb certain types of energy. The U-Factor is usually a number between 0.2 and 1.20. The lower the number, the less heat is lost through the window and the better its insulation properties. (from National Fenestration Rating Council).

R-Value measures the windows resistance to heat loss, or its conductivity. While the R-Value and the U-Factor are similar, the R-Value does not take the window's ability to absorb energy into account. This makes it a less accurate measure of heat transfer. Highly conductive products allow heat within a building to escape to the outdoors, resulting in higher energy costs. A high R-value indicates that the product is more efficient (from NFRC).

SHGC, or the solar heat gain coefficient, measures how well the window blocks heat from the sun. The SHGC, a value between 0 and 1, can be thought of as a ratio. For example, s SHGC of .4 would indicate that the window allows 40% of solar heat to pass through it. A low SHGC indicates that the window blocks more solar heat. **Spectrally selective glass** has become increasingly popular as a means of decreasing a windows solar heat gain (from NFRC).

Emissivity coatings (Low-e), or spectrally selective coatings, are usually used with dual paned windows or in insulated glass units (from NFRC). Low-e coatings can be applied in several ways. One option is to directly apply the coating to the windowpane. The coating can also be applied to a thin plastic sheet, which is suspended in the air cavity between the interior and exterior panes. Use of Low-e coatings can reduce the amount of heat transferred through the pane by a factor of 5 to 10. In heating based climates, Low-e coatings can be used to let solar heat enter the building and trap it inside. In this way, the house can be passively solar heated. In cooling climates, the Low-e coating keeps solar heat from entering the building (from www.ci.austin.tx.us/greenbuilder/srcbk_6-7.htm).

Visible Transmittance (VT) refers to the amount of possible light that a window conducts. Represented as a number between 0 and 1, a higher VT signifies that the window has a higher potential for **day lighting**. When used in conjunction with lighting controls, day lighting can save between 30% and 60% in building energy. Day lighting is directly related to the number of windows in a building and whether the glass is tinted or reflective. While tinted and reflective glass decreases the amount of solar gain, they also limit the amount of daylight entering the building (from NFRC).

Air Leakage (AL), represented as a number between 0.1 and 0.3, measures how much outside air comes through the windows. The lower the AL, the more effective the window is at keeping out air (from NFRC).

The number of glass panes used also greatly affects the window unit's energy efficiency. A **single pane** window, characterized by a single sheet of glass or plastic, provides little to no protection from heat transfer. In contrast, **double** and **triple pane**

windows have two or three sheets of glass that are separated by a layer of air or **inert gas**, typically argon or krypton. The layer of gas acts as insulation, dramatically decreasing the amount of heat transferred through the window. Low-emittance (Low-e) coatings for windows have decreased the need for triple pane windows (from www.ci.austin.tx.us/greenbuilder/srcbk_6-7.htm).

The material used for the frame and sashing also affects a window unit's efficiency. Wood, aluminum, vinyl, and a combination of wood and vinyl or aluminum can be used. While **wood** minimizes heat transfer, it is susceptible to damage from moisture and insects. In contrast, **aluminum** is an inexpensive, long-lasting material, but it transmits the most heat of all the possible options. The use of **thermal breaks** can be effective in lowering the rate of aluminum's heat transfer. **Vinyl** frames also minimize the heat transfer and have the benefit of being insect and rot resistance. Vinyl can be used as an exterior casing for wood frames and wood can be used to clad aluminum. Both of these options are durable and provide protection from heat transfer (from www.ci.austin.tx.us/greenbuilder/srcbk_6-7.htm).

Because of the sun's east-west path, the sides of a building are exposed to different amounts of solar heat. Exposure to **east**-facing windows should be minimized, while exposure to **west**-facing windows should be eliminated. This is due to the fact that the east and west sides of structures receive the majority of solar heat (from www.ci.austin.tx.us/greenbuilder/srcbk_6-7.htm). While solar exposure can be reduced with the use of awnings, using reflective film or glazing can also be effective. On west facing windows, a low SHGC, or .40 or less, is most desirable (from www.green-rated.org/take_action.asp?smid=6&aid=13).

