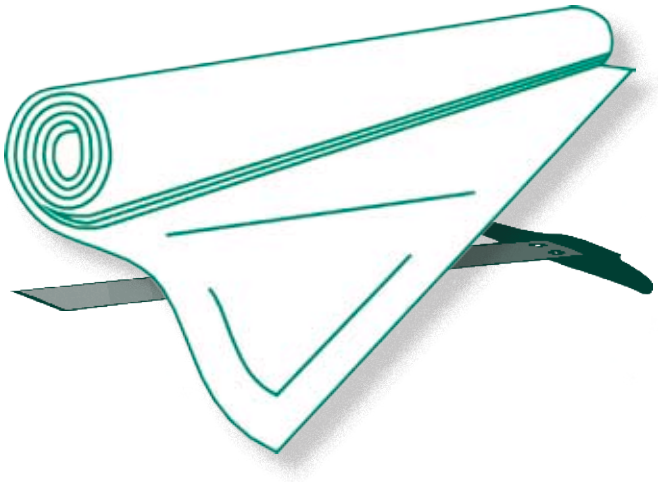
GREEN BUILDING GUIDE

Design Techniques, Construction Practices
&
Materials for Affordable Housing



RCAC

GREEN BUILDING GUIDE
Design Techniques, Construction Practices & Materials for Affordable Housing

Principal Author

Craig Nielson, LEED AP
Rural Community Assistance Corporation

Co-authors

Connie Baker Wolfe
Rural Community Assistance Corporation

Dave Conine
Rural Community Assistance Corporation

Contributor

Art Seavey
Rural Community Assistance Corporation

Design

Dave Conine

Sharon Wills
Rural Community Assistance Corporation

Managing Editor and Production

Sharon Wills

RCAC Corporate Office:
3120 Freeboard Drive, Suite 201, West Sacramento, California 95691
916/447-2854 | 916/447-2878 fax | *www.rcac.org*

Published by Rural Community Assistance Corporation (RCAC), a nonprofit organization dedicated to assisting rural communities achieve their goals and visions by providing training, technical assistance and access to resources. RCAC promotes quality, respect, integrity, cooperation and commitment in our work.

Table of Contents

Table of Contents (continued)

1 Green Building Basics

Introduction

Green building is a time-tested, practical and intuitive approach to creating environmentally sound buildings. Green building combines age-old wisdom; tradition and collaborative design processes; and modern building science, technology and materials application.

Green building structures are energy efficient, conserve resources, create healthier indoor environments and offer durable and beautiful spaces that use environmentally suitable materials. Green building incorporates integrated design concepts, solar orientation, appropriate footprint sizing, glazing awareness, material durability, economic life-cycle analysis, material reuse and salvage, natural material content, locally available materials and economic sustainability.

Historically, buildings in the United States were constructed with locally available and generally sustainable materials. These materials were often indigenous to the region and resulted in unique design solutions based on their availability and the climate where the building was constructed.

Today, the typical American home is a collection of materials from every corner of the continent and from suppliers across the globe. Green builders acknowledge the environmental impacts of materials selected and shipped long distances and make appropriate design choices.

Green Building Benefits the Environment

Modern construction causes unwanted environmental impacts and limiting these impacts is within the scope of green building. Perhaps the easiest way to understand green building is to first consider the various environmental impacts that buildings generate and then consider how negative impacts can be reduced or eliminated through more effective planning, design and construction. Modern American buildings impact the environment in the following areas: site selection, materials and resources, energy use and air pollution, water use and quality, and indoor air quality.

Site Selection

In addition to the impacts housing developments have on the environment, project location can have an even greater impact if it is too distant from community services and infrastructure. This is one area of green building where the larger community context of sustainability (sustaining natural resources for use by future generations) is particularly

relevant. If housing development residents have no choice but to travel long distances by automobile to get the basic goods and services they need, the overall development sustainability, regardless of how green the units themselves are, will be compromised. A green built project should not increase the residents' reliance on the automobile.

Projects built on productive farmland or sensitive natural areas, such as wetlands, wildlife corridors or critical habitats further compromise the community's long-term sustainability.

In addition to site selection, site development impacts should be considered. Erosion control, dust containment and compact developments minimize site disturbance. Site design that takes advantage of topographic and other features contributes to greening the project.

Materials and Resources

Negative environmental impacts can be minimized through responsible and intentional use and application of green materials. Products that contain a high percentage of rapidly renewable resources (such as agricultural by-products like wheat-board or materials with a high post-consumer recycled content, such as cotton/denim batt insulation) have a much lighter environmental footprint. Materials that are locally mined, harvested and manufactured (usually defined as coming from within 500 miles of the project site) have less overall impact than those shipped long distances.

Material durability is an important consideration in green building. Using durable materials reduces life-cycle costs and limits environmental impacts. For example, using natural linoleum flooring that may last up to 40 years in place of sheet vinyl saves replacement costs and reduces negative environmental impacts. Sheet vinyl emits dangerous polyvinyl chloride (PVC); whereas, natural linoleum is non-toxic and requires almost no maintenance. It can be chipped and composted at the end of its life cycle. By contrast, the PVCs in sheet vinyl takes years to break down in a municipal landfill.[1]

Energy Use and Air Pollution

According to the U.S. Department of Energy – Energy Information Administration, buildings are responsible for almost half (48%) of all green house gas emissions, and 76 percent of all electricity generated by United States power plants goes to supply the building sector.[2]

When residential areas are located far from basic services, the automobile can become the biggest household energy consumer. Most domestic and imported oil is used to fuel automobiles and other transportation systems, so residential location is a major factor in energy conservation.

Green building and more energy efficient planning and zoning regulations can result in significant reductions in energy use and atmospheric pollution. Energy costs continue to soar and climate change effects are becoming more widespread, so creating stable and predictable operating costs for low- and moderate-income (LMI) homeowners and renters makes good economic sense and preserves long-term housing affordability.

Water Use and Quality

Buildings also significantly impact water usage and affect water quality through runoff and wastewater contamination. Showers, sinks, dishwashers, washing machines and toilets all consume significant amounts of water. The per-capita water consumption in the Intermountain Region averages about 250 gallons per day. Per capita water consumption includes water for landscape irrigation and household use. Green building should include water conserving landscapes as well as water saving fixtures and appliances.

1 An extensive study performed on the components of PVC and their breakdown in landfills can be accessed at: *http://ec.europa.eu/environment/waste/studies/pvc/landfill.pdf*

2 For more information Energy Information Administration can be accessed at: *http://www.eia.doe.gov/*

Chemical-based indoor/outdoor cleaners, chemical-based fertilizers, and weed and insect control substances all affect water quality by polluting the soil and contaminating storm water runoff. Additionally, storm water runoff from roofs, parking lots and driveway surfaces contributes to groundwater pollution.

Indoor Air Quality

Many modern building materials contain dangerous chemicals that offgas into the atmosphere. Offgassing is the slow release of toxic chemicals into the air from materials used in building construction. Products, such as paints, carpet, insulation and kitchen cabinets can produce significant offgassing for many years. The offgas, combined with the lower air exchange rates of tighter building envelopes, can result in greatly reduced indoor air quality.

Chemicals ranging from pest control to cleaning supplies used inside the home can cause further pollution. Many health experts attribute the increase in children's respiratory diseases and allergies to pollution from both indoor and outdoor sources.

Green building addresses these serious health concerns by using materials with less chemical content and offgassing potential. Green building also incorporates proper home ventilation to provide an adequate supply of fresh outside air and monitoring for contaminants, such as radon and carbon monoxide. ■

Going Green is Good Business

Besides providing significant environmental and occupant benefits, green building offers several business advantages to both for-profit and nonprofit affordable housing developers who include it as part of their business practices.

Improved Marketing

Due to the rapid growth of the green building industry, an increase in environmental awareness and ever-rising energy costs, the public is eager to go green. Following the commercial success of the 2006 documentary *An Inconvenient Truth* that documented the effects of climate change, the American media began routinely reporting on environmental issues and their solutions. All this media attention has increased public interest in green building.

Developers that incorporate green building into their projects have a significant market advantage over their not-so-green competitors. Affordable housing consumers look for energy cost savings, healthier indoor air quality and other green features in their homes and apartments.

Agency Profile

In addition to the obvious market advantages for customers, agencies that incorporate green building practices in their operations are likely to be regarded as progressive and innovative. Many municipalities throughout the United States are pursuing sustainability measures, such as energy conservation, recycling, carbon credit trading, greener transportation vehicles and, of course, green building.

Green Funding

Green building funds are another compelling reason for nonprofit agencies to adopt greener practices. As traditional sources for affordable housing financing decreases and accessing funds becomes more competitive, greener affordable

housing projects will have an advantage. Some affordable housing funding sources have added ratings for green building in their grant or request for proposal applications.

Adding Value to Affordable Housing

Green built housing has a life cycle cost-advantage over conventionally constructed units. A green built home that incorporates renewable energy systems can save more than $100,000 in energy costs during a 30-year mortgage period assuming a 5 percent annual energy price increase. These savings are realized monthly and allow occupants to stretch their limited budgets further to include other necessary items, such as food, clothing, transportation, medical care and daycare.

In an environment of ever-increasing prices for all commodities, a green built home offers stability in operation costs, which is a hedge against inflation that often outpaces wage earnings by a wide margin. Therefore, green building helps bridge the "future" affordability gap that many conventionally built units will experience due to high operating costs.

Green building reduces temperature swings within the building envelope, incorporates natural daylight and protects indoor air quality by limiting or eliminating toxic building materials. These techniques increase occupant comfort and promote good health.

Together, these benefits add value to affordable housing by creating more durable, safe and economically viable living environments. ■

Getting Started with Green Building

The sensible approach to starting a green building program is to survey the housing agency and its staff to determine which of its values best match the myriad of green building strategies. For example, an agency may want to address its housing units' cost containment value by increasing their energy efficiency, which reduces operating costs for the agency's client families. The agency could start by considering alternative building envelope designs, such as Advanced Framing or Structural Insulated Panels (SIPs). (See Section Three for more information on these systems.)

Once the agency reaches the learning curve on the first measure, it may want to address water conservation by specifying, purchasing and installing dual flush toilets and low-flow shower heads. Specifying low Volatile Organic Compound (VOC) paints and stains, and using ceramic tile or natural linoleum flooring in place of sheet vinyl might follow this. Given the many shades of green, this process can continue to the point where the agency is building increasingly greener units.

Initial measures are likely to be financed within the constraints of existing budgets. As a green building program grows, additional construction funds in the 3 to 7 percent range may be needed for higher up-front costs, as many green materials cost more than standard materials. Keep in mind, however, that the additional up-front costs are usually more than recovered in life-cycle cost savings. Many assumptions about the higher cost of building green are becoming obsolete as green building products gain market share and decrease in price.

A green building program's ultimate goal might be to produce "net zero" energy buildings. Net zero energy buildings produce as much energy as they use in their operations, thereby resulting in a net zero energy use. Getting to this point requires increased implementation of green measures, including the application of renewable energy and many other energy saving methods.

No matter where an organization starts, going green is a great way to move its housing production to the cutting edge of development. It can be a great way to infuse a new level of excitement and innovation into an organization.

To assist agencies in choosing specific techniques or strategies that match their budget constraints, this guide is organized in order from no-cost to moderate-cost measures. In the next section the discussion focuses on the importance of design and how to develop a successful project team. ■

2 Green Building Design

Design Matters

A design process that integrates a project team of dedicated professionals and accounts for project location and climate is essential for successful green building.

Design success is achieved by developing a strong green building project team that includes design professionals. Design professionals are experienced home designers, architects, landscape architects and interior designers who are trained and experienced in green building techniques, including solar design and sustainable site planning. They can create a vision that reflects the project's goals and budget.

There is a myth that affordable housing projects cannot justify the costs of including design professionals as part of the project team. In reality, the opposite is true. Project teams cannot afford to exclude design professionals; doing so will likely result in higher overall project costs, poorer green performance and missed funding opportunities.

Another myth is that affordable housing cannot be green. However, green affordable housing developments exist across the nation and represent a growing sector of the construction industry. Enterprise™, through its Green Communities program, is on target to produce 8,500 green affordable units nationwide by 2010.[1] Indeed, the new mantra for affordable housing should be, "If it's not green, it's not affordable."

Developing a Successful Green Team

The project complexity will largely determine the team assembled and individual member's respective roles. The key to a successful team is to assemble all the necessary expertise to plan, design, build and operate the green project.

In-House Staff

The staff development director could be the team's key organizer for any green project, assuming the agency has this position. For smaller organizations, the executive director or a board member may take this role, or the agency could partner with an experienced green for-profit developer.

It is a good idea to bring the agency's family coordinator or marketing director into the process. This person's role will include both the challenge and the advantage of marketing to prospective owners or renters,

1 For more information on Enterprise Green Communities go to: *http://www.greencommunitiesonline.org/*

who may not be familiar with green building. The good news is that green built units are easier to market than conventional units (as noted earlier).

For larger rental or ownership projects, all post occupancy management and maintenance staff should be included on the project team. These folks will ensure that mechanical and other systems operate as designed and that overall operational efficiencies are realized. They also will educate tenants and owners on operating their individual housing units for maximum efficiency and comfort.

A basic knowledge of green building is strongly recommended for the project coordinator/manager and family coordinator/marketing positions. Basic green building training is now available in most states through agencies, such as Rural Community Assistance Corporation (RCAC), NeighborWorks® America, Enterprise's Green Communities program and most state chapters of the U.S. Green Building Council. Organizations like the National Association of Home Builders, Energy and Environmental Building Association, Southface and government agencies (such as U.S. Department of Housing and Urban Development, U.S. Department of Agriculture – Rural Development and U.S. Department of Energy) also provide green building publications and training.

Architects and Design Professionals

Green building is a design-based approach that works best when at least one design professional is included on the project team. For small projects an architect or competent professional designer can handle all the design elements including site planning and architecture. Select an architect or design professional with demonstrated green building experience or a professional – someone with Leadership in Energy and Environmental Design (LEED) Accredited Professional (AP) certification or other recognized credentials. A professional with LEED AP credentials has demonstrated a comprehensive understanding of green building principles, practices and implementation, and in-depth knowledge of the LEED green building rating system administered though the U.S. Green Building Council.

Engineer

The team also should include an engineer that has broad knowledge about alternative site planning methods such as smart growth, new urbanism or conservation design as well as understanding building orientation principles and basic solar design. Look for LEED certification or membership in Smart Growth and/or The Congress for New Urbanism for credentials as well as experience in working on green development projects.

Landscape Architect

For larger projects a qualified landscape architect may be a good addition to the project team. A landscape architect with green building experience can take full advantage of the site's green potential and unique characteristics. Similar to architects and engineers, landscape architects should have the necessary credentials or experience that demonstrate competency in green building.

Lenders

Although lenders are not typically part of the core project team, having the primary project lender included as part of the larger project team can be advantageous. Although green lending is a rapidly growing sub-part of the larger green building movement, many lenders will need education and direct experience on a green project before they are fully on board with an agency's green goals and mission. Including lenders in the process will help them understand how funding green projects can actually decrease the owner's energy costs, thereby reducing their monthly expenditures.

In some cases, green building will require additional up-front costs for items, such as high efficiency HVAC systems, that need to be accounted

for in the project's financing. Having the primary project lender involved from the beginning helps them understand the benefits involved and they are more likely to support the project's goals and budget. An added benefit is that the lender also may share his/her knowledge with other lenders, thereby spreading green awareness.

Community Stakeholders

Inviting key community stakeholders and elected officials to a project planning meeting can go a long way toward garnering public support for the green development and raise the agency's profile in the community. If stakeholders and the community-at-large are included as part of the planning process, problems associated with NIMBYism (Not in My Back Yard syndrome) may be avoided.

Contractors, Subcontractors and Suppliers

The project team should also include the general contractor, various subcontractors and technical experts from companies supplying certain equipment or materials.

If the project goes to bid after design work is complete (the more traditional sequence) it may be advantageous to require potential bidders to attend pre-bid sessions or design charrettes to become better acquainted with green building requirements. After the bids are awarded, regular progress meetings involving the project team and various contractors, certain suppliers and others are an essential requirement.

In both the design-build and conventional contracting approach, it is important to coordinate material sourcing and purchasing. This can help avoid delays in securing materials that may be in high demand. It also can help to obtain bulk prices and improve coordination with green product manufacturers. The key relationship will be between the green materials supplier, the project architect and the general contractor.

Progress Meetings

Progress meetings that occur during the construction phase must include the general contractor, the various subcontractors and technical experts from specialty equipment suppliers. The equipment manufacturers or suppliers play an essential role if the project design includes systems that may be unfamiliar to the designers and contractors (the installation requirements for a grid-tied photovoltaic system, for example). Regular progress meetings ensure that the design and construction goals match.

Construction progress meetings help resolve the problems of differing interpretations between the architects and contractors on plan discrepancies, change orders and other issues that only emerge after construction begins.

Trades and specialties personnel that need to be involved in the construction progress meetings include: framers, plumbers, electricians, finish carpenters, and HVAC and insulation installers. As green building involves the correct application of many new and unfamiliar materials and installation requirements, getting subcontractors to understand their respective roles in the larger green effort is essential.

Including key suppliers as part of the project team will make the task of specifying and securing green building products much easier as the project moves from the planning stages to actual development. It also is a great opportunity to educate suppliers about the diversity of green building products available and to encourage them to contact green and sustainable product manufacturers and distributors. ■

Design Integration

Design integration is a collaboration that should involve the entire project team. It requires team building, foresight, early planning and often going through a process such as a design charrette or a visioning session.

Collaboration early in the design development process enables the entire team, including contractors, maintenance and management staff to benefit from the collective knowledge of all the different skills and disciplines. For example, collaboration between the landscape architect and the maintenance supervisor might result in a plan to use water captured from roof drains and other site runoff as a low maintenance, water conserving landscape plan. (Note: Check state laws regarding the capture and use of water runoff.)

Design Charrettes

One of the easiest and most effective ways to coordinate a team is to have a green design charrette early in the green project planning stages. Charrettes are carefully structured brainstorming sessions where all team members and other key stakeholders are encouraged to participate in establishing goals, priorities and design parameters for the green building aspects of the affordable housing project.

During the charrette process, green measures are discussed, costs are considered, coordination among the various design team members is established and next steps are clearly mapped out. At the end of a design charrette, the group or agency should have a strong direction and clear priorities to follow. This process also gives the core design team (architect, contractor, project manager, landscape architect and engineer) clear directions to develop preliminary site and architectural designs.

A follow-up charrette is then typically scheduled as the project progresses and questions arise, and final decisions are needed to proceed with the design and construction documents. A third charrette also can be held at the completion of project construction. This meeting is used to conduct an overall assessment of the project's success and to set up any monitoring or commissioning that may occur during project operation.

Enterprise's Green Communities program offers grants to host a charrette as well as predevelopment grants and project financing for organizations developing green built affordable housing.[2] RCAC is a registered design charrette facilitator and can provide technical assistance to help apply for green grants. ■

2 *http://www.greencommunitiesonline.org/tools/funding/grants/*

Site Location and Selection

Environmental Suitability

A Phase I Environmental Assessment must be completed and made available before any land purchase is finalized. An environmental assessment allows an agency to more fully understand potential liability related to previous land uses, environmental constraints, such as flood planes, and the presence of endangered species or conditions that may increase construction costs. Remediation measures may be suggested and cost estimates determined.

Affordable housing developers should consider soil limitations before construction, such as slope and site drainage, depth to water table and site orientation for solar access (especially unimpeded southern exposure for winter season solar access). Also, the site may have enough suitable land to consider including trails for hiking or bicycling, which promotes physical activity and better health.

Infrastructure

Infrastructure is expensive. It is a sizeable portion of a project budget and uses significant resources to develop. Every effort should be made to reduce infrastructure costs and impacts when deciding to develop affordable housing. The easiest way to do this is to locate the project adjacent to existing development on the edge of the community, or to look for infill opportunities within the existing community core. The greatest resource and cost savings comes from developing in areas that have existing utilities.

Proximity to Basic Services

An organization might have the greenest built affordable housing project in its state, but if it is in a remote location far from basic services, the development's overall sustainability will be compromised.

In the current culture of "drive till you qualify," we are accustomed to linking affordability with long distances and commuting. With rapidly rising energy costs, distance can create economic hardships for families who must spend an increasing percentage of their monthly budget on transportation. Combined with high utility costs, families are then left with fewer dollars for rent or mortgage expenses.

For these reasons, affordable housing developers should choose sites within close proximity to basic services, such as grocery stores, libraries, post offices, cafes, medical facilities, hospitals and schools. This may mean developing an undesirable site, such as a Brownsfield or underutilized commercial area. These sites may have other issues, but they are most likely zoned for higher density that makes affordable housing development more feasible.

Density/Compact Design

Affordable housing and density are synonymous; it is difficult to have one without the other. The economic viability of a project may not be realized unless a certain density threshold can be reached. Compact development also encourages more efficient land use and usually reduces overall development costs. Compact development patterns can reduce the dependence on automobile travel and can foster greater social interaction of residents.

Site Design and Planning

Most site design takes place at the engineer's office. The main task is to maximize the number of lots and make the infrastructure work. Often, very little thought is given to creating a sense of community, conservation and natural assets preservation or taking advantage of energy flows. Good project team coordination can result in a well-engineered site plan that also addresses these green concerns.

Time tested site design protocols, such as new urbanism or traditional neighborhood design,

smart growth, clustering, conservation subdivisions and ecovillages all offer intelligent and ecological alternatives to standard affordable housing development. Although they are distinctly different, each of these design approaches incorporates the principles of higher density and compact design.

