Green 200: The Science of Green Building

Student Manual

NATIONAL ASSOCIATION of REALTORS®

REALTOR®

Official Designation

green

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Acknowledgments

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Green 200: The Science of Green Building

Course Learning Goal

Green 200: The Science of Green Building is one of three required courses comprising the curriculum of the Green **RE**source Council's green Designation—the only designation of its kind recognized by the NATIONAL ASSOCIATION OF REALTORS®.

The goals of this course are to:

- Familiarize students with green principles and choices in home design and construction
- Raise awareness of innovative materials, systems, and construction methods
- Learn about energy-efficient systems including onsite power generation
- Distinguish levels and cost benefits of retrofitting, remodeling, or renovating existing homes

Learning Objectives

200.1 Green Home Design

- Describe considerations in site and design selections
- Follow the sequence of steps in green home design and the selection of materials and systems
- Suggest methods and find sources for managing construction waste

200.2 Green Home Construction—The Building Envelope

- Identify the components of the building envelope
- Learn about innovative building technologies and materials

200.3 Green Home Construction—Systems

- Recognize types of green systems for homes
- Communicate the pros and cons and interrelationships of interior systems

- Guide consumers to information about incentives for greening existing homes

200.4 Power Off the Grid

- Communicate the pros and cons of generating your own energy
- Discuss the technologies and methods for on-site power generation including wind and solar power

200.5 Greening Existing Homes

- Explain the benefits of retrofits for existing homes
- Evaluate cost-benefit balance of retrofitting, remodeling, renovating

Completion Exam

At the conclusion of the course, students will take a 30-question multiple-choice exam to demonstrate achievement of learning objectives. Passing grade is 80% (minimum of 24 correct answers).

Resources

The manual's Resources section (page 126) offers information on learning enrichment sources.

Can You Identify These Green Building Features?

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

H. _____

I. _____

Green 200.1: Green Home Design

If you were to pass a construction site for a green home or building, it probably would look like any other construction site—at first. If you talked with the architect, builder, or subcontractors you would learn that the construction activities are carefully planned and implemented so that the design, systems, and materials, as well as construction methods, are sustainable and the home attains the intended green goals.

New construction presents the best opportunity to incorporate green features and systems because they can be designed and integrated into the home as it is built. How does a design and building team go about the process of creating a green home? How do they choose materials and systems and use the site to maximum advantage? And, how can the real estate professional be part of the process?

This chapter looks at how design, construction, and building systems professionals make choices and work together to create the next generation of green homes.

3 Reasons for Going Green

- Health and indoor air quality concerns are major motivators for designing homes with green features. As we will see later in the course, retrofitting and remodeling efforts in existing homes often target indoor air quality improvements.
- Energy efficiency is probably the number one motivator for home greening efforts. Escalating energy prices are accelerating the push to future-proof homes by enhancing both energy efficiency and self-sufficiency.
- Environmental concerns also motivate green choices particularly for the next generation of homeowners—the millennial generation—as we learned in *Green 100: Real Estate for a Sustainable Future*. As we also learned in the preceding course, consumers are willing to reward or penalize a company based on its green actions and priorities.

Green Design, Green Choices

The best opportunities for incorporating green strategies and systems into home construction happen in the design phases. Best-practice green home design happens in four phases:

❶ Site selection	❷ Home design	❸ Materials selection	❹ Interior systems and design
			

Site Selection

Traditional home construction starts by designing the house and dropping it into the site. What distinguishes green home design? The green building process starts with a thoughtful assessment of the site—challenges and opportunities. The goal is to create a structure that integrates into the environment and takes advantage of aspects such as sunlight and breezes. Best-practice green building involves an all-season observation of the site to study the following elements.

- **Location—transportation and walkability**
  The location and site must meet personal needs and priorities, such as proximity to work, shopping, services, and schools. As we learned in *Green 100: Real Estate for a Sustainable Future*, access to public transportation and walkability enhance quality of life as well as value.

- **Greenfield, greyfield, or brownfield?**
  The previous use of the site impacts its future use. Some communities offer incentives for infill development or redevelopment of greyfield sites, sites of former commercial structures, which already have utility infrastructure in place. Brownfield sites may involve environmental

cleanups like soil remediation. A greenfield site, land that has never been used before, doesn't have to deal with the issues of demolition of a previous building or remediation measures, but may not be the best choice in terms of sustainability.

- **Sunlight patterns**
  Orientation to sunlight is an important factor for taking advantage of solar technology: generating electricity, passive lighting, solar heating, and solar water heating. Green home design entails a thorough analysis of light patterns in order to take advantage of the positive aspects while avoiding the negative like excess solar heat gain. In North America, a home oriented with a long axis facing south will capture maximum sunlight for illumination, heating, and energy generation. In hot climates, orientation on the site must balance need for sunlight with excess heat generation. As we will see later in the course, building technologies and designs can help achieve the balance.

- **Prevailing winds**
  Wind patterns indicate how the home should be situated and windows placed to take advantage of cross breezes for natural ventilation during temperate seasons. In cold climates, the north- and west-facing sides of the home usually require more insulation. If the homeowner plans to use wind power to generate electricity, wind patterns and velocity are a key factor.

- **Storm water runoff and snow accumulation patterns**
  Orientation should take advantage of natural drainage—for both rain and snowmelt—away from the home. Drainage can be aided through use of previous pavement and limiting the amount of asphalt and concrete paving. Rain gardens and bioswales with deep-root plants encourage the natural seepage that replenishes groundwater. Where local regulations allow, catchment systems can collect and store rainwater for watering lawns and gardens and flushing toilets.

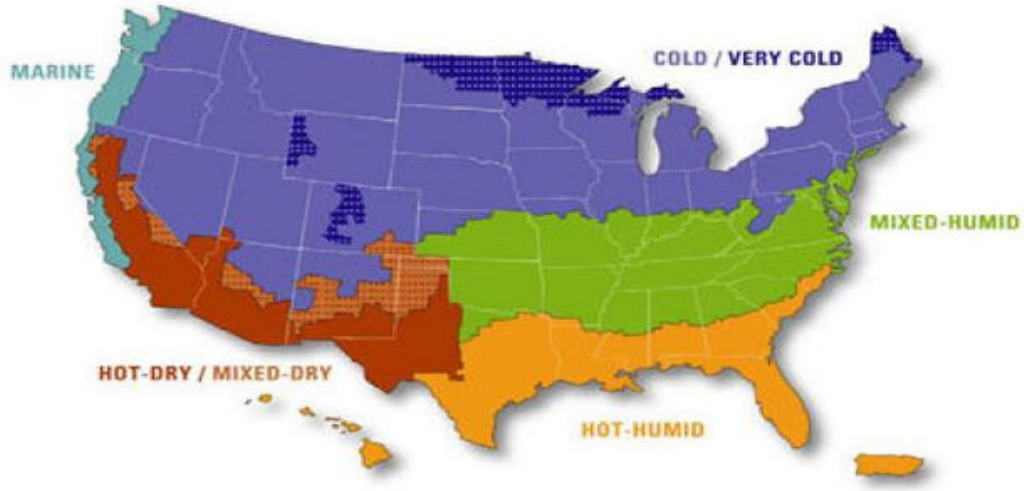
- **Natural features such as hills and trees**
  Orientation of the home on its site should take advantage of the scenic views that inspire, relax, and enrich the connection to nature. It should also block out unpleasant views and preserve privacy. Blending with the natural landscape and topography reinforces the connection to nature. It can also offer natural shade for summer cooling or a wind break for winter winds.

- **Ecosystems, wildlife habitats and corridors, wetlands**
  The best green home design protects plant and wildlife habitats and ecosystems; it seeks to be part of the balance of nature instead of imposing on it. Preservation of the natural environment includes choosing native plant species for landscaping, limiting fertilizers and pesticides, and working with the weather conditions, such as xeriscaping in hot, dry climates.

- **Climate and microclimates**
  Climate is a major determinant for decisions about design, materials, construction methods, and systems. The United States has five major climate zones: cold/very cold, mixed humid, hot humid, hot/mixed dry, and marine. In general, architects design homes according to these climate zones, but green home design also takes in consideration the microclimate, for example breezes, surrounding hills, or lakes and rivers. As might be expected, climate greatly influences choices like orientation on the site, design of the building envelope, and selection of HVAC systems.

5 major climate zones of the United States.

1. Cold/Very Cold, 2. Mixed Humid, 3. Hot Humid, 4. Hot Dry/Mixed Dry, 5. Marine



The Green Team

A successful design process includes everyone involved in the planning, design, construction, operation, and maintenance of the home including the homeowner. It works best when all team members understand the issues and concerns of all the other stakeholders, as well as the interconnectivity of systems, and collaborate throughout all phases of the project.

Green construction relies on careful administration of the project and job site management to achieve sustainability goals. This administration begins before the integrated design team comes together, as the owner identifies priorities, continues through the construction and installation of building systems, and persists into the ongoing maintenance of the home or building. Homeowners must take responsibility to learn how the home and its systems function and how to maintain the built-in sustainability features.

Can Real Estate Professionals Participate?

The real estate professional who is tuned into green may have an opportunity to participate in choosing a site, developing new homes, or offering real-time market knowledge and experience for architects and builders—what consumers want, value, and are willing to pay a premium for. Real estate professionals can guide clients and customers to reliable information on green design, construction, operations, and maintenance and refer clients and customers to experts when making design decisions. Becoming familiar with the differences between conventional and green construction will help you interact with other professionals—architects, contractors, designers, landscapers, and inspectors—in your network to better serve your clients and customers. Green real estate professionals can also help home shoppers appreciate the design elements, enhancements to property value, and support for green living.

Practitioner Perspective: Green Is the New Reality

"Trends are coming this way. Green will become the norm."

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I see green as the new reality even though many consumers are suffering green fatigue and view it as a fad. But to such skeptics and real estate practitioners who care little about the broad issues of sustainability, I would say "look West." In California limited resources have prompted greater action on green issues and code changes have made green building the norm. It's far more regulated than what we've experienced here in the Midwest. Those trends, however, are coming this way. Whether you're on the front end or you wait until it happens is for you to decide. It's a slow drip message that's starting to take hold now.

Green Collaborating and Consulting

I serve as both a consultant and referral source, depending on the audience. For buyers, for instance, I'm often tapped for advice and referrals from those interested in replacing water heaters, improving insulation, and upgrading HVAC systems. And eco-charettes bring together various project stakeholders and professionals, such as developers, architects, general contractors, real estate practitioners, and other building team members, so they can offer their expertise and advice early in a new construction project. Real estate practitioners weren't always part of that team but more developers are interested in agents' feedback. After all, we have our finger on the pulse of what prospective buyers want. That input early in the design and construction processes can help position a building to appeal to potential buyers.

Getting in the Door with Green Building Pros

It can be a long, slow slog, but networking with like-minded professionals often works best. I'm involved in an array of groups including the Chicago Sustainable Business Alliance and the Illinois Chapter of the USGBC. Getting known and building relationships and respect have always entailed showing up at and participating in industry events and networking. It's no different in this arena.

Differentiating a Green Real Estate Business

I don't take an aggressive or high-tech route to get the word out about my green expertise. About 98 percent of my business comes from referrals. I keep my sphere of influence abreast of new developments by using old-school methods. That means regular calls, e-mails, and chats with past clients and sharing lunch or tea with them.

Home Design

After working through the choices and issues involved in site selection, the next step in the design process is developing the plans for the home. Homeowners should certainly have the option to build as large or small a home as the site, zoning, and building codes allow. But with green building, the watchwords are functional and compact.

Small but functional homes cost less to build and maintain, use less material to construct, and feel cozy and sheltering. Overly large homes contribute to sprawl, require more materials, and consume more energy even if they are energy-efficient. What is the right size? Some designers recommend making a detailed list of all of the activities the family will do inside, from everyday activities to hobbies. Is there a need for an artist's studio, home office, pantry space, exercise room, children's play area, guest accommodations, entertainment space, storage for bikes, electric vehicle charging? Comparing the list with the home design will show if the planned spaces can accommodate every need and activity.

Green Home Design Checklist

Layout and size	Design a functional, compact layout that is convenient, big enough to meet occupants' needs but not overly large, and adaptable for future uses.
Minimize solar heat gain	Design deep overhangs to protect siding, shade exterior walls from excess heat, and prevent overheating of interior spaces.
Maximize natural lighting	Capture natural lighting and desired solar heat gain with south-facing windows and skylights. Install smaller north-facing windows to reduce heat loss and air infiltration. Enhance luminosity with light-colored finishes and coverings for walls and floors too.
Framing	Optimize material use with advanced framing methods that avoid excess usage and provide more potential for insulating and sealing the building envelope. Consider structural insulated panels or prefabrication.
Building codes and zoning	Comply with local zoning and building code specifications on size, orientation, systems, and materials. Some municipalities fast-track the permit process for green building projects that achieve sustainability goals, like infill development and energy efficiency.
Incentives	Research and take advantage of federal, state, municipal, and utility company incentives, rebates, grants, and other assistance that may be available for green construction.
Landscaping	Use native plants. Design water-thrifty landscaping with plants with similar water needs grouped together. Preserve existing trees and vegetation or replant. Trees, hedges, and shrubbery block winter drafts, cool summer breezes, and replace bird habitats that may have been destroyed in the construction process.
Water management	Include water catchment systems and greywater usage systems. Manage runoff from storm water and snowmelt.
Energy efficiency	Design a tight building envelope and install an energy-efficient HVAC system and appliances. Consider energy-generation equipment like solar photovoltaic roofing.
Recycling	Make it easy to recycle household waste.
Certifications	Consult design guidelines for certifications. LEED, NAHB Green Certified™, Energy Star, airPlus, Earthcraft™, and others publish design guidelines—required and optional—for earning the certification.
Future marketability	Consider the future marketability and resale value design to maximize short- and long-term appeal.
Architectural appeal	Harmonize with the architectural style and heritage of the community. Create an aesthetically pleasing design.

Building Materials

It seems like a green choice exists for every type of building material. Sustainable materials turn up in some unexpected ways:

- Reclaimed sawdust in composite floorings
- Rapid-growth bamboo in decorative veneers
- Shredded paper and cardboard in waterproof building sheathing
- Recycled glass in countertops and flooring
- Crushed seashells in decorative tiles

As we learned in *Green 100: Real Estate for a Sustainable Future*, many products and claims compete for consumers' attention and wallets. So how can you make good choices? Sources of objective information on green building materials include:

- Green Seal Standard at www.greanseal.org
- USGBC at www.usgbc.org
- Green Building Pages at www.greenbuildingpages.com
- California Department of Resources, Recycling, Recovery at www.calrecycle.ca.gov/GREENBUILDING/Toolkit
- Green Building Supply at www.grenbuildingsupply.com

Refer to page 129 for a chart of building material certifications.

The Life Cycle of Green Buildings

Two important concepts to keep in mind for selecting green building materials: embodied energy and low toxicity.