Cost Comparison:

Type & Manufacturer	**U-Factor**	**Cost**
MW Twinseal (vinyl/wood) double hung 3/0 x 5/2	.50	$200
MW Twinseal (vinyl/wood) double hung 3/0 x 5/2 With Low-E Argon gas	.33	$242
Caradco Trad Plus (aluminum/wood) double hung 3/0 x 5/2	.52	$377
Caradco Trad Plus (aluminum/wood) double hung 3/0 x 5/2 With Low-E Argon gas	.38	$389

MW Twinseal bid from Charlottesville Stock Building Supply.
Caradco bid from Phillips Building Supply 7/19/2004.
For comparison purposes only.

Flooring and Carpets

The choice of flooring materials can have a significant environmental impact, as well as influence the level of indoor air quality for residents.

Wood: Wood is a durable, attractive option for flooring. In addition to common wood flooring options, consider using salvaged timbers, old flooring, or wood from rapidly renewable products. Unfortunately, laminated products cannot be recycled. But, in the event that you decide to use them, avoid the use of glue and adhesive, as they contain **volatile organic compounds** (VOCs). Also look for finishers, required for all wood floors, which contain minimal amounts of VOCs.

Made from the bark of cork trees, **cork** flooring uses a sustainable resource (removing the bark does not damage the tree). Cork flooring insulates against temperature and noise. Cork floors are durable and resilient. Because cork floors are easy to install and maintain, they are less expensive than other options.

Like cork, flooring made from **bamboo** stalks is an excellent renewable option because of its rapid growth rate. Bamboo can be harvested every 5 to 6 years. The stalks are **then cut into strips and laminated into planks.**

Linoleum: Natural linoleum products, made from soft wood powder, sawdust, linseed oil, pine tree resins, cork, and chalk, are great alternatives to the traditional linoleum. The cost of natural linoleum is comparable to a high quality vinyl. Because it is made from a renewable resource, natural linoleum is an environmentally friendly option. Because the linseed oil makes the product anti-bacterial, natural linoleum is a good choice for medical and hygienic environments.

Tile: Of the tile products, recycled-content tile is a good green option. Recycled-content tile is made with glass products like salvaged light bulbs, auto windshields, or the byproducts of feldspar mining. Tiles with high percentages of recycled materials can be more expensive than typical tiles. Like other ceramics, products with recycled-content are durable and attractive. Adhesives that have low toxicities and are price competitive are available.

Vinyl –vinyl composite tiles (VCT): If possible, use linoleum, cork, or tile in place of vinyl. However, if vinyl must be used, vinyl composite tiles (VCT) should be used, which contains less VOCs and can be repaired more easily than sheet vinyl.

Concrete: Exposed concrete can be left exposed, rather than adding additional flooring materials. Concrete is appropriate for radiant, in-floor heating systems.

Carpet: The main issues to consider when choosing carpeting is the process required to manufacture the carpet, the influence it has on indoor air quality, and methods of disposal or recycling of old carpets.

Most carpets are made of **synthetic fibers**, such as nylon, polyester, olefin these days. This is because synthetics, such as nylon, olefins, and polyester, are durable, lightweight, can easily be cleaned, and are cheaper than natural fibers, such as wool. All synthetic fibers are petroleum based and require a high-energy use to manufacture. Unlike other synthetic fibers, polyester carpets can be manufactured from post-consumer recycled plastic packaging.

Wool is the most durable type of carpet or rug. Wool carpets are available without toxic dying and other environmentally destructive processes. The main drawback from using wool is that it tends to be more expensive than synthetic fibers.

Some polyester carpets can be produced using post-consumer recycled plastic packaging. The EPA's Comprehensive Procurement Guidelines (CPD) designates 25-100% total recovered materials content (all post-consumer) for polyester carpet face fiber.

Some carpet manufacturers, such as Milliken, will take back modular carpet tiles and restore them to "like new" condition.

Adhesives: Adhesives used to install carpet can outgas VOCs. It is recommended to use water-based glues, or mechanical fasteners such as tack strips or double-sided tape for carpet when possible. When installing tile, cement mortar should be used in place of glue.