Land use regulations can be a significant barrier to developing a more compact, green project. Uniform lot size requirements, arbitrary density limitations, excessive setbacks and street widths are among the most common regulatory constraints against greener site development and additional affordable housing units. Prohibitions against mixed-use developments also impose barriers to more efficient development patterns. Most communities have Planned Unit Development (PUD) provisions in their codes that allow for greater flexibility in these areas. PUDs can be sought as one means for making the code adjustments needed to accommodate increasingly mainstream green living preferences.

Walkable Neighborhoods

Green design approaches emphasize walkability, which allow, even encourage, residents to walk within their neighborhoods to access basic goods and services. Good walkability generally dictates a total walking time of five minutes or less from any edge of the community to the commercial core where services and goods are located. Not only does this practice provide for healthier, more interesting and friendlier neighborhoods, it also has a huge impact in carbon reduction by eliminating excessive automobile trips.

Good walkability is achieved by providing quality streetscapes that are welcoming and safe to someone on foot or bicycle. Sidewalks and bike friendly roadways need to link to other parts of the community. The simplest way to do this is to use the time-tested block/alley system in a grid configuration. This grid is the most efficient way to move both human and automobile traffic due to the numerous route options available as compared to curvilinear subdivisions with cul-de-sacs.

Walkable community garden – Boulder, Colorado

Site Stewardship

During construction it is important to practice good land stewardship. This should include erosion control measures, a good drainage plan, native plant preservation to the extent practical and a landscaping plan that is appropriate for local climactic conditions. Generally, this effort will include a combination of dust mitigation, sensitive area fencing, designated storage and loading zones, directing truck traffic along certain routes and establishing site protocols with all key contractors and suppliers.

Storm and Surface Water Management

Water is a precious resource and human existence depends on its responsible management. Green sites effectively manage surface water from precipitation by capturing it on-site and using it for landscaping or greywater purposes. Typically, storm runoff is simply diverted in the storm water system rather than being directed to landscaping or retained for irrigation. (Greywater collection and on-site surface water retention is not allowed in all jurisdictions.)

Storm water can be used by incorporating pervious hardscape materials in the landscaping. Where allowed by law, water also can be captured in cisterns and used for landscape irrigation and/or for greywater storage systems, such as toilet flushing.

Water Efficiency and Suitable Local Landscaping

Landscape irrigation is one of the largest water consumers in residential development. Every effort should be made to minimize the disturbance of the native landscape. Landscaping added to the site should be indigenous to the locale or at least compatible with local climatic conditions. Native vegetation and xeriscaping conserves or possibly eliminates water use for landscaping once plants are established. Xeriscaping technical knowledge and guides should be available for all climactic zones in the United States and are available through most state and county extension offices.

Reducing Heat Island Effect

Buildings, pavement, concrete and other materials increase the heat island effect — a phenomenon that increases the air temperature in urban areas, which adds to cooling costs and affects comfort levels. The heat island effect can be mitigated by decreasing impervious surface areas and incorporating a tree canopy in the landscaping. Tree shade surface areas absorb heat, which is radiated back to the surrounding environment.

Color choices also make a difference. Parking lots, roofing surfaces and other large surface areas should be light, reflective colors to reflect heat energy. Black asphalt parking lots, for example, absorb heat energy and continue to radiate heat long after sunset.

Building Orientation

Proper building orientation can save enormous amounts of energy and reduce carbon output. Good solar orientation refers to the position of a building or buildings in relation to the direction of the sun's path in the sky. In North America, regardless of location, the sun arcs across the sky from east to west in a path that is south of vertical. The degree of this deviation from vertical is dependent on the season and the site latitude. The general rule is to position buildings within 20 degrees of true south.

For project sites where building orientation is only possible beyond the 20-degree rule, it is possible to step the footprint to add needed shading for southwest orientations, or open up glazing for southeast orientations, thereby taking advantage of morning to midday sun energy.

Incorporating Passive Solar Design

Passive solar designs work by allowing southern winter sun into buildings and keeping unwanted summer sun out. The amount of heat allowed in depends largely on window size and orientation and the shading used. It is important to use a solar chart or calculator for the latitude to determine the correct configuration of the roof overhang or the shading device to allow solar gain during the heating season and avoid excessive solar gain during the summer. The most common error in passive solar system construction is failure to correctly design the shading to avoid excess solar gain during the summer. Properly designed roof overhangs are the most cost effective devices for providing proper shading.

In a passive solar building, glazing ratios are often used as benchmarks for determining location and quantity of windows (see the Quick Guide to Going Green in the Appendices). Ratios are based on glazing area as a ratio of floor area and the amount of thermal mass available to store the heat. It is important not to exceed ratios to avoid over heating. Glazing on south facades should be clear to maximize heat gain and low-emittance (Low-E) on the remaining facades to retain interior heat. Once the sun energy is collected through properly placed and

sized solar glazing, it must be stored for night use when winter temperatures drop below the human comfort range.

Thermal mass inside a building (usually concrete) buffers daily temperature swings by absorbing heat during the daylight hours and radiating heat at night. A concrete floor, brick or concrete walls or even water storage systems, can provide the necessary thermal mass to store heat in a passive solar heating system. The same thermal mass temperature buffering helps reduce summer cooling loads.

Thermal mass also is comprised of standard materials in most dwelling units, such as sheetrock, tile and concrete slab floors. Mass is generally expensive to add to a building. An insulated concrete floor is cost effective because it combines thermal mass with the finished floor and a major structural component of the building.

Another way of introducing thermal mass is to double up sheetrock throughout the unit or in primary living spaces. Studies have shown that this distributed mass can provide an effective alternative to more expensive mass, such as stone, concrete or earthen walls and floors.

Other than insulated concrete floors, extra mass usually comes with an extra price, so designers should control overheating by reducing the amount of south glazing toward the more conservative side of the glazing scale.

Passive Cooling

Basic passive design should include proper cross ventilation to take advantage of free passive cooling during the night. Forced air refrigeration is the most expensive component of summer electricity usage. Passive cooling of a well-insulated building containing sufficient thermal mass makes it possible to reduce or even eliminate the need for mechanical cooling in many areas of the United States.

Basic passive cooling, combined with basic passive solar can substantially improve a building's energy performance and comfort. One key aspect of this strategy is to reduce unwanted heat gain by shading the building's western facade during the summer months. This is easier said than done due to the setting sun's angle decreasing each hour through the evening until the horizon line finally offers some relief. To avoid this unwanted heat gain simply eliminate or reduce the glazing amount on the building's west side. Other strategies include western screen porches or patios that can take the brunt of the heat gain while protecting the main structure. Planting conifer trees to the west of the building will provide year-round protection from unwanted heat gain, and planting deciduous trees will shield the building from summer sun while allowing sunlight through during winter months. ■

Realizing No Cost Measures Through Building Design

One of the myths about green built affordable housing is that it costs more. The following section will help dispel that myth by offering simple, time tested techniques for making projects greener without adding additional project costs.

Building Footprint

One of the easiest ways to start building green is using something the affordable housing industry has practiced for years, building smaller. Smaller footprint size is the single biggest cost savings technique on the construction side of the budget. It also is a great green building strategy. Smaller, efficient units use significantly fewer resources to construct and less energy to operate. The affordable housing industry has long been doing this out of necessity to keep budgets in check, but many agencies are still building new unit footprint sizes based on old demographics.

Family size and space needs have shifted dramatically since the early 1990s, and many communities now have a significant population of one or two person households. The trend is clearly moving away from larger families to smaller ones. This presents a market opportunity for housing agencies that may have typically relied on the standard three-bedroom, two-bath house plan to start thinking about much smaller units and unit types.

Emerging unit types, such as live/work spaces, townhomes, stacked flats, one- to two-bedroom homes, carriage houses and studio units have all become more viable marketplace options because household sizes continue to shrink and building costs continue to rise.

In many communities market prices have increased so significantly that small units have become mandatory for cost reasons. In these tighter markets low-income families who purchase affordable housing often do not have market choices. Therefore, they are more likely to accept smaller units, particularly if they are green built, over continuing to rent.

Townhomes in Boulder, Colorado

Smart Sizing™

One of the overarching goals of green building is to minimize the use of resources that go into a building. While building small is the first "no-cost" measure in affordable green building, the structure's dimensions should be consistent with the standard modules of common construction materials. For example, a building footprint of 35 feet by 47 feet does not make nearly as much sense as one that is 36 feet by 48 feet. Odd dimensions require more material cuts, additional labor and result in a larger volume of construction waste. Smart sizing calls for building footprint dimensions based on 2-foot modules. Standard building materials are available in 2-foot measurements and smart sizing takes advantage of this fact.

If the entire building footprint is divisible by 32 square feet (the size of all standard sheet goods), further efficiencies can be realized and the total construction waste stream can be reduced to around 5 percent—a much lower figure than the national average of 15 percent.

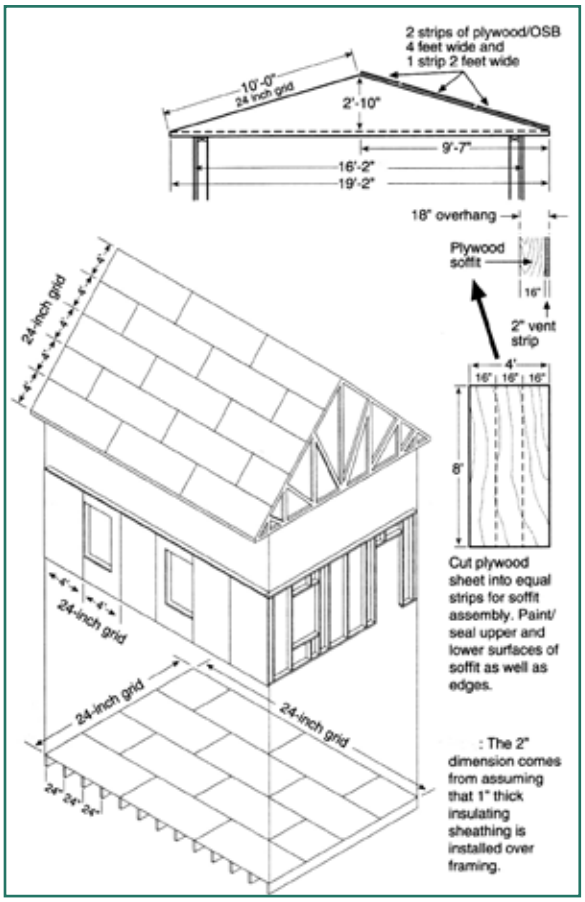


Diagram illustrating smart sizing principles[3]

This principle not only applies to the building footprint but also to the wall surfaces and roof planes. Therefore, the entire building envelope can be "modularized" using the 2-foot and 32-square foot rules to transfer these building efficiencies throughout the structure.

Smart sizing can be applied to both single family and multifamily units of any configuration. Measurements should be calculated to the outside of all structural framing or other wall systems. Once designers start working with this simple and time-tested technique, its intuitive nature will become apparent and ingrained into the agency's building practices.

Building Shape

Square dimensions are more resource efficient than are rectangular dimensions. Square building footprints and walls enclose more volume per square foot of building envelope than rectangular dimensioned building envelopes. However, this benefit must be weighed against the passive solar design benefit of a building with an elongated east-west axis.

Daylighting

Natural daylight saves electricity by reducing the need for artificial lighting. Studies have proven its effectiveness in maintaining a person's mood and mental well being, especially during long winter months. Because people spend so much time indoors, this becomes increasingly important.

Good green design provides natural daylight to living and private spaces within the structure while respecting passive solar heating and cooling rules. Window placement and size are balanced with lighting needs for the various activities taking place within the building. For smaller spaces often encountered in affordable housing, it is relatively easy to add daylighting within the building envelope.

Passive solar design has inherent advantages in this area, as it naturally results in great daylighting for spaces along the south facade. However, for spaces deeper in the building where direct sunlight may not be available, or for rooms lacking exterior walls, such as powder rooms or walk-in closets, tubular skylights can be a great way to daylight these areas. For the price of a window, these units offer excellent daylighting and are very energy efficient.

Clerestory windows are another option for daylighting internal spaces. Clerestories are windows that are placed in the uppermost portion of a wall. They may require a jog in the roofline, which can increase construction costs.

3

Example of clerestory windows added for daylighting, Salida, Colorado

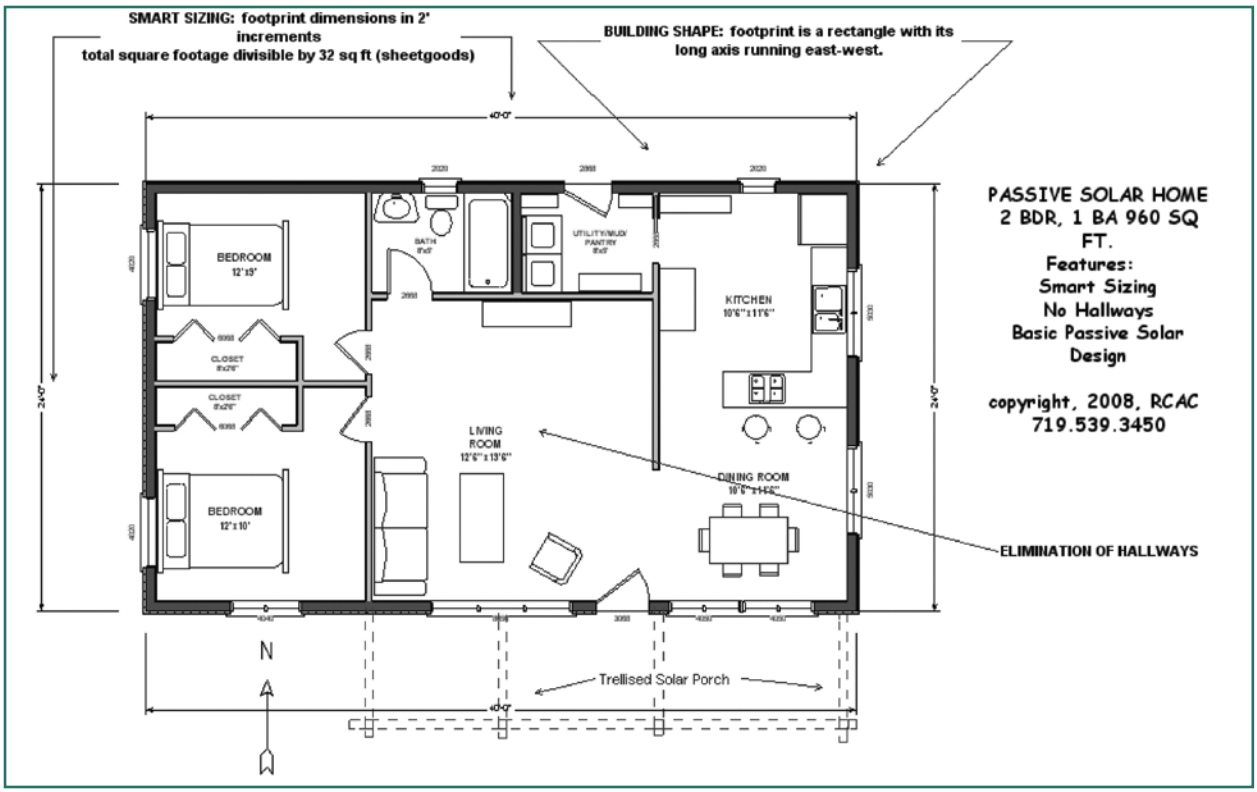
Space Utilization Strategies

For small dwelling units, good design is essential to ensure that precious space is used to the fullest extent. Affordable housing designers need to balance the need for activity, storage, living and private spaces. Effective space use is essential to a building's livability and the reduction of its environmental impact. The following compact design principles can help develop interesting and functional homes that cost less and save energy.

Eliminating Hallways

Floor plans centered around a common living room offer more space per square foot by eliminating all hall areas. Private rooms and auxiliary functions radiate outward from this central living space, which not only becomes the focal point or heart of the home, but also the main circulation hub that allows residents to move to any other area from the central core.

This type of configuration can be a very effective way of organizing space and accommodating an active family lifestyle. Eliminating hallways for circulation and access to other rooms frees up valuable space for living areas.



Passive solar home floor plan illustrating smart sizing, building shape, daylighting and hallway elimination

Loft Space Uses

Most everyone has heard the old adage that "it's cheaper to build up than to build out." This is true because the two most expensive building systems in a home are the foundation and the roof. Building up does not change the cost of either of these two systems, so the overall cost per square foot is actually reduced.

Loft spaces take full advantage of this design trick by also eliminating the cost of additional exterior wall space. New space gained with a loft is contained entirely within the existing building envelope and usually only requires minimal additional framing to make it work. Generally, a 10/12 or 12/12 roof pitch is needed to get the proper head height in the loft.

Daylighting for loft spaces can most effectively be accomplished by using tubular or standard skylights and gable-end windows.

Loft spaces can be accessed by a ship's ladder instead of a conventional, space consuming stairway. The very compact ship's ladder can be an interesting architectural element while providing convenient access to a small office or sleeping loft.

Note: ***If a skylight is used, invest in a high quality product. When installed correctly, operable skylights can be an efficient means for venting excess heat from a building. On the other hand, inexpensive skylights can reduce a building's energy efficiency and lead to water damage from condensation and leaks. Also, if the skylight is not installed correctly and carefully oriented, it may allow excessive solar gain.***

Multi-Function Flex Spaces

Another design tool worth considering is to create flex spaces that can change over time as family needs change. For example, a child's bedroom can become a home office or studio when he/she goes off to college. The point is to design flexibility in living and private spaces to accommodate changing family circumstances and a wider variety of family types. Demographics are changing and many future dwelling units will be needed for seniors, singles and smaller families — many of whom may telecommute.

In smaller homes constructed in response to soaring costs, spaces may need to serve double duty. Dining rooms may need to double as living rooms with fold-away tables; bedrooms may need to double as informal living spaces with futon beds and entertainment centers built into closets; guest rooms may serve as home offices; and informal eating areas may need to be transformed into formal eating areas for special occasions. Designers should consider how much space is necessary for each activity and which spaces need to be separated.

Built-ins and Other Storage

Years ago, it was very common to find built-ins in affordable homes. Properly designed and strategically placed, these features not only add a high degree of functionality, they also add much of the charm and sense of craftsmanship that is largely absent in today's production housing.

Although they may add a small amount to the up-front costs, they invariably will save the occupant the cost of certain furnishings. Examples of built-ins that make sense include bookshelf room dividers, informal eating nooks, children's beds, laundry counters, storage drawers and kitchen shelving in lieu of expensive cabinets. Read more about these ideas in Section Three of this guide.

It is important to design and incorporate them into the floor plan from the beginning. Because built-ins are likely to be around as long as the home, they should have a high degree of functionality while providing a satisfactory aesthetic appeal. Designers and craftsman style home builders of the past were masters of this art.

Green building provides an exciting design opportunity to save costs, add character and increase the durability of affordable spaces. Thanks to the growing availability of green building products, creative design pioneers are finding it more possible than ever before to go green. These exciting ideas are explored in detail in the next section as the discussion focuses on how to reduce energy and resource impacts through affordable green building. ■

3 Green Building Blocks

Reducing Material Impacts, Increasing Energy Efficiency and Comfort

As previously stated, building construction represents a major portion of the demand for raw materials in the United States, creating a substantial environmental impact. Green building can minimize material impacts, increase energy efficiency and comfort through appropriate material choices and waste reduction.

However, not all green materials are created equal. Developers will have to determine which materials are suitable for their projects based on factors, such as cost, design and local climate. This section discusses several ways to analyze green materials and products; defines green building materials and resources; gives tips on improving indoor air quality; offers guidance on using recycled and salvaged materials; and presents ways to implement a waste management program.

Material Resource Efficiency

Life Cycle Assessment (LCA)

LCA is perhaps the most comprehensive and recognizable measurement of a material's true environmental impact. LCA is a method used to conduct a full environmental accounting of a building's impact based on the materials used in its construction.

Life Cycle Cost Analysis

Life cycle cost analysis measures real financial benefits of a certain material, taking into account its "first-cost" (what a material costs to purchase and install); its expected life span; and replacement and maintenance costs in comparison to the material or product being replaced.

Embodied Energy Analysis

Besides the significant impact buildings have on energy use and greenhouse gas emissions, the construction materials used in a building can have a significant amount of "embodied" energy. Embodied energy is the total energy used to produce and transport a specific building material. According to the organization Architecture 2030, embodied energy often accounts for 15 to 20 percent of a building's total energy use during a 50-year period. Using low embodied energy materials reduces a building's overall life cycle carbon footprint.

Locally Available Materials

Using locally available materials, typically defined as coming from within a 500 mile radius, is both an environmental solution and an economic development measure. Purchasing green building materials within the project's region supports the community's economic stability.

Many rural communities have local sawmills that may be a source for both structural framing and trim package lumber. Keep in mind that many jurisdictions require all structural materials to be rated by an approved lumber rater, which may increase the cost of using locally available materials.

There may be a window manufacturer in or near the project area that can provide the window and door packages. Look for small manufacturers in the area that make green materials, such as recycled glass tiles or metal roofing panels. For example, south central Colorado produces some of the nation's best construction straw bales and northern New Mexico produces some of the best adobe blocks.

Using locally produced building material helps restore the distinctive regional character to houses and buildings. For example, the adobe blocks produced in northern New Mexico fit into the architectural heritage of that region far better than a vinyl-sided New England Colonial.