Embodied Energy

Embodied energy is the sum of all the energy inputs over the lifetime of the material. The lower the total embodied energy, the "greener" the product. A simple way to think of this concept is to picture the "before, during, and after" phases of a product. Although opinions vary on how and what to measure, most indexes calculate the energy consumed by:

- Mining or harvesting and the raw materials and shipping to the manufacturing plant
- Processing the raw materials into building products
- Shipping the materials to the job site
- Installation of the material
- Maintenance over the lifetime
- Disposing, reclaiming, or recycling of the material when a building is remodeled or replaced

Embodied Energy in Green Building Materials—Before, During, After

Before

- Environmentally friendly harvesting and production
- Rapidly renewable sources
- Locally sourced
- Recycled and reclaimed material
- Hauled short distances by clean-fuel transport

During

- Durable and low maintenance
- Aesthetically pleasing
- Efficiently measured and cut to reduce waste
- No VOCs or toxins
- Minimal, recyclable packaging
- Clean-fuel construction site generators
- Minimal use of pressure-treated woods

After

- Deconstruction, not demolition
- Material reclamation or recycling
- Minimal construction waste dumped in landfills

Indoor Air Quality and Building Materials

Many materials used in traditional home construction –paint, carpet, cabinetry, wall board, wall coverings—can emit, or offgas, unpleasant and even toxic volatile organic compounds (VOCs) or formaldehyde. VOCs and toxins can emit from paints, floor and wall coverings, and pressure-treated lumber, among other sources. Green construction materials are manufactured and installed to minimize or eliminate these emissions.

Later in the course we will look at air quality issues in relation to building materials in existing homes (page 105). New homes have the opportunity to avoid offgassing problems by selecting low-VOC materials during the design and spec process.

What Is Pressure-Treated Lumber?

Pressure-treated lumber is infused, under pressure, with chemicals to retard rotting and repel pests such as termites. It is used in exterior, below-grade, and underwater structures, like porches, deck support posts, picnic tables, mailbox posts, and underwater dock pilings. Prior to a 2003 EPA ban, pressure-treated wood was commonly infused with a highly toxic chemical—chromated copper arsenate (CCA)—which leached into surrounding soil and water. Although no longer used in residential construction, CCA-infused lumber may still linger in lumber yards' unsold inventories. It is present in buildings constructed before the ban, particularly in the '70s–'80s. For already installed wood, the EPA recommends application of a sealant to reduce exposure. Disposal of pressure-treated lumber, including sawdust, requires special handling by a solid waste facility; burning or shredding CCA-infused wood releases a toxic substance—arsenic.

The alternative to arsenic-based preservatives in pressure-treated wood is copper-based preservatives: alkaline copper quaternary (ACQ), copper azole (AZ), and micronized copper quaternary (MCQ). For more information on pressure-treated wood, its uses, and proper handling, go to the American Wood-Preserver's Association at ***www.AWPA.com***.

Managing Construction Waste

The least green, and often overlooked, aspect of building can lurk in construction waste. The National Association of Homebuilders estimates that construction of a 2,000-square-foot home generates up to 8,000 pounds (4 tons) of waste. By both volume and weight, the top three components are wood, cardboard, and drywall. Without a management plan, almost all of this waste winds up in landfills. Green construction includes a plan for managing the waste stream through methods such as efficient cuts, minimal or recycling packaging, and reclamation instead of demolition. The online Construction Waste Management Database at www.wbdg.org/tools/cwm.php lists companies and vendors that remove and process recyclable materials from construction projects.

Cradle to Cradle® Certified—a New Recycling Paradigm

The traditional view of a product life cycle begins with resource extraction, moves to product manufacturing, and ends with a "grave" when the product is disposed of in a landfill or incinerator. The Cradle to Cradle® strategy views all materials as continuously valuable and circulating in closed loops of production, use, and recycling. Cradle to Cradle® certified materials earn the distinction if they are recyclable, if it is technically possible to recycle them, and if at least one commercial recycling facility exists. Manufacturers of certified products include familiar companies like Pendleton Woolen Mills, Steelcase, Inc., Alcoa, Proctor & Gamble, Dow Building Materials, Herman Miller, and the U.S. Postal Service. The Cradle to Cradle® certification is offered by McDonough Braungart Design Chemistry (MBDC), a sustainability consulting and product certification firm founded in 1995 by architect William McDonough and chemist Dr. Michael Braungart; visit ***www.mbdc.com***.

Discussion Question

What other innovative ways to recycle building materials do you know about? Are there recyclers in your area?

Managing Construction Waste

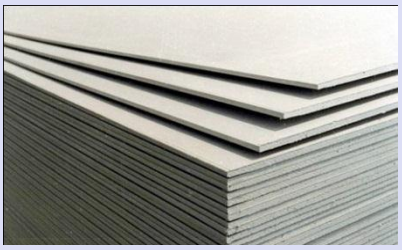
How can these leftover and waste materials be handled in an environmentally friendly way?

Old Growth Lumber

Uncontaminated Wood

Structural Steel

Drywall



Cabinets

Insulation

Packing Materials

Leftover Paint

Bricks

Interior Systems

The fourth phase in green home construction focuses on planning the interior systems. In the following chapters we will look more closely at the function and interaction of various systems. For now, let's focus on key decision points that shape these choices.

- **Interrelationships**
  Green building relies on a whole-building design approach to the interconnectivity of the home—as an envelope of interconnected systems and a structure within the community. As we learned earlier, there are many points of interaction between the site and building orientation. Similarly, systems and design elements interact. For example, a tight building envelope requires a right-sized ventilation system for indoor air quality and moisture control. In some cases, choices may involve some tradeoffs; for example, more spent on insulation may make downsized HVAC equipment a feasible option.

- **Sound and Light**
  The visual and aural elements of a home must balance several factors: privacy, natural lighting, visual variety, ventilation, connection with nature, and interior heating or cooling, as well as quiet spaces with low sensory stimulation for rest and relaxation.

  Designing the interior spaces to minimize distracting noise from other occupants or outside activities may impact the layout and also require additional insulation.

  Bringing natural light inside, daylighting, enhances the sensory experience of interior spaces with variations of indoor light intensity, color, patterns, and textures. On the other hand, excessive glare from daylight introduces a discordant element into the interior space.

  Daylighting not only enhances interior luminosity, it lowers energy consumption and impacts HVAC choices. For example, lighting with insulation-compatible air-tight (IC-AT) recessed fixtures prevents the chimney effect of conditioned air escaping through the fixture into the attic or ceiling cavity.

  Although heating and cooling are the major energy consumers, lighting impacts energy load too. Conventional, multi-bulb chandeliers typically installed in dining rooms, living rooms, and kitchens are among the highest-wattage fixtures in the home and the bathroom vanity is one of the highest-use fixtures in the average home. Strategies that bring natural daylight into these high-use areas

not only brighten the space but also reduce the energy load of these high-wattage fixtures.

- **Indoor Climate**
  It's a given that people want to be comfortable in their indoor environment—even cavemen built fires for warmth. Comfort and energy efficiency are by no means irreconcilable goals. Green design seeks to balance livability with sustainability and energy efficiency. Well-designed spaces are not only low in pollutants, but also have well-balanced thermal heating with controls that provide the option not to heat or cool unoccupied space, like lowering nighttime heating in a living room but maintaining it in bedrooms. Choices such as radiant floor heat or geothermal heating and cooling are best implemented at the design and construction stage.

- **Water Management**
  Water management systems involve both supply and heating. In dry climates, systems to catch and use rainwater—free water—reduce consumption costs as well as depletion of sources. A catchment system can be as simple as rain barrels or more sophisticated like underground holding tanks. The most natural use of rainwater is irrigation of lawns and gardens, but it also can be used for flushing toilets or washing cars.

  Central core plumbing design is a simple idea for energy efficiency that is gaining popularity in new green home design. When the bathrooms, kitchen, and water heater are designed around a central wall in close proximity to each other, hot water runs quickly to faucets and showerheads. In homes that do not have this plumbing design, the cold water is either wasted as the user waits for hot water, or a recirculating hot water pump must be installed to ensure quick hot water, at an additional energy cost. Central core plumbing designs avoid both negative consequences.

- **Energy Load**
  As we saw in *Green 100: Real Estate for a Sustainable Future*, modeling predicts the energy use of a home throughout a typical year of operation. The value of an energy modeling exercise is in estimating the energy consumed—in BTUs, dollars, or pollution avoidance—as a result of design and system choices.

  Energy modeling also takes into consideration sizing issues for systems. For example, air conditioning is frequently sized for the space based on temperature extremes—the amount of energy

needed to cool the space on the hottest days of the year—instead of median temperature cooling needs. As a result, air conditioning units are not as efficient on the many days of the cooling season when it is hot but not at the temperature extreme for which the system was designed.

- **On-Site Energy Generation**
  The possibility of on-site power generation links closely with energy load estimates. With growing interest in energy self-sufficient homes—net zero energy—the home design may incorporate systems for generating and storing, or selling back, electricity. For example, the design may include installation of a photovoltaic system for converting solar energy into electricity or, where building codes permit, a turbine for harnessing wind power. A solar water heating system must be interlinked with the overall plumbing system. In the near future, if the power grid cannot keep up with the power recharging needs of electric cars, home electricity generation may be a solution to filling the gap.

The Net Zero Energy Home

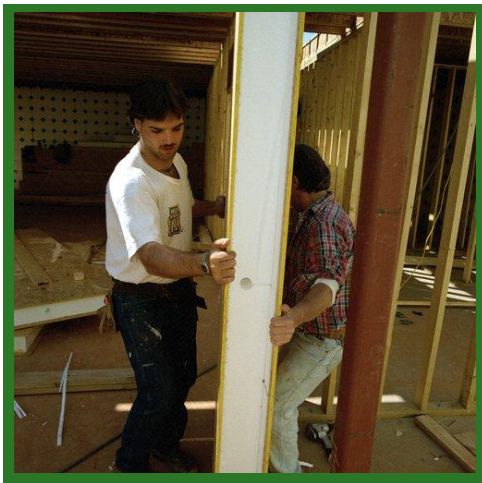
The simple definition of a net zero energy home is one that produces as much electricity as it uses. Two important concepts to remember are:

- The net-zero bottom line is calculated over time, like a year of energy costs. Depending on time of year and usage, power may be drawn from the grid or excess power sent back to the grid.
- If a home also uses natural gas, a true net zero energy home would have to produce enough electricity to offset the cost of gas in order to achieve a total “wash” at the bottom line of the homes utility costs.

Design teams have an array of options to meet sustainability goals within the project budget, and each option has its pros and cons. Solutions should be evaluated in relation to the green goals both individually as well as in the context of the entire home. The sum of a successful set of design solutions makes a home comfortable, durable, aesthetically pleasing, and energy-efficient.

The Next Chapter

In this chapter we have looked at planning phases for green homes from the site selection to choosing materials and designing the interior spaces and systems. An important theme throughout this chapter is the interrelationship of choices and systems. In the next chapter we will learn about how the design choices move from the drawing table to the building site. The starting point is construction of the building envelope from the ground up and outside in.



Green 200.2: Green Home Construction—The Building Envelope

In this chapter we will focus on the building envelope and its role in achieving an energy-efficient home based on sustainable principles. The basic functions of the building envelope are shelter and safety. It has the potential to be the most or least green component of a home.

Although most real estate professionals are not directly involved in the building envelope construction decisions, they do sell the houses that builders construct. Knowing the relationship between choices and environmental quality, indoor air quality, and energy efficiency can help real estate professionals appreciate the efforts of green builders and homeowners. You can help buyers evaluate the homes they view too. If you are going to sell homes with green features you should know how the features operate and their effect, individually and cumulatively, on the greenness of the home.

The basic functions of the building envelope are shelter from the elements—wind, cold, heat, and precipitation—and safety.

Defining the Building Envelope

In modern construction, the building envelope, or shell, provides structural integrity, impermeability, safety, security, aesthetics, and sustainability. The building envelope separates the indoor and outdoor environments including the components that are below ground. It divides conditioned—intentionally heated and cooled—from unconditioned space. But, based on the concept of conditioned and unconditioned space, the demarcation line for the building envelope can be a bit fuzzy. Clearly the main living areas of a house—living rooms, kitchen, dining room, bedrooms, baths, and so forth—are inside the building envelope. Some definitions include the attic, but others do not because it is typically not conditioned space. An unfinished basement is usually not included inside of the envelope, but may be if it is finished and intentionally conditioned; Canadian builders routinely include the basement—finished or unfinished—as part of the building envelope. For purposes of this study, it isn't important to develop a hard and fast definition. It is more important to look at the components and function of the building envelope as opportunities for sustainable construction and energy efficiency.

An examination of the building envelope in the context of green homes is important because:

- A tightly sealed building envelope is crucial to energy efficiency because it impacts the energy load for heating, cooling, water heating, and lighting.
- Air leakage from a porous building envelope compromises energy efficiency as conditioned air escapes through roofs, exterior walls, and joints between the walls and the roof or floors, as well as at the corner of two walls.
- Construction of the building envelope requires a large quantity of materials—more than any other part of the building. Both the materials and methods offer an opportunity to make sustainable choices, such as low-embodied energy materials, or material-thrifty building techniques like advanced framing.

Building Envelope Components

Let's take a look at the components of the building envelope from the ground up and how each can contribute to the creation of a green home.

- **Below-grade systems**: foundation walls, floor slabs, basement and crawlspace (maybe)
- **Exterior walls**: structural and nonstructural (air and vapor retarders, finishes)
- **Fenestration systems:** windows and doors
- **Roof**

Below-Grade Systems

Building foundations and the basement, crawlspace, or floor slab comprise the below-grade portion of a home's building envelope. Although for a home built into the side of a hill, the below-grade system could also incorporate living spaces that are above-grade for homes situated on flat land.

The below-grade portion of the envelope provides structure support for the vertical loads—the framing and exterior walls—of the rest of the house. A basement or crawlspace allows space for distribution systems like water and sewer pipes, ducts, electrical and electronic wiring, and

gas supply. In many homes the basement serves as the utility space for a washer and dryer, furnace, and water heater. A finished basement can provide additional living space.