Checklist for buying green carpet (from GreenSeal):

- Buy refurbished carpet whenever possible
- Specify carpet with high overall recycled content
- Ask whether environmental leasing or take-back programs are provided by the manufacturer
- Use carpet tiles where appropriate
- Buy carpet that will likely be easily accepted for recycling. (Carpets containing nylon 6 face fiber and vinyl-backed carpets are currently recyclable, polyester is not).
- Consider purchasing carpet made of wool or other natural fibers
- Buy carpet that is solution dyed
- Buy carpet that meets CRI Indoor Air Quality standards (Green Label program)
- Ensure that low VOC adhesives are used during installation
- Select an appropriate color for the carpet (light colors tend to get soiled easily and may require frequent use of harsh cleaning chemicals).

Siding

Vinyl: Vinyl, also known as **polyvinyl chloride** or PVC, is widely used for siding due to its relatively low cost, low maintenance, and easy installation. However, the process required to manufacture vinyl siding is highly toxic. The chemicals used in the production of PVC have been linked to a variety of health problems including respiratory problems, liver and kidney damage, birth defects, and cancer. The end product can also give off dangerous gases, particularly when burned. In addition, vinyl is not biodegradable and it cannot currently be recycled.

Wood: Wood siding is attractive, but is often more expensive than other options and requires extensive maintenance. Wood siding is also susceptible to rot and termites. Another option is using wood composite siding, which is made from wood chips or shavings and is often more durable than ordinary wood. However hardboard, a wood composite material, is not recommended for use since several manufacturers are currently involved in litigation over the rotting, discoloring, and buckling conditions of hardboard. If wood siding is used, it should be approved by the Forest Stewardship Council, which certifies wood that is derived from renewable sources and is the result of responsible forestry practices.

Engineered siding materials: Fiber-cement siding such as Hardiplank lasts longer than wood and is better for the environment than vinyl. However, it must be installed properly in order for its benefits to be realized. Fiber-cement siding is durable, stands up well against harsh weather and is resistant against termites. Another benefit of fiber-cement siding is that it is fire resistant. Fiber-cement siding can either be purchased unprimed, pre-primed, or already painted. Fiber-cement siding tends to be cheaper than wood, but more expensive than vinyl.

Other: Other options include brick, stone, aluminum, or stucco. Each of these depends on the climate, cost, and durability desired. Many of these materials can be attractive exteriors, but are often more expensive than the other materials listed above.

(Sources: Austin Green Building Sourcebook, Green Building Guidelines for New Home Construction www.stopwaste.org, The Lifecycle of Vinyl: Past, Present, and Future Harm, www.bluevinyl.org)

Cost comparison from Home Energy Magazine Online (November/December 2000)

Table 1. Siding Materials Costs	
Siding Type	**Cost*/Square****
Vinyl	$150
Aluminum	$180/ft^2
Steel	$220/ft^2
Composite/engineered board	$240-270
*1998 dollars **One "square" (one yd^2) equals 9ft^2	

Roofing

Selecting light colored materials that will reflect solar heat will help to keep down energy bills in cooling-based climates. Light colored, reflective roofs are often referred to as **cool roofs**. In heating-based climates, darker roofs will absorb heat from the sun, reducing the amount of energy needed to heat the building. The weight of the roofing material is also important to consider. The heavier the product, the more structural support is needed to hold the weight. The lifetime of the product is also very important. Durable products will last longer, require less maintenance, and reduce the amount of waste entering landfills. Using materials containing reclaimed products, as well as materials that can be recycled after their use, will also achieve this goal.

Asphalt

Of the roofing materials, asphalt shingles are the most common. Shingles can be made with recycled, mixed paper bases and some companies use recycled products in the surface aggregate. Selecting light colored shingles will increase the amount of solar heat reflected. Even light asphalt shingles will absorb more heat than other roofing materials because of their standard black bases. Ordinarily shingles typically last from 20 to 30 years. New developments in asphalt shingles has produced laminated shingles, which have a reported life of 25 to 50 years. Regardless of the type of shingle, asphalt-roofing materials cannot be recycled.

Slate

Slate shingles are a very durable roofing material that can last from 45 to 75 years. Because of their weight—they are 3 times heavier than asphalt slates—your structure must be able to accommodate this additional burden. Slate is an expensive option. Expect the cost for the materials and instillation to be around 4 times more expensive than asphalt shingles. Slate can be easily recycled and is considered an environmentally benign option. Because of the darker color of the slate, the roof will absorb solar heat.