Material Durability

Green building also includes selecting durable materials that reduce waste and save costs associated with repair and replacement. Long material life cycles ensure lower environmental impacts and better serviceability. This becomes critically important for organizations involved in property management, where replacement and upgrade costs can be significant.

Fortunately, most green building materials offer superior durability, partly due to high natural material content. For example, natural linoleum flooring can last more than 40 years with very little maintenance compared to sheet vinyl that often needs replacing every six to eight years.

Corrugated galvanized metal is another durable green building material that can be infinitely recycled and literally lasts a lifetime. In addition, its first-cost is very soft on the budget. ■

Building Systems that Reduce Material and Energy Impacts: Green Foundations

Green building starts from the ground up. The following is a list of green foundation building techniques and products that help reduce material impacts to the environment and improve the performance of foundation systems.

Fly Ash Concrete

Concrete production is both energy intensive and environmentally damaging. U.S. Concrete, a multi-state ready-mix concrete producer, says that Portland cement, the component that binds concrete, accounts for 6 to 8 percent of human generated carbon dioxide in the environment. U.S. Concrete has reduced emissions of 328,000 tons of carbon dioxide annually by replacing traditional Portland cement with reclaimed fly ash and/or slag.[1]

Fly ash is a fine, glass-like powder recovered from gases created by coal-fired electric power generation. U.S. power plants produce millions of tons of fly ash annually, which is usually dumped in landfills. Fly ash consists mostly of silica, alumina and iron. It is a pozzolan — a substance containing aluminous and siliceous

1 *http://www.us-concrete.com/pdfs/PressReleases/20070604_U.S._Concrete_Makes_Company-Wide_Commitment_to_Environmentally_Friendly_Production_Technologies.pdf*

material that forms cement in the presence of water. Class C fly ash, produced from western coal is more commonly used for structural concrete.[2]

Adding fly ash to concrete reduces the energy needed in processing Portland cement and reduces the impact of fly ash disposal. In addition, fly ash cement requires less water, is somewhat easier to use in cold weather and is less likely to crack. Fly ash is reported to have greater workability, permits greater pumping distances and has greater strength. One reported drawback of fly ash concrete is that it takes longer to set up to full strength.[3]

Frost Protected Shallow Foundations (FPSF)

A FPSF foundation can be a cost effective foundation system for cold climates where seasonal ground freezing and frost heaving are present. Shallow foundations are typically less expensive due to shallower excavation and the need for less concrete. FPSF systems are prescribed in the International Residential Code (IRC).

FPSF systems work by effectively raising the frost depth at the foundation perimeter. The system uses heat input from the conditioned building into the ground in combination with strategically placed exterior vertical and horizontal polystyrene insulation. Geothermal heat from the ground under the building also helps to raise the frost depth.

FPSFs are suitable to slab construction and use what is often called the monolithic slab, because the entire footer, stem wall and slab floor can be done in a single pour. The monolithic system can save time over traditional designs which may take up to three pours to complete.[4]

2 *http://www.toolbase.org/Technology-Inventory/Foundations/fly-ash-concrete*

3 *http://www.berkeley.edu/news/media/releases/2000/12/27_grn.html*

4 *http://www.nahbgreen.org/Guidelines/nahbguidelines.aspx*

Insulating Concrete Forms (ICF)

ICFs are an alternative to standard wood framing for wall systems. They are concrete foundation and wall forms that stay in place as a permanent part of the wall assembly. ICFs are lightweight, interlocking blocks, made of polystyrene foam insulation, typically connected with plastic ties and easy to set up. The forms come in planks or separate panels. According to the Insulating Concrete Form Association (ICFA), about one-third of all ICFs sold are used in residential basements. ICFs have all the advantages of concrete: strength, durability, fire, wind and insect resistance with the added advantage of excellent thermal performance achieved by both interior and exterior foam insulation. Homes constructed with ICFs are reported to be quiet and comfortable.

Combining insulated foam and structural concrete allows otherwise poor energy performing concrete to achieve significant thermal efficiency. ICF forms will protect concrete from freezing in cold climates and slow the curing process for a stronger wall. Likewise, they will slow evaporation in hot climates, which enhances curing.

ICF foundation walls are common, particularly in colder climates, but it does require an exterior application of protective sheeting or flashing. ICF walls provide higher R-values (between R-17 and R-26) and lower air infiltration rates than typical wood frame construction (typically R-12 to R-20).[5]

Once the ICF blocks are stacked, standard rebar is added and the concrete walls are poured to create a reinforced matrix. Exterior and interior finish materials are then fastened to either a metal or plastic flange that runs from the top of the form to the bottom. Most cladding can be attached with screws.

According to Building Works, Incorporated,

> "... houses built with ICF exterior walls

5 *http://www.toolbase.org/Technology-Inventory/walls/Insulating-Concrete-Forms*

require an estimated 44% less energy to heat and 32% less energy to cool than comparable wood-frame houses. A typical 2000 square foot home in the center of the U.S. will save approximately $200 in heating costs each year and $65 in air conditioning each year. In colder areas of the U.S. and Canada, heating savings will be more and cooling savings less. In hotter areas, heating savings will be less and cooling savings more. The energy efficient performance comes in large part from the polystyrene foam on the interior and exterior of ICF walls, which range from R-17 to R-26, compared to wood frame's R-9 to R-15 walls. Also, ICF walls are tighter, reducing infiltration (air leakage) by 50% over wood-frame homes."[6] ■

Autoclaved Aerated Concrete

"Builders in the U.S. can use an innovative concrete material that Scandinavians have built their homes with for decades. Autoclaved Aerated Concrete (AAC) is a precast structural product made with all-natural raw materials. In 1914, the Swedes discovered a mixture of cement, lime, water and sand that expands by adding aluminum powder. The material was further developed to what we know today as autoclaved aerated concrete (also called autoclaved cellular concrete).

It is an economical, sustainable, solid block that provides thermal and acoustic insulation as well as fire and termite resistance. AAC is available in a variety of forms, ranging from wall and roof panels to blocks and lintels. Although it has been a popular building material in Europe for over 50 years, AAC has only been introduced to the U.S. in the past two decades."[7]

Green Floor Framing Systems

Wood framed floor systems typically use engineered joists that require much less wood than framing with dimensional lumber. Engineered joists are a green alternative that's vastly superior and more economical. Structural Insulated Panels (SIPs) represent another green alternative for floor system construction. [See the Green Wall Systems (Standard Framing Alternatives) subsection for details on SIPs.]

Engineered Structural Lumber

This popular structural floor option uses engineered lumber for all span and rim joists as well as blocking. Any solid dimensional framing member larger than 2 inches by 10 inches probably comes from old growth forests and is non-sustainable. Engineered lumber is a greener option because it is made from small wood fibers compressed or laminated together.

LVL beam with engineered floor joists

6 *http://www.forms.org/index.php?act=faqs*

7 NAHB Research Center's Toolbase.org at – *http://www.toolbase.org/Building-Systems/Foundations/autoclaved-aerated-concrete*

Engineered structural lumber also is widely used for other applications in the residential building industry. Structural composite lumber (SCL), which includes laminated veneer lumber (LVL), laminated strand lumber and oriented strand lumber, is a family of engineered wood products created by layering dried and graded wood veneers or flakes with waterproof adhesive into blocks of material known as billets.

SCL offers several advantages over typical milled lumber. It is stronger, straighter and more uniform. It is much less likely to warp, twist, bow or shrink due to its composite nature. Laminated solid joists can be used as headers for windows, doors and floor openings. I-joists also can be used in roof systems where engineered trusses cannot be used due to space and design considerations. Engineered sheathing has become the standard in the industry, and some companies now manufacture formaldehyde free versions. ■

Green Wall Systems (Standard Framing Alternatives)

There are several noteworthy green alternatives to standard framing. Many use the principle of prefabrication; others are more labor intensive but offer substantial green and cost benefits.

Advanced Framing

Advanced framing is the easiest alternative to standard framing currently available. It is often called Optimum Value Engineering and uses 24-inch stud spacing. Designing homes on 2-foot increments can save time and materials. By spacing studs on 24-inch centers, the number of studs needed for a 200 lineal foot exterior-walled home is reduced by approximately 50 studs. Aligning the floor, wall and roof framing directly above or below each other can eliminate the need for a double top plate. This reduces the lumber needed for top plates by half.

Using two-stud corners on exterior walls with waste material for drywall backing will save one stud per corner. Eliminating headers in non-bearing walls and sizing structural headers appropriately will reduce material costs. Using existing framing for one side of windows will reduce stud count by one per opening. Jack or shoulder studs in window openings can be eliminated when structural headers are not used

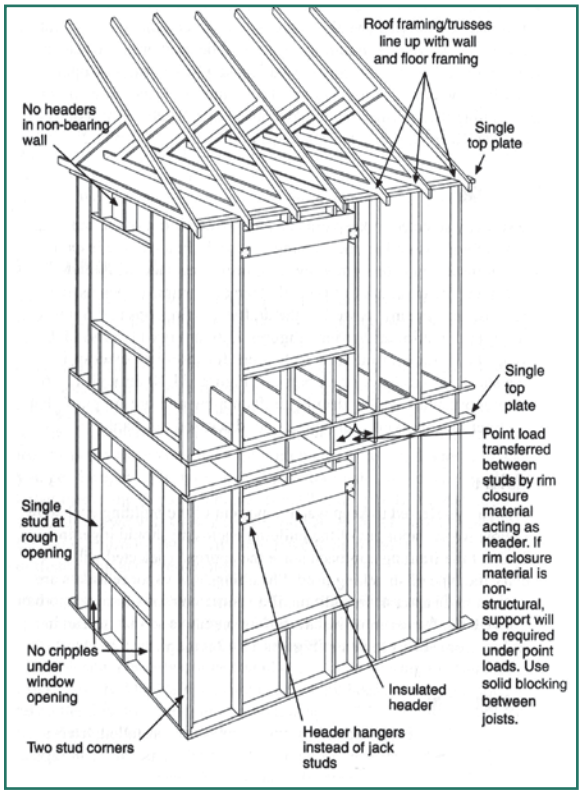


Diagram showing Advanced Framing details[8]

8

or when headers are supported by metal hangers. Using ladder-style blocking from scraps instead of full-length studs at partition connections will reduce the number of studs needed, while providing more area for insulation. The thermal performance of exterior walls also can be improved by using insulating foam sheathing.

Panelized Homes

The completion time for conventional-built homes usually depends on weather, material availability, and subcontractor and building inspector schedules. Any disruption in the process causes a ripple effect that results in construction delays.

In panelized systems, complete packages or building components are delivered to the construction site as partially or fully fabricated walls, floors and roofs. There are several types of panel systems available including open-wall technology, closed-wall SIPs and precast concrete panels. The most popular panel systems are open-wall systems and SIPs.

Construction includes assembling the panels on a previously poured foundation and floor system. This results in faster construction, reduced waste, greater precision and an overall higher quality building. Also, there is less need for architectural and/or engineering services, which reduces costs.

Generally, companies that produce panelized homes have their own sets of building plans. Customizing these plans may be possible. There is a learning curve in using panel construction but most of the required skills are the same as for conventional construction.

Open Wall

The open-wall panel system is comprised of open stud exterior walls, with exterior sheathing attached. Once assembled, they are utility and insulation ready. Walls can be erected quickly and there is uniformity amongst the wall sections. Interior partitions and roof systems can be either manufactured at the panel plant or built on-site. Furthermore, this system poses the least difficulty for building inspections because all aspects of construction are visible. Construction waste materials are reduced which saves time and cost and, if constructed in conjunction with advanced frame 24-inch stud centers, open-wall systems can be a greener choice due to material reductions.

Picture above shows a SIP wall, glu-lam ridge beam, LVL column and 10-inch thick SIP roof panels on far right side of photograph

These insulated headers consist of foam cores sandwiched between LVL beams

Closed Wall SIP Construction

SIPs offer a number of significant advantages in affordable home and commercial building construction. SIPs are sandwiches of oriented strand board (OSB), also known as wafer-board, laminated to a rigid insulating foam core.

SIPs are proven to provide better thermal performance than conventional-framed walls due to the foam cores high insulation value. Additionally, SIPs allow for more precision in construction, thereby eliminating many of the gaps that normally contribute to air infiltration. Normal frame construction allows substantial thermal bridging through wall studs, blocking and other structural components. SIPs nearly eliminate the need for framing members, which reduces energy loss by thermal bridging.

SIP structures are usually much easier and faster to construct than a framed building. The reduction in labor usually saves as much as the cost difference in the materials. SIPs are stronger than conventional framing, and they have higher seismic safety ratings and better wind loading.

SIP manufacturers cut the panels for the plans submitted. The precut panels are site assembled according to the plans and the SIP company shop drawings.

SIPs have horizontal and vertical built-in electrical raceways. The raceways line up between adjacent panels and wiring is not overly difficult. Careful planning and good communication with the panel company and subcontractor will ensure that wiring is an easy job. Generally, it is best to avoid placing plumbing within the exterior walls in any house, and because most SIP applications are limited to the building envelope, the plumbing work should be the same as in conventional structures.

Most SIP manufacturers produce panels in several thicknesses. A typical wall consists of a 5½-inch foam core with $^{7}/_{16}$-inch OSB on both sides. Roof panels are typically made with 9½-inch or 11½-inch cores. There are numerous SIP manufacturers in the United States within a reasonable distance for shipping to most regions.

According to the Structural Insulated Panel Association, the expanded polystyrene used in SIPs may lower energy cost by up to 50 percent and improve noise abatement by as much as two-thirds compared to ordinary frame walls with fiberglass insulation.

Although more commonly used for wall systems, SIPS also are an easy way to construct a floor system designed for a framed structure over a crawl space, and for use in roofing applications. They can span distances similar to that of joists and rafters used in residential and light commercial construction. Another advantage of SIPs floor or roof systems is that once installed they are insulated and, therefore, offer excellent energy performance.

Insulated Headers

There are several manufacturers of insulated foam and engineered lumber structural headers. The combination results in a structural member that is more precise and energy efficient. The insulated structural members avoid the thermal bridging energy losses that occur with conventional solid wood header framing systems. The engineered lumber is less subject to shrinking and warping, which often causes drywall to crack in conventionally framed header areas. ■

Natural Building

Straw-bale Construction

"Straw-bale construction is not a new technology. It is merely getting more recognition today as consumers and builders look for more efficient and economic forms of construction. Straw-bale construction has been around in the United States since the turn of the century. Straw is a renewable resource in plentiful supply that can offer simple construction and great versatility.

There is approximately 200 million tons of straw available each year for use in construction that would otherwise go to waste. This waste straw is left over from crops such as wheat, oats, barley, rye, rice and flax, after all the food has been extracted. The straw is gathered and baled using a baling machine. Sizes of straw bales vary from 18"x14"x36" to 24"x18"x48" and weigh between 50 to 90 pounds. The straw is compressed by the baler and tied together with wire or string. A typical 2000 square feet house requires about 300 medium sized bales."

Adobe, Cob, Soil-Cement & Rammed Earth

Building with soil based materials

"Homes made from soil based materials have been called various names; adobe and cob are terms often used to describe sun dried clay materials. Rammed earth and soil-cement brick refer to a popular method used today, with a cement additive and pressure to mold the blocks or bricks.

Earth building techniques are practiced in many parts of the world. While most people might associate this construction practice with third world countries, there are earth building standards in China, Peru, Turkey, New Zealand and Australia. A renewed interest in green building materials has also kept the technique visible in the United States, mostly in the southwestern area of the country.

Public perception may not accept earthen buildings in some regions more familiar with wood framed or masonry homes. Lending, insurance and code requirements may also provide barriers.

Adobe and rammed earth construction are an insignificant percentage of the residential construction market. Experienced labor may be unavailable for this specialized technique in some areas of the country."[9]

Green Roofing Systems

Engineered Trusses

Engineered trusses that use small dimensional lumber have become the construction norm and remain the least resource intensive way to build a framed roof system. Although standard trusses are common in affordable housing, there are other available truss options that free up low-cost living spaces.

Attic Trusses

Attic trusses free up space in the loft or attic area, which can be finished as living spaces. If designed right, the bottom chord of the truss can be used for the loft floor system. Special care must be taken to ensure that this type of application does not create air convection within the floor system that can lead to heat loss. Blocking between trusses at the outside of the exterior perimeter wall can alleviate this problem.

9 NAHB Research Center's Toolbase.org at:
http://www.toolbase.org/Building-Systems/Whole-House-Systems/straw-bale-construction

http://www.toolbase.org/Building-Systems/Whole-House-Systems/adobe-cob-soil-cement-rammed-earth

Parallel Chord Trusses

Parallel chord trusses maximize interior spaces. Homes with this type of system have the same angle for both the roof slope and the cathedral ceiling, as the top and bottom chords are parallel to each other. When building two stories, this truss system requires the use of a second floor structural system, unlike the attic truss that allows the bottom chord to carry the floor.

Scissor Trusses

Scissor trusses result in a finished cathedral ceiling that is half the pitch of the roof. If the roof pitch is steep enough, the space can be used for attic or loft spaces with a conventional floor system, such as the kind used in the parallel truss system mentioned above.

The intersection between a vertical wall and a pitched roof is often left without insulation because there is little space to insulate. Even a green building design will have compromised energy performance if insulation is not carefully installed at this critical location. Most conventional truss designs do not provide sufficient space to properly insulate the wall to roof connection. Raised heel and dropped heel trusses are designed specifically to provide insulation space at the wall to roof connection.

Cool Roofs

Roofs can be a significant contributor to the heat island effect, which increases cooling costs and energy use. The easiest and quickest solution to combat heat is simply to specify and use light colored or reflective roofing materials instead of dark roofing materials. In the same way that white clothing helps keep people cool in the summertime, light colored roofs reflect sunlight and heat.

This urban high rise uses a green roof to provide a pleasant amenity

Green Roofs

An alternative to cool roofs is landscaped living green roofs. Living roofs reclaim the land taken by the building's footprint and allow insect and bird species to continue to use the land. In addition, a green roof captures rainwater and a portion of the water is returned to the atmosphere through evapotranspiration. The plants on the roof also help oxygenate the air and process airborne toxins. If living green roofs became common practice in urban settings, the benefits would be significant. ■

Raised Heel Truss

The raised heel truss may be the most cost effective energy saving investment. The point where the top of a wall meets the pitched roof leaves little or no room for insulation. The result is that the wall/roof connection is a major source of energy loss in the typical house. Raised heel trusses provide adequate space above the wall top plate for enough insulation to significantly reduce the heating or cooling loss. The raised heel truss adds very little to the construction cost. The small additional cost is quickly recovered by the energy savings.

Green Roofs

"Green roofs, also called living or planted roofs, are systems of living plants and vegetation installed on the roof of an existing or new structure. The green roof concept is not new. The Hanging Gardens of Babylon constructed around 500 B.C. were perhaps one of the first green roof systems. Terrace structures were built over arched stone beams and waterproofed with layers of reeds and thick tar on which plants and trees were placed in soil.

Popular in Europe for decades, technology has improved upon the ancient systems, making green roofs available in and appropriate for nearly all climates and areas of the United States. All green roof systems consist of four basic components: a waterproofing layer, a drainage layer, a growing medium, and vegetation. Some green roofs also include root retention and irrigation systems, but these are not essential.

Green roof systems are often broken down into two types—extensive and intensive systems. An extensive system features low-lying plants such as succulents, mosses, and grasses. They require relatively thin layers of soil (1-6 inches), and plants usually produce a few inches of foliage. Extensive systems have less of an impact on the roof structure, weighing 10-50 pounds per square foot on average, and are generally accessible only for routine maintenance. Most residential applications are composed of extensive green roof systems. Intensive systems feature deeper soil and can support larger plants including crops, shrubs, and trees. Intensive systems can be harder to maintain, depending on the plants used, and are much heavier than extensive systems—they range from 80 to more than 120 pounds per square foot. Intensive systems are typically designed to be accessible to building inhabitants for relaxation and/or harvesting.

There is a wide variety of materials used for each component of the green roof system, depending on the chosen plants, type of system employed, climate, and underlying structure. Growing mediums include soils, peat and other organic materials, gravel, and other aggregates. A drainage layer is required to adequately distribute water and prevent pooling. To minimize the weight of the system, drainage layers are often made from plastic or rubber, but may also be made of gravel or clay. The drainage layer may or may not include filter media to ensure aeration. The waterproofing membrane is a critical component of the system and should include a root barrier to ensure the underlying roof surface is not compromised. If the weatherproofing material is not root-resistant, an additional layer must be applied to serve this purpose.

Plants used in green roof applications must be easy to maintain and tolerant of extreme weather conditions including heat, freezing, and drought, and must have relatively shallow, fibrous root systems. The plants should also be resistant to diseases and insects, and not generate airborne seeds in order to protect surrounding plantings. Climate-appropriate succulents, mosses, and grasses are often best suited for extensive green roof systems. These types of plants are available in a variety of colors, in both deciduous and evergreen options. Many nurseries throughout the country specialize in vegetation for green roofs."[10]

10 NAHB Research Center's Toolbase.org at – *http://www.toolbase.org/TechInventory/TechDetails.aspx?ContentDetailID=3820*

Green Exterior Finish Materials

Numerous green options are available for finishing building exteriors. This is an area where material durability is critically important, both in terms of maintenance and replacement frequency.