Challenges in constructing the below-grade building envelope include:

- Waterproofing, moisture control, and drainage
- Controlling air infiltration at the points where the foundation connects to the exterior walls and façade
- Insulation for the main floor above

Radon Infiltration

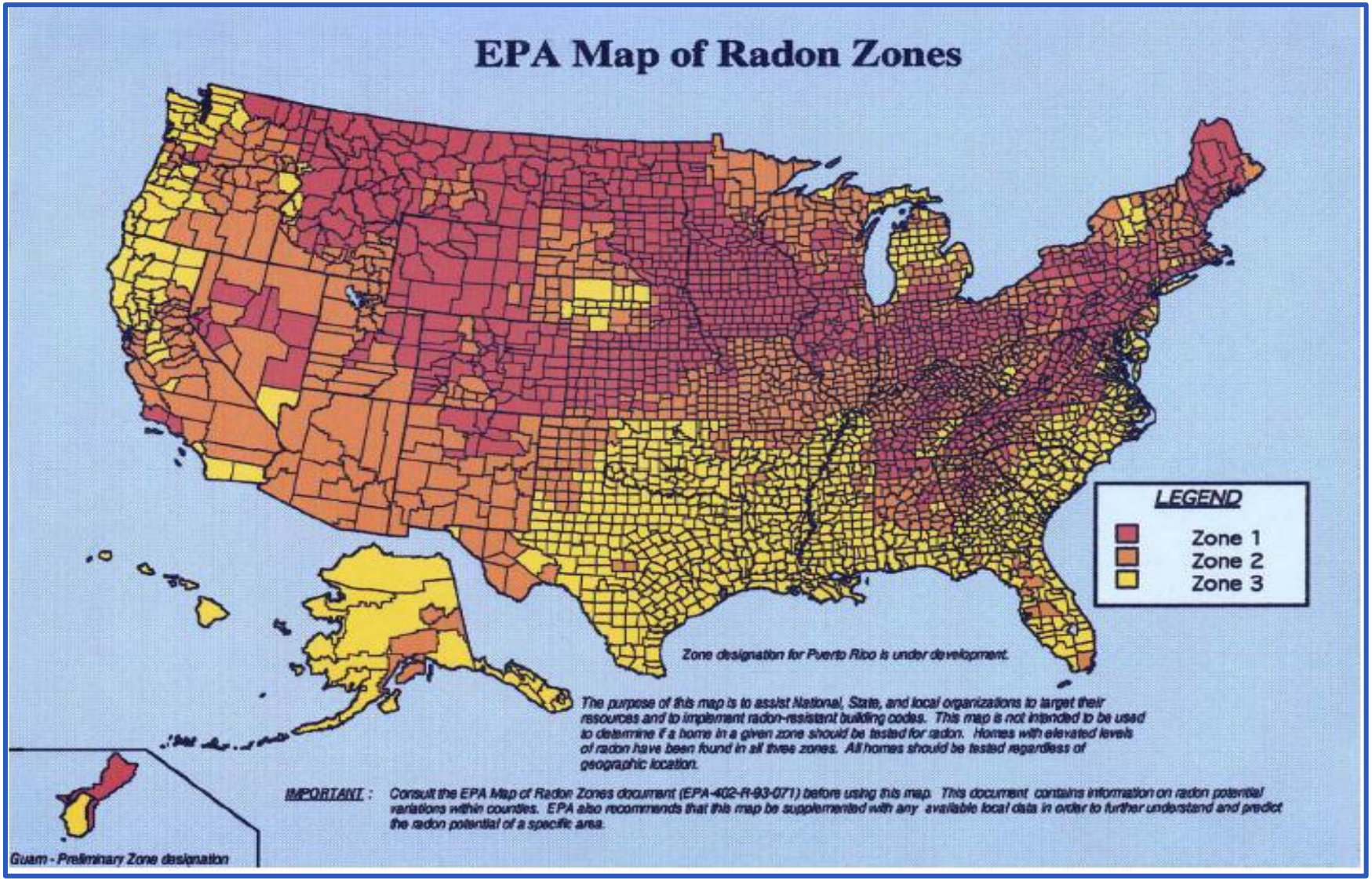
For homes located in high radon potential zones, new construction offers the best and most economical opportunity for installation of radon control in the below-grade structures. According to the EPA, installation costs $350–$500; retrofitting a home can cost up to $2,500.

A typical passive radon control system consists of:

- Clean gravel or aggregate layer under the slab or flooring system
- Polyethylene sheeting on top of the gravel layer
- Gas-venting pipe from the gravel level through the house to the roof
- Sealed and caulked foundation

If the passive systems don't reduce radon levels to safe ranges (4.0pC/L or less), addition of a ventilating fan, an active system, can increase exhaust capacity. Post-construction, testing is the only way to know if a home has radon issues, even if a passive system is installed. If test results show elevated levels, the EPA recommends upgrading to an active system, which can reduce radon emissions to a safe level.

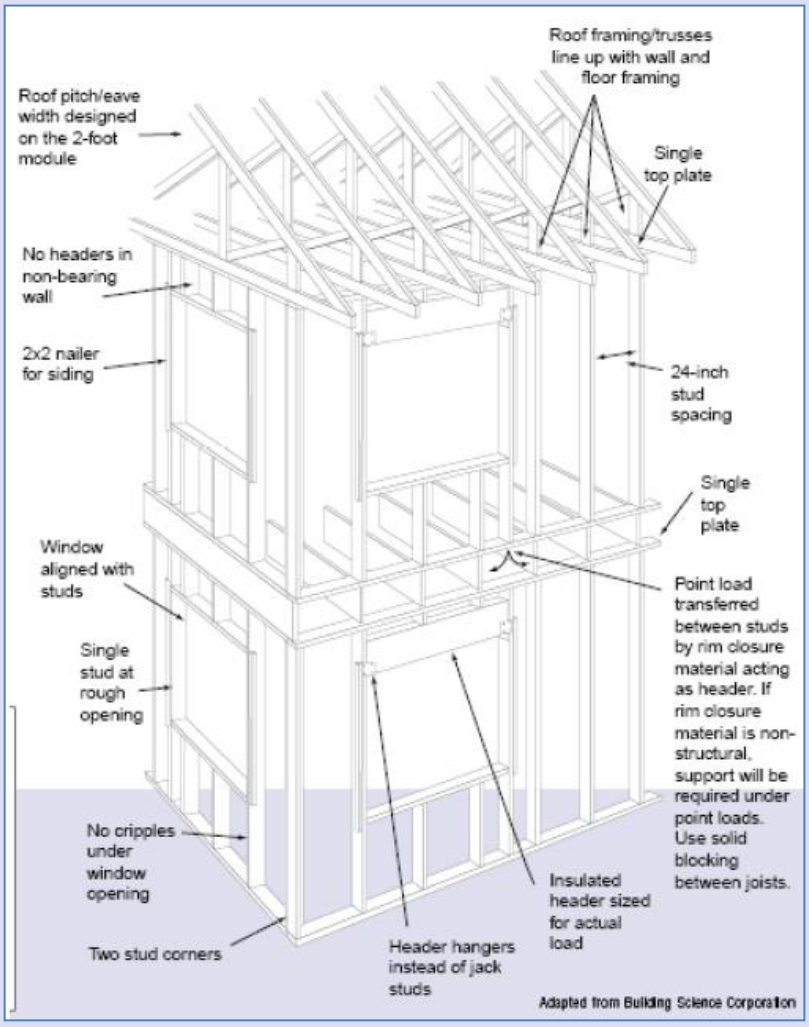
How do you know if your area is prone to high radon levels? The EPA maintains an online map at www.epa.gov/radon/zonemap. Counties are ranked by zones: Counties in zone 1 have the highest potential for elevated radon levels. An increasing number of states and municipalities in these high radon potential areas require or recommend installation of radon systems. The EPA also publishes detailed building standards, architectural drawings of systems, and installations fact sheets. Call 1-800-55 RADON (1-800-557-2366) or go to ***www.epa.gov/radon/pdfs/archdraw***.



www.epa.gov/radon/zonemap

Constructing a Green Building Envelope

Advanced Framing



Structural Insulated Panels

Insulated Concrete Forms

Composite Floor Joists

Prefab Modules

Prefab Roof Trusses

Photos courtesy of National Renewable Energy Lab, www.nrel.gov

Framing and Walls

Moving up from the below-grade portion of the building envelope, the next element involves construction of the frame and exterior walls. Let's look at some innovations in framing and exterior walls that employ sustainable methods and materials.

Advanced Framing

Advance framing, sometimes called optimum value engineering (OVE), accomplishes two sustainability goals: it reduces the amount of materials and increases space for insulation thus boosting the overall R-value of the structure. Advanced framing uses techniques like wider spacing between studs, single top plates, and precise cuts to reduce materials and waste. These methods must, of course, comply with local building codes.

Prefab Modular Construction

The idea behind modular construction—homes factory-produced in pieces, shipped, and assembled at the construction site—has been around for several decades, since the housing construction boom of the '50s and '60s. But early low-quality prefab efforts earned a negative connotation that is now misplaced. Today, even stick-build contractors use prefabricated elements like roof trusses and floor joists. Advances in modular building provide many green benefits and make it cost-effective too. Green modular construction offers high levels of quality assurance and systemization, reduces the amount of material required for construction, and produces a durable, energy-efficient building envelope.

The traditional framing method stick-builds the frame on site. Framers construct an individual wall panel on the ground and then raise, brace, and nail it to the first. They then build the next wall panel, and so on. With modular construction, the entire house shell is built with automated precision in a weather-protected factory environment instead of outside where it is exposed to the elements and built on the ground. Delivery of complete wall panels to the job site reduces both construction time and cost.

Structural Insulated Panels

Structural insulated panels (SIPs) consist of a thick layer of foam sandwiched between two layers of oriented strand board (OSB). Pressure laminating the components produces an extremely strong material for structural framing, insulation, and exterior sheathing. Integrating SIPs into framing reduces the sawn lumber requirements. Because SIP construction has fewer seams for air infiltration, it creates a very air-tight, energy-efficient building envelope.

Insulated Concrete Forms

Insulated concrete forms (ICFs) look like concrete blocks, but the composition and thermal properties are quite green. ICFs combine cement with polystyrene foam and sometimes bonded wood fiber. The forms can be used in both structural and below-grade construction. ICF construction yields a low-waste building shell with high insulation and superior wind, seismic, and exterior noise resistance.

More Green Choices for Framing and Walls

- **Engineered wood**
  As the supply of large, old-growth timber diminishes, engineered wood provides a sustainable solution. Timber from small-diameter fast-growing trees—fir, pine, and poplar and scrap wood—is reassembled into boards, beams, and veneers as well as structural framing, joists, and 2x4 and 2x6 lumber.

- **Wood/plastic composite lumber**
  Recycled wood/plastic composite lumber is one of the main uses for recycled plastic trash bags. A combination of recycled plastic and waste wood fibers, like sawdust, produce extremely durable lumber suitable for exterior uses. The composite wood contains no toxic chemicals and is a good replacement for pressure-treated wood.

- **Pre-printed sheathing and gypsum board**
  Wood sheathing and gypsum board stamped with measurement guidelines reduces installation time as well as waste. Conventional construction techniques require separate steps for measuring, marking, and cutting. Pre-printed boards and sheathing simplify these steps because builders can use the guidelines to cut panels to size.

- **Cladding from recycled paper**
  Shredded paper from offices and cardboard can be recycled into waterproof exterior cladding and architectural panels.

- **Straw bale construction**
  Bales of straw tightly compressed and then finished with a material such as stucco offer an inexpensive, eco-friendly construction material.

- **Soil-based materials**
  The search for eco-friendly alternatives to wood and plastic has renewed interest in centuries-old methods like adobe, cob, rammed earth, and soil-cement.

- **Strawboard panels**
  Panels manufactured from compressed wheat or rice straw combined with borate, an insect-repelling natural mineral, can be used as self-supporting wall, roof, and floor panels, and also integrated into structural insulated panels.

Insulation

Insulation is perhaps the most important element in constructing an energy-efficient building envelope. It is rated by the R-value, which indicates how well the material resists (R) heat transference. The higher the R-value, the greater the insulating effectiveness. R-value depends on the type of insulation, thickness, and density. Installing more insulation increases the R-value.

Effectiveness of insulation also depends on proper installation. For example, insulation that is compressed will not provide its full rated R-value. Other issues that lower R-value include:

- **Gaps and shrinkage**
  Air infiltrating or escaping through gaps caused by insulation shrinkage effectively lowers R-value. Heat and air can escape or infiltrate around studs, joists, and gaps in framing.

- **Moisture**
  R-value drops significantly when insulation is exposed to moisture from leaks or condensation. It also provides an environment for growth of mold, mildew, and wood rot.

- **Thermal bridging**
  When materials with different heat conductivity span the space from unconditioned to conditioned space, like metal framing studs surrounded by fiberglass insulation, more heat flows through the higher-conductivity material. The resulting thermal bridging lowers the R-value of surrounding insulation. In short, the metal studs act as chillers and the R-value of the insulation drops to almost zero. Thermal bridging also happens frequently around metal window frames.

Insulation from Recycled Materials

Denim insulation from recycled blue jeans

Blown-in cellulose from recycled newspapers

Icynene® foam insulation is made from the oil of the castor plant

Aerogel produced from silica, sometimes called frozen smoke

Photos courtesy of National Renewable Energy Lab, www.nrel.gov

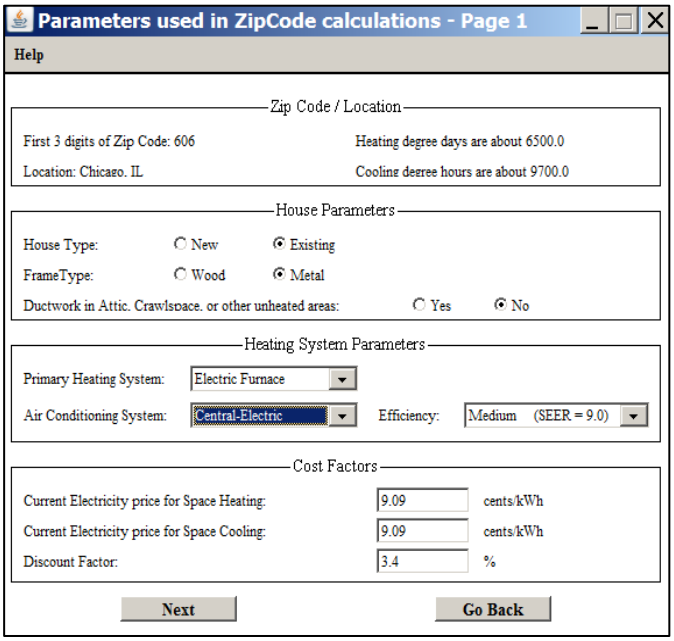
How Much Insulation and Where?

The amount of insulation needed depends on climate, section of the house, and type of HVAC system. An energy-efficient, tight envelope requires proper insulation from the foundation up:

- Foundations: basement, crawl space, or slab
- Floors about unheated garages
- Exterior walls
- Ceilings
- Ducts in unconditioned spaces
- Attic spaces: around the attic hatch and knee walls in finished attics

Local building codes usually specify minimum insulation requirements, but achieving an energy-efficient home may require exceeding the minimum code.

The U.S. Department of Energy provides an online Zip-Code Insulation Program that provides information on recommended R-values. Homeowners can learn where and how much to insulate based on climate and type of HVAC. The online database, developed in cooperation with the Oak Ridge National Laboratory, also provides cost estimates on rate of return. View the calculator and learn more about it at ***www.ornl.gov/~roofs/Zip/ZipHome.***



The Passive House

Developed in Germany, the Passive House method of home construction that produces a super-insulated and airtight building envelope. Insulation R-values are generally in the range of R-40–R-60 for walls, R-60–R-90 for roofs, and R-30–50 for slabs. Walls up to 15 inches thick and triple-glazed windows complete the building envelope. In addition to using passive solar gain, Passive House homes make extensive use of heat from internal sources like lighting and appliances as well as the body heat of occupants.

Passive House homes do not need a conventional central heating system. In place of a furnace, a heat exchanger, which continually replaces warm stale air with fresh, transfers the warmth of expelled air to the fresh air drawn in from the outside. A Passive House requires space heating energy of 1 BTU per square foot per heating degree day, compared with about 5–15 BTUs per square foot per heating degree day for conventional homes. The heating and cooling systems may incorporate geothermal technology to maintain a constant year-round temperature. A Passive House achieves overall energy savings up to 90 percent of space heating without applying technologies like solar photovoltaic.

In February 2011, the U.S.-based Passive House Institute and RESNET announced a collaborative agreement to align the Passive House Planning Package (PHPP) energy modeling with HERS Index software.

There are about 20,000 certified passive houses, almost all in northern Europe; less than a dozen are currently documented in the United States but interest is growing. Designers concede that the approach is best suited for cold climates where heating is used more than cooling. Learn more at the Passive House model at ***www.passivehouse.us.***

Fenestration—Windows and Doors

In constructing the building envelope, choices and placement of windows and doors must balance convenience and natural lighting with energy efficiency and the potential for air leakage.

Windows

As noted earlier in the discussion of site selection, south-facing windows provide the best opportunities for natural daylighting as well as solar heat gain—wanted or unwanted. Green construction sometimes calls for

low-emissivity (low-e) windows. Low-e coatings are microscopically metal oxide thin coatings that reduce infrared radiation from a warm pane of glass to a cool plane, thus lowering the U-value of the window. In hot climates, the low-e coating should be applied on the outside. For cold climates, the low-e coating should be applied to the inside pane. The National Fenestration Rating Council provides detailed information on window performance, which is summarized on their label. Certification participation is optional for manufacturers. The NFRC online directory lists more than 1.6 million certified products manufactureD by more than 700 manufacturers.