Clay

Clay tiles are fired in locations close to clay quarries. Consider finding a local clay quarry to minimize transportation and environmental costs. The durability and life of the tiles depends heavily on the quality of the clay used to produce them. Low-end tiles are more susceptible to changes in temperature, which cause them to crack and break. Clay is a good option for those seeking to collect rainwater. Tiles are also available in light or white colors, reducing the roof's retention of heat. Like slate, clay tiles are significantly more costly than asphalt shingles. Make sure that your building can support the heavy weight of clay tiles.

Concrete

Considered a cost effective alternative to clay tiles, concrete tiles are also durable and heavier than metal and asphalt options. They tend to retain heat longer than clay, making them less energy efficient. Additionally, concrete tiles are more energy intensive to make. Yet, making them closer to the construction site eliminates the need for transporting them long distances.

Fiber-cement composite slate and shakes

Fiber-cement composite is durable, fireproof, and have warranties of up to 60 years. Lighter than concrete tiles, these composite slates were made with recycled materials. Unfortunately light color options are rare.

Recycled rubber roofing

Made from discarded tires, recycled rubber roofing appears to be a durable option for roofing materials. Because this product is new, its long-term value is unclear. It is still uncertain whether the material will impact the purity and taste of water runoff collected from it.

Wood

Wood shingles are usually made of cedar, pine, or spruce. Cedar has proven to be the most durable option and can last up to 30 years. Weather and sun exposure will fade the wood from its original brown or reddish color to a gray. Wood is susceptible to shrinking and warping, as well as rotting. The cost of instillation tends to be high.

Metal

Steel, aluminum, and copper shingles, tiles, and panels are also used for roofing. While a metal option is less expensive than slate or tiles, it tends to be at least 50 percent more expensive than using asphalt shingles. Metal roofs have a lifetime of 30 to 50 years. Copper roofs, while significantly more expensive, have lasted up to 100 years. Metal is lightweight, easily recycled, and works well with rainwater catchments. Although durable, hale has been know to dent metal roofs. Metal roofing is also energy intensive to produce.

Metal coatings can provide your metal roof with more protection. **Zinc** (galvanized) coatings can be used to protect steel from rusting. Once the oxidation uses up the zinc (on a low slope roof in a wet climate, this can happen in 5 years), the steel will begin to rust. **Aluminum** coatings work better than zinc and can have warranties of up to 20 years. **Aluminum-zinc alloys** provide even more superior protection and have warranties of over 20 years.

Paint can also be used, although you should only use factory applied paint. **Polyester resin finishes** are not very durable and are not recommended. Expect your paint to fade within 5 to 7 years. **Silicone-modified polyester finishes** work very well and generally have 20 year warranties. **Fluoropolymer resins** are even more superior. **Bare aluminized or galvalume panels** are also extremely durable and can last up to 40 years with little to no maintenance. This option is superior to a polyester resin finish.

Because metal expands and contracts with temperature changes, your metal roofing panels and shingles move. These **thermal movements** can increase the size of the fastener holes, leading to leaks. Using washers on your fastener holes effectively protect them from heat and solar rays, keeping them covered and protected. Movement over **purlins** will not harm your roof. If your metal roofing is installed directly over the solid deck, use **Z-shaped metal sleeps** to prevent leaks and roof damage. Darker colored roofs will move more because they absorb more energy and heat. Solid aluminum panels tend to move more than steal ones.

(From www.schindlerroofing.com/shinglepage2.ivnu, members.aol.com/jcarlon/roofs.htm, and www.greenbuilder.com/sourcebook/Roofing.html)

Lighting

The **ballast** controls the starting of the lamp and maintains the voltage going to it. Of the two types, the electronic ballast is preferred over the magnetic ballast (from www.ci.austin.tx.us/greenbuilder/srcbk_6.htm).

Color Rendering Index (CRI) is used to measure a lamps ability to effectively render color. Based on a scale of 0 to 100, natural light is represented by 100. Ratings between 60 and 70 are considered acceptable; between 70 and 80 are good; between 80 and 90 are better; and, between 90 and 100 are the best (from www.lightenergysource.com/ColorRendering.htm).