Locally Manufactured Metal Roofing

Metal roofing is more suitable than asphalt shingles in many climactic zones in the United States, particularly in areas with wide temperature swings like the mountain west. Asphalt shingles may not hold up to the freeze-thaw cycles typical to these zones. In harsh climates composite shingles may only last eight to 12 years. Metal roofing, on the other hand, is very durable and typically lasts for 40 to 60 years. This material can be made from recycled content and can be infinitely recycled. There are companies in many communities that can fabricate roofing panels from stock rolled metal purchased from manufacturers.

Locally manufactured metal roofing

Cementatious Siding

Cementatious or cement board siding that combines recycled concrete and wood by-products is cost effective and offers great durability. Some companies produce cementatious siding that is pre-painted at the factory for longer durability and reduced labor costs.

Cement board siding is made from a mixture, such as cement, sand, fly ash and a cellulose fiber material. It is extremely resistant to fire, high winds, moisture and insects. Cement board siding resembles the traditional look of wood siding, can be painted in a variety of colors, requires very low maintenance and has a 30 to 50 year warranty. Cement board manufacturers use post-consumer recycled materials that are durable and have a long life cycle, which increases the structure's sustainability. Cement board siding is priced comparably to hardboard siding. It costs less than brick or synthetic stucco and more than vinyl.

Corrugated Metal

Corrugated metal is an excellent exterior finish green option due to its incredible durability, its high recycled content, its low cost and ease of installation. Corrugated metal has long been a staple of the commercial building industry. More and more home builders, including high-end builders, are discovering that metal exterior finishes are attractive and timeless.

Cementatious Siding

Cementatious siding products contain silica, which produces a fine dust when cut with a saw. Silica is hazardous! Wear an approved dust mask! Better yet, do not use a saw. Cement board siding is easy to cut with special electric shears – no dust!

Cementatious siding should be nailed with a coil nailer that allows precise setting of the nail depth.

Invest in the right tools to install cementatious siding neatly and safely.

Porch and Deck Flooring

Composite decking material is now widely used for porch and deck applications. The decking is more durable and much easier to maintain than real wood. Most composites combine recycled plastic and wood by-products that are pressed into dimensional boards, trim and rail pieces. Composite decking material can be cut, fabricated and fastened in the same manner as wood.

Natural Clay Plaster

In temperate and tropical climates natural clay and lime plasters can be a green exterior finish material. Plasters are typically matched to a wall system of like materials, such as straw, adobe, earth block or cob**.** Natural plasters have been used worldwide for thousands of years and in all temperate and tropical climate conditions. In England, Wales and Denmark, it is common to see naturally plastered buildings that are 800 years old. ■

Green Interior Finish Materials

Standard drywall contains formaldehyde that offgasses and, thereby creates poor indoor air quality that can be a health risk, especially to children. Using a drywall product that does not contain formaldehyde is a simple solution. Many green finish wall surfaces are worth considering.

Wheatboard

Wheatboard is an agricultural by-product produced from wheat straw. It is available in standard sized 4-foot by 8-foot sheets and can be used as a decorative finish material. Wheatboard can be attached to walls in the same way as plywood or other sheet materials.

Plywood

Due to its compositional nature and high durability, plywood can be used as an interior finish material. It is widely available and can be purchased with a smooth sanded face or decorative hardwood veneer. To minimize material impacts, purchase it from a Forest Stewardship Council partner dealer. Keep in mind that most plywood products contain chemical binders that can affect indoor air quality.

Corrugated Metal

Corrugated metal also makes a great interior finish material for the same reasons that it works great as an exterior siding material; its relatively cheap, has a high recycled content, superior durability and ease of maintenance (simply wipe it with a damp rag).

Corrugated sheet metal used in ceiling application

Sheet Galvanized

Green interior finishes also can include smooth sheets of galvanized metal that offer the same benefits as corrugated metal. It works well as a durable and easy to clean backsplash in kitchens or as a finished wall surface in bathrooms and other areas throughout the house.

Sheet metal used for open shelf backing

Natural Clay Plaster

Although paint is the standard interior wall finish, natural clay plaster is a beautiful alternative. Though more expensive, the color is fixed in the material and once the final coat is on the wall, the job is done and the results are stunning. This green alternative adds character and charm, and can be applied over drywall and other surfaces with relative ease. Natural clay plaster also can be applied to sheetrock that has been taped but not sanded to perfection.

Natural Fiber Wall Coverings

There are a number of natural wall coverings made from sisal, grass, cork or organic cotton. These coverings must be applied by a professional over a rigid surface, but eliminate the need for painting.

Green Cabinets and Storage

Standard kitchen and storage cabinets are among the least green finish materials found in a typical home. Cabinets often contain unsustainable harvested wood fronts and composite boxes that offgas dangerous chemicals from the binding agents that are used to keep the composite together. There are greener options to solve household storage needs.

Open Shelving

It is possible to reduce the number of cabinets in a unit by designing open shelving in combination with adequate pantry storage. Open shelves in kitchens are the standard in Scandinavia where cultural values consider good design a necessity of life. Green open shelves are constructed with natural materials like wood or more durable materials, such as metal or glass. Not only will this reduce the offgassing potential, but it reduces construction costs as well. (See the photograph on the left for an example of open shelving.)

Green Cabinets

Green cabinets also are a viable option. Thanks to products like wheat board, bamboo and other natural fiber materials, several manufacturers now offer very green alternatives to standard cabinets, though prices can be limiting. However, Swedish based IKEA® offers numerous household storage solutions that are low cost, environmentally friendly, and now widely available in the United States. ■

Green Flooring

Numerous green flooring options are available that are exciting alternatives to typical flooring choices.

Recycled Content PET Carpet

The easiest and most cost effective flooring choice is green carpet made from recycled polyethylene terephthalate (PET), which typically comes from plastic soda bottles, thus containing post-consumer recycled materials. This product is widely available and is cost competitive with standard carpet lines. Most of the approximately five billion pounds of carpet replaced each year in the United States, and the millions of plastic soda bottles in landfills, can be woven into new carpet fibers. Recycled carpet has a similar look, feel and price as "virgin" fiber carpet. According to NAHB Research Center's Toobase.org, a housing industry resource,

> "... recycled content carpet fiber is said to be more resilient and colorfast than virgin fiber carpet. Recycled carpet usually comes with the same warranties for colorfastness, static control and resistance to stain, crushing, and matting as virgin synthetic fiber carpets."[11]

Carpet Squares

Carpet squares are another option for green flooring. This product can be used in wall-to-wall installations or as an area rug. Squares are held together by adhesive dots that attach to other squares, but not to the floor underneath. Carpet squares can be removed like other furnishings when a resident moves. However, some carpet squares contain PVC and should be avoided.

Green Carpet Pads

Several green carpet pad products are available and are made from recycled fibers that do not offgas. Conventional carpet pads are made from foam and synthetic rubber and are non-renewable petroleum sources. Green carpet pads can be made from new, recycled or natural renewable fibers, such as cotton, felt, sea-grass or jute. Look for The Carpet and Rug Institute's (CRI) Green Label Plus rating.

Natural Linoleum

Like flooring products of years ago, this new generation flooring is made with the same time tested, natural materials that have made it a staple for high traffic areas from kitchens to battleships. Linoleum was invented in 1860 and is still manufactured with the same natural ingredients of linseed oil, wood, cork, wood pulp and wood resins. When linoleum finally does wear out, it can be shredded and used as garden compost. Linoleum is a very tough and practical flooring material that offers years of easy service and enjoyment, making it an ideal green choice for multifamily units.

Sustainable Harvested Wood

Sustainable harvested wood flooring products include bamboo, eucalyptus and other soft and hard wood species that have been certified sustainable by a reputable third party certifying agency, such as the FSC. Prices vary widely and generally start in the $4 per square-foot range. Higher prices must be weighed against the product's durability over standard affordable housing flooring, such as sheet vinyl and low-grade carpet. Be cautious of natural wood flooring products that are much cheaper. Less expensive products can be inferior in terms of how they were manufactured; their durability and sustainability is not equal.

Natural Cork Flooring

Cork flooring is made from cork oak tree bark originating primarily from Portugal. Cork flooring contains 100 percent natural content

11 NAHB Research Center's Toolbase.org at – *http://www.toolbase.org/Building-Systems/Floors/recycled-content-carpet*

materials. It has a resilient composition that is soft underfoot and very comfortable in work spaces such as kitchens. However, cork flooring can easily be dented or chipped by dropping dishes or pans onto its surface.

Wool and Wool Blend Carpets

Wool and wool blends are higher cost carpet alternatives, which offer superior durability and comfort. Because they are made from natural wool fibers, they are both green and sustainable. Less costly wool blends may be cost effective in limited applications due to their superior durability. ■

Controversy Over Cork

There is growing debate about the true sustainability of harvesting cork from cork oak trees and how the proliferation of cork flooring is or is not, affecting the wine industry. Harvesting cork bark does not kill the tree, but the relatively sudden demand for cork flooring may be threatening tree regeneration. Likewise, the wine industry has increasingly been going to synthetic corks, which cork detractors argue is the result of the flooring industry gobbling up all the available cork resources.

Green Trim Packages

Trim is usually installed in the final stages of any building project and is often the last opportunity to green the project before completion.

Radius Drywall Corners

One of the best green trim strategies is to simply minimize the need for certain trim pieces. To accomplish this, use radius or bullnose drywall corners around all window openings. Radius drywall corners are a fairly cost-effective strategy that add consumer appeal and a touch of elegance to any project.

Reduced or False Baseboards

Another strategy is to use small trim pieces, such as a 1 inch by 2 inch to finish off the bottom of wall surfaces rather than using larger baseboard materials. False baseboards can be painted to mimic the look of more expensive and taller base but require more care in finishing the bottom edge of drywall surfaces.

Standard Pine Board

Where trim is used or needed, widely available and cost effective number two pine boards can be used instead of typical medium-density fiberboard (MDF) or other composite materials. MDF and other standard trim materials often contain chemicals that offgas and do not always provide the serviceability of natural and readily available wood. Window and door side and head casings can be finished with pine. Butt joints are easier to fit precisely than miter joints at the corners of door and window casings, and can cover imperfections in the way sheetrock covers the headers and framing. ■

Butt jointed 1-inch standard pine boards used as window casings

Reducing Energy Use and Increasing Comfort: Insulation

Proper installation is at least as important as the type of insulation selected. There are many insulation choices and price ranges. Most insulation products on the market perform reasonably well. Some are more cost effective than others and a few are excellent green choices.

Fiberglass Batts

Fiberglass batts are perhaps the most familiar insulating material and are typically sold in paper faced batts designed to fit between joists, studs or rafters. Fiberglass insulation is not a barrier to air movement, so it does not work well unless it is in a well-sealed wall cavity. Most fiberglass batts contain recycled material and may be considered green. Fiberglass batts are easy to install. If handled correctly, fiberglass is considered safe, though it can be a skin, eye and airway irritant. Fiberglass insulation packages display cancer-warning labels required by the U.S. Occupational Safety and Health Administration based on determinations made by the International Agency for Research on Cancer and the National Toxicology Program. Plastic wrapped batts are now commonly available as a safer alternative.

Fiberglass Loose Fill Insulation

Fiberglass loose-fill insulation is an effective insulating material that is designed for use in attics and hard-to-reach locations, such as corners, nooks and crannies. It is installed dry, and because it will not settle over time, maintains its full R-value over the life of the home. Fiberglass loose-fill insulation is fed into a pneumatic blowing machine and blown under high pressure through a long flexible hose into attics and walls. Although homeowners can rent the equipment, it is common practice to have blown-in insulation installed by a professional, often at a better price than sold retail.

When fiber bibs are attached across studs or when water and adhesive is added, fiberglass also can be sprayed into wall cavities. According to The Partnership for Advancing Housing technology it has a slightly lower R-value than cellulose, but because it does not absorb moisture it dries quicker.

Cellulose

Cellulose is made from ground-up newspapers treated with borate as a fire retardant. All loose-fill insulation manufacturers are required to detail their product's installed and settled thickness on the bag label to let consumers know the expected settled R-value. Cellulose is applied using a mechanical blowing machine. In an attic, cellulose is not typically installed above an R-30 value because its weight can cause the ceiling drywall to sag. Most energy codes now call for R-38 to R-49 in attics.

Cellulose is routinely sprayed into wall cavities. It is important to monitor the water content of the material and to avoid closing off the wall cavities with vapor barriers and drywall before the moisture content is stable (around 10 percent). Moist cellulose creates its own adhesive binders to keep the product in the cavity, but some manufacturers add adhesives.

Cotton Batt and Loose Fill Insulation

Cotton batt insulation is another green alternative. It is manufactured from recycled denim and cotton fibers. The product is available in R-13 (3 ½-inch thick) or R-19 (5 ½ inch-thick) unfaced batts. Cotton is both easy and safe to install. Scissors are needed to trim batts and due to their weight, they may need to be stapled or otherwise pinned to wall cavities to keep from slumping. This product also is available in loose fill for blown-in applications.

Spray Foam Insulation

Spray foam is a more costly option, but it is a very effective insulating product with approximately twice the R-value per inch of traditional batt insulation. The insulation is sprayed into wall cavities and expands to fill void spaces. Excess foam is scraped off the studs to form a uniform wall cavity. Spray foam insulation makes it easy to completely fill wall cavities and to perform initial air sealing in the same step, reducing labor.

There are two types of spray foam: open-cell (isocyanurate) and closed-cell (polyurethane). The closed-cell foams typically have a higher R-value than open-cell foams.

The insulation is applied as a liquid, which contains a polymer (such as polyurethane or modified urethane) and a foaming agent. Sprayed foam insulation does not shrink, sag, settle or biodegrade, but it does require special equipment and trained installers.

Because of its excellent air sealing properties, some builders agree that no further air sealing is required, which helps to offset the higher cost. Most foams are environmentally friendly and do not contain hydrochlorofluorocarbons (HCFCs) that damage the Earth's ozone layer or offgas formaldehyde. For an even greener option soy-based foam also is available.

Rigid Foam Insulation

One of the best hedges against thermal bridging is the installation of rigid extruded polystyrene insulation. This product is manufactured by several companies and has become widely available through most material suppliers. Rigid foam insulation is typically installed on the exterior sheathing and covered with stucco or siding. Extruded polystyrene has an R-value of about four per inch. An installation of two-inch foam by itself cannot be considered adequate for energy efficiency. However, it is an excellent insulating addition to an already insulated wall. Carefully consider potential problems involved with applying siding materials to studs that are behind two inches of foam insulation.

In applications where rigid foam is used as a sheathing material, special care should be taken during installation to ensure that all joints are tight and taped. Tongue and groove foam should be used when available to guard against air infiltration that can quickly reduce the wall system's thermal performance.

Use of Rigid Foam Insulation for Remodel Applications

When remodeling a masonry structure with a finished brick or stucco exterior, particularly in cold climates, properly insulating the wall system may be difficult and expensive. It may not be

Expanding foam aerosol cans are a convenient way to fill gaps around penetrations that allow air infiltration. Unfortunately, the foam cans are single use devices so any leftover foam is wasted. The system on the left uses a gun that attaches to the specially designed can. The gun allows the foam to be dispensed multiple times until the can is empty. The canned foam and gun setup costs a bit more but there is no waste if more than one application is needed. The foam is available in different mixes including a low expansion version for window installations. The smaller can in the picture is a solvent cleaner to clear out the gun. Be aware that most of these products contain high levels of VOCs. A greener choice is latex foam that comes in multi-use cans and is water-based for easy clean up.

practical or cost effective to install rigid insulation on the exterior walls. However, a good alternative would be to install it against the existing interior plaster or masonry surface underneath the drywall or other finished wall surface.

When using furring strips to attach new drywall or other final wall surfaces, you might consider adding additional rigid insulation between the strips to increase thermal performance. This will add cost to the project, but will greatly improve comfort and decrease energy costs.

Air Infiltration

A building envelope that limits air infiltration is as important as proper installation of good insulation. There is an adage in the industry that says "build it tight and ventilate it right." Green builders strive hard to build tight envelopes. Air infiltration robs a home of heat energy through the process of convection, following the laws of thermodynamics where heat always moves from hot to cold and thereby leaks out through building envelope penetrations.

In a typical home there are dozens of exterior penetrations in the envelope. Most of these occur during framing with the balance coming from plumbing and electrical openings, such as outlets, recessed ceiling lights, ducts and vents. It is difficult to achieve acceptable comfort levels in a home with poor air sealing.

Air sealing combined with proper ventilation has a threefold effect: it reduces drafts, keeps unwanted pollutants and contaminants from entering the home, and can reduce energy use. In hot humid climates proper air sealing keeps moisture from entering wall cavities, which can lead to costly mold and mildew problems. In cold climates, warm inside air that leaks into wall cavities can condense on cold surfaces and cause moisture damage. According to EPA, air leakage accounts for 25 to 40 percent of the energy used for heating and cooling in a typical home. Poor air sealing also affects the performance of wall cavity insulation.

There are numerous materials and devices to reduce air infiltration, including seal plate gaskets, sealants, caulks, foams, tape, weather stripping, door stops, house wraps and electrical outlet gaskets, all of which are readily available.

Drainage Planes

Properly installed house wraps provide an excellent drainage plane to prevent outside moisture, including driving rain, from penetrating wall cavities. For house wraps to work effectively they must be installed according to the manufacturer's recommendations, particularly around window and door openings. Moreover, there must be a place at the bottom of the wall assembly between the house wrap and the exterior cladding for any collected moisture to escape so moisture is not trapped. ■

Windows and Doors

Double pane low-E windows are now the industry standard and are used in most affordable housing.

Vinyl Sash Windows

Top-shelf windows, made of wood and clad with aluminum or vinyl, are too expensive for most affordable housing developments. But if the budget permits, these windows will increase comfort and aesthetic appeal and may even save energy. For both new affordable housing construction and renovation, vinyl sash units are probably most cost effective. Please see passive solar design and glazing ratios in Section Two for guidance on how window placement and using clear glass on windows facing south can increase energy efficiency.

When looking for windows it is important to consider the quality of the window components, including the opening and locking mechanisms. Becoming familiar with window ratings and performance numbers is important. The National Fenestration Rating Council (NFRC) rates all windows sold in the United States and places its rating sticker on the window. They will list U-factors (the inverse of R-values), Solar Heat Gain Coefficient (measure of how much heat gain enters a window) and Visible Transmittance (measure of how much light enters the window). This rating also will include specifications on air leakage and condensation resistance.

Remodel Sash Kits

Typically, windows in the nation's historic housing stock are wood double hung units. In order to increase the thermal efficiency of the envelope while retaining the historic wood interior of the window sashes and muntins, window sash kits are an easy and cost effective alternative. Many companies manufacture high quality replacement windows for use where the existing window jamb and frames are in good condition. These kits include new top and bottom sashes, jamb liners, gaskets and stops.

The jamb liners mount to the existing jamb to provide a positive seal and the new sashes then fit into the jamb liners. The entire installation can be done without disturbing existing interior and exterior window casings. Sash kits cost around 50 percent less than the same window purchased as a complete unit. However, given the short installation time and lack of demolition and refinish required, cost savings may actually exceed 50 percent.

Super Performance Windows

"Window technology has evolved over the years to the point where windows can be selected not only for their aesthetic qualities, but also for their performance abilities. For example, windows can be made from laminated glass that resists impact from flying debris in hurricanes, have special coatings that control the amount of heat gain and loss, or prevent water spots and dirt accumulation.

An NFRC label on the window will contain the information regarding the glazing features of a window — U-value, Solar Heat Gain Coefficient (SHGC), and Visible Light Transmittance (VT). Generally, the lower the U-value, the better the window performs at preventing heat loss (or gain in hot climates). U-value is equal to the inverse of R-value. SHGC is the fraction of sunlight which is admitted through a window and released as heat indoors. It is expressed as a number between 0 and 1 the higher the number, the more solar heat the window transmits. VT is the portion (between 0 and 1) of the sun's visible light that is transmitted through a window.

Typically, distributors and retailers will stock windows with the glass that is recommended for given climates, but custom sizes and brands that require special order will allow a greater choice of glass features. The Efficient Windows Collaborative and Energy Star provide websites to aid in specifying the most efficient window for a given climate."

Typical Center-of-Glass Window Properties

	VT	*SHGC*	*U-Value*
Double-Pane-Clear	0.82	0.78	0.46
Low-E	0.78	0.58	0.25
Solar Control Low-E	0.72	0.4 or less	0.27[12]

12 NAHB Research Center's Toolbase.org at – *http://www.toolbase.org/Building-Systems/Windows/high-performance-glass*

Exterior Doors

Exterior doors should be insulated units or wood units with composite cores for primary entry use with a minimum R-value of five. The latter of these are primarily manufactured in China; far from a locally available product. However, because prices start at about $400, they may fit into the budget and offer high quality and stability against checking and warping.

Insulated steel exterior door units are the most cost effective. Although insulated fiberglass units typically perform better, they also are more expensive. Glazing should be considered for exterior doors. Doors facing north or west work best with not more than half lights (windows), while doors facing south or possibly east can use full tempered glass to allow additional light and solar gain. Doors also are rated for energy performance by NFRC.

Weather seals are the most problematic part of any exterior door so compare the seal quality in the various options available on the market before ordering. Seals do not last forever and some can be very difficult to fix or replace. Builders should try to avoid placing doors on building elevations that face into prevailing winds. A driving rain pushed by 70 to 80 MPH winds can get past almost any door seal.

Regardless of the application used, check the local codes for minimum window and door ratings, or follow a reputable green building rating system that addresses windows and doors. ■

Space and Water Heating

On-Demand Tankless/Instantaneous Water Heaters

On-demand water heaters provide heated water only when it is needed. Because they are tankless in design, there are no standing energy losses from hot water storage tanks. Therefore, they are typically more energy efficient than tank models.