Doors

Energy efficiency of doors and skylights are rated on same scale as windows —U-factor, SHGC, and air leakage. Doors, like windows and skylights, lose or gain heat through direct conduction, radiation of heat into or out of the house, and air leakage through and around the door or frame. According to Energy Star, the R-values of most steel and fiberglass-clad entry doors range from R-5 to R-6. A layer of expanding foam caulking around the door frame can help prevent air leakage. Glass sliding doors are probably the least energy-efficient windows. Most modern glass doors with metal frames have a thermal break, which is a

plastic insulator between inner and outer parts of the frame. Models with several layers of glass, low-emissivity coatings, and/or low-conductivity gases between the glass panes are a good investment, especially in extreme climates.

Roofs

Insulation in attics and under roofs presents the best opportunity for preventing heat loss. But there are green options that can be incorporated into the exterior structure of the roof. Cool roofs and green roofs provide a multitude of sustainable benefits from reducing storm water runoff to lowering the impact of solar heat gain and reducing the urban heat island effect.

Cool Roofs

Radiant barriers, also known as reflective insulation, block the transfer of heat to the home and reduce air conditioning costs in climates with high levels of solar radiation. A layer of material with a reflective surface, such as aluminum, is installed in the attic in a variety of configurations. The material may be applied to the attic floor, the roof system, or to the underside of rafter framing, as shown in the illustration on the next page. Radiant barriers typically result in a 2 to 10 percent reduction in cooling costs.

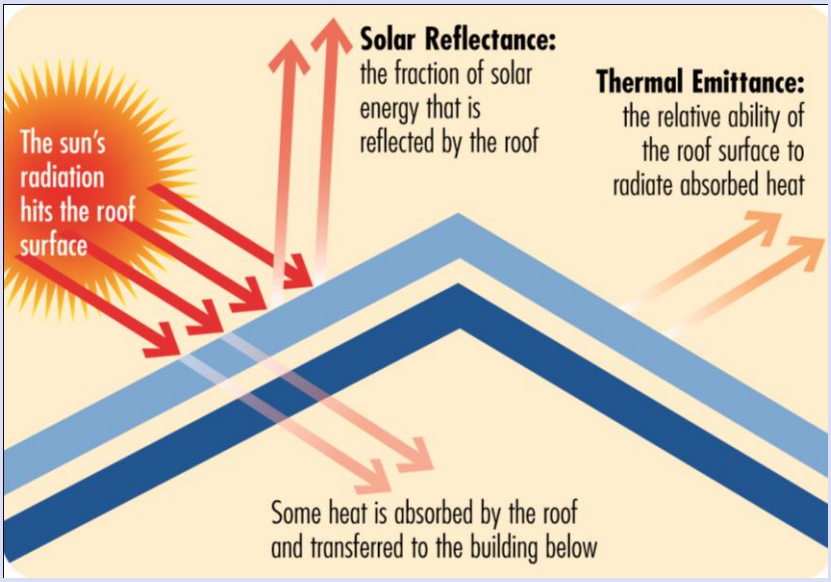
The reflectivity of a cool roof is measured by solar reflectance and thermal emittance. Two major factors are the degree of slope in the roof—from flat to steeply sloped—and climate. The Cool Roof Ratings Council and Energy Star both provide ratings for roofing products and guidance on how to choose the cool roofing system and materials.

Green Roofs

Today's green roofs are a new interpretation of an old building method; prairie sod houses and thatched-roof cottages are the original green roofs. A rooftop expanse of soil and vegetation reduces urban heat-island effect as well as heating and cooling loads. It also absorbs carbon dioxide, air pollution, and rainfall run-off. Green roofs have a longer life expectancy due to protection from UV rays and temperature extremes. Green roofs come in two types—intensive and extensive. Intensive green roofs, similar to traditional roof gardens, involve deep soil to grow large

plants and require irrigation and regular maintenance. Extensive green roofs are designed to be self-sustaining and require minimum maintenance. Extensive green roofs involve a thin layer of soil for shallow-root plantings.

How cool roofs reduce solar heat gain



Light-colored roofing materials reflect sunlight and reduce interior temperature. Learn more about cool roofs at ***www.coolroofs.org.***

Green roofs

◀ Rain or sprinkler

◀ Growing medium

◀ Root barrier

◀ Drain core

◀ Insulation

◀ Roof membrane

◀ Structural support

Source: Reprinted with permission of AmeriGreen Prefabricated Drainage Solutions, Green Roofs and Planters, www.americanwick.com

Three urban green roofs

U.S. Naval Station Norfolk, Virginia

Botanical Gardens Singapore

City Hall, Chicago

Green roof—before you build

- Check building codes
- Test the structural capacity for extra weight
- Plan access to the roof
- Design irrigation and drainage systems
- Select plants and growing media

Learn more about green roof technology at ***www.greenroofs.org.***

The Solar Roof

Solar installations expand the function of a roof from shelter and make it an integral part of the home's energy system. The systems are a hallmark of the new generation of net-zero-energy homes. As we learned in *Green 100: Real Estate for a Sustainable Future*, new materials like photovoltaic shingles and coatings are replacing the build panels and arrays usually associated with solar energy. Instead of creating a system to deflect the heat of the sun, solar roofs capture the thermal energy and convert it into electricity to power the home and heat water.

Solar roof technology

Solar panel retrofit

Solar shingle installation

Photos National Renewable Energy Lab, www.nrel.gov

What Do You Need to Know?

In this chapter we have looked at the components and many technical aspects that go into construction of the building envelope. We have focused on this element of home design because it is so crucial to energy efficiency, indoor air quality, and other green aspects of a home. But this is not intended to be an exhaustive study of home construction. So, as a real estate professional what do you really need to know? Important concepts are:

- Understanding of the relationships between design choices and environmental quality, indoor air quality, and energy efficiency
- Appreciation for the efforts of builders and homeowners to integrate green systems and feature into homes
- Recognition of systems and green features and understanding of the functions

Practitioner Profile: Finding the Sweet Spot

"Real estate professionals can make an impact on conserving natural resources and improving the earth."

Sue Bechtel, GREEN
Iowa Realty
West Des Moines, Iowa
suebechtel@iowarealty.com

I'm an environmentalist at heart. My involvement in green real estate stems from seeing a huge need to save natural resources. The book by Sarah Susanka, *Not So Big House*, inspired me too.

Living green

When it comes to green, I live it. It's important for establishing credibility. I drive a Prius, recycle and compost, and use a rainwater collector. I try to teach by example. Harvested rainwater makes my flowers gorgeous. Others hide their rain barrels in inconspicuous spots in the backyard, but mine is in the front yard for all to see.

Working with builders

Promoting green, particularly among old-school builders can be a difficult, uphill battle. Sometimes people say, "green's a joke." But you have to remain persistent. The best ways to establish yourself with builders include:

- Getting educated—research your builder, know their product, and stay up on green tax incentives and rebate programs you can share with them.
- Building trust—let builders talk and see what they want and what their hot-button issues are.
- Finding the soft spot—sometimes that means appealing to their wallets and showing them that consumers will buy houses with energy-efficient features.

My strategies with consumers and fellow practitioners are similar to those I use with builders in terms of being educated and finding their sweet spot. I try to feel out prospects' understanding of green. For some, I stress the simplicity and getting back to nature of green choices, like "Why not use water from the sky?" When prospects are concerned with costs, I acknowledge that up-front costs of certain systems can be high, but explain the potential savings over the long haul. With my fellow practitioners, I try to share what my knowledge about the various financial incentives that are available. When they come to me with questions, the more knowledge I have the more credibility I have.

My dream home

My ultimate vision is to design a demo home built to NAHB's Green Building Standard. I envision a design charette with fellow green professionals, like general contractors, suppliers, solar experts, and so forth, to design and construct an affordable green home. It would give visitors an opportunity to see real-life examples of green building.

The Next Chapter

In this chapter we've looked at the components and technologies that go into construction of the building envelope. We learned about the importance of a tight building envelope as well as materials and methods to make it green. In the next chapter, we will move inside the home and take a look at green systems.

Notes:

Green 200.3: Green Home Construction—Systems

In this chapter our focus moves from the outer shell, the building envelope, to the systems that create the indoor environment. Why should a homeowner or builder make an effort to install green home systems? These systems are healthful for the home's residents, energy efficient, easy on the environment in terms of pollution and carbon footprint, and cost effective in the long term. Whether new construction or a retrofit, the homeowner or builder can make choices that achieve these goals.

Although cost-benefit balance and energy efficiency are important, keep in mind that these factors are not the only motivators. Ultimately the systems must work together to create a healthful and comfortable indoor environment. Let's take a look at some of the green options, potential cost savings, environmental benefits, and interrelationships of home systems.

Do Green Systems Cost More?

Do these statements sound familiar? "Green costs too much" or "with the state of the economy, we can't afford green." How can the real estate professional respond? It's true that some green home system choices may cost more up front, but they are an investment that pays off in the long term and often in the short term too.

- **Cost-Benefit Balance**

  A major determinant in making green choices is of course the balance between cost and benefit. A system may cost more to buy and install, but less to own and operate over the long term. For example, a highly energy-efficient furnace can cost up to $1,000 more than a less efficient one, based on AFUE rating (see page 48); but in a cold climate with a long heating season the difference between an AFUE 80- and AFUE 90-rated furnace is a savings of about $16 for every $100 of fuel.[1] A savings of $50 a month would make the extra cost in less than two years. Furthermore, for major systems like heating and cooling, tax credits can help ease the initial cost outlay. And, don't forget local utility companies; some may provide incentives and rebates to encourage installation of energy-efficient systems.

  For home buyers, the cost of a home with energy-efficient systems may be higher than a similar conventional home. But the additional

[1] American Council for an Energy-Efficient Economy, www.aceee.org/consumer/heating

amount of mortgage payment may be more than offset by savings on utility bills. It's also important to remember that energy efficiency may result from the interaction of the building systems, not just one source.

System size and capacity usually determine price, but when it comes to cost benefit, a bigger system isn't always needed or better. In fact, as we'll learn later in the chapter, when the capacity of an air conditioning system or heating exceeds the specification of a home the result can be higher costs and less comfort.

- **Value Enhancement**

  As we learned in *Green 100: Real Estate for a Sustainable Future*, energy-efficient homes tend to sell faster and closer to list price. We also learned that consumers, particularly millennial-generation home buyers, will reward or penalize a company for its environmental policies and actions. Home builders who don't pay attention to energy efficiency and consumers' environmental concerns risk both a negative public perception and lost business. When a home buyer can choose between a conventional or an energy-efficient home at little or no extra cost, the operational savings for the green home make it an easy choice.

- **Future Proofing**

  Although alternative energy sources are developing at a fast pace, the reality is that most of the country is dependent on fossil fuels for electricity, heating, and cooling. The finite supply of these fuels makes future costs and supplies inherently uncertain. Energy-efficient home systems can help homeowners withstand the uncertainties. Think of energy-efficient choices as a way to future-proof a home.

- **Money Isn't the Only Motivator**

  Remember, not every benefit of green choices can be monetized. People value aspects of green systems for different reasons—health concerns, environmental concerns, lifestyle choices, or just keeping up with the latest trends.

Discussion Question

What would you respond to a home buyer who says “green costs too much”?

What Do You Need to Know?

The following discussion will cover a number of technical details and ratings for various systems so that you can gain a better understanding of how they function and what makes a system energy-efficient. But the bottom line is—you don’t have to remember all of the technical details, but you do need to know how the systems contribute to the greenness of a home and interrelate to create a home’s economy, living environment, and comfort.

Before we begin the study of individual systems, let’s take a look how systems are rated. It’s helpful to know the following terms and acronyms because they are the methods for rating and comparing systems.

HVAC System Ratings

	Stands for	Applies to	Calculation: Is higher or lower better?
SEER	Seasonal Energy Efficiency Ratio	Central air conditioners and heat pumps	Amount of cooling (BTUs) divided by Electricity (watts) consumed over a year's performance. Higher is better. The higher the SEER rating, the more energy-efficient.
EER	Energy Efficiency Ratio	Air conditioners	Same as SEER but evaluates one point in time or a particular set of conditions (temperature and humidity.) Higher is better. The higher the EER rating, the more energy-efficient.
HSPF	Heating Seasonal Performance Factor	Furnaces	Amount of heat produced (BTUs) divided by electricity (watts) used. Higher is better. The higher the HSPF rating the more energy efficient.
AFUE	Annual Fuel Utilization Efficiency	Gas and oil furnaces	Heat output divided by total energy consumed. Higher is more energy-efficient. AFUE 90 means 90% of energy is transformed into heat. Electric heating is AFUE 100%. (Say A-few)
CFM	Cubic Feet Per Minute	Ventilation	Length x width x height of space divided by frequency of air change. The higher the number the faster the change of air in the space.
ACH	Air Changes Per Hour	Ventilation	CFM divided by volume (length x width x height) of space. The higher the number the greater frequency of complete air changes per hour.
COP	Coefficient of Performance	Heating, cooling, and heat pump	BTUs produced divided by BTUs of electricity used Higher is better. The higher the COP, the more efficiently energy is consumed for heat or cooling.

Cooling Systems

The basic function of a cooling system is to remove hot air from a room and replace it with cool. Air-conditioning systems cool the air pumped into the room by transferring the heat in it to a refrigerant. In simplest terms, the more heat that is transferred to the refrigerant, the more efficient the air conditioning system. The most common type of central air conditioner is a split system, which consists of an outside condenser unit and an inside evaporative coil. Package systems combine both the condenser and evaporative coil in one housing.

Central air conditioning systems use the fan, blower motor, and air ducts of the heating system to move cool air through the home. An old furnace (more than 15 years) can considerably reduce the cooling capability of even the newest and most efficient air conditioner. For this reason, it makes sense to replace both systems—furnace and central air conditioner—at the same time.

Cooling system capacity is measured in BTUs, like heating systems. The SEER ratio, however, is the most common performance rating. As of January 2006, air conditioners manufactured in the United States must achieve a SEER rating of 13 or higher; Energy Star air conditioners must achieve a minimum rating of SEER 14 and 11 EER.

Rightsizing

Matching the capacity of the cooling unit to the size of the home, rightsizing, is a major issue in achieving both thermal comfort and energy efficiency. When contractors base cooling systems specifications on temperature extremes, the result is often a system that is too big for the many days of average temperatures. Rightsizing an air conditioning system must take into consideration the climate zone, day and nighttime temperatures, and humidity levels as well as the size and layout of the home; green home design also considers the location's microclimate and site orientation. Another consideration involves the tightness of the building envelope because it presents an opportunity for possible downsizing of the HVAC systems. While an over-capacity system will cool a home quickly, the system can cycle off before removing an adequate amount of humidity, resulting in clammy air. Furthermore, frequent on-off cycles create temperature swings and cause more wear and tear on the equipment.

Air Source Heat Pumps

Air source heat pumps are an option for moderate climates. Most split systems consist of a compressor and two copper tubing coils (one indoors and one outside), surrounded by aluminum fins to aid heat transfer. In the heating mode, liquid refrigerant in the outside coils extracts heat from the air and evaporates into a gas. The indoor coils release heat from the refrigerant as it condenses back into a liquid. A reversing valve, near the compressor, can change the direction of the refrigerant flow for cooling.