Lumen output is a standard measure of the light emitted by a lamp. Although it is a standardized measurement, the lumen of the lamp actually changes depending on the visibility conditions. There are three light conditions—photopic, scotopic, and mesopic. When light levels are very high, **photopic** conditions exists. **Scotopic** refers to conditions of low light. **Mesopic** identifies twilight conditions, when the levels of light are neither high nor low. For example, in scotopic conditions the eye's response to blue lights heightens while its response to yellow and red lights is reduced. In contrast, in photopic conditions the eye has greater sensitivity for yellow light and reacts less to blue light. In photopic conditions, lamps producing a high percentage of yellow light will appear brighter than lamps with lower levels. Likewise, high producers of blue light appear brighter in scotopic conditions. Lumen output represents the overall production of light, but does not reflect the actual color of light emitted. This makes the use of lumen output to determine the brightness of a lamp difficult (from www.betterroads.com/articles/broct99b.htm)

The **efficacy** measures the amount of power going into the lamp that is being converted into light. A higher efficacy rating indicates that the lamp is more efficient (from www.ci.austin.tx.us/greenbuilder/srcbk_6.htm).

Lamp Families

Incandescent lamps, the most prevalent residential lamp, are inefficient light sources. Of the incandescents, the **A-lamp** is the most common. The **tungsten-halogen lamp** is the most efficient. Compared to other incandescents, they produce more light, have longer lives, and use less energy. In fact, halogens require 30 percent less energy to run than A-lamps. Although halogens are much more efficient, they produce large amounts of heat and have been know to start fires.

Fluorescent lamps, commonly used by the commercial sector, have relatively high efficacy. Their long operating lives also make them attractive. Improved phosphor coatings have also enhanced fluorescent lamps' color rendering. The use of electronic ballasts eliminates the hum and flicker often associated with fluorescent lamps.

In order for a fluorescent light to operate efficiently, the temperature of the glass tube must be at a particular temperature. The lamps' heat output and its environment determine its optimal temperature, usually close to 105 degrees Fahrenheit. Although the lamp generally starts at a lower temperature when initially turned on, it will heat up to its optimal temperature. Well-ventilated indoor areas provide the best locations for fluorescent use. Lamps will not function efficiently if they are not at the optimal operating temperature.

The **T8** has become the industry standard. New technology has produced the **T5**, but this model has yet to become the norm. Fluorescents are also available with mercury.

(From www.greenconcepts.com/producttips/lighting/, and oikos.com/library/eem/cfl/selecting.html, www.ci.austin.tx.us/greenbuilder/srcbk_6.htm).

Compact Fluorescent Lamps (CFL) are good substitutes for incandescent lamps because they have long operating lives and are energy efficient. In fact, they require a third less energy and last 10 times as long. CFL's ballast and lamp can also be purchased separately. Because the ballast's life is approximately two times longer than the lamp, the lamp can be replaced without wasting the working ballast (See "Replacing Incandescents with CFLs").

High Intensity Discharge (HID) lamps were originally developed for use outdoors but now include indoor lamps. This family of lamps has a **re-strike time** of 5 to 15 minute. This long start up time makes HID lamps best suited for environments where they are infrequently switch on and off. Despite this drawback, HID lamps are the most energy efficient light sources available commercially.

Of the HID lamps, **Mercury Vapor Lamps** have the lowest efficacy. Their lumen output reduces rapidly over the lamp's life cycle and they have low values on the Color Rendering Index. Mercury vapor lamps are not considered to be good green options.

Metal Halide (MH) **Lamps**, similar to mercury vapor lamps, use metal halide additives in addition to mercury and argon in the arc tube. MH lamps have good CPIs. Metal halides can be used both indoors and outdoors, but are best suited for lighting sports arenas, stadiums, convention halls, and large auditoriums.

High Pressure Sodium (HPS) **Lamps** are used for both industrial and outdoor applications. They have high rates of efficacy, as much as 140 lm/W. Technology is also working to improve HPS's CPI with optical coatings. Unfortunately, these coatings reduce their energy efficiency.