Tankless heaters only heat water as it passes through on its way to the final destination (shower, sink, washer, dishwasher). They are capable of supplying a constant supply of hot water, usually at a flow rate of about two to five gallons per minute. Electric units produce lower flow rates than gas fired tankless heaters.

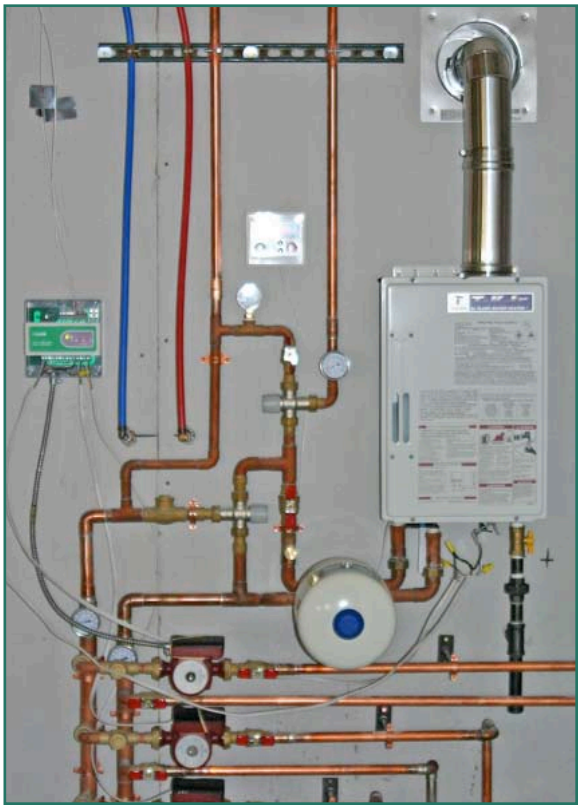
A single tankless water heater can supply the hot water needs of an entire home. However, smaller units are sometimes installed near a point of use, such as a dishwasher. Tankless heaters also are used to boost the temperature of solar water heating systems. Tankless water heaters are increasingly being used as the heat source for in-floor radiant heating systems. It is fairly common practice to use the same tankless heater for both radiant floor heating and domestic hot water.

Gas fired on-demand units can waste energy if they have a pilot light that remains lit when not in use, as this energy is not heating water when in standby mode. Some models are equipped with an electronic ignition device that resembles the spark ignition found on gas kitchen ranges and ovens.

Most on-demand water heaters have a life expectancy of more than 20 years. They also have easily replaceable parts that can extend their life by many more years. Storage or "tank" water heaters typically last eight to 12 years.

According to the U.S. Department of Energy,

> "For homes that use 41 gallons or less of hot water daily, demand water heaters can be 24%–34% more energy efficient than con-



Wall mounted tankless heater that provides domestic hot water and space heating for a 2,400 square foot building

ventional storage tank water heaters. They can be 8%–14% more energy efficient for homes that use a lot of hot water—around 86 gallons per day. You can achieve even greater energy savings of 27%–50% if you install a demand water heater at each hot water outlet."[13]

Comfort Cove® Radiant Heat

Comfort Cove radiant heat panels are a relatively new type of radiant heat system consisting of thin electric resistance heating panels mounted high on the wall and angled down to directly heat objects in the room. Radiant heaters are unique because they can maintain comfort at a lower air temperature, by warming objects in the room — not the air. This system features zonal temperature controls so that seldom used rooms can be set at a lower temperature to realize increased cost savings. Radiant panels are approximately one-eighth the cost of in-floor systems. Panel heaters also are less expensive than radiant ceiling drop-in panel systems, and they are comparable in cost to wall-mounted fan-forced heating units.

Electric radiant panels are durable because there is simply very little to go wrong—no belts, blowers, motors, bearings, filters, flues or compressors to replace and service.

According to a recent study performed by the American Society of Heating and Refrigeration and Air Conditioning Engineers, radiant electric heat had significant energy savings over electric baseboards, and was found to be much more energy efficient than air-to-air heat pumps. Savings are due primarily to improved thermal comfort.[14]

Geothermal (or Water Source) Heat Pumps

Geothermal heat pumps rely on the relatively constant heat of the earth (thermal energy) to provide heating, air conditioning and, in most cases, hot water. Ground-loop and water-loop heat pump systems are slightly affected by higher temperature fluctuations but they are not as sensitive to temperature changes as air-source heat pumps. Ground and water temperatures a few feet below the earth's surface stay relatively constant throughout the day or year. For this reason, ground loop heat pump systems remain highly efficient throughout the year in virtually any climate.

In winter, geothermal heat pump systems collect the earth's natural heat through a series of pipes installed in the ground or submersed in a body of water. Fluid circulating in the loop carries heat to the home where an electric compressor and a heat exchanger release it inside the home at a higher temperature. Duct-work distributes the

13 *http://apps1.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12820*

14 *http://www.radiantsystemsinc.com/*

Affordable Radiant Heating Systems

During the past 50 years most new home heating installations have been forced air systems. Hot water radiant systems were expensive and the earlier examples using copper tubing in concrete proved to have serious (and expensive) corrosion problems. Today's radiant systems are reliable, energy efficient and affordable.

Hydronic radiant heating systems now use cross-linked polyethylene (PEX) tubing. PEX tubing is easy to install, it is reliable, durable and affordable. Modern hydronic systems often utilize the same heat source for both domestic water heating and space heating.

The Radiant Floor Company specializes in selling radiant heating system packages for the do-it-yourself market. They will design the system to fit your plans and ship the components for your system. They publish an informative Design and Installation Manual and offer very good technical support.

heated air to different rooms. In summer, the process is reversed to cool the home. Excess heat is drawn from the home, expelled to the loop and absorbed by the Earth.

According to U.S. Environmental Protection Agency (EPA), geothermal heat pumps can reduce energy consumption and related emissions by 23 to 44 percent. Compared to residential electrical resistance heating and standard air-conditioning equipment, EPA finds geothermal heat pumps are up to 70 percent more efficient. In addition, the EPA has found that geothermal heat pumps offer the lowest carbon dioxide emissions and lowest overall environmental cost of all the residential space-conditioning technology available today.

Installation costs for geothermal systems are somewhat higher than air-source heat pumps because they require underground connections. ■

Radiant heating system PEX tubing installed before pouring concrete slab. Zip ties are used to secure the tubing to the rebar. The ties are spaced close together to ensure that the tubing will not float to the surface when the concrete is poured.

Gypcrete poured onto second floor provides thermal mass for radiant heat tubing

The ENERGY STAR Program — Green Appliances and Lighting

ENERGY STAR is a joint program of EPA and the U.S. Department of Energy that focuses on energy efficient products and practices to help save money and protect the environment. According to ENERGY STAR,

> "Americans, with the help of ENERGY STAR, saved enough energy in 2007 alone to avoid greenhouse gas emissions equivalent to those from 27 million cars — all while saving $16 billion on their utility bills."[15]

ENERGY STAR began in 1992 and has grown steadily in terms of the energy efficiency solutions it offers businesses and households as well as the number of partnership organizations involved in its programs. This has resulted in thousands of homes realizing reduced energy use and cost, increased comfort, and reduced unwanted environmental impacts.

Appliances

ENERGY STAR qualified appliances use 10 to 50 percent less energy and water than standard models. The additional cost of purchasing ENERGY STAR appliances is minimal and is quickly offset by savings in energy and water use. The ENERGY STAR Quantity Quotes program is a free on-line service of the U.S. Department of Energy that allows purchasers to register for bulk purchase pricing from ENERGY STAR suppliers.

Qualified ENERGY STAR appliance products include clothes dryers, washing machines, dishwashers, dehumidifiers, refrigerators, freezers, room air conditioners and room air cleaners.

Lighting

Although daylighting should be the first strategy for green lighting, another simple way to green affordable housing lighting is to select ENERGY STAR Qualified Light Fixtures. Special purchase programs are available in some jurisdictions through participating local electric utility or energy efficiency providers. In these programs, instant rebates are available through on-line or paper catalogs.

If recessed ceiling lights are installed in an insulated ceiling cavity, use sealed can units to ensure that thermal leaks in the envelope are minimized. Units suitable for insulation will be labeled as such and will include a listing of the maximum bulb wattage allowed. Compact florescent lamps (CFLs) provide more light per watt so a fixture normally limited to a 60 watt incandescent bulb can have the light of a 100 watt bulb from a 23 watt CFL. ■

Compact florescent lamps (CFLs) produce more light at lower wattages than standard incandescent lights, and they last longer. Manufacturers have improved the start up time and color of CFLs. CFLs contain small amounts of mercury; dispose of properly.

15 *http://www.energystar.gov/index.cfm?c=about.ab_index*

Green Plumbing

Cross-linked polyethylene (PEX) pipe is increasingly popular for residential water system plumbing. PEX pipe systems do not corrode or develop pinhole leaks. They are chlorine and scale-resistant and have fewer fittings, connections and elbows than rigid plastic or metallic pipe.

PEX is a high-temperature, flexible plastic (polymer) pipe. The cross-linking raises the thermal stability of the material under load. Thus, the resistance to environmental stress cracking, creep, and slow crack growth are greatly improved over regular polyethylene.

PEX pipe is approved for potable hot and cold water plumbing systems and hot-water (hydronic) heating systems in all model plumbing and mechanical codes across the United States and Canada. PEX piping systems are durable, provide security for safe drinking water and use reliable connections and fittings.

PEX tubing can withstand operating temperatures of up to 200° F (93° C). It is light weight, flexible and can easily bend around corners, obstacles and through floor systems. PEX tubing sizes range from 3/8 inch to more than 2 inches. ■

Renewable Energy

Solar Water Heaters

Many solar products are now available for domestic hot water and space heating. Solar water heating systems include passive applications for warm climates to active systems involving pumps and valves to protect from freezing. These products range in price from $1,700 to $17,000 for the most sophisticated systems.

Solar hot water systems are generally tied directly to a conventional water heater, serving as a pre-heater, except in warm climates. Some solar water heating systems also use insulated storage tanks.

A progressive tube solar water heater is available, which manufacturers claim can operate year-round in the majority of United States locations, while still being effective in the coldest regions of America for seven months of the year. The water progresses from one tube to another, each holding progressively hotter water. Naturally, where sustained freezing occurs these systems must be drained.

Solar Air Heaters

Solar air heaters are made of layers of insulation, framing, aluminum and glazing panels that are secured together. A hole is cut in the roof or side of the house to allow air to pass through. Solar air heaters work by heating the air inside the panels with the sun's energy and then venting the warmer air into the house while cool air filters out. This process allows the house to be heated more efficiently using less energy as well as improving indoor air quality by bringing in fresh, outdoor air. Solar air heaters are most effective when placed on south facing walls. They can be installed with or without a fan to circulate the air and are expected to pay for themselves over seven to 10 years of use. Solar air heaters are tested and certified by the Solar Rating and Certification Corporation. A system can cost between $500-$2,000 based on size and whether or not it includes a fan. Rebates or incentives are available in most states. To see which states participate – check: *http://www.dsireusa.org* and select "solar space heating."

Evacuated Tube Solar Water Heaters

Evacuated tube solar water heaters are more technologically advanced and, therefore, more expensive than flat plate systems. They work by absorbing energy through twin vacuum tubes that contain a specially coated heating element, which absorbs solar radiation in the absence of air between the tubes. This heat is then transferred to a fluid-filled heat exchanger located at the top of the unit that sends the heat to the home's distribution system. These systems have been used for years in Germany, Canada, China and the UK and are now widely available in the United States.

Acting like a large thermos, evacuated tubes provide excellent insulation, allowing more than 90 percent of solar radiation to enter the tubes, with losses under 5 percent. The insulation properties in these systems are so good that while the inside of the tube may be more than 300° F, the outer tube is cool to touch. Evacuated tube water heaters perform very well, even in cold and overcast weather, making them better overall performers than flat plate collector systems, especially during conditions of wide ranging temperature swings. Also, if the individual tubes break or malfunction, they can be replaced without special tools.

Solar Photovoltaic Panels

There are many manufacturers of photovoltaic (PV) solar panels ranging from small battery chargers to large panels installed as arrays. PV technology is evolving rapidly and becoming more cost effective. Efficiencies also have climbed steadily during the years.

Many states offer rebate programs that effectively reduce costs for PV solar systems. Net metering policies in many states, and even more favorable buy back rates in a few states, provide long-term financial incentives for investing in a PV solar system. With the likelihood of plug-in hybrid vehicles in the future, having an independent distributed power plant on roofs will start to make more sense as the current energy crisis deepens.

Currently PV solar systems are too costly for most affordable housing development. However, the real cost of PV solar systems can be offset substantially by utility company rebates and government tax credits. Watch for the incentives available through the federal and state governments as well as your utility company. Information on rebates and government incentives can be found online at *http://www.dsireusa.org/*. ■

Solar Direct offers the following comparison to standard water heaters[16]

Standard Water Heater	Solar Water Heater
Annual operating cost: $500+	Annual operating cost: $50
Storage capacity: 40-50 gal	Storage Capacity: 80-120 gal
Life expectancy: 8-12 years	Life expectancy: 15-30 years
Lifetime operating cost: $10,000	Lifetime operating cost: $1,000
Depletes fossil fuels	Doesn't pollute
No added value	Increased equity
No return on utility payments	25% return on investment
At mercy of utility payment hikes	Protection from future increases
No hot water during blackouts	Hot water during blackouts

16 *http://www.solardirect.com/swh/swh.htm*

Building Integrated Photovoltaic (BIPV) Shingles

"Many homeowners recognize the value of solar energy technologies but have been leery of the highly visible collectors on their roofs. Although the term "solar power" may be synonymous with environmental-friendliness and freedom from fossil fuel dependence, some types of solar systems have been avoided because of their unattractive (or unique) appearance from the curb. For this reason, photovoltaic (PV) modules, which convert sunlight directly into electricity, have been integrated into roofing or other building materials as an alternative to traditional PV modules that are mounted above the roof on racks. The result is a photovoltaic system that is less noticeable but has benefits that are hard to miss. Once installed, BIPV components not only protect the home from storms and rainy weather but produce free electricity for use in the home. The residential industry most often uses building-integrated photovoltaic roofing products; however PV systems can also be integrated into façade materials, awnings and covered walkways.

The many types of photovoltaic roofing products compliment many different roofing materials including asphalt shingles, standing seam metal roofing, and slate or concrete tiles. BIPV roofing products are produced by manufacturers whose products are designed to serve both functions — as a roofing material to protect the home and as an electrical device to produce electricity. PV systems can be sized on a small scale to produce a limited amount of energy or be large enough to power an entire home and send excess electricity to the utility.

Most residential BIPV systems are used in conjunction with utility-supplied power. In addition to the PV-active roofing, an inverter, located near the electrical panel, converts the PV produced electricity into utility compatible alternating current (AC) electricity for the home. PV systems that utilize battery storage can produce electricity for the home even when the utility power is disconnected or when the sun is not shining. Utility-provided electricity is used when the house demand is greater than can be supplied by the photovoltaic roofing. PV systems can be sized on a small scale to produce a limited amount of energy or be large enough to power an entire home and send excess power produced during daylight hours back into the utility's lines. Typical residential PV systems commonly have a peak power production of between 1,200 and 5,000 watts, AC requiring 150 to over 1000 square feet of roof area depending on the efficiency of the PV technology used."[17]

17 NAHB Research Center's Toolbase.org at – *http://www.toolbase.org/Building-Systems/Roofs/photovoltaic-building-integrated*

Water Conservation

Indoor Water Usage

Clean potable water is likely to be among the most pressing issues facing the world in coming decades. America's per-capita domestic water use is the highest in the world. With the trend toward multiple head showers and luxurious spa tubs, domestic water use is increasing. Fortunately, most affordable housing budgets do not allow for extravagant water-use appliances.

Thankfully, awareness of this issue has risen significantly in the last decade and there are many easy-to-use fixtures and other strategies to help conserve water. For starters, low flow aerators can be installed in sink faucets and shower heads at very little cost. In addition, timers can be installed on shower heads to help occupants monitor their water use and conserve.

Low water use toilets are now required in every state. It is easy for contractors to specify ENERGY STAR dishwashers that use less water. Dual flush toilets are another way to reduce water use. Long used in Japan and Europe, these models have two flush modes to handle waste with the appropriate amount of water for each use rather than one flush cycle for all uses. The lower flow flush uses only half the water of the full flush, which matches the 1.6 gallon industry standard.

Water recirculation pumps save water by continually circulating hot water so it is available immediately when the faucet is turned on. This saves water and energy by not requiring the water to run to reheat the water lines and deliver hot water to the faucet. A much cheaper remedy is to simply insulate the hot water supply lines to reduce heat loss.

Landscape Water Usage

Landscape irrigation represents a major portion of residential water use. Lawn watering and other landscape maintenance varies with climate but it is interesting to note that the very highest per-capita water use is in communities located in the most arid portions of the Southwest. Considerable water savings can result from replacing water intensive landscaping with drought tolerant plants that are appropriate for the local climate.

Landscaping should consist of native species or plants selected for suitability to the local climate. To determine which landscape plants are suitable to a specific area, visit the American Horticulture Society website for a map[18] of Master Gardener websites throughout the United States or visit the H2ouse Water Saver Home website.[19]

Design

Consider using a collection of native plants. Native plants are adapted to your area, which means they naturally require less maintenance and water than exotic plants. They are more resistant to pests and diseases than many exotics, reducing the need for pesticides. Additionally, native plants attract wildlife and beneficial insects and are generally more maintenance free.

Native plant xeriscaping at the Housing Authority of Southeastern Utah

18 *http://www.ahs.org/master_gardeners/index.htm*

19 *http://www.h2ouse.org/gardensoft/browser04.aspx?SearchType=Characteristic*

Soil

Ensure that the soil has the proper additives and nutrients to absorb and retain water. This not only helps plants thrive but also reduces run-off into the storm drain system. Compost can loosen clay soils and helps sandy soils retain water.

Compost

Keep waste out of the landfills and nurture the soil by composting food scraps and other organic matter. Using compost improves soil structure, texture and aeration and increases the soil's water-holding capacity. Compost needs a proper ratio of carbon-rich materials, or "browns," and nitrogen-rich materials, or "greens." Among the brown materials are dried leaves, straw and wood chips. Nitrogen materials are fresh or green, such as grass clippings and kitchen scraps. Check with the local Master Gardener program or extension service for availability of a free or low-cost composting bin.

Irrigation

Efficient water use means reducing waste and using sound irrigation methods. By using a drip irrigation system, water is provided to the plant roots where it is needed and little is wasted through evaporation as would be the case with a sprinkler system. The optimum system would save water and maintain a balance of air and water in the soil through low volume water applications.

Water

Get creative by developing rain catchment systems on the property. Capture or divert most, if not all of the rain water that lands on the roof and store it for later use as irrigation water or divert it away from the storm drain system back into the ground. Downspouts should put rain water to good use. Many Master Gardener programs sell a composite barrel with a closeable lid to catch rainwater and a spigot to make watering plants easy. Keep in mind that some states, such as Colorado, have laws that make rain water catchment illegal.[21]

Greywater Systems

"Greywater is wastewater from bathtub, shower drain, sinks, washing machines, and dishwashers. Greywater accounts for 60% of the outflow produced in homes. It contains little or no pathogens and 90% less nitrogen than black water (toilet water). Because of this, it does not require the same treatment process. By designing plumbing systems to separate it from blackwater, greywater can be recycled for irrigation, toilets, and exterior washing, resulting in water conservation. When planned into new residential construction, the home's wastewater treatment system can be significantly reduced, resulting in cost and space savings.

Systems generally consist of a three-way diverter valve, a treatment assembly such as a sand filter, a holding tank, a bilge pump, and an irrigation or leaching system. The holding tank cools the water and temporarily holds it back from the drain hose. Systems can either be custom designed and built, or purchased as a package. Techniques include recessed or raised planter soilboxes, water injection without erosion, gravity or pressure leach chamber, and irrigated greenhouses. Some system components can retrofit existing irrigation systems."[20]

20 NAHB Research Center's Toolbase.org at – *http://www.toolbase.org/Techinventory/TechDetails.aspx?ContentDetailID=907&BucketID=6&CategoryID=11#top*

21 Casey, Solomon, Mackne and Lake. Water efficiency: A Project funded by the U.S. Environmental Protection Agency. National Small Flows Clearinghouse, 1998.

Keep It On-site

If there is a lawn to mow, use a mulching blade to chop the grass into small pieces and distribute back onto the lawn, thus feeding the lawn and keeping the waste out of the landfill. It also reduces the need for fertilizer. Turn yard trimmings into mulch by chipping or composting them. Also, let the leaves that drop from trees and shrubs act as natural mulch.

Integrated Pest Management (IPM)

By using beneficial insects, watering correctly, implementing sound horticultural practices and planting the right plants in the right place, the need for toxic pesticides and herbicides can be avoided. ■

Improving Indoor Air Quality

Improving indoor air quality is an increasingly important component of green building. In non-green buildings there are literally hundreds of contaminants in the materials used to construct, finish and furnish homes. These dangerous chemicals have been linked to childhood asthma, adult respiratory problems, headaches and central nervous system ailments. Often called sick building syndrome, these contaminants directly affect the health of occupants. They can easily be detected by the presence of the "new house smell" in newly constructed homes.