Cooling Systems in Brief

Air conditioning system efficiency reduced by

- Incorrect level of refrigerant
- Old blower motor
- Duct leakage
- Obstructions of airflow
- Thermostat exposed to heat as from sunlight
- Condenser unit exposed to rain, snow, vegetation
- Inadequate insulation—insulation aids cooling and heating, keeps conditioned air contained
- Heat buildup in attic and from appliances

Green Options

- **Use natural cooling**
  Deciduous trees planted on south- and west-facing sides
- **Reduce heat build-up**
  - Reflective window shades or drapes
  - Close curtains on south and west windows
  - Awnings and deep overhangs
  - Open attic vents
  - Use window and exhaust fans placed to expel warm air and draw in cool outside air
- **Evaporative cooling**
  - Suitable for hot, dry climates, also called swamp coolers or desert coolers
  - Uses water evaporation to reduce interior temperature. Outdoor air passes over water-saturated pads and is cooled before transferring inside
  - Windows or vents remain open to allow displacement of warm interior air
  - Low electricity usage, but continuous water usage—a consideration in water-scarce areas
  - Added humidity swells wood paneling and doors and causes pianos to go out of tune

Energy Star Ratings

- Central air conditioners: SEER 14, EER 11
- Room air conditioners: EER 9.4–10.7 depending on BTUs

IAQ Considerations

- Dirt build up on air filters lowers efficiency
- Clogged condensate drain on central unit can cause water damage inside home, increase indoor humidity, and provide a breeding place for mold and bacteria

Programmable Thermostat

- Improves system efficiency and thermal comfort
- Dept. of Energy setpoint recommendations:
  - 78° evenings and mornings (upon waking)
  - 80°–82° during sleeping hours
  - 85° while home is unoccupied
- Model Options
  - **7-day** models—different setting for each day
  - **5+2 day** models—same schedule Monday–Friday, different one Saturday and Sunday
  - **5+1+1 day**—same schedule Monday–Friday, different settings for Saturday and Sunday
- No longer rated by Energy Star

Information Sources

Visit these sites for authoritative information on systems, ratings, rightsizing, and quality testing:

- Database of State Incentives for Renewables and Efficiency, ***www.dsireusa.org***
- Energy Star, ***www.energystar.gov***
- Consortium for Energy Efficiency (CEE), ***www.cee1.org***
- Air Conditioning, Heating, and Refrigeration Institute (AHRI), ***www.ahrinet.org***

Heating Systems

The basic operation of a forced-air furnace passes cool air (from the home interior or outside) over a heated surface called a heat exchanger. The heat exchanger warms the cool air and sends it through ducts to warm air registers. Boilers heat water or steam, which circulates through a system of radiators. Natural gas fuels most U.S. homes; oil comes second, particularly in the northeast where access to natural gas can be limited. Electric furnaces are almost 100 percent fuel efficient (AFUE 100) and require no venting because there are no combustibles, but are usually less cost-effective because electricity is more expensive than natural gas.

In the following discussion of heating systems, keep in mind that AFUE is a rating of how much of the fuel is converted to heat. It doesn't take into consideration the amount of heat lost through leaky ducts, drafts, inadequate insulation, or the electricity needed to operate the furnace.

High-Efficiency Furnaces

High-efficiency furnaces use fuel more completely, usually have larger primary heat exchanges, and may have additional heat exchangers to wring even more warmth out of heated air. Because of these additional components, high-efficiency furnaces tend to cost more than those with lower AFUE ratings. But contractor markup and installation charges are a major variable; gathering several estimates, even for installation the same model, is a good idea.

Natural gas powers the most efficient furnaces though some may run on oil, propane, or electricity. To qualify for an Energy Star label, gas furnaces must have an AFUE rating of 90 or better.

Different efficiency standards complicate comparisons of various types of systems. For example, air source heat pumps are rated by SEER, while furnaces are rated by AFUE. To help your clients and customers understand the different standards, remind them that Energy Star compares, evaluates, and rates a system relative to its type.

Heating Systems in Brief

Low Efficiency

- Natural drafting chimney
- Continuous burning pilot light
- Large case and heavy heat exchanger
- AFUE 68%–72%

Mid Efficiency

- Fan controls exhaust and combustion air
- Compact size and light weight, recyclable
- Small diameter flue pipe
- AFUE 80%–85%

High Efficiency

- Condensing flue and multiple heat exchangers
- Sealed combustion
- Electronic ignition
- AFUE 90%–97%

Potential Energy Wasters

- Leaky duct work and connections
- Kinks in flexible ducts
- Dirty burners and air filters
- Cracks in heat exchangers reduced heating capacity and can cause carbon monoxide fumes in the home and fire

Energy Star AFUE Ratings

- Gas furnaces: AFUE 90
- Oil-fired furnaces: AFUE 85
- Boilers AFUE: 85

The Federal Trade Commission requires new furnaces and boilers to display AFUE ratings in order to facilitate comparison of the heating efficiencies of various models.

IAQ Considerations

- Combustion fumes
- Dust circulated through ducts
- Carbon monoxide danger
- Forced air heat causes indoor dryness
- Improper venting and leaky ducts allow fumes into the home

Energy-Thrifty Thermostat Settings

Dept. of Energy setpoint recommendations:

- 70° evenings and mornings (upon waking)
- 62° during sleeping hours
- 62° while home is unoccupied

Green Options

- Electronic ignition eliminates continuously burning pilot light
- Sealed combustion uses outside air, reduces drafts, and improves safety
- Programmable thermostat
- Insulate ducts in unconditioned spaces like attics, garages, and crawlspaces
- In northern climate zones, close drapes at night to keep heat in, open drapes on south-facing windows during daytime

Information Sources

Visit these sites for authoritative information on systems, ratings, quality testing, and incentives:

- Database of State Incentives for Renewables and Efficiency, ***www.dsireusa.org***
- Energy Star, ***www.energystar.gov***
- Consortium for Energy Efficiency (CEE), ***www.cee1.org***
- Air-Conditioning, Heating, and Refrigeration Institute (AHRI), ***www.ahrinet.org***

Green Choices

- **Zoned systems**: In a conventional home, one thermostat controls temperature levels for the entire house. The thermostat cycles the heating (or cooling) system off and on based on the temperature in that room and cannot sense temperature levels in other rooms. The result in most homes is hot and cold spots and a family battle over thermostat settings. Zoned systems provide an energy-efficient, and family harmony preserving, solution as well as an alternative to costly separate systems for different parts of the house. Zoned systems are particularly effective for multilevel and large homes as well as those with large south-facing windows and finished basements and attics. Of course the ability to isolate rooms adds to the efficiency of zoned systems.

  Zoned systems divide the home into two or three areas (zones) with similar heating needs; for example, the living room, dining room, and kitchen might comprise one zone and the bedrooms another. With the installation of a multizone programmable thermostat and a few motorized dampers in the ductwork, the output of warm, or cool, air can be directed to the zones where it is most needed and deflected from areas like unoccupied bedrooms.

- **Condensing furnaces**: These systems capture the heat in the water vapor produced by combustion exhaust and extract heat from it by passing it though an additional heat exchanger. This extra cycle can boost AFUE ratings by 10 percent compared to noncondensing models. A downside is that the vapor condensation process produces several gallons of water daily, which must be routed to a drain. A key feature to look for when buying a condensing gas furnace is a long-term warranty on the heat exchanger; the best types resist the corrosive effects of moisture. On the plus side, condensing furnaces may be vented through a wall with inexpensive PVC pipe, instead of a chimney or rooftop flue.

- **Sealed combustion**: Sealed combustion furnaces draw outside air for combustion through a sealed passage direct to the burner and exhaust flue gases direct to the outside through a separate, sealed vent. As a result, sealed units pose little danger of carbon monoxide and combustion fumes escaping into the home. Sealed units do, however, produce acidic exhaust gases that must be vented through a duct. If exhaust gases vent through the chimney, it must be lined with fireclay masonry or a metal flue liner.

- **Electronically Commutated Motor**: An electronically commutated motor (ECM) is a brushless, direct current motor technology that can

be integrated into a forced air heating system. The ECM sensors react to changes in duct pressure and vary the blower motor speed to maintain an even flow of heated air. An ECM can reduce the electrical consumption of the furnace motor by as much as 60 percent compared to standard furnace blower motors.

Rightsizing

Matching furnace capacity to home size and climate—rightsizing—is important, just as it is for cooling systems. An under-capacity system will not provide adequate heat. An over-capacity heating system on the other hand can result in the wide temperature swings plus wear and tear of frequent on-off cycles.

Heating contractors can take advantage of online software programs to calculate the right size of furnace for the home. These tools produce more reliable results than estimates. Before investing in an expensive system, a homeowner should look for a contractor who uses one of these applications to rightsize the system.

Solar Heating—Active and Passive

Solar heating—whether active or passive—deliver the best combination of savings and comfort when they are used to replace a more expensive form of energy like gas or electricity. But total dependence on solar heating is not realistic in most homes and a supplement backup heating system is needed. Furthermore, most lenders and building codes require installation of a backup system.

The “brain” of a solar heating system is a differential thermostat that measures the difference in temperature between the collector and storage unit. When the collectors are warmer than the storage unit, the thermostat signals a pump or fan to circulate air or water through the collector to heat the storage medium or the house.

Active Solar Heating

Active solar heating systems are one of two types based on the medium—liquid or air—used to capture and store solar energy. The systems absorb solar radiation into the liquid or air and then relay the

heat directly to the indoor environment or to a storage unit for later distribution. Electric fans or water pumps distribute the solar heat.

- **Hydronic systems**: Active systems that use water or an antifreeze solution as a solar collector combine particularly well with radiant floor heating systems. Although it takes longer to heat up from a cold start, once operating, the solar-heated radiant system provides a consistent level of heat. A supplemental boiler or even a standard water heater can supply backup heat.
- **Air systems**: Active air-based systems use a collector consisting of a black metal absorbing plate covered with glazing. The sun heats the air in a gap between the glazing and the absorber. A fan pulls cold air from the room through the collector and replaces it with warm air. Wall-mounted collectors, sometimes called thermosiphon air panels, can be placed on south-facing walls with openings cut through the wall for air inlets and outlets. Air systems can heat individual rooms or the whole house when combined with an air-source heat pump. The systems are, however, less efficient than hydronic because air is a less effective transfer medium than liquid.

Solar heating components

Thermal mass flooring

Thermosiphon air pump

Trombe wall

Solar heating panels

Photos National Renewable Energy Lab, www.nrel.gov

Passive Solar Heating

As the term implies, passive solar heating uses no mechanical systems or appliances. A passive solar heating system requires the following five elements.

- **Aperture (collector):** A large south-facing glazed area through which sunlight enters the homes. It should receive full, unshaded sunlight daily between 9:00 a.m. to 3:00 p.m.
- **Absorber/thermal mass:** This hard, darkened surface absorbs, stores, and releases warmth from the sun. The surface could be a masonry wall (like a trombe wall), floor, or partition.
- **Distribution:** A passive design uses the three natural heat transfer modes—conduction, convection, and radiation—to circulate solar heat from the collection and storage points to different areas of the house. Fans, ducts, and blowers may sometimes augment heat distribution.
- **Control**: A simple control feature like a roof overhang, awnings, or blinds deflects solar heat gain during summer months. A differential thermostat that signals a fan to turn on and operable vents and dampers to open helps manage heat flow.

Trombe Wall

The trombe wall, patented in the 1880s, is an old technology for passive solar heating adapted for modern application. The basic design involves a thick south-facing masonry wall that absorbs solar heat, which migrates through the wall to the interior of the home. A modern alternative to a masonry trombe wall is a double-pane glass wall. A wide space between the panes is filled with water, which absorbs solar energy without blocking the benefit of natural illumination. The heat captured in the water between the glass panes radiates into the room. During hot weather a trombe wall may need the protection of an overhang, awning, or natural shade.

More Green Heating Choices

Radiant Heating

Radiant heating works best in a space where the occupants need quick heat but don't require whole-room heating, such as a workshop. It is very efficient because it heats people, not the whole room. Radiant heaters provide a steady stream of heat or hot air to warm the people within the reach of the heater. Don't confuse this type of radiant heating with radiant floor heating.

Radiant wall heater installation. Photo National Renewable Energy Lab, www.nrel.gov

Radiant Floor Heating

The most cost-effective radiant heating system is a hydronic floor system. Electric radiant floor heating is an alternative to a hydronic system, but the cost of electricity usually makes it a less economical solution. In a hydronic system, water heated by a boiler, solar, or ground-source heat pump circulates through pipes installed in the subfloor. Heat radiates evenly from the floor, providing consistent thermal comfort. Radiant heaters also can be installed on walls and ceiling panels, but heat rising from the floor provides the most even heating. For best efficiency the floor covering should be a good conductor like ceramic tile. Hardwood, engineered wood, stone, or vinyl can be used but conduct less heat than tile. Carpets and rugs decrease heating efficiency.

Zero energy loss through ducts or flues makes radiant floor heat extremely energy-efficient. Because there are no combustion exhaust fumes to vent or air forced through ductwork, radiant is an excellent choice for people with allergies and respiratory problems.

The main downside of radiant floor heating is installation cost. And, because it does not offer cooling, a separate cooling system must be installed. The expense is hard to justify in mild climate zones but in cold climates, once installed, it is extremely energy-efficient and cost-effective.

Radiant floor heating installations

Photo Aldo Leopold Foundation, Leopold Legacy Center Construction Journal, Report 15.2—Mechanical Systems, www.aldoleopold.org

Photo National Renewable Energy Lab, www.nrel.gov

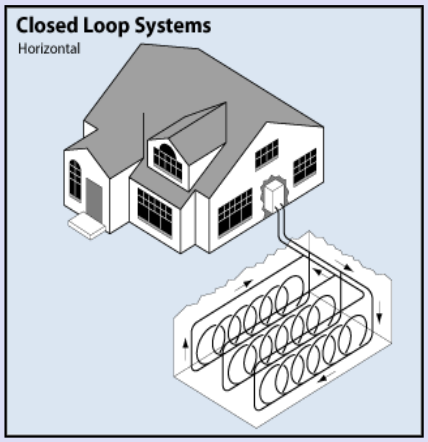
Air Source Heat Pump

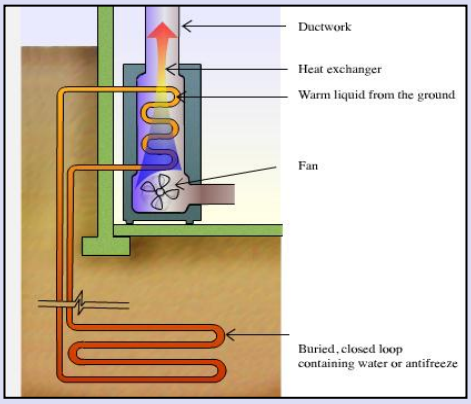
An air source heat pump (ASHP) uses heat transfer instead of fuel combustion to produce heat. The air source pump draws in warm outside air and pumps it across heating coils filled with a refrigerant. In heating mode, the refrigerant extracts heat from the air and evaporates into a gas, and the indoor coils release heat from the refrigerant as it condenses back into a liquid. When the temperature drops below 40° a panel of electric resistance coils, like those found in a toaster, kick in to supply additional heat. The pump can cool the inside air by reversing the process. This technology is most suitable and efficient in moderate climates. Energy Star-qualified ASHPs have higher efficiency ratings than conventional fuel-based models. Energy Star ratings for air source heat pumps are HSPF 8.0–8.2, SEER 14.0–14.5., and EER 11–12.