Low Pressure Sodium (LPS) **Lamps** are the most efficient lamps of the HID family but they also provide the poorest quality of light. Because LPS lamps are monochromatic, making all colors appear in a grayscale, they work best for outdoor use (from www.ci.austin.tx.us/greenbuilder/srcbk_6.htm and www.greenconcepts.com/producttips/lighting/).

Replacing Incandescents with CFLs

When selecting CFLs to replace incandescent lamps, you should keep several factors in mind. The CFL's wattage, lumen output, and shape are important to keep in mind when making your selection. When selecting the wattage of the new CFL, using a ratio of 3:1 is helpful. For example, a CFL of 20 watts can replace an incandescent of 60 watts. Lumen output can be helpful in determining how bright the CFL will be.

Because incandescents produce high levels of yellow light, a CFL with the same lumen output may not appear to be as bright. If your new CFL appears duller, consider choosing a CFL with a higher lumen output. Remember to account for the 20 percent decrease in output at the end of the CFLs' life cycle.

Also take into consideration the lamp fixture in which the CFL will be used. Because the CFL emits the majority of light perpendicular to its tube, installing a lamp in a recessed downlight would be inefficient. The fixture itself would absorb most of the light. Integral reflectors or diffusers can be used to ensure that light is distributed better.

Be cautious purchasing cheap CFLs. They often have efficacies of less than half that of the better units. You will be happier investing in a quality lamp. Although the first CFLs purchased may not be exactly want you wanted, through experimentation you will find the CFLs that best fit your needs

(from www.green-rated.org/take_action.asp?MID=2&SMID=9&AID=22, oikos.com/library/eem/cfl/selecting.html and www.ci.austin.tx.us/greenbuilder/srcbk_6.htm)

Lighting Controls

Lighting Controls are an effective means of reducing the operating hours of lamps, thereby maximizing energy savings.

Motion Control and **Occupancy Sensors** can be used to turn lights off and on automatically. These sensors use passive infrared and ultrasonic technology to turn the lights on when movement is registered and turn them off when movement has not been registered in a given period of time. Motion control can shorten the lives of the lighting units and do not hold up as well in humid climates.

Scheduling Controls turn lights on and off on an established schedule. While many systems are simple, they can also be highly sophisticated. These schedules can be set to specific times and dates as well as changes in the amount of daylight available.

Panel-Level Dimming systems can be used with HID lamps and fluorescents. Installed at the electrical panel, panel-level dimming devices uniformly control all of the lamps on a particular circuit.

Although not a device itself, **"Light Trespass"** refers to light that falls into unintended areas, for example, a neighbor's yard. Light trespass is a waste of energy and can also have negative affects on the environment. For instance, light affects bird migrations and insect pollinations. Light trespass can be reduced with the use of shields, hoods, and the redirection of light fixtures

(from www.ci.austin.tx.us/greenbuilder/srcbk_6.htm).

Comparison of kinds of lighting

	Advantages	Disadvantages	Applications
Standard Incandescent	• Warm, full spectrum color • Can be sharply focused • Easily dimmed • Low initial cost • Wide variety of bulbs	• Inefficient (less than 25 lumens per watt) • Short life (typically 1, 000 hours) • High heat output	• Accent, atmospheric lighting • Decorative sparkle
Halogen Incandescent	• Same as standard incandescent, plus • More efficient • Longer life (up to 2,000 hours)	• Very high heat output • More limited bulb and fixture selection	• Accent lighting • Tasks requiring very high visibility
Fluorescent	• More efficient (up to 90 lumens per watt) • Very long life (10,000 – 20,000 hours) • Lower heat output • Wide variety of fixtures and bulbs	• Less precise focus control • Limited dimming options • Higher initial cost • Older models may flicker, hum and be slow to illuminate	• General, diffuse lighting • Indirect lighting • Task lighting

Appliances

Appliances such as refrigerators, dishwashers, and clothes washers consume variable amounts of energy depending upon size, model, and usage patterns. Great strides have been made in the past decade to increase efficiency of appliances. To ensure that you get the most efficient model, look for products that are certified as Energy Star. The **Energy Star** program certifies products that are 10-15% more efficient than standard products.