Source Contamination Control

Green Cleaning Products

Improve indoor air quality by limiting or eliminating source pollution from cleaning chemicals and pesticides. There is a wide selection of green alternatives to these dangerous chemicals available on the market.

Limiting Carpets and Using Stomp-Off Zones

Limiting the use of carpet, which traps dust and other contaminants, is a good strategy. Most carpets are a direct source of contaminants caused by the dangerous chemicals used as binders and adhesives. Carpet padding is often a primary culprit. At a minimum, consider designing and installing stomp off zones or simply using stomp off mats near entrances to keep outside dust and contaminants contained near entry ways where they can easily be removed rather than be distributed throughout the home.

Non-Toxic Finish Materials

The next thing to look for is what goes into the home during the construction finish phase. Cabinets, flooring, trim and counter tops are often direct contaminant sources. Binders and adhesives used in these products often contain formaldehyde and other dangerous chemicals that can quickly degrade indoor air quality.

Green Paints, Stains, Sealers and Adhesives

Traditional paints, stains, sealants and adhesives contain high levels of toxic chemicals and give a new home that new house smell. The new house smell could be the result of dangerous chemical offgassing. The good news is that there are numerous green options to replace the potentially harmful products.

Low or no Volatile Organic Compound (VOC) paints, stains, sealers and adhesives are an easy way to dramatically improve indoor air quality. Considering the large quantity of these materials used in the construction and finishing of a home, using standard varieties of these products can introduce significant levels of contaminants. Using green alternatives is an easy way to green the home and should be considered as a key part of any green building program. See the resource section of this guide for a listing of companies that offer these products.

Ventilation

Whole House

Air within homes quickly becomes stale and even toxic when odors and offgassing contaminants enter the home. Leaky homes may allow enough "accidental" ventilation to occur from penetrations in the building envelope but tight homes, as advocated in this guide, require mechanical ventilation to ensure good indoor air quality and increased comfort. Moreover, accidental ventilation is unreliable due to temperature and pressure variations that allow too much or too little fresh air to enter the building.

Mechanical balanced ventilation systems remove the exhaust of stale polluted air and provide a supply of fresh outside air to all living spaces in the home. The exhaust and supply fans of this type of system are balanced to maintain constant indoor air pressure.

In cold climates a balanced ventilation system can be equipped with a heat exchanger that recovers heat from the exhaust loop. These systems are known as heat-recovery ventilation systems or HRVs. Total heat exchangers transfer both heat and humidity to help prevent moisture-related problems and work well in moderately humid climates. Sensible heat exchangers recover dry heat and are well suited for cold climates.

Benefits of a balanced ventilation system include improved indoor air quality, increased comfort due to fewer drafts, improved health due to the removal of harmful indoor contaminants and lower utility costs where HRV units are used.

Kitchens

It also is important to provide separate ventilation systems for source contaminants inside the home like cooking. Kitchens should have a separate manually operated ventilation system to exhaust cooking related contaminants.

Bathrooms

Bathrooms, if they are not part of the HRV system, should have manually operated ventilation systems that expel moisture and humidity to avoid mold and mildew associated with wet and humid areas. Mold can be a serious health risk to home occupants and can be costly to mitigate.

Combustion Ventilation

Appliances, such as furnaces, boilers, water heaters and pellet stoves require separate outside air for combustion.

Garage/Vehicle Emission Control

While attached garages are commonplace, they are often a key source for carbon monoxide poisoning resulting from pressure differences between conditioned living spaces and unconditioned garages. When the pedestrian door between the garage and house is opened, air from the garage can enter the home and bring in carbon monoxide.

The easiest way to eliminate this pollution source is to design a detached garage. If this option is not available, designing an attached mud room that is closed off from the main house will help. Only starting vehicles after the garage door is fully open will help avoid vehicle emissions from entering the living space.

Radon Control

Radon is a naturally occurring, odorless and radioactive gas that can accumulate in buildings. Except for smoking, radon exposure is the leading cause of lung cancer.

It is more cost-effective to build with radon resistant measures rather than retrofitting a mitigation system into an existing home. One proven sub-slab radon mitigation strategy is to place several inches of gravel above a gas permeable membrane. The gravel is topped with a non-permeable plastic membrane and the concrete

slab. A vent pipe is installed from the gas permeable layer to above the roof level to vent the radon. A junction box should be installed near the vent pipe so a fan can be added if testing shows that forced venting is necessary. All foundation floor openings should be caulked.

Radon vent system installed on an older home. It is a sub-slab suction system that reduced the basement radon level from 6.4 pCi/L to 2.6 pCi/L.

For existing homes, short term radon tests are available. If the results are above the EPA limit of 4 picoCuries per liter of air, then measures should be taken to reduce the radon, usually through soil suction. Sub-slab suction utilizes a suction pipe installed beneath the floor to vent to the outdoors above the roof. A specially designed fan maintains a negative pressure in the pipe, pulls the radon gas from under the slab and exhausts it to the outdoors. A radon mitigation system retrofitted to an existing home costs about $1,500. [22]

Radon-resistant construction methods for homes with crawl spaces consist of a vent pipe (stack) and fan installed from the crawl space floor through the roof. The bottom of the stack terminates in a tee fitting attached to a length of 3-inch or 4-inch diameter perforated pipe or a strip of manufactured drainage matting that should be installed horizontally across the floor. This assembly is installed below a vapor barrier sheeting that rests on the crawl space floor. The floor is completely covered with the vapor barrier and is sealed at the foundation walls, piers and seams. The sealed vapor barrier and vent stack (sealed under the vapor barrier) is designed to vent radon to the outdoors before it can enter the living space.[23] ■

22 *http://www.epa.gov/radon/*

23 *Passive Radon-Resistant Construction Performance in Ventilated Crawl Space Homes Final Report,* conducted by the NAHB Research Center, Inc., Upper Marlboro, MD for the U.S. Environmental Protection Agency, Washington, D.C., EPA Assistance ID No. X819586-01-5, Task 1, May 1996.

Recycled, Salvaged Materials and Waste Management

We have all heard the adage "reduce, reuse and recycle" and green building is no exception. There are many ways to incorporate a comprehensive strategy of recycling, reuse and waste management into a green building project.

Using Recycled Materials

Introduce green materials into a project by using recycled or salvaged materials or by reusing materials during a renovation. Recycled materials fall into two categories — new materials with pre-consumer recycled content and new materials with post-consumer recycled content.

Pre-consumer recycled materials come from industry scraps. For example, cotton batt insulation is made with cotton trimmings that come from the blue-jean industry.

Post-consumer recycled materials come from trash recycled by residents and businesses. Cellulose insulation, for instance, is made predominantly from recycled newspapers.

The substantial waste stream offers great promise in closing resource loops where a raw material can have an endless life cycle. For example, glass bottles can be recycled into ceramic or glass tile, which in turn can be recycled into more tile in an endless cycle that bypasses the landfill. It also provides a chance for manufacturers of other products to use their waste stream as source material for new applications.

Using Salvaged and Reuse Materials

Although it takes some effort to locate and retrofit into a project, using salvaged and reused materials is another way to go green. According to an EPA study, U.S. residential renovations during 1996 created more than 31 million tons of waste. A typical kitchen remodel results in five tons of waste. Renovating a total house can result in up to 13 tons of construction waste. Much of this waste stream can be diverted by reusing or salvaging materials that normally would be headed to the landfill. Building reuse centers make it easy to purchase these materials and fixtures. If an agency is renovating or upgrading existing buildings, it may acquire materials for reuse and donate used items to the local building material recycling center.

Overall, the goal should be to minimize the waste stream going into and coming out of the project. When project materials are wasted or landfilled, the material resources and energy used to manufacture them are squandered.

Salvaged Materials

Salvaged materials are those materials suitable for reuse that come from either on-site, in the case of a renovation, or from an off-site location. Salvage materials should not contain hazardous substances, such as asbestos and lead-based paint.

Reuse Centers

Many communities have building reuse centers that specialize in collecting, organizing and retailing salvaged building materials. These centers make it much easier and faster to access salvaged materials as users do not have to track down,

ReSource Architectural Salvage and Used Building Materials operate recycling centers in Boulder and Fort Collins, Colorado

remove and refurbish the materials. End users can expect to pay upwards of 75 percent of retail value for materials at a reuse center. This savings can be used to offset the extra staff time and construction time needed to incorporate salvaged materials in a project.

On-site reuse, for obvious reasons, is the easiest form of recycling, as it requires no material transport. Nor does it take time to research, locate and secure used materials from an outside source. For this reason, it is a significant green building strategy in terms of its environmental impact. The following is a list of reusable building materials.

List of Reusable Items:

- Solid wood flooring
- Trim, molding
- Lumber (especially larger dimensions and longer pieces)

ReSource Architectural Salvage and Used Building Materials recycling centers are examples of good sources to purchase used building materials. Habitat for Humanity also has recycling stores in most larger cities.

- Architectural details (mantels, columns, stair rails)
- Sinks, tubs, toilets
- Faucets, showerheads and related plumbing
- Light fixtures, fans, grounded outlets, switches
- Doors (all interior and exterior if insulated or solid wood)
- Windows (if double pane and seals intact)
- Cabinetry, shelving
- Hardware (knobs, pulls, hinges, closures, hooks, curtain rods, blinds)
- Roof tiles and panels (terra-cotta, slate, metal)
- Ceramic tile
- Shower doors and stalls
- Brick and stone

Steps to Follow for an Overall Recycling Program

By following these four steps when planning a project, material impacts can be lessened:

STEP One: Plan to reduce waste:

a. Design wisely to maximize space and think about what can be reused

b. Reduce packaging or return packaging to suppliers, if possible

c. List and mark all items to be salvaged

d. Find clean and dry storage for salvaged materials

e. Designate bins for all items to be recycled

f. Identify all hazardous materials and dispose of properly

g. Dismantle or de-construct rather than demolish building components

STEP Two: Reuse materials

a. Reuse on-site

b. Salvage scraps for landscaping, carpentry, mulch

c. Donate unused materials — thrift shops, theater sets, shop or art classes

d. Sell more valuable items

STEP Three: Recycle materials

a. Recycle at home – compost

b. Put in recycle bins

c. Drop off centers

d. Call a salvage yard for metal, appliances

STEP Four: Dispose of correctly or utilize grinding or waste management plans [24]

Waste Management

According to the National Association of Home Builders, the average American home contributes 15 percent of its material package as landfill waste. Wood, drywall and cardboard typically account for 75 percent of construction waste by volume. This "waste" often needlessly ends up in the landfill.

Besides the waste saving strategies previously discussed, agencies can adopt a waste management plan that can reduce what is shipped to the landfill by up to 80 percent, greatly extending the life of small landfills. This also will reduce the associated and rising costs of landfill dumping fees.

Waste Grinding Services

Waste grinding services exist in many areas. They can convert certain construction waste into useful mulch for landscaping and soil amendments. These services often occur directly on the

24 *Natural Home Magazine,* May/June 2007, Ogden Publications, Inc. Topeka, KS — *http://www.naturalhomemagazine.com/*

Construction waste pile before grinding
Photo taken by Don Stephens, Valley Grinder

construction site where they can be used in the landscape. This saves energy and resources and reduces community impacts and also may be seen as a good marketing advantage as part of an agency's overall green strategy.

Construction waste pile after grinding
Photo taken by Don Stephens, Valley Grinder

Recycling Bins

To take advantage of this type of waste management program, it is important to organize work sites to allow for the storage and sorting of materials in a way that makes them easy to recycle. Storage bins can be made of scrap OSB boards and placed next to the site dumpster for easy use. Once the project is completed, the bins themselves can be ground into mulch. Cardboard, in most places, can be directly taken to recycling facilities.

For remodeling projects, it may be beneficial to create bins for metal recycling (including old appliances) as well as bins for glass and salvage items that can be donated to building reuse centers. ■

4 Green Building Checklist

General Guide to Greening Affordable Housing Projects

The checklist in this section is a quick reference guide that summarizes and compares green building strategies, costs and benefits. It will assist agencies in choosing a green course of action or shade of green for their projects.

Mix and match items to meet the agency's goals, or use the recommendations specific to each green shade for a more generic and straight forward approach. The checklist is a general guide. Follow a specific program or checklist to ensure that the green building strategy is comprehensive. Using an established green building rating system is recommended. Several rating systems are listed in Section Five, Green Building Resources.

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
1. DEVELOPING YOUR GREEN TEAM				
a. Assembling the Team	No green team assembled	In-house green team assembled	In-house, design professional, engineer, contractor/supplier team assembled	In-house, design professional, engineer, contractor/supplier team, stakeholders assembled, plus design process is integrated
b. Using Green Building Checklists	No checklist is used`	Checklist used as a general guide	Checklist is used in conjunction with a certified green building program	Higher points/rating is sought for the project through a certified green building program
2. SITE SELECTION CRITERIA				
a. Location	Very little consideration for proximity to community services	Close to community services	Infill site, close to community services, close to alternative transportation	Infill/reclaimed/Brownfield site, close to community services, close to alternative transportation, bicycle and pedestrian linkages
b. Zoning	Low density single family or multi-family	Medium density single family or multi-family	Medium density mixed semi-compact design	High density mixed and compact design
c. Solar Access	No consideration	Some solar access	Good solar access	Excellent solar access
d. Infrastructure	Cost consideration only	Cost and resource considered	Cost, resource and infill opportunities considered	Cost, resource, infill, and density is considered
3. SITE DESIGN AND LANDSCAPING				
a. Site Protection	No site protection	Protect natural areas of site	Protect natural areas of site, save and re-use all top-soil from site	Protect natural areas of site, save and re-use all top-soil from site, develop landscape and site preservation plan to address above items.
b. Storm and Surface Water	No consideration other than required by law	Channeling storm water to planning areas to reduce irrigation water use	Channeling storm water and Incorporating impervious surfaces	Channeling storm water, Incorporating impervious surfaces, storing for grey-water and irrigation use
c. Water Efficient Landscaping	Default landscape planning using non-native plants	Intentional landscape plan using climate appropriate plants	Intentional landscape plan using climate appropriate plants and low-water use irrigation practices	Intentional landscape plan using xeric native plants, low-water use irrigation practices, soil amendments and bedding mulch, and turf alternatives
d. Reducing Heat Island Effect	No consideration	Using light colored roofs	Using light colored roofs, reducing paving areas, and planting canopy trees	Using light colored roofs, reducing paving areas and using alternative heat deflecting materials, planting canopy trees, preserving native vegetation where possible

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
4. MATERIAL RESOURCE EFFICIENCY: BUILDING ENVELOPE DESIGN				
a. Orientation	No solar orientation	Solar orientation within 45 degrees of due south	Solar orientation within 30 degrees of due south	Solar orientation within 20 degrees of due south
b. Footprint Size	Odd dimensions	Smart Sizing: even dimensions in 2' increments	Smart Sizing with footprint divisible by 32	Smart Sizing with footprint divisible by 32, long axis of building running east and west, two story construction
c. Passive Solar Heating	No consideration for passive solar or window placement	Proper window placement, sizing and shading	Proper window placement, sizing and shading, introduction of low cost mass	Proper window placement, sizing and shading, introduction of higher cost mass, and increased solar glazing area
d. Passive Solar Cooling	No consideration for passive cooling	Strategic placement of vented windows, use of overhangs to reducing unwanted heat gain	Strategic placement of vented windows, use of overhangs, use of ENERGY STAR fans, and use of other architectural shade structures	Strategic placement of vented windows, use of overhangs, use of ENERGY STAR and whole house fans, use of other architectural shade structures and strategic placement of landscaping for shading
e. Day-lighting	No intentional day-lighting strategies	Intentional day-lighting design through proper window placement	Intentional day-lighting design, passive solar design, use of tubular skylights	Intentional day-lighting design, passive solar design, use of tubular skylights, and clearstory windows
f. Space Efficiency	Default space efficiency planning	Intentional space efficiency planning	Intentional space efficiency planning, elimination of hallways	Intentional space efficiency planning, elimination of hallways, designing loft spaces, incorporation of multi-function flex space, and using built-ins
5. MATERIAL RESOURCE EFFICIENCY: FOUNDATION SYSTEMS/CONCRETE				
a. Concrete Forms	Dimensional lumber footer and stem-wall forms	Aluminum forms to eliminate wasteful use of wood	Aluminum forms with non-toxic no VOC biodegradable release agents	Aluminum forms with non-toxic no VOC biodegradable release agents
b. Fly Ash Content Concrete	No fly ash content	Low-content fly ash concrete	Medium-content fly ash concrete	High-content fly ash concrete
c. Alternative Foundation Design	No alternatives considered	Insulated foundation with rigid R-10 foam insulation from footer to top of wall.	Frost protected shallow foundations (FPSF)	Insulating concrete forms (ICF) stem wall, or insulated monolithic slab
d. Damp Proofing, Expansion Joint Filler	Solvent based damp-proofing and expansion joint filler.	Non-solvent based damp-proofing and expansion joint filler	Non-solvent based damp-proofing and expansion joint filler	Non-solvent based damp-proofing and expansion joint filler with recycled content

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
6. MATERIAL RESOURCE EFFICIENCY: FLOOR FRAMING SYSTEMS				
a. Rim Joists	Dimensional lumber	Engineered rim joists	Engineered rim joists	Third party certified sustainably harvested engineered, finger jointed rim joists
b. Air Sealing/Plate	None	Foam gasket under sill plate	Foam gasket under sill plate	Foam gasket under sill plate
c. Beams	Dimensional lumber	LVL engineered beams	LVL engineered beams	Third party certified sustainably harvested engineered beams
d. Floor Joists	Dimensional lumber	Engineered floor joists	Engineered floor joists placed at 2' OC	Third party certified sustainably harvested engineered joists, placed at 2' OC
7. MATERIAL RESOURCE EFFICIENCY: WALL AND ROOF FRAMING				
a. Framing	16" OC 2x4 or 2x6 framing, no insulated headers, multiple studs together causing thermal bridging	24" OC 2x6 OVE framing with insulated headers, point loading, and elimination of multiple studs where possible to minimize thermal bridging	24" OC 2x6 OVE framing with insulated headers, point loading, no structural headers on non-bearing walls, no cripples under windows, 3 stud corners, no multiple studs	24" OC 2x6 finger jointed OVE framing with insulated headers, point loading, no structural headers on non-bearing walls, openings lined up with stud locations, no cripples under window, two stud corners, single top plates, no multiple studs
b. Panelized Wall/Roof System	Standard framing	Open wall OVE framed wall sections made off-site, standard roof framing	Closed wall Structural Insulated Panel (SIP) wall system, standard roof framing	Closed wall Structural Insulated Panel (SIP) wall, floor, and roof systems
c. Roof Framing System	Standard trusses	6" raised heel engineered trusses	8" raised heel engineered trusses	10" raised heel engineered trusses, attic trusses, parallel chord trusses, or scissor trusses for better space efficiency (see 4f)
d. Cool Roofs	Dark color roofing	Light colored roofing	Locally manufactured light colored metal roofing	Green roofs
8. MATERIAL RESOURCE EFFICIENCY: EXTERIOR FINISH MATERIALS				
a. Wall Finishes	Non-recycled content siding and/or stucco	Partial recycled content siding, fiber cement fascia and soffit	Fiber cement siding, fascia, and soffit and corrugated metal mix	Fiber cement siding, fascia and soffit, corrugated metal, natural plaster mix and native stone
b. Porch and Deck	Redwood	Composite decking	Composite decking with minimal recycled content	Composite decking with maximum recycled content

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
9. MATERIAL RESOURCE EFFICIENCY: INTERIOR FINISH MATERIALS				
a. Finish Wall Surfaces	Standard drywall	Formaldehyde free drywall	Combination formaldehyde free drywall, wheat-board, corrugated metal, sheet metal, FSC plywood	Combination wheat-board, corrugated metal, sheet metal, FSC plywood, natural clay plaster and natural fiber wall coverings
b. Cabinets and Storage	Standard cabinets with toxic finishes	Urea-formaldehyde resin free cabinet boxes	Combination of urea-formaldehyde resin free cabinet boxes and open shelving	Combination of wheat board cabinet boxes, sustainably harvested cabinet fronts and open shelving, low VOC finish, recycled content counter-tops
c. Flooring	Standard carpet and vinyl hard surfaces	Standard carpet and ceramic tile hard surfaces	PET carpet and natural linoleum or ceramic tile hard surfaces	Certified natural fiber or no PVC recycled content carpet squares and pad or no carpet in home, natural linoleum, cork, or bamboo hard surfaces
d. Trim Package	Standard composite trim boards with toxic finishes	Standard composite trim boards with non-toxic finishes, radius drywall corners	Urea-formaldehyde free trim boards with non-toxic finishes, radius drywall corners	Sustainably harvested wood trim boards with non-toxic finishes, radius drywall corners, false or reduced baseboards
10. ENERGY EFFICIENCY: INSULATION, AIR SEALING AND DRAINAGE PLANES				
a. Wall Insulation	Fiberglass Batts	Blown fiberglass or cellulose	Cotton batt and loose fill with rigid foam wrap, insulation quality control measures	Open or closed cell spray foam, advanced rim joist insulation, insulation quality control verification
b. Roof/Ceiling Insulation	Fiberglass Batts	Blown fiberglass or cellulose	Blown cotton	Blown cotton or open/closed cell spray foam
c. Air Sealing/Drainage Plane	No drainage plane, no air sealing	Properly installed house wrap, basic air sealing	Properly installed house wrap, air sealing package	Properly installed house wrap, advanced sealing package
d. Windows and Doors	No air/moisture sealing	Properly installed window and door sealing, with shingled flashing	Properly installed window and door sealing, window U values .35 or lower, R-5 exterior doors	Properly installed window and door sealing, window U values .35 or lower, R-5 exterior doors
11. ENERGY EFFICIENCY: SPACE AND WATER HEATING				
a. Space Heating	Standard efficiency forced air furnace or electric resistance heating	High efficiency forced air furnace, electric radiant system, programmable thermostats, duct sealing	On-demand tankless or radiant floor system, programmable thermostats,	On-demand tankless radiant floor heating or ground source geothermal system, sealing of all ducts, programmable thermostats