Geothermal Heating and Cooling

Geothermal heating and cooling using ground-source heat pumps offers one of the greatest savings in energy efficiency. While many parts of the country experience seasonal temperature extremes, a few feet below the earth's surface the ground maintains a constant temperature between 45° and 72°. Geothermal heating and cooling takes advantage of this by exchanging heat with the earth through a ground source heat exchanger or pump. A ground-source heat pump is a two-way air conditioner that heats or cools by exchanging heat with the ground through buried loops. If so equipped, it also can supply the house with hot water.

Geothermal heating and cooling

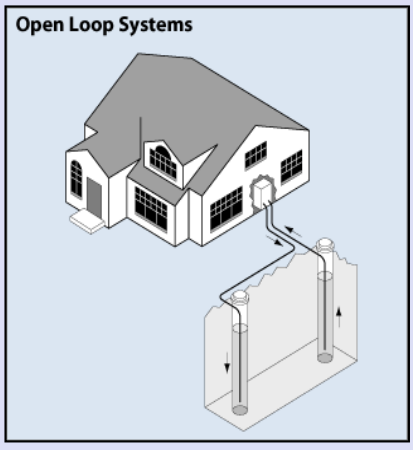




*Ground source heat pump**

Geothermal system underground pipes

Ground source heat pump



Excavation for underground loops

** Reprinted with permission of the California Energy Commission Consumer Energy Commission, www.consumerenergycenter.org. Photos and diagrams National Renewable Energy Lab.*

The largest systems component consists of a series of heat-conducting pipes, called loops, buried in the ground below the frost line. The loops circulate water or antifreeze that absorbs or relinquishes heat depending on whether heating or cooling is needed. Geothermal systems cost more upfront, but the potential energy savings far exceed any other type of system. The most efficient fuel-burning heater can reach efficiencies around 95 percent, but a geothermal heat pump can move up to four units of heat for every unit of electricity needed to power the system, resulting in a practical equivalence of more than 400% efficiency.[2]

Ventilation

Greener, more energy-efficient homes rely on tighter building envelopes to reduce air leakage. However, buildings still need ventilation to mitigate moisture and combustion build-up and supply a stream of fresh air. Ventilation and indoor air quality are inseparable whether bringing in a stream of renewing fresh air or pulling stale air, odors, and fumes out of the home.

Green Choices

- **Natural ventilation**: The greenest way to ventilate a home is natural ventilation. Breezes combined with the chimney effect created by moving air keeps the inside air freshened and cool. In moderate climates and breezy coastal areas, natural ventilation may provide adequate year-round comfort. Natural ventilation can be enhanced or deflected by site orientation and tree or hedge windbreaks.

  Avoiding heat build-up is the main issue for natural ventilation. In a home, windows near the top of the house, such as clearstory windows or operable skylights, help prevent heat build-up as well as enhance the natural chimney effect. In hot, humid climates, attic louvers and vents can reduce heat build-up in that space by 30°.

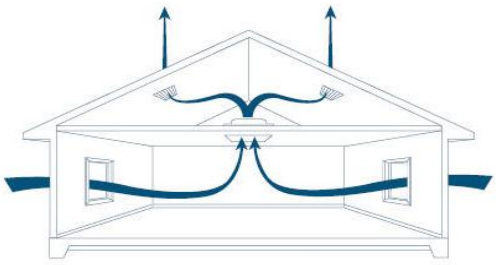
- **Whole House Fan**: A whole house fan enhances natural ventilation and in moderate climates may provide an adequate substitute for energy-intensive air conditioning on many days. A whole house fan installed in the attic pulls air in through windows and vents and exhausts it through vents in the attic and roof. It can supply 30–40 air changes an hour. A whole house fan must, however, be operated with open windows in order to prevent a powerful, concentrated

[2] Geothermal Heat Pump Consortium, www.geoexchange.org.

suction. If air intake is inadequate, dangerous back drafts from combustion sources like the furnace or water heater can be drawn into the house.

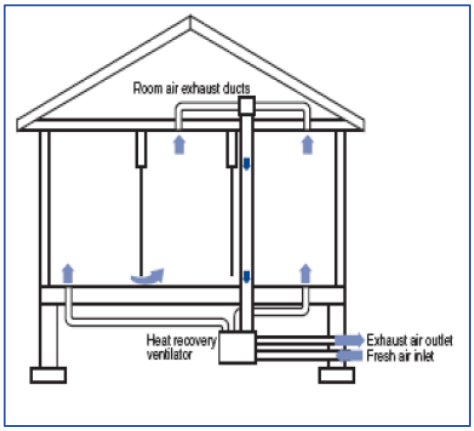
A downside to whole-house-fan ventilation is potential noise from the unit. Proper installation including rubber or felt gaskets can minimize noise issues.

Whole house fan



Reprinted with permission of Alameda County Waste Management Authority & Source Reduction and Recycling Board, Home Remodeling Green Guidelines, www.stopwaste.org.

- **Heat Recovery and Energy Recovery Ventilation**: If a whole house fan can help cool a home, is there a system that can help retain warmth? Two types of recovery systems can be integrated into the home to transfer heat from warm inside air exhaust to fresh air drawn in: heat recovery ventilation (HRV) or energy recovery ventilation (ERV). The systems also can enhance summer cooling by cooling the warm intake air. Both types include a heat exchanger and fans to move air. The main difference is that the heat recovery system transfers warmth between intake and exhaust air but the energy recovery system also transfers water vapor. An ERV system maintains an even humidity level in the home by transferring humidity in the incoming air to the drier interior air. The ERV system should be turned off if atmospheric humidity is very high.



Indoor airPlus

The EPA Indoor airPLUS guidelines encompass construction specifications for careful selection and installation of systems for heating, cooling, ventilation, moisture control, and radon control as well as offgassing materials.

In order to earn the Indoor airPLUS qualification, a new home must first qualify for the Energy Star certification. Earning the Indoor airPLUS label requires inspection by an independent third party to ensure verification with guidelines and specifications. The result is a home that is energy efficient, emits few greenhouse gases, and provides a healthy indoor air quality.

Indoor Environmental Quality

Indoor environmental quality (IEQ) is a broad concept that encompasses indoor air quality (IAQ) as well as other comfort factors like aesthetics, light, acoustics, and control of heating and cooling.

IEQ is a particular priority in commercial buildings where studies have shown correlations between the quality of the workplace environment and worker productivity. The EPA defines IEQ as the quality of the inside air and environment that affects the health, comfort, and performance of occupants; for example:

- **Acoustics:** diminishing noise distraction from other occupants or outside activities
- **Glare:** deflecting excessive glare from daylight and other light sources
- **Thermal comfort:** balancing heating, cooling, and ventilation
- **Aesthetics:** designing a comfortable and convenient interior layout that integrates with the surrounding outside natural and built environment
- **Controls**: access and ease of control of heat, cooling, light, and ventilation

The concept and impact of indoor environment quality is important to keep in mind throughout the following discussion of home systems, especially for lighting.

Lighting

In the average home, lighting accounts for about 15 percent of energy usage. Many homeowners would be surprised to learn that conventional multibulb light fixtures, like dining room and foyer chandeliers, are among the highest wattage fixtures in the house and the bathroom vanity is one of the highest usages. Replacing incandescent bulbs in these fixtures with compact fluorescent lamps (CFLs) is a simple green option. As we'll see in the following discussion, aesthetically pleasing and energy-efficient interior illumination can be incorporated into home design and construction.

Does replacing one light bulb make a difference?

According to the Department of Energy, if every American home replaced just one incandescent light bulb with one Energy Star CFL bulb we would save enough energy to light 3 million homes for a year, save about $600 million in annual energy costs, and prevent 9 billion pounds of greenhouse gas emissions per year equivalent to those from about 800,000 cars.

CFL versus Incandescent Bulbs

A couple of shortcomings of compact fluorescent lamp (CFL) bulbs, in comparison to incandescent bulbs, slowed early consumer acceptance. Flip the light switch and the incandescent bulb instantly lights up. For CFL bulbs, however, there is a slight delay before the bulb lights up. Although only a split second delay, the eye perceives it and some find it annoying. Early CFL models were not dimmable but newer models can be dimmed. Incandescent bulbs give off a warm amber light; CFL bulbs on the other hand tend to emit a white or blue-tinged light. Energy Star CFL bulbs in the range of 2700k–3000k match the color range of incandescent bulbs. (The color-quality of light is based on temperature and measured on the Kelvin (k) scale.) When first introduced in the marketplace, the price of CFL bulbs was considerably higher than incandescent bulbs but CFL prices are dropping quickly.

Much anecdotal evidence praises the ability of full spectrum light bulbs, which aim to simulate natural sunlight, to alleviate seasonal affective disorder resulting from lack of sunlight. But full spectrum lighting is more

of a marketing term than a scientific one. The brightness of full spectrum bulbs, however, gives them excellent color-rendering capability.

Light Emitting Diode (LED) Bulbs

LED bulbs are even more energy-efficient and long-lasting than CFL bulbs. Residential use of LEDs has been slow to catch on because of cost. LED bulbs have some advantages over incandescent and CFL bulbs. The greatest advantage is probably bulb light. Energy Star estimates a 25,000-hour bulb life for residential use, which means an LED light installed in an infant's room won't need to be changed until she graduates from college. LED bulbs not only burn longer, they also give off less heat. Another advantage of LEDs is directional light. Incandescent bulbs give off light in all directions; LEDs emit light in one direction, which makes them a good choice for task lighting and down lighting. And unlike CFLs, the bulbs can be tinted any color. Watch for expanding model options and dropping prices for LEDs.

The Light Bulb Ban?

In 2007, the U.S. Congress passed a bipartisan Energy Independence and Security Act. Among the provisions of the 800-page Act was a phase-out of the familiar incandescent light bulb. The Act mandates phase out of manufacture in three steps: December 2011, January 2013, and January 2014. Although CFL bulbs consume far less energy than incandescent bulbs and last 3–4 times longer, consumer acceptance has been lukewarm. Why? CFL bulbs:

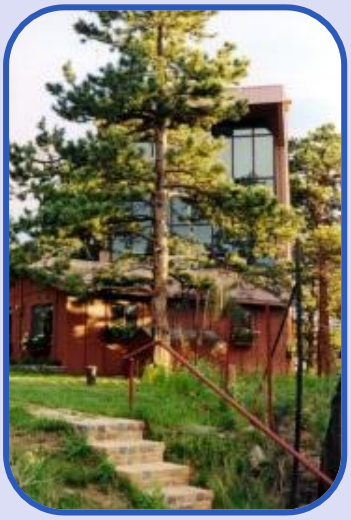
- Produce a cool, blue-tinged light, unlike the warm amber tone of incandescent bulbs
- Have a delayed-on versus incandescent instant-on
- Cost significantly more, $3–$10 per bulb

A small amount of mercury contained in CFL bulbs raises concerns about proper disposal and handling in case of breakage. Federal legislation to repeal the "light bulb ban" has gathered numerous congressional sponsors but so far has not progressed. Some consumers have reacted by stocking up on incandescent bulbs.

Daylighting

Daylighting—natural illumination—provides both energy savings and an aesthetically pleasing connection between the outdoor and indoor environments. An effective daylighting strategy must balance illumination needs with thermal comfort or the potential benefit is far outweighed by extra air conditioning. The experience of too much interior sunlight, especially in hot climates, is as simple as sunbathing on a warm day; too long or bright an exposure leaves us sweat covered, squinting against glare, and sunburnt.

Daylighting strategies start on the architect's drawing board

Exterior	*Building Envelope*	*Interior*
		
▪ Light pattern and sun angle analysis ▪ East-west site orientation ▪ Natural shading	▪ Window placement ▪ Glazing quality ▪ Top lighting and skylights ▪ South-facing windows, overhangs	▪ Open floor plan ▪ Non-glare surfaces on walls and floors ▪ Solar control— blinds ▪ Supplement task lighting

Photos National Renewable Energy Laboratory, www.nrel.gov

Daylighting strategies start on the architect's drawing board with a thorough analysis of the sunlight patterns and angles of the building site. This analysis helps the architect plan the site orientation and home design to take advantage of solar illumination and energy while avoid the negative aspects of overheating and glare. For nighttime and cloudy days, the next goal is to augment natural daylight with strategies that provide both an appropriate quantity and pleasing quality of light.

Appliances

After heating and cooling, appliances are the next largest use of home energy. Choosing Energy Star appliances provides two benefits:

- Lower energy costs
- Tax credits, incentives, and product rebates

Energy Star partners may also sponsor recycling incentives for proper disposal of old products like refrigerators and air conditioners.

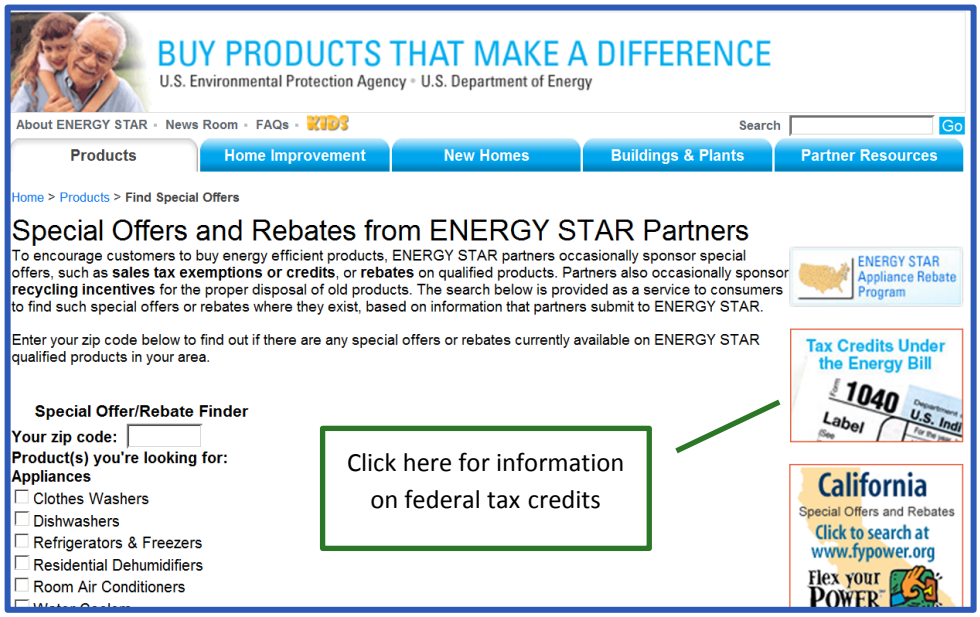
Although the dollar savings from any one appliance may not seem like much, when all are added together the enhanced efficiency of Energy Star appliances can make a significant impact on a household's annual utility expenditures.