However, products that do not have the Energy Star rating still may provide added efficiency, with little added cost. All manufacturers are required to post energy guidelines on a yellow **EnergyGuide label**, which provides estimated energy consumption and estimated costs.

Refrigerators

Refrigerators have become much more efficient over the years. For example, today a typical refrigerator with automatic defrost and a top-mounted freezer uses less than 500 kWh per year, whereas a typical model sold in 1973 used over 1,800 kWh per year. Bottom freezer models use even less energy than top freezer models, both of which are more efficient than side-by-side models. Automatic ice-makers and through-the-door water systems add cost to the refrigerator and expend additional energy. The most energy efficient models are in the 16-20 cubit foot sizes.

(Source: Sustainable Building Sourcebook, City of Austin, American Council for an Energy-Efficient Economy, *Top Rated Energy-Efficient Appliances* www.aceee.org/consumerguide/topfridge.htm, Energy Star www.energystar.org)

Clothes washers

Front loading horizontal axis clothes washers are 50% more efficient, both in water and energy use, than top loaders with a vertical axis. This is because horizontal axis machines have a higher spin speed, requiring less drying time. As with other appliances, the level of energy efficiency largely depends on usage habits of consumers. For example, consumers should use cold water cycles when possible, and only operate clothes washers with a full load (to diminish frequency of use). When choosing a clothes washer, consider the **Modified Energy Factor** (MEF) and **Water Factor** (WF). The higher the MEF, the more efficient the washer, and the lower the WF, the less water used by the machine. (Source: Sustainable Building Sourcebook, City of Austin, American Council for an Energy-Efficient Economy, *Top Rated Energy-Efficient Appliances*, www.aceee.org/consumerguide/topfridge.htm, Energy Star www.energystar.org

Dishwashers

As with other appliances, much of what determines the energy efficiency of a dishwasher is based upon the consumer's habits and choice of settings, which are available on most new dishwashers. Many dishwashers now use booster heaters, which can allow the remainder of the cycle to operate at lower temperatures. Also, no-heat or air-dry settings will save considerable energy during the dry cycle. A good water saving dishwasher will use seven gallons per load on regular cycles. You can further conserve water and energy by only using a dishwasher when it is at full capacity.

(Sources: American Council for an Energy-Efficient Economy, *Top Rated Energy-Efficient Appliances*, www.aceee.org/consumerguide/topfridge.htm, Energy Star www.energystar.org)

U.S. Department of Energy
How to Buy an Energy-Efficient Dishwasher
(http://www.eere.energy.gov/femp/technologies/eep_dishwashers.cfm):

Efficiency Recommendation				
Product Type	**Recommended**		**Best Available**	
	kWh/yr[a]	**Energy Factor[b]**	**kWh/yr[a]**	**Energy Factor[b]**
Standard Dishwasher[c]	**555 or less**	**0.58 or more**	**277 or more**	**1.16 or more**

[a] Based on 322 wash cycles per year, where one cycle is one normal operation with a fully loaded machine.
[b] Energy factor is the inverse of the power consumption (in kWh) for one full wash cycle.
[c] This recommendation does not cover compact models.

Cost-Effectiveness Example			
Performance	**Base Model[a]**	**Recommended Level**	**Best Available**
Energy Factor	0.46	0.58	1.16
Annual Energy Use	700 kWh	555 kWh	277 kWh
With Electric Water Heating			
Annual Energy Cost	$42	$33	$17
Lifetime Energy Cost[b]	$400	$320	$160
Lifetime Energy Cost Savings	**—**	**$80**	**$240**
With Gas Water Heating			
Annual Energy Cost	$21	$18	$8
Lifetime Energy Cost[b]	$220	$170	$90
Lifetime Energy Cost Savings	**—**	**$50**	**$130**

[a] The efficiency (energy factor) of the base model is just sufficient to meet current U.S. DOE national appliance standards.
[b] Lifetime energy cost is the sum of the discounted value of annual energy costs based on average usage and an assumed dishwasher life of 13 years. Future energy price trends and a discount rate of 3.4% are based on Federal guidelines (effective from April 2000 to March 2001).