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
11. ENERGY EFFICIENCY: SPACE AND WATER HEATING (continued)				
b. Water Heating	Standard efficiency tank system	High efficiency tank system with thermal blanket insulation	Side-arm or on-demand tankless system	Solar with high efficiency electric storage tank or tankless backup system, insulate all hot water lines
12. ENERGY EFFICIENCY: APPLIANCES, ELECTRICAL AND PLUMBING				
a. Appliances	Standard appliances	Energy Star dishwashers and fridges	Higher scoring Energy Star dishwashers and fridges with electronic ignition	Appliances that exceed Energy Star ratings with electronic ignition
b. Lighting	Standard lighting with incandescent bulbs, not designed for natural day-lighting or southern orientation	Good day-lighting, standard fixtures with 30 percent of hard-wired fixtures having compact florescent bulbs (CFLs)	Better day-lighting, 60 percent of hard wired fixtures Energy Star rated with CFLs, including ceiling fans, recessed ceiling lights in unconditioned cavities only, simple lighting controls	Advanced day-lighting, including use of clearstory or tubular skylights, all fixtures Energy Star rated with 90 percent CFLs and LED bulbs, no recessed ceiling lights, advanced lighting controls, whole house fan properly insulated
13. ENERGY EFFICIENCY: RENEWABLE ENERGY				
a. Sun-Tempering or Basic Passive Solar Design (see 4c)	No consideration for orientation or passive design	Building orientation within 45 degrees of due south, proper window glazing ratios, overhang protection	Building orientation within 30 degrees of due south, proper window glazing ratios, overhang protection, low cost mass	Building orientation within 20 degrees of due south, proper window glazing ratios, overhang and other shade protection, introduction of solar mass
b. Solar Water Heating	Standard water heating, no orientation of building or roof, no pre plumbing	Proper roof orientation, Installment of framing chase from utility room to attic space for future solar water heating piping and wire	Proper roof orientation, Installment of framing chase, plumbing and wire, for future solar water from utility room through roof	Proper roof orientation, Installment of framing chase, plumbing and wire, from utility room through roof, installation of solar water heating system to fully operational state
c. Solar Photovoltaic	No orientation of building or roof, no pre-wiring	Proper roof orientation, Installment of framing chase from utility room to attic space for future solar PV wiring	Proper roof orientation, Installment of framing chase, PV wiring from utility room through roof	Proper roof orientation, Installment of framing chase, PV wiring from utility room through roof, installation of solar PV system to fully operational state, optional PV attic ventilation fan

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
14. WATER CONSERVATION				
a. Bathroom and Kitchen Faucets	Standard faucets with no aerators	Low flow faucet aerators installed on faucets	Low flow faucet aerators installed on faucets	Low flow faucet aerators installed on faucets
b. Showers	Standard shower head with no aerator	Low flow aerator installed on all shower heads	Low flow aerator installed on all shower heads	Low flow aerator installed on all shower heads with use timers
c. Toilets	1.6 gallons/flush as required by state law	1.6 gallons/flush as required by state law	1.3 gallons/flush high efficiency toilet or dual flush gravity toilets	Dual flush pressure or vacuum assisted toilets
d. Plumbing	Disbursed copper water supply plumbing	Consolidated copper water supply plumbing	Consolidated PEX water supply plumbing	Consolidated PEX water supply plumbing with hot water recirculation pumps installed for showers and kitchen
e. Clothes Washer	Standard clothes washer	Energy Star clothes washer	Higher efficiency Energy Star clothes washer	Clothes washer that exceeds Energy Star rating
f. Landscape (see 3 b, c and d)	No consider-ation for landscape water savings	Landscape plan based on water budget, basic owner education	Landscape plan based on water budget with irrigation controls, basic water catchment, owner education	Landscape plan based on water budget, certified irrigation plan design, advanced irrigation controls, rainwater catchment, grey-water system, owner education
15. HEALTH AND SAFETY: IMPROVED INDOOR AIR QUALITY, SOURCE CONTAMINATION CONTROL				
a. Cleaning Products	Standard toxic cleaning products	Semi-green cleaning products	Green cleaning products	Third party certified green cleaning products
b. Limiting Carpets	Maximum amount of carpet	Minimum amount of carpet	Minimum amount of non-toxic carpet, stomp off zones	No or a minimum amount of certified green carpet and pad, stomp off zones
c. Finish Materials	Standard toxic finish materials	Mixed use of standard and non-toxic finish materials	Higher percentage of non-toxic finish materials, toxic surfaces sealed with low VOC primer	Majority of all finish materials non-toxic and durable, with easy maintenance and low replacement cycles
d. Paints, Stains, Sealers and Adhesives	Standard high VOC finishes	Low VOC paints and stains	Low or no VOC paints, stains and sealers	Low or no VOC paints, stains, sealers, and adhesives

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
16. HEALTH AND SAFETY: IMPROVED INDOOR AIR QUALITY, VENTILATION				
a. Whole House	No whole house ventilation	Whole house fan system	Heat recovery whole house ventilation system	Heat recovery whole house ventilation system
b. Kitchens	No kitchen ventilation	Outside vented range hood ventilation fan	Outside vented range hood ventilation fan	Low sone Energy Star outside vented fan system
c. Bathroom	Standard bath vent fan to meet code	Energy Star ventilation fan	Low sone Energy star ventilation fan	Low sone Energy star ventilation fan
d. Combustion	No outside combustion air unless required by code	Outside combustion air provided for all combustion appliances	Outside combustion air provided for all combustion appliances	Outside combustion air provided for all combustion appliances
e. Garages	Attached garage with no ventilation	Detached garage or isolated garage design	Detached garage or isolated garage design with mechanical ventilation	Detached garage only
f. Radon	No radon testing	Radon testing to determine if mitigation is needed, owner education	Radon testing and approved mitigation measures implemented	Radon testing and approved mitigation measures implemented with post testing and ongoing monitoring conducted
17. RECYCLED AND SALVAGED MATERIALS				
a. Recycled Materials	No recycled materials used	Specify some pre and post consumer recycled materials for finish materials	Specify certain percentage of pre and post consumer recycled materials for both structural and finish	Specify and source a higher percentage of pre and post consumer recycled materials for both structural and finish
b. Salvaged Materials	No salvaged materials used	Specify some salvaged materials for finish	Specify certain percentage of salvaged materials for both structural and finish	Specify and source a higher percentage of salvaged materials for both structural and finish
c. Re-Use Materials	No re-use materials used	Specify some re-use materials for finish	Specify certain percentage of re-use materials for both structural and finish	Specify and source a higher percentage of re-use materials for both structural and finish and provide bins and other storage areas for collection

Green Building Guide Checklist

Reference	Standard Construction	Light Green Construction	Medium Green Construction	Dark Green Construction
18. WASTE MANAGEMENT				
a. Recycling	No recycling program	Establish basic construction waste management plan to recycle cardboard	Establish coordinated construction waste management plan with contractors and provide bins	Establish coordinated construction waste management plan with all contractors and suppliers and provide bins and other storage areas for collection
b. Waste Grinding	No waste grinding services	Work with contractors to establish basic waste hauling and grinding services for scrap wood	Arrange to have wood and drywall waste materials hauled to grinding location for grinding	Establish on-site waste grinding services for all appropriate materials and incorporate ground wood materials in landscape plan
ESTIMATED UP-FRONT COST AND OPERATIONAL AND MATERIAL REPLACEMENT SAVINGS				
a. Up-front Cost Increases	None due to no green measures used	None if integrated design is implemented; cost increases of 1-2 percent are possible otherwise (based on total construction costs)	Green costs in the 3-5 percent range can be expected (based on total construction costs)	Green costs in the 5-10 percent range can be expected (based on total construction costs)
b. Operating Costs Savings	No operation savings	Savings of 10-25 percent are possible due to improved energy efficiency	Savings of 25-50 percent are possible due to significantly improved energy efficiency	Savings of 50-100 percent are possible due to dramatically improved energy efficiency
c. Material Replacement Savings	No savings, cheaper non-green finish materials will need regular replacement	Savings of 10-20 percent are possible over the life of the building due to the superior durability of green building materials	Savings of 20-30 percent are possible over the life of the building due to the increased durability of green building materials	Savings of 30-60 percent are possible over the life of the building due to the increased durability of green building materials
RECOMMENDED GREEN BUILDING PROGRAMS AND RATING SYSTEMS				
a. General Guides	Not Applicable	RCAC Green Guide, American Lung Association Healthy House	RCAC Green Guide	RCAC Green Guide, Green Globes
b. Points/ Rating based Guides	Not Applicable	State Built Green Programs, Green Globes	Enterprise Green Communities, NAHB Model Green Building Guidelines	US. Green Building Council, LEED for Homes

5 Green Building Performance Standards

Performance Testing

To ensure good performance of a green built housing project, implement a testing and performance monitoring program. Actual benchmark measurements, such as air infiltration rates and operating costs, are the only way to really know how the units are performing and how closely the energy efficiency goals are being met. Homeowners, homebuyers and homebuilders can measure energy performance through an energy rating provided by certified energy raters.

Residential Energy Services Network, Inc. (RESNET®)

RESNET is one of the most prevalent and meaningful home rating systems available throughout the United States.

RESNET's mission is:

> "... to ensure the success of the building energy performance certification industry, set the standards of quality and increase the opportunity for ownership of high performance buildings.
>
> RESNET is a membership 501-C-3 nonprofit organization.
>
> RESNET's standards are officially recognized by the U.S. mortgage industry for capitalizing a building's energy performance in the mortgage loan, certification of "White Tags" for private financial investors, and the federal government for verification of building energy performance for such programs as federal tax incentives, the Environmental Protection Agency's ENERGY STAR program and the U.S. Department of Energy's Building America Program.
>
> RESNET ratings provide a relative energy use index called the HERS® Index – a HERS Index of 100 represents the energy use of the "American Standard Building" and an Index of 0 (zero) indicates that the Proposed Building uses no net purchased energy (a Zero Energy Building). A set of rater recommendations for cost-effective improvements that can be achieved by the Rated Building is also produced." [1]

Home Energy Ratings

> "Home energy ratings provide a standard measurement of a home's energy efficiency. Ratings are used for both new and existing homes.

1 Reprinted with permission from RESNET, excerpted online January 23, 2009 at: *http://www.resnet.us/default.htm*

In new homes, ratings often verify energy performance for the ENERGY STAR homes program, energy efficient mortgages, and energy code compliance. Homeowners who want to upgrade the home's energy efficiency can use the energy rating to evaluate and pinpoint specific, cost-effective improvements. For existing homes, homeowners can receive a report listing cost-effective options for improving the home's energy rating. An energy rating allows a homebuyer to easily compare the energy performance of the homes being considered.

There are two types of ratings:

- Projected ratings — Ratings performed prior to the construction of a home or prior to the installation of energy improvements to an existing home.
- Confirmed ratings — Ratings completed using data gathered from an on-site inspection, which could include performance testing of the home.

Confirmed ratings involve an on-site inspection of a home by a residential energy efficiency professional, a home energy rater. Home energy raters are trained and certified by a RESNET accredited home energy rater training provider.

The home energy rater reviews the home to identify its energy characteristics, such as insulation levels, window efficiency, wall-to-window ratios, the heating and cooling system efficiency, the solar orientation of the home, and the water heating system. Performance testing, such as a blower door test for air leakage and duct leakage, is usually part of the rating.

The data gathered by the home energy rater is entered into a RESNET accredited computer program and translated into a rating score. The home receives a score between 1 and 100, depending on its relative efficiency. An estimate of the home's energy costs is also provided in the report. The home's energy rating is then equated to a Star rating ranging from one star for a very inefficient home to five stars for a highly efficient home.

Unlike an energy audit or a weatherization assessment, a home energy rating is a recognized tool in the mortgage industry. Home energy ratings can be used in a variety of ways in the housing industry. The star and the rating score provide an easily understandable means to compare more efficient homes by their relative energy efficiency, since a rating quantifies the energy performance of a home.

Energy Mortgages

An energy mortgage is a mortgage that credits a home's energy efficiency in the home loan. For an energy efficient home, for example, it could mean giving the home buyer the ability to buy a higher quality home because of the lower monthly costs of heating and cooling the home. For homes in which the energy efficiency can be improved, this concept allows the money saved in monthly utility bills to finance energy improvements.

There are two types of energy mortgages:

- Energy Improvement Mortgage — Finances the energy upgrades of an existing home in the mortgage loan using monthly energy savings
- Energy Efficient Mortgage — Uses the energy savings from a new energy efficient home to increase the home buying power of consumers and capitalizes the energy savings in the appraisal"[2]

ENERGY STAR

"To earn the ENERGY STAR, a home must meet strict guidelines for energy efficiency

2 Reprinted with permission from RESNET, excerpted online March 4, 2009 at: *http://www.resnet.us/ratings/overview/default.htm*

set by the U.S. Environmental Protection Agency. These homes are at least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC), and include additional energy-saving features that typically make them 20–30% more efficient than standard homes.

Any home three stories or less can earn the ENERGY STAR label if it has been verified to meet EPA's guidelines for energy efficiency. This includes site-constructed homes, attached or detached homes, single or low-rise multi-family residential buildings, manufactured homes, systems-built (e.g., SIP or modular) and log homes, existing homes, or retrofitted homes.

ENERGY STAR qualified homes achieve energy savings through established, reliable building technologies. Builders work with Home Energy Raters to select from a number of features when planning and building homes.

Effective Insulation

Properly installed, climate-appropriate insulation in floors, walls, and attics ensures even temperatures throughout the house, less energy consumption, and increased comfort.

High-Performance Windows

Energy-efficient windows employ advanced technologies, such as protective coatings and improved frame assemblies, to help keep heat in during winter and out during summer. These windows also block damaging ultraviolet sunlight that can discolor carpets and furnishings.

Tight Construction and Ducts

Sealing holes and cracks in the home's "envelope" and in duct systems helps reduce drafts, moisture, dust, pollen, and noise. A tightly sealed home improves comfort and indoor air quality while reducing utility bills.

Efficient Heating and Cooling Equipment

In addition to using less energy to operate, energy-efficient heating and cooling systems can be quieter, reduce indoor humidity, and improve the overall comfort of the home. Typically, energy-efficient equipment is also more durable and requires less maintenance than standard models.

Lighting and Appliances

ENERGY STAR qualified homes may also be equipped with ENERGY STAR qualified products — lighting fixtures, compact fluorescent bulbs, ventilation fans, and appliances, such as refrigerators, dish washers, and washing machines. These ENERGY STAR qualified products provide additional energy savings to the owner.

Third-Party Verification

With the help of independent Home Energy Raters, ENERGY STAR builder partners choose the most appropriate energy-saving features for their homes. Additionally, raters conduct onsite testing and inspections to verify that the homes qualify as ENERGY STAR."[3] ■

3 Reprinted with permission from ENERGY STAR, excerpted online March 4, 2009 at: *http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_features*

The following steps can help ensure that performance parameters are met:

Measure One:	Conduct a Projected energy rating from a certified Home Energy Rater.
Measure Two:	Conduct a Confirmed energy rating from a certified Home Energy Rater.
Measure Three:	In addition to measures one and two, budget for an infrared testing of units after occupancy to determine thermal leakage.
Measure Four:	Monitor the units for utility cost performance by obtaining utility billing statements with occupant permission.
Measure Five:	Monitor the units for comfort and specific appliance performance by installing simple data loggers.
Measure Six:	Address any deficiencies identified in the above measures.

Operations, Maintenance and Tenant Education

Once the units have been tested and certified to perform at the standards adopted at the outset of the project, it is time to focus on operations and maintenance. If the project is an ownership product, then this step will fall on the owners and the education program they develop (see below). If the units are rentals, management needs to be certain that ongoing operations are reasonably maintained to meet the newly documented energy performance parameters. ■

The following steps can help ensure management performance parameters are met:

Measure One:	Develop and implement a post occupancy tenant education program focused on energy efficiency.
Measure Two:	If possible, install separate meters for each unit so use habits are reinforced by direct feedback, such as utility costs.
Measure Three:	Train all maintenance personnel on the specific heating and cooling equipment installed in order to maintain optimal performance.
Measure Four:	Develop effective budgeting processes to ensure adequate capital improvement and maintenance/replacement reserves.
Measure Five:	Follow a replacement/maintenance schedule. Don't be tempted to cut corners which may save in the short run but will cost more in the long run.
Measure Six:	Consider offering ongoing tenant education and incentives as part of an energy efficiency training and awareness program (some states offer this training).

Homeowner Education

If the project is homeowner based, the builder will need to develop an owner education program that is implemented largely before the homes are completed and occupied. While there may be some post-occupancy monitoring as outlined on the previous page, new owners should receive adequate operation training, especially if the homes include any renewable energy systems such as passive solar design. ■

The following steps can help ensure ownership performance parameters are met:

Measure One:	Start educating owners early during the recruitment phase of the project. Let them know you are building green houses and what that will mean for them.
Measure Two:	Schedule at least one energy and operations training prior to the home being occupied. Make this a requirement of the buyer process, but make it fun and useful as well.
Measure Three:	Obtain permission before occupancy to conduct post occupancy testing as outlined above.
Measure Four:	Consider offering buyer incentives for homeowners willing to participate in additional trainings beyond the minimum threshold.
Measure Five:	Develop an ongoing post occupancy energy efficiency campaign via direct mailing and e-mailing to occupants.
Measure Six:	Conduct follow-up interviews with occupants at regular intervals to access overall performance and energy satisfaction. Use this anecdotal data to guide future project decisions.

6 Green Building Resources

Energy Efficiency

The U.S. Department of Energy through the Office of Energy Efficiency and Renewable Energy's Building Technologies Program offers information on energy-efficient building practices. The program provides tools, guidelines, training and access to technical and financial resources.

For more information: *http://www1.eere.energy.gov/buildings/*

The Energy and Environmental Building Association provides education and resources to assist builders and designers deliver energy efficient and environmentally responsible buildings and communities.

For more information: *http://www.eeba.org/*

The National Fenestration Rating Council rates and labels the energy performance of products such as windows, doors and skylights. By using the information contained on the label, builders and consumers can reliably compare one product with another to make informed decisions. The label lists the manufacturer, describes the product, provides a source for additional information, and includes ratings for one or more energy performance characteristics.

For more information: *http://www.nfrc.org/default.aspx*

Residential Energy Services Network (RESNET®) set the standards for quality energy efficiency rating services for new and existing homes.

RESNET's standards are officially recognized by the U.S. mortgage industry for capitalizing a building's energy performance in the mortgage loan, certification of "White Tags" for private financial investors, and by the federal government for verification of building energy performance for such programs as federal tax incentives, the U.S. Environmental Protection Agency's ENERGY STAR program and the U.S. Department of Energy's Building America Program.

For more information: *http://www.resnet.us/*

ENERGY STAR offers affordable housing stakeholders proven, turn-key solutions to cost-effectively increase energy efficiency for low-income households. Housing finance agencies, state and local governments, public housing authorities, asset management companies, architects, builders, developers and building owners can incorporate ENERGY STAR measures into new and existing housing to provide long-term value. These solutions may be product-specific or systems-based and include:

Appliances, heating and cooling equipment, home envelope and lighting

For more information: *http://www.energystar.gov/index.cfm?fuseaction=find_a_product*

Construction guidelines for new homes

For more information: *http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.homes_guidelns*

Whole house improvements including home performance with ENERGY STAR

For more information:

http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_index
http://www.energystar.gov/
http://www.e-star.com/homeowners/hers.html

U.S. Department of Energy, Energy Efficiency and Renewable Energy Consumers Guide

For more information: *http://apps1.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12820*

Building Systems

Toolbase Services is the housing industry's resource for technical information on building products, materials, new technologies, business management and housing systems.

For more information: *http://www.toolbase.org/index.aspx*

The National Association of Home Builders' (NAHB) Research Center certifies products to nationally recognized standards. The NAHB certification label assures builders, code officials and consumers that products meet or exceed appropriate industry standards.

For more information: *http://www.nahbrc.org/*

The NAHB Research Center provides services, with funding from the U.S. Department of Housing and Urban Development, in cooperation with The Partnership for Advancing Technology in Housing and other industry sponsors.

For more information:

http://www.hud.gov/
http://www.pathnet.org/

Foundation Systems

Dirtcheapbuilder.com is a resource for how to build a monolithic slab foundation

For more information: *http://www.dirtcheapbuilder.com/dvbumocosl.html*

Toolbase Services provides a builder's guide to frost protected shallow foundations.

For more information: *http://www.toolbase.org/PDF/DesignGuides/revisedFPSFguide.pdf*

Insulating Concrete Form Association (ICFA)

For more information: *http://www.forms.org/*

American Coal Ash Association (ACAA)

For more information: *http://www.acaa-usa.org/*

Wall Systems

A calculator at the following Oak Ridge National Laboratory website will allow you to compute the R-values of a variety of wall systems.