The EPA estimates the following savings for Energy Star appliances:

- Refrigerators—20%
- Clothes washers—37%
- Dehumidifiers—15%
- Dishwashers—10%
- Freezers—10%
- Room air cleaners and purifiers—40%
- Water heaters—10%–20%
- Water coolers—45%

Credits, rebates, and special offers at www.energystar.com

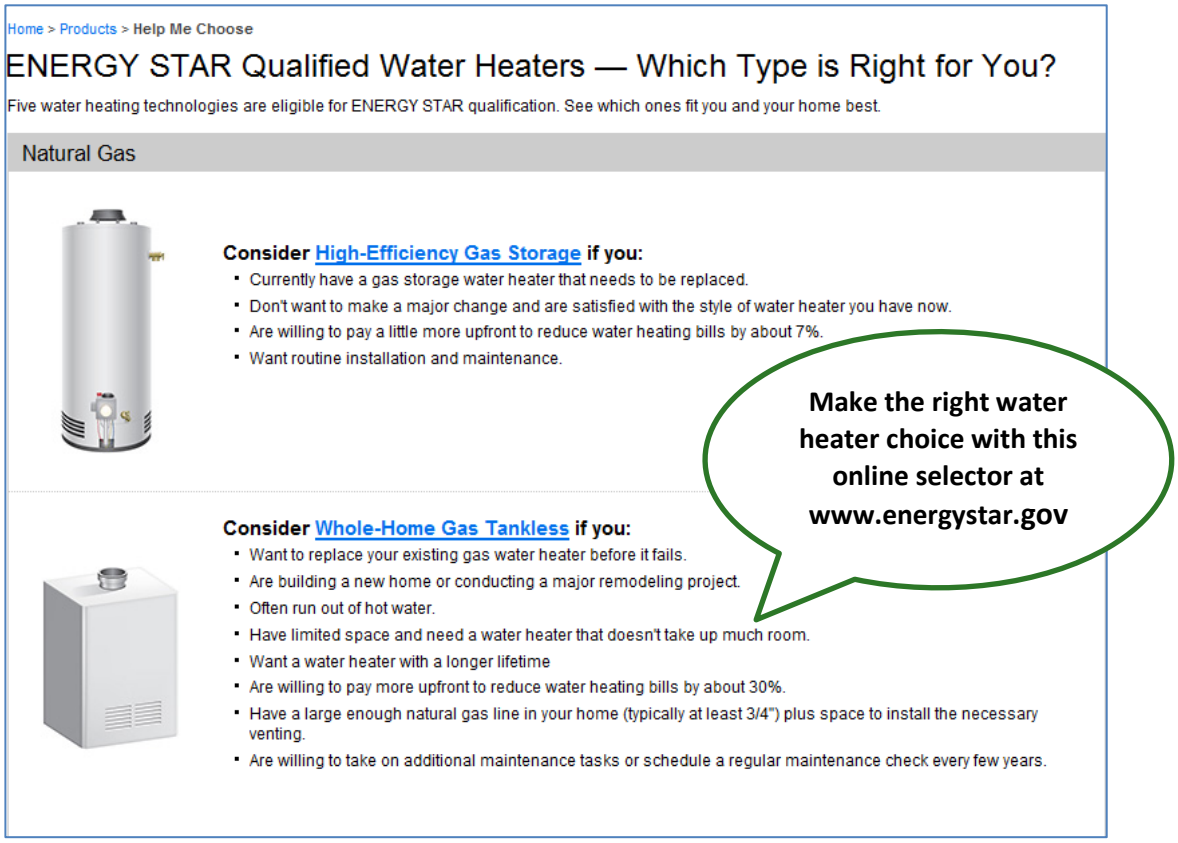
Real estate professionals can provide a valuable service for clients and customers by directing them to this Energy Star webpage for information on special offers and rebates.



This directory of rebates and incentives, searchable by Zip Code, is available at the Energy Star website. ***Click on special offers at www.energystar.gov.***

Water Heating

Among green choices for home systems, water heaters offer a wide range of energy-efficient, water-thrifty options. Depending on climate and site orientation, the water heating may be completely dependent on solar energy or supplemented by a conventional or tankless heater. As we'll see in the following discussion of green options, technologies include drain water heat recovery systems, on-demand water-circulation pumps, tankless water heaters, and other types.



Green Choices

- **Insulation**: An inexpensive but very effective solution with a quick payback time frame is wrapping a water heater with a jacket of insulation. Electric water heaters are generally easier to wrap than gas- or oil-fired water heaters. Insulation on pipe sleeves and around hot water pipes prevents heat loss of the water in the pipes and decreases the wait time at the faucet, which also conserves water.
- **Solar hot water heater**: Depending on climate and site orientation, the water heater may be completely dependent on solar energy or supplemented by a conventional heater. One drawback of total dependence on solar water heating is day-round supply. Hot water is available in the evening, after a full day of solar heating, but not in the morning when overnight temperatures allow water to cool. A supplement electric heater can remedy this drawback. Solar water heater systems include direct and indirect methods.
  - **Direct-pumped system:** Solar energy collectors on the roof connect to a storage tank installed somewhere below, usually in a

garage or utility room. A pump circulates the water between the tank and collector. This is called a direct (or open loop) system because the sun's heat is transferred directly to the potable water circulating through the collector tubing and storage tank; no anti-freeze solution in the collectors or heat exchanger is involved.

- **Indirect-pumped system:** An antifreeze solution circulates through the collector, and a heat exchanger transfers the heat from the antifreeze solution in the collector tubes to the tank water. This system is used in northern climates.
- **Integral collector storage (ICS) system:** This type of system combines the collector and storage system. Cold water flows progressively through the collector to be heated by the sun. Hot water is drawn from the top and cold replacement water flows into the bottom. Pumps and controllers are not required.

- **On-demand water-circulation pumps**: On-demand water circulation pumps rapidly move water from a water heater to fixtures. The device saves water by reducing the wait time at the faucet.

Tankless water heaters

The tankless water heater produces hot water on-demand instead of storing a tank of heated water for later use like conventional water heaters. When the hot water faucet is turned on, cold water flows through a heating device and directly to the faucet. Tankless water heaters save energy because none is used to maintain the temperature of water in a tank. Heating units close to the faucet shorten the wait time.

- **Tankless water heaters**: Tankless water heaters are particularly useful for remote bathrooms or hot tubs, as a booster for appliances, or as a backup for a solar water heating system. They deliver a continuous flow of hot water at 2–5 gallons per minute. A large home may require several units in order to meet household needs.
- **Tankless coil indirect water heaters**: Another form of tankless water heating, the coil heater uses the main furnace or boiler as a heat

source. Because this system relies on the furnace, they are most efficient in climates with a high number of heating days. Indirect water heaters, like coil heaters, use the furnace as an energy source, but the heated water is stored in a side tank, which alleviates the need to fire the furnace each hot water demand.

- **Drain water heat recovery systems**: Drain water heat recovery systems recover the heat from used water, reducing the energy required to heat fresh water.

EPA WaterSense

The EPA's WaterSense program promotes water usage efficiency and conservation by qualifying products and new homes. The program seeks to:

- Decrease indoor and outdoor non-agricultural water use through more efficient products and practices
- Help consumers make water-efficient choices of products and services and adopt simple daily activities to reduce water usage
- Establish and standardize certification criteria that ensure product efficiency, preferences, and quality.

The EPA also provides the WaterSense label to qualified new homes. The EPA estimates that WaterSense homes can save up to 10,000 gallons of water a year—enough water to fill a swimming pool. Qualified homes must feature WaterSense labeled plumbing fixtures, hot water systems, and water-thrifty landscaping. Clothes washers and dishwashers must be Energy Star appliances. Builder partners provide buyers of WaterSense qualified homes a certificate signed and dated by an inspector and the licensed certification provider. Find builder partners, inspectors, and certification providers at ***www.epa.gov/WaterSense***.

Two more green choices

Dual flush toilet

Low flow faucet
Photo courtesy of greenplumbing.com

Greywater

One topic of special interest in meeting sustainability goals in green homes and buildings is reuse of greywater. Potable wastewater is either greywater or blackwater, depending on the initial use. Wastewater contaminated by human or animal waste is often referred to as blackwater. Greywater results from low-contamination uses like hand washing, laundry, and bathing. Reusing greywater conserves freshwater and reduces the volume of water sent to sewage systems.

Building codes in some municipalities restrict the use of greywater. However, codes are changing quickly in response to public pressure and the need to conserve water in dry areas.

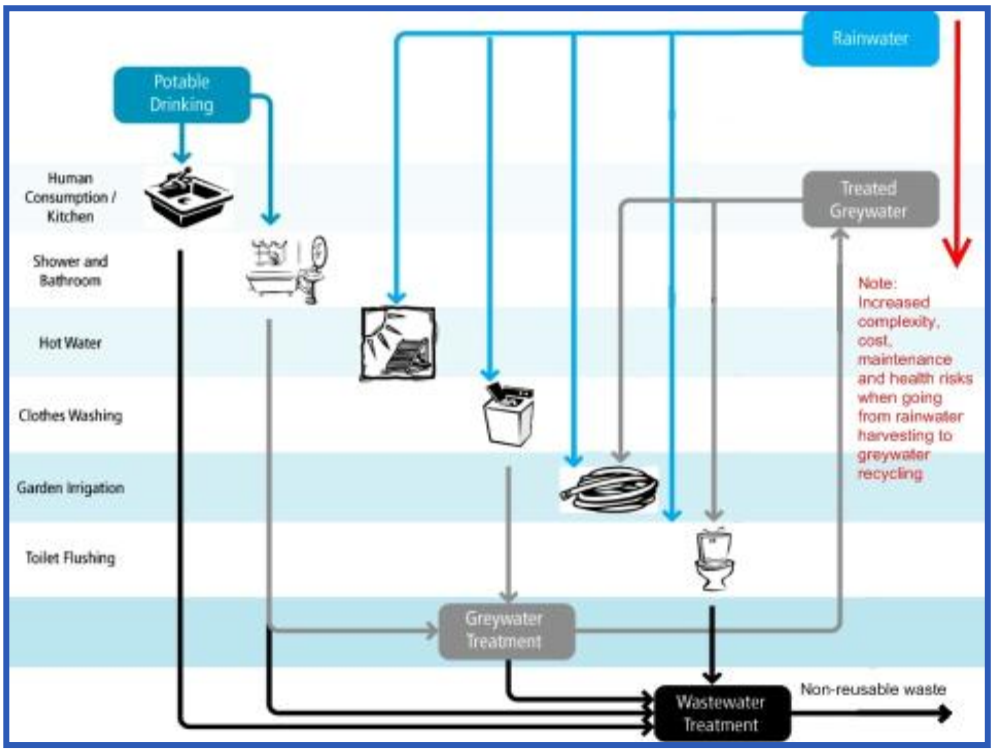
Greywater can be used in applications that do not require potable water, such as irrigation and toilet flushing. Depending on the application and the degree of contamination, it may require treatment before reuse. Treatment methods include filtering, disinfection, and settling tanks. Qualified professionals should be consulted if a client or customer is interested in greywater reuse, as the water is still contaminated and may cause illness or result in contamination of plants or soil if used improperly. The New Mexico State University College of Agriculture and Home Economics suggests the following guidelines[3] for using greywater to irrigate plants:

- Attach a cloth bag to the end of a hose to filter greywater when applying
- Apply only to flat areas where runoff is unlikely
- Disperse over a large area, and rotate with fresh water to avoid buildup of sodium salts
- Apply directly to the soil; avoid any method, like sprinklers, that allows contact with the above-ground portion of the plants
- Use only on well-established plants, not seedlings or young plants
- Do not use on root crops that are eaten uncooked
- Avoid use on plants that thrive only in acid soil (greywater is alkaline)

[3] New Mexico State University College of Agriculture and Home Economics, "Safe Use of Household Greywater," http://www.cahe.nmsu.edu/pubs/_m/m-106.html.

Dual plumbing system for greywater and rainwater recycling

Recycling greywater (and rainwater if used in interior) for household use requires a dual plumbing system for potable and non-potable water.



Graphic courtesy of AECOM Opportunity Down the Drain? Published at Speak Up, Winnipeg. Available at: www.speakupwinnipeg.com.

Water Management—Outside

In a natural hydrological process water from rainfall and snowmelt filters through the ground to nourish plant life and replenish aquifers. Impervious surfaces, such as asphalt driveways, paved parking lots, sidewalks, and roads, inhibit this natural process. Instead of percolating into the ground, storm water washes directly into storm sewers or waterways and carries with it debris, silt, and pollutants like road salt, oil, and nitrogen from fertilizers. Communities expend tremendous amounts of energy to manage storm and wastewater removal. Any steps that begin at home can make a huge difference when adopted community wide. In the preceding section we look at ways to recycle household greywater. Now let's look at possibilities for managing water from storm runoff.

Green homes and buildings are designed to minimize impact on hydrological cycles, conserve water, reduce runoff, and manage and collect storm water for use in landscape irrigation and bathroom facilities. Storm water runoff management must be attuned to the context of the house. Low density and high density developments have different challenges and possibilities to limit damaging runoff.

Green Choices

- **Pervious surfaces**: Permeable paved surfaces—roads, parking lots, driveways, sidewalks—that allow rainwater to seep through prevent soil-eroding runoff. Permeable surface options include:
  - Porous asphalt: Appropriate for pedestrian-only areas and very low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls
  - Porous concrete: Pebbled, open surface that is roller compacted
  - Grid systems: High-strength plastic grids (often made from recycled materials) filled with gravel on top of an aggregate and topsoil that allows grass growth on the surface
  - Block pavers: Porous surface with the aesthetic appeal of brick, stone, or other interlocking paving
- **Bioswales and rain gardens**: Bioswales and rain gardens mimic the action of natural wetlands by collecting storm water runoff from roofs, driveways, and other impervious surfaces. By slowing and retaining storm water runoff, they facilitate aquifer-restoring seepage. Bioswales are basically ditches that slope to a particular point and rain gardens are planted on level surfaces. A swale, however, may end with a rain garden. Plants must be able to tolerate standing water for several days. In addition to managing runoff, bioswales and rain gardens provide food and shelter for wildlife.
- **Rain barrels**: An example of an old technology adapted for modern use is the simple rain barrel. Water catchment arrangements can be as complex as underground cistern systems or a simple as a downspout connected to a rain barrel. “Free” rainwater can be used for irrigation without any need for filtering. Reuse for household purposes, like clothes washing or toilet flushing, require filtering through dual plumbing systems.
- **Xeriscaping**: Landscaping that conserves water and protects the environment by planting drought-resistant native plant species is called xeriscaping.

Green choices for water management

Permeable pavement

Sidewalk with curb cut

Xeriscaping with native plants

Pervious walking trail under constructions

Interlocking permeable pavers

Rain gardens provide wildlife habitat

Rain barrel

Deep root plants encourage seepage

Combined bioswale and rain garden

Discussion Question

What innovative ways to manage water resources do you know about?

The Next Chapter

Throughout this chapter we've looked at green choices for home systems from the inside to outside. In the next chapter we will learn about a distinct home system that interrelates with almost all of the others and holds the promise for net zero energy—generating electricity off the grid.

Green 200.4: Power Off the Grid

Have you ever met a homeowner who wanted to spend more money on electricity? Or thought adding more carbon and pollutants to the atmosphere from power plants was a good idea? Saving money on utility bills is a motivator for all consumers, no matter how green. The ultimate energy-efficiency goal for any home would be net zero energy—a home that has zero bottom-line utility cost from season to season because it produces enough electricity to meet or exceed household needs.

Net zero energy homes are not "homes of the future." Escalating energy prices are accelerating the push to make homes energy efficient and self-sufficient. Cost-effective, affordable technologies exist and are in use now. But a lot of questions linger:

- Are solar and wind power viable, reliable alternatives to the fossil fuel-dependent power grid?
- Do utility companies support or try to stifle consumers' at-home power generation efforts?
- Is it really possible to "sell" power back to the grid? How does it work? How does it show up on utility bills?

As we learned in *Green 100: Real Estate for a Sustainable Future*, production builders are beginning to bring energy-generating homes to market at prices comparable to conventional homes. And, as we'll see in the next chapter of this course, there are viable choices for retrofitting existing homes. Real estate professionals need to understand how these systems work, the pros and cons, and opportunities for generating power off the grid.

The Net Zero Energy Home

The simple definition of a net zero energy home is one that produces as much electricity as it uses. If a home also uses natural gas, a true net zero energy home would have to produce enough electricity to offset the cost of gas in order to achieve a total "wash" at the bottom line of the home's utility costs.