Insulation

Cellulose: Cellulose is a widely accepted insulation material among homeowners. It is made from recycled material such as newspaper. Cellulose is treated with fire-retardants as well as insect protection using Borates, which are derived from Boron. One problem with cellulose insulation is **outgassing**. Outgassing occurs when the newspaper containing printer's ink leaks formaldehyde into a home. Cellulose is available in non-ink paper form for this very reason. Cellulose can also be installed as a wet spray, which effectively covers the entire wall area. One long-term concern of this option is fire retardant protection loss. Another concern for wet spray cellulose is that it can take quite a while for the insulation to dry thoroughly.

Mineral Wool: This form of insulation can come in two forms: slag wool and rock wool. Slag wool is a waste product from iron ore blast furnace slag while rock wool is produced from natural rocks such as basalt and diabase. Rock wool accounts for only about 20% of mineral wool insulation while slag accounts for the other 80%. It is available in blown-in form, loose blown-in, and in batt form. This type of insulation will not burn and is chemically inert. The fibers in mineral wool are susceptible to becoming airborne and inhaled.

Fiberglass: Fiberglass is produced using a phenol formaldehyde binder glue to hold the fibers together. This binder mostly dissipates during manufacturing but some of it stays and can be released into the building where the insulation is installed. Some new fiberglass insulations have been made with acrylic binder or no binder at all. Fiberglass is made from at least 20% recycled glass cullets. There are some newer forms being produced by fusing and spinning to create a steel wool form which is less harmful due to less tendency to become airborne as well as reduced amount of binding glue.

Rigid Foam Insulation Board: This insulation is produced using chlorine-based chemicals that destroy the ozone layer. The recycled content used can range from 0-50%. **Chlorofluorocarbons** (CFCs) were used as blowing agents until recently when **hydrochloro-fluorocarbons (**HCFCs) have been used. HCFCs are much less damaging on the ozone but are still not totally environmentally friendly. Due to the depletion of the ozone layer, it is recommended that both types of blowing agents not be used anymore. There are alternatives that do not use CFCs or HCFCs. **Expanded polystyrene** (EPS), polyicynene and foam polyurethane foam insulations all do not use CFCs or HCFCs.

Cementitious Foam: Cementitious foam insulation comes from **magnesium oxide** derived from seawater. It is blown into place using only air. No CFCs or HCFCs are used in the process. This insulation is non-combustible, totally inert and has a very low emissions rate. This insulation is the most benign with regards to indoor air quality but is also more costly.

Perlite: Made from a naturally occurring volcanic mineral, perlite is used as loose fill insulation in concrete block cavities. It can be bound into other materials and then used in a sheet form. It is non-flammable and chemically inert.

Source: http://www.aerias.org/kview.asp?DocId=95&spaceid=1&subid=4

Construction Standards

The Thomas Jefferson Planning District Commission and partner non-profit housing foundations (Albemarle Housing Improvement Project; Fluvanna/Louisa Housing Foundation; Piedmont Housing Alliance; Skyline Community Action Program serving Greene County; and the Nelson Community Development Foundation), and the Blue Ridge Home Builders Association have adopted EarthCraft House construction standards for green housing. Earthcraft worksheets are included in the appendices. The full EarthCraft standards may be reviewed at the following website:

http://www.southface.org/web/earthcraft_house/ech_main/ech_guidelines.htm

Examples of Local Affordable Green Building

Several non-profit organizations in the Thomas Jefferson Planning District are building green. Here are two examples:

Piedmont Housing Alliance

The Piedmont Housing Alliance has built and remodeled several homes in the 10th and Page neighborhood in the City of Charlottesville. Models of efficiency, these homes use most of the green building techniques citied in this Sourcebook. The design of these homes pays careful attention to the architecture of existing homes in this neighborhood and uses them as models for their work. In so doing, the homes fit nicely into the neighborhood. For general information about the Piedmont Housing Alliance visit www.pha.org.

Albemarle Housing Improvement Program

The Albemarle Housing Improvement Program has developed a small subdivision, called Camp Springs, in the Esmont area of Albemarle County. These homes are both affordable and highly efficient and built with the most up-to-date green building materials available. Camp Springs won recognition at the Governors Housing Conference for its innovative approach to affordable housing. For general information about the Albemarle Housing Improvement Program visit www.ahipva.org.

Appendices

Products Available Locally

EarthCraft Worksheets