For more information: *http://www.ornl.gov/sci/roofs+walls/AWT/InteractiveCalculators/NS/Calc.htm*

There is a SIP manufacturers association, Structural Insulated Panel Association (SIPA). SIPA lists member manufacturers and offers convenient access to SIP company websites. The association has quality standards for member manufacturers and buyers should require their supplier to be a SIPA member.

For more information: *http://www.sips.org/*

Note: *HUD's Partnership for Advancing Technology in Housing has recently partnered with SIPA and the NAHB Research Center to develop a prescriptive method for design and code acceptance.*

Windows

Efficient Windows Collaborative (EWC) members have made a commitment to manufacture and promote energy-efficient windows. This site provides unbiased information on the benefits of energy-efficient windows, descriptions of how they work, and recommendations for their selection and use.

For more information: *http://www.efficientwindows.org/index.cfm*

The National Fenestration Rating Council rates and labels the energy performance of products, such as windows, doors and skylights. By using the information contained on the label, builders and consumers can reliably compare one product with another to make informed decisions. The label lists the manufacturer, describes the product, provides a source for additional information, and includes ratings for one or more energy performance characteristics.

For more information: *http://www.nfrc.org/default.aspx*

Composite Decking Materials

Composite decking materials are required to have a valid Evaluation Service (ES) Report to be considered approved for use by many local building departments. The following lists cross reference composite decking to their ES Reports and are frequently updated to provide the most up-to-date status for each material. It is a good idea to read the ES Report before installing the product.

For more information: *http://www.decks.com/article330.aspx*

Green Building Material Sourcing

Real Goods

Real Goods is a comprehensive source for green building and living products, including renewable energy systems. One of the nation's oldest sustainable living stores and 12 acre solar learning center with a large inventory of products.

For more information: *http://www.realgoods.com/*

The Green Building Center, SLC, Utah

For more information: *http://www.greenbuildingcenter.net/*

GreenSpec®

The online GreenSpec Directory lists product descriptions for more than 2,000 environmentally preferable products. To choose these products GreenSpec's editors conduct their own research based on the organization's current editorial focus. Thus, not all product suggestions they receive are selected for review. This independent research ensures that product descriptions contain unbiased, quality information. Unlike many other directories, GreenSpec does not charge for listings or sell ads.

For more information: *http://www.buildinggreen.com/menus/index.cfm*

Green Cabinet and Furniture Products

A link to manufacturers of green cabinet and furniture products provided by GreenHomeGuide.com, which provides resources about greening your home. Users can find resources and post questions to their network of green architects, designers, contractors and consultants.

For more information: *http://www.greenhomeguide.com/index.php/product/C126/P10/*

Building For Health

Building for Health is a supplier for healthy, environmentally sound building materials, appliances and home comforts to meet your building needs. They provide "one-stop shopping" for more than 2,000 building materials and home comforts to improve indoor air quality with minimal environmental impact. Building For Health Materials Center offers contractor, quantity and package discounts.

For more information: *http://www.buildingforhealth.com/*

General Green Building Resources

Think Green, Act Green: NeighborWorks America's Healthy, Sustainable Communities Agenda was launched Feb. 27, 2008 with a $750,000 grant from The Home Depot Foundation. This agenda focuses on further advancing environmental responsibility across the community development industry and bringing more "green" benefits to low- and moderate-income families. NeighborWorks America will use its prominent role as an educator and facilitator of community development to act on this agenda.

For more information: *http://www.nw.org/network/aboutUs/green/default.asp*

BuildingGreen.com

BuildingGreen.com is an independent company committed to providing accurate, unbiased and timely information designed to help building-industry professionals and policy makers improve the environmental performance and reduce the adverse impacts of buildings. They offer both print and electronic resources to help you design and build construction projects from a whole-systems perspective and take an integrated design approach that minimizes ecological impact and maximizes economic performance.

For more information: *http://www.buildinggreen.com/*

What's Working

What's Working is an agency that provides solutions to assist agencies incorporate sustainability to their green building projects. For more than a decade, the agency has helped its clients turn a vision into reality.

For more information: *http://www.whatsworking.com/about_us.html*

The National Center for Healthy Housing

The National Center for Healthy Housing (formerly the National Center for Lead-Safe Housing) was

founded as a nonprofit organization in October 1992, to bring the public health, housing and environmental communities together to combat our nation's epidemic of childhood lead poisoning. The National Center for Healthy Housing continues its important role in reducing children's risk of lead poisoning and has expanded its mission to help to decrease children's exposure to other hazards in the home including biological, physical and chemical contaminants.

For more information: *http://www.centerforhealthyhousing.org/*

Arhitecture 2030

Architecture 2030, a nonprofit, non-partisan and independent organization, was established in response to the global-warming crisis by architect Edward Mazria in 2002. 2030's mission is to rapidly transform the United States and global building sector from the major contributor of greenhouse gas emissions to a central part of the solution to the global-warming crisis. Its goal is straightforward: to achieve a dramatic reduction in the global-warming-causing greenhouse gas (GHG) emissions of the building sector by changing the way buildings and developments are planned, designed and constructed.

For more information: *http://www.architecture2030.org/home.html*

Recycling and Reuse

Recycling

Building Savings: Strategies for Waste Reduction of Construction and Demolition Debris from Buildings. Published by the EPA; details projects that recovered 42 to 82 percent of their waste.

For more information: *http://www.GETF.org/file/toolmanger/016F8895.pdf*

Alameda County Waste Management Authority website – Search the "Recycling+Purchasing Wizard" by ZIP code to find area locations to recycle construction waste and buy used building materials.

For more information: *http://www.StopWaste.org*

List of recycling options organized by zip codes.

For more information: *http://www.Earth911.org*

1-800-Got-Junk; 500 Habitat Reuse stores in the United States

For more information: *http://www.1800GotJunk.com*

Reuse and Disposal

Free listings of items to be given away.

For more information:

http://www.CraigsList.com
http://www.Freecycle.org

Habitat Restores

For more information: *www.Habitat.org/env/restores.aspx*

Building Materials Reuse Association

For more information: *http://www.UBMA.org*

Recycling, reuse and hazardous waste disposal

For more information: *http://www.Earth911.org*

Hazardous waste handling and disposal of asbestos and vermiculite (insulation material often containing asbestos)

For more information: *http://www.EPA.gov/asbestos*

Disposal of appliances containing refrigerants

For more information: *http://www.epa.gov/Ozone/title6/608/608fact.html*

Lead and lead-based paint

For more information: *http://www.EPA.gov/region02/health/leadpoisoning.htm*

Renewable Energy

The National Renewable Energy Laboratory (NREL) is the nation's primary laboratory for renewable energy and energy efficiency research and development.

NREL focuses on advancing the U.S. Department of Energy's and our nation's energy goals. The laboratory's scientists and researchers support critical market objectives to accelerate research from scientific innovations to market viable, alternative energy solutions. At the core of this strategic direction are NREL's research and technology development areas.

For more information: *http://www.nrel.gov/science_technology/*

These areas span from understanding renewable energy resources, to the conversion of these resources to renewable electricity and fuels and, ultimately, to using renewable electricity and fuels in homes, commercial buildings and vehicles. The laboratory thereby directly contributes to our nation's goal of finding new renewable ways to power our homes, businesses and cars.

For more information: *http://www.nrel.gov/*

Database of State Incentives for Renewables & Efficiency (DSIRE) established in 1995, is an ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council (IREC) funded by the U.S. Department of Energy. The online database contains a complete listing of renewable energy incentives, organized by state.

For more information: *http://www.dsireusa.org/index.cfm?EE=1&RE=1*

Sustainable by Design is the consulting firm of Chrisopher Gronbeck in Seattle, Washingon. They provide solar engineering, green building consulting, graphic design and website design and programming services, primarily within the sustainable energy and architecture fields.

For more information: *http://www.susdesign.com/*

National Green Building Rating Systems and Programs

Enterprise™ Green Communities®

Green Communities is a five-year, $555 million commitment by Enterprise to build more than 8,500 healthy, efficient homes for low-income people and make environmentally sustainable development the mainstream in the affordable housing industry.

Green Communities provides funds and expertise to enable developers to build and rehabilitate homes that are healthier, more energy efficient and better for the environment — without compromising affordability. Green Communities also assists state and local governments to ensure their housing and economic development policies are smart and sustainable.

Green Communities' homes are built according to the Green Communities Criteria, the first national framework for healthy, efficient, environmentally smart affordable homes.

For more information: *http://www.greencommunitiesonline.org/*

2008 Green Communities Criteria: *http://www.practitionerresources.org/cache/documents/666/66641.pdf*

2008 Green Communities Criteria Checklist: *http://www.greencommunitiesonline.org/tools/criteria/green_criteria_checklist.pdf*

U.S. Green Building Council (USGBC) LEED for Homes

Leadership in Energy and Environmental Design (LEED®) for homes is a rating system that promotes the design and construction of high-performance green homes. A green home uses less energy, water and natural resources; creates less waste, and is healthier and more comfortable for the occupants. Benefits of a LEED home include lower energy and water bills; reduced greenhouse gas emissions; and less exposure to mold, mildew and other indoor toxins. The net cost of owning a LEED home is comparable to that of owning a conventional home.

For more information: *http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147*

LEED® for Homes Rating System guide and checklist: *http://www.usgbc.org/ShowFile.aspx?DocumentID=3638*

National Association of Home Builders (NAHB) Model Green Building Guidelines

NAHB's voluntary *Model Green Home Building Guidelines* are designed to be a tool kit for builders that want to engage in green building practices and home builder associations considering local green building programs. Since their debut in 2005, the guidelines have helped move environmentally friendly home building concepts further into the mainstream marketplace.

For more information: *http://www.nahb.org/publication_details.aspx?publicationID=1994&sectionID=155*

Green Globes Rating System

The Green Globes rating system is a building environmental design and management tool. It delivers an online assessment protocol, rating system and guidance for green building design, operation and management. It is interactive, flexible and affordable, and provides market recognition of a building's environmental attributes through third-part verification.

For more information: *http://www.greenglobes.com/*

American Lung Association Health House

A Health House® home gives the residents the satisfaction of knowing that their new home has a healthy, safe, durable and energy efficient environment. Health House homes are built to the most stringent building standards in the United States, which include site inspections during construction and performance testing upon completion. Health House homes cost 3 to 5 percent more than traditional construction techniques. However, building to the Health House guidelines can actually save money through a reduction in utility bills, ranging from 30 to 40 percent. Health House homes can actually increase the residents' monthly cash flow. Because these homes are built to such strict standards, the home qualifies for energy efficient mortgage programs, which can increase the buyer's purchasing power.

For more information: *http://www.healthhouse.org/consumer/build.cfm*

State Green Building Rating Systems

Many states have their own rating systems. Check within your state to see if a rating system is available. Below is a limited sample of some states with their own rating systems.

Built Green Colorado

Introduced in 1995, Built Green Colorado is one of oldest and largest green home building programs in the nation. A voluntary industry-driven program of the Home Builders Association of Metro Denver offered to builders across the state, the purpose of Built Green Colorado is to encourage home builders to use technologies, products and practices that result in homes that are better built and better for the environment.

For more information: *http://www.builtgreen.org/*

Evergreen Sustainability Development Standard (ESDS), Washington State

The Evergreen Sustainable Development criteria promote public health, energy conservation, operational savings and sustainable building practices in affordable housing design. The strategies ESDS follows enhance affordable housing and communities as a whole.

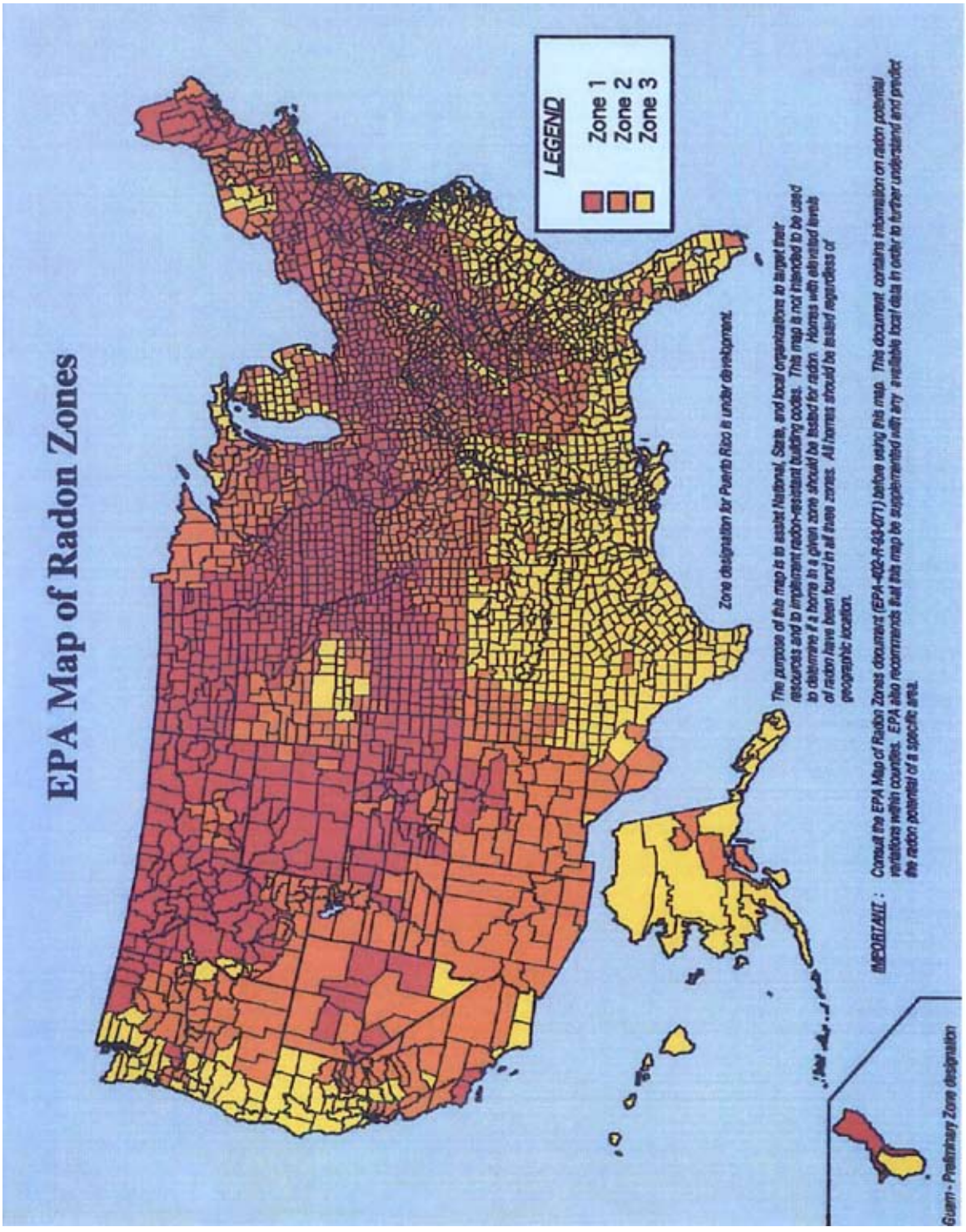
For more information: *http://cted.wa.gov/site/1027/default.aspx*

7 Green Building Appendices

Appendix A — RCAC Quick Guide to Going Green

RCAC Quick Guide to Going Green			
What	**How**		**Tips**
The Basics	1. Set your agency's goals and priorities 2. Assemble your multi-disciplinary green team: architect engineer, builder, subcontractors, lenders, agency and stake-holders 3. Green Building is a collaborative process that may take more time than existing models of development at least the first time around 4. Conduct a design charrette and involve the community 5. Commit to performance targets and measurements for all buildings 6. Many green building measures do not add to construction costs		Start early, begin with no/low cost measures first, integrate the design process, and start small: practice "going" green, before becoming green
6 Areas of Eco-Impact	1. Energy Reduction 2. Resource Depletion 3. Landfill Reduction 4. Habitat Loss 5. Air Pollution 6. Water Conservation		Going green also makes economic sense!
6 Key Components of Your Buildings	1. The Site: Solar access, human amenities, proximity to services 2. Orientation: Long axis east/west, solar gain/shading/passive cooling 3. Building Envelope: Alternative wall system, insulation, air sealing, window placement: S 6-12%, E 4%, W and N, 3% glazing/floor area ratios 4. Energy Systems: Efficient space and water heating, appliances and lighting 5. Green Materials: Durability, low VOC, natural content 6. Operations: Owner's manual, routine maintenance and education		Start with the site and follow the normal building process, greening from the bottom up.
Selected Menu of Practical Green Materials/Equipment	SITE AND FOUNDATION a. Stem-wall/slab insulation b. Insulating concrete forms (ICF's) c. Fly ash content concrete d. Xeric landscape e. Low water irrigation system BUILDING ENVELOPE a. Engineered Lumber b. Cotton, foam, cellulose Insulation c. Low-E Solar Windows d. Green, no formaldehyde OSB e. House Wrap/Drainage Plane	SYSTEMS/EQUIPMENT a. On Demand Space Heating b. In-Floor Space Heating c. On-Demand H2O d. Solar H2O e. Heat Recovery Ventilation EXTERIOR/INTERIOR FINISH a. Cement Siding b. Locally Made Metal Roofing c. Corrugated/sheet metal d. Low/No VOC Paint, Stains e. No.2 Pine Trim f. Linoleum/cork/bamboo floors	Applying green materials to a non green site and envelope isn't green building. Get the basics right and the materials can take you to the next level.
Selected Internet Resources	ENERGY/CONSERVATION US EPA ENERGY STAR: Home rating system and appliances/equipment — *http://www.energystar.gov/* National Renewable Energy Lab NREL: Research center — *http://www.nrel.gov/* DOE Energy Efficiency and Renewable Energy — *http://www.eere.energv.gov/* Renewable Energy Incentives: State by state energy incentives — *http://www.dsireusa.org* HUD, Energy Action: Energy Training Programs — *http://www.hudenerpyfraining.com/index.html* National Association of Homebuilders Research Center — *http://www.nahbrc.com* Rocky Mountain Institute: A major energy resource center — *http://www.mii.org* GREEN BUILDING US Green Building Council: The industry leader — *http://www.usgbc.orq* Green Builder: On-line resource center — *http://www.greenbuilder.com/* Overhang Design: Animated design tools — *http://www.susdesign.com/overhanq/index.php* AFFORDABLE HOUSING/GREEN BUILDING Enterprise Green Communities: Funding and support — *http://www.preencommunitiesonline.orq/* Rural Community Assistance Corporation RCAC: Green Team Services/Lending — *http://www.rcac.org* HAC Green Building/Healthy Home Initiatives — *http://www.ruralhome.org*		

Appendix B — U.S. Radon Zones



For more information on how to use this map, go to: *http://www.epa.gov/radon/zonemap.html*

Appendix C — RCAC GREEN SERVICES

Rural Community Assistance Corporation (RCAC) is a proud partner in the growing national community greening and sustainability movement. As a leader in rural development in the West, RCAC's green initiative services help communities realize a future where healthy neighborhoods, a sustainable economy and responsible environmental stewardship can co-exist.

Green (or sustainable) practices promote building construction, infrastructure and community planning that is healthier for residents and the environment. These practices include using renewable energy, energy efficiency, water conservation, environmentally sensitive site planning, efficient building materials and attention to indoor environmental quality.

Going green strengthens and improves the quality and health of rural communities, enhances the bottom line of building projects, creates healthier living environments, conserves precious resources, lessens energy dependence and reduces the impact of national building trends.

RCAC green services provides rural communities access to viable and proven options and solutions to address common problems. RCAC also offers rural communities a variety of core services that promote green building, green lending, community sustainability, local based economic development, rural leadership, energy conservation, renewable energy, innovations in water/wastewater management, integrated neighborhood design and green meeting planning.

The following services are offered by RCAC:

Green Housing Development

Site Design, Green Building, Green Materials Purchase Program and Energy Efficient Performance Review

Services include sketch-plan through preliminary site-plan development, solar orientation/analysis, and advanced planning principles application (new-urbanism, clustering and smart growth), which all contain green site design elements. RCAC offers architectural design, passive and active solar specifications, material specifications, building system specifications, cost estimates and health/performance evaluations. RCAC also provides referrals to green building manufacturers and suppliers.

Community Sustainability

Sustainability Planning, Renewable Energy Development and Green Charrettes Facilitation

Services include assisting communities with planning and development strategies designed to conserve natural resources and preserve local capital while limiting the environmental and social costs normally associated with growth.

Green Infrastructure Development

Drinking Water, Wastewater, Storm Water and Solid Waste Systems

New, expanded or rehabilitated drinking water, wastewater, storm water or solid waste systems also could consider going green. These systems may consume considerable amounts of energy. In addition, wastewater, storm water and solid waste often have hidden resource value. RCAC

can assist communities evaluate energy, efficiency and resource conservation options. A green infrastructure approach takes advantage of reuse and recycling (for wastewater and solid waste), which reduces costs and minimizes the use of natural resources.

Green Lending

Green Points Lending

In partnership with Wells Fargo Bank, RCAC is a CDFI green lender that provides green community development financing. RCAC staff provide assistance with the process of greening a project to ensure that it meets the criteria to qualify for a green housing, infrastructure or community facility loan.

Visit RCAC's website at *www.rcac.org* to contact a local RCAC field office for additional information, or contact Craig Nielson at 719/207-0035, cnielson@rcac.org; Ellen Drew at 505/421-0261, edrew@rcac.org or Connie Baker Wolfe at 303/455-7882, cbakerwo@rcac.org.

Creating the future just got a lot Greener!

RCAC

Creating opportunities in rural America

www.rcac.org