Unless disconnected completely from the power grid, net zero energy homes still have utility bills. And to achieve a true wash at the bottom line the utility company must enable net metering. The difference between net zero energy and conventional homes is that the savings from home-generated electricity offsets the cost of electricity drawn from the grid and, if used in the home, natural gas.

Although the popular idea of a net zero energy home envisions a pile of solar collectors on the rooftop, the concept is much broader. It involves a balance of conservation, energy efficiency, and power generation. If not attuned to energy conservation, the habits and usage patterns of the home's occupants can offset savings from efficiencies and home-generated power. Many of the steps to achieve this balance involve design, construction, and system choices covered in the preceding chapters of this course.

Net zero energy homes balance. . .

Conservation

- Adequate insulation
- Turning off lights, electronics, and appliances when not in use
- Lowering the heat or air conditioning when away from home

Energy Efficiency

- High-efficiency heating, cooling, water heating, and appliances
- Site orientation for natural ventilation, lighting, and solar heat gain

Power Generation

- Solar photovoltaic (PV)
- Wind power
- Back-up connection to power grid, storage batteries, or generator

Photos: National Renewable Energy Lab, www.nrel.gov

Initial Outlay Versus Payback Period

The initial capital outlay presents a hurdle for both solar photovoltaic (PV) and wind systems. It may help to think of the investment as prepaying a number of years' utility bills. Both photovoltaic (PV) and wind-generated power should be regarded as methods for reducing energy bills and carbon footprints, not in most cases as a total replacement for power from the grid. Variables that impact the payback

period include: initial outlay, size of the system, available credits and financial incentives, and local electricity rates. Payback time can be considerably shortened in areas where electricity rates are high.

In My Backyard

Solar and wind electricity production estimator at ***www.nrel.gov/eis/imby.***

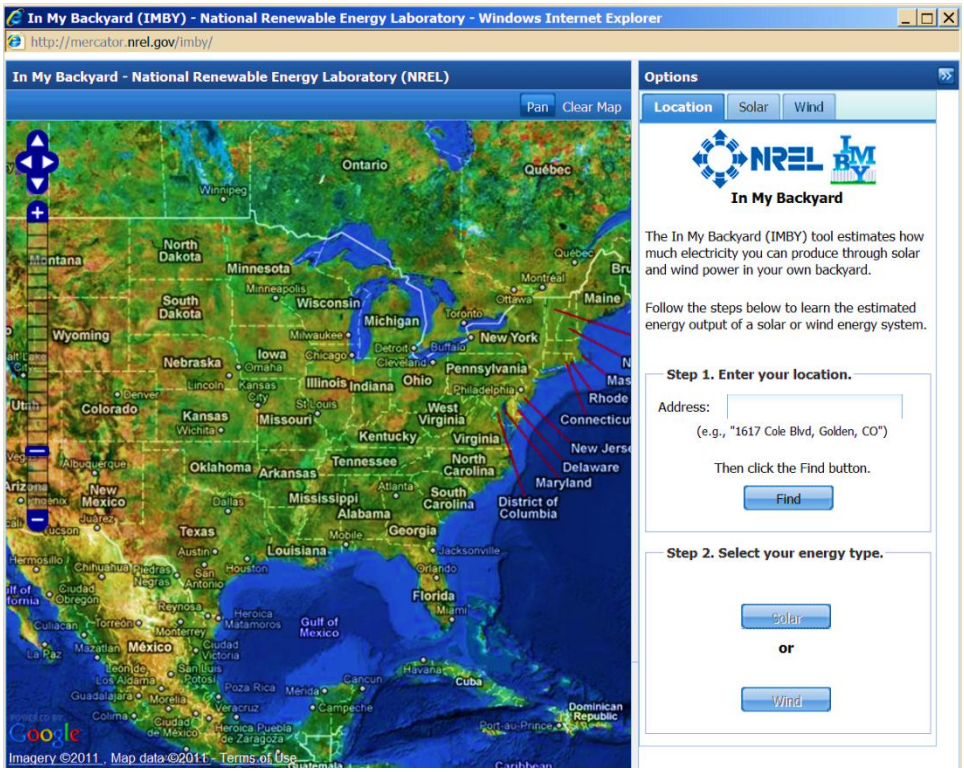


Diagram and photos: National Renewable Energy Lab, www.nrel.gov

Back-Up Systems?

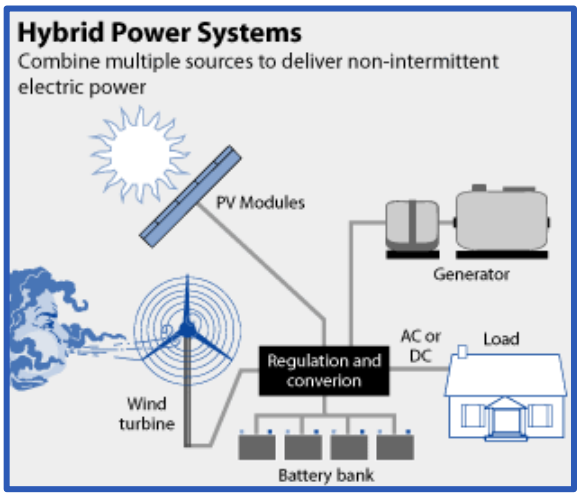
Few net zero energy homes can completely disconnect from the power grid. In almost all cases, home-generated electricity supplements power drawn from the power grid. Why? If the sun isn't shining or the wind isn't blowing, the off-grid system isn't generating any electricity. Furthermore, the system may not generate enough electricity to supplement all of the household's needs every day. For these reasons, most systems stay connected to the grid, store excess electricity in back-up batteries, or rely on a generator as a back-up.

Year-Round Operation

There is just as much solar power in winter sunlight as summer but there are some subtle seasonal differences. Summer days are longer with more hours of intense sunlight, which means more hours of potential power generation. Shorter days and lower sun angles decrease power-generating capacity during winter months. Winds, however, blow year round and may be both stronger and more frequent in winter months.

Hybrid Systems

"According to many renewable energy experts, a small "hybrid" electric system that combines wind and solar (photovoltaic) technologies offers several advantages over either single system. In much of the United States, wind speeds are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when less sunlight is available. Because the peak operating times for wind and solar systems occur at different times of the day and year, hybrid systems are more likely to produce power when needed."[4]



New Technologies, New Issues

Wind turbines and solar panels popping up all over the landscape introduces some new issues and challenges, particularly in urban settings.

- **Building codes**: In many urban settings, home-generated power trends outpace building codes and homeowners who want to install solar panels and wind turbines encounter permitting obstacles. For example, height limits may preclude raising a wind turbine high enough to clear obstacles like trees or other buildings. A vertical axis wind turbine (VAWT) may offer a solution.
- **Clutter**: Visual clutter has popped up as an issue in relation to both solar panels and wind turbines. In urban settings, some residents complain that the proliferation of solar panels on utility poles and ground installation block scenic views and cast glare.

[4] "Small Hybrid Solar and Wind Electric Systems," U.S. Dept. of Energy, Energy Efficiency and Renewable Energy, Energy Savers, www.energysavers.gov.

- **Easements**: Sunlight easements, the right to unimpeded sunlight, can become an issue when new construction, particularly high-rise buildings, threatens to block sunlight and neutralize the possibilities for daylighting and photovoltaic power generation. As wind turbine technologies develop, wind easements may become an issue too.
- **Power grid capacity**: As we learned in *Green 100: Real Estate for a Sustainable Future*, the wind-power generation installations are coming online faster than the national power grid can make connections available. Furthermore, the current state of the power grid lacks flexibility to sense and adjust for periods of high or low usage. Imagine the possibilities of a power grid that was smart enough to draw excess power from small power generation installations, like home-based photovoltaic, and feed it to heavy-demand parts of the grid, like a heat wave in one part of the country requiring extra power for air conditioning.
- **Wind farms**: A developing issue is the impact of wind farms on property values and quality of life. It's a windfall for those who lease the land to the utility companies but nearby residents complain about the noise and unsightliness of multiple windmills. The whooshing sound produced by one turbine is minimal—about the same decibel range as a conversation. But the cumulative noise of a cluster of turbines can make an acoustic impact. In an urban setting, the noise blends into the ambient city sounds. But most of the current wind farms are located in pristine rural settings surrounded by nature's sounds and any mechanical sounds are jarring intrusions. Modern wind turbines, however, produce significantly less noise than older designs and designers strive to minimize noise because it represents lost energy output.
- **Electric car recharging**: So far the power grid has kept pace with the recharging needs of electric cars. But more models and availability and decreasing prices seem certain to put more hybrid and all-electric cars on the road. It's not hard to imagine the impact on the power grid on a hot day when commuters arrive home, turn on home air conditioning, and plug in their cars for recharging.
- **Knowledgeable technicians**: Installers may be familiar with the installation of a free-standing wind or photovoltaic system, but not so familiar with connecting it to the grid.
- **Energy monitoring**: The more that systems like photovoltaic and wind turbines are adapted for home use, the more crucial it becomes for the homeowner to be able to monitor energy usage, storage, and net metering. Google PowerMeter provides this capability.

Discussion Question

What issues—or incentives—impact installation of home-based power generation systems in your area?

Where does the electricity go?[5]

According to the U.S. Energy Information Administration the average U.S. home consumes about 30 kilowatts of electricity a day.

** Other includes items like small appliances, microwave ovens, battery chargers, power tools, hair dryers, electric blankets, Jacuzzis, pool pumps, aquariums, and phantom power.*

[5] *U.S. Residential Electricity Consumption End Use, 2009*, U.S. Energy Information Administration, www.eia.doe.gov/tools/faqs

Net Metering

Net metering is an informal term for what happens when a home system generates more electricity than it can use or store. In simplest terms the excess electricity feeds back to the power grid. The meter spins backward, subtracting costs from the utility bill and effectively banking the electricity until the customer needs it. Simple net metering provides a dollar-for-dollar credit for excess electricity sent to the grid.

Utility companies have the option to offer avoided-cost pricing on excess power generated by consumers. This means that the consumer receives a credit for costs not expended (avoided costs) to generate the excess electricity. An additional meter must be installed, at the consumer's own expense, and the resulting credit is less than a dollar-for-dollar offset. Although less attractive than simple net metering, the avoided-cost approach still yields significant savings for consumers. Utility companies may also use the avoided-cost method for crediting the consumer's account when the cumulative total of power sent back to the grid exceeds the consumer's entire year of usage.

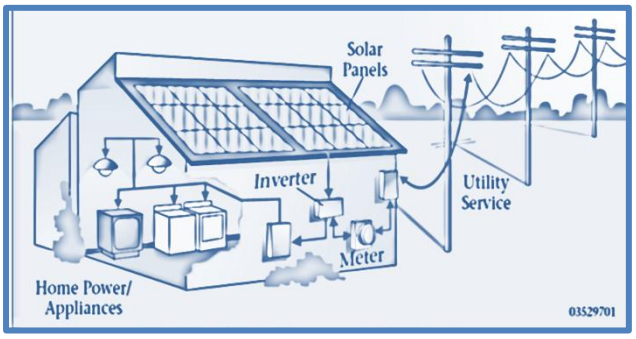
In order to participate in a net metering arrangement, the consumer must complete an interconnection agreement with the utility company. The Federal Energy Regulatory Commission (FERC) publishes guidelines, procedures, and model agreements for consumer–utility interconnections. The interconnection agreement spells out the basis and procedure for net metering, as well as the consumer's responsibility and liability for equipment maintenance and insurance. A homeowners insurance policy usually can cover the solar components as a building extension, but before installing the system the homeowner should confer with the insurance company to obtain complete information coverage for the equipment as well as liability coverage as set forth in the interconnection agreement.

Solar Photovoltaic (PV) In Brief

Components

- Solar panels on the roof or ground
- Inverter to convert direct current to alternating current for household use
- Battery (optional) to store excess power
- Back-up connection (optional) to power grid or generator
- Lightning arrester (optional) protects against lightning strike

Residential Grid-connected PV System*



Solar Panel Placement

- South-facing sloped roof or on ground
- Full sun 9:00 a.m.–3:00 p.m.
- No shade or overshadowing from other buildings

Information Sources

- National Renewable Energy Lab, ***www.nrel.gov***
- Solar map showing potential kWh by location, time of year, and time of equipment, **http://rredc.nrel.gov/solar**

Tax Incentives and Rebates

- Federal tax credit of 30 percent through 2016. Use IRS Form 5695
- State incentives and rebates, go to ***www.dsireus.org***

Measuring Electricity

1,000 watts = 1 kilowatt
1,000 kilowatts = 1 megawatt
1,000 megawatts = 1 gigawatt

- An average home consumes 30 kilowatts daily
- New York City consumes 1.1 gigawatts daily

Roof Area Calculator †	**Roof Area Needed in Square Feet (in bold type)**						
‡ PV Capacity (watts /hours) ▶	100 w	250 w	500 w	1 kwh	2 kwh	4 kwh	10 kwh
8% module efficiency ▶	**15**	**38**	**75**	**150**	**300**	**600**	**1,500**
12% module efficiency ▶	**10**	**25**	**50**	**100**	**200**	**400**	**1,000**
16% module efficiency ▶	**8**	**20**	**40**	**80**	**160**	**320**	**800**

* Adapted from *A Consumer's Guide, Get Your Power from the Sun*, U.S. Department of Energy, Energy Efficiency and Renewable Energy, www.eere.energy.gov
† Ibid.
‡ Efficiency depends on type of PV technology. Efficiency usually correlates with cost.

Solar Photovoltaic (PV)

Every home is in fact a solar home. All homes are bombarded by sunlight every day and the elements of the home adapt to it with windows, overhangs, eaves, and natural shade. The difference is that the solar photovoltaic (PV) captures the sun's energy and turns it into electricity.

How Do Solar Photovoltaic (PV) Systems Work?

A photovoltaic (PV) system typically consists of several PV modules containing solar cells installed on a south-facing roof or a suitable roof location stand-alone on the ground. In simplest terms:

- PV modules capture sunlight and convert it to direct electric current.
- An inverter converts the direct current to alternating current for household use and sending current back to the grid.
- Batteries (optional) store and provide back-up energy.

Making the Decision to Go Solar

- **Project location**: Remote locations make the most economic sense for PV installations. An interactive map showing solar potential based on location, time of year, site orientation, and type of equipment is available at the National Renewable Energy Lab at ***www.nrel.gov***.
- **Capital outlay**: Installation of a PV system requires a substantial capital outlay. Although there are many cost variables—size of installation, labor, components, roof design—an outlay of $15,000–$20,000 is common. In order to calculate the potential payback period, homeowners should compare the initial outlay costs less any financial incentives or credits against the potential savings on the cost of electricity from the power grid based on average consumption. In areas where the cost of electricity is very low the payback period may exceed the life expectancy of the components as well as the length of time the owners expect to own their home. Where ongoing cost of consumption is high the initial outlay may be paid back within a few years.
- **Credits and incentives**: Fortunately, a federal tax credit available through 2016 offsets 30 percent of the cost. Federal and state credits and incentives can offset a substantial portion of the initial outlay. Utility companies may offer rebates and incentives too. A good

information source is the Database of State Incentives for Renewable Energy at ***www.dsireusa.org***.

- **Roof area and capacity**: Refer to the roof area calculator on page 86. When the roof cannot accommodate the required solar array, a ground-mounted system may be a good alternative. The type of roof makes a difference too. Solar installations are easier to mount on shingled roofs and more difficult on slate and tile roofs.
- **Needs**: A major consideration, of course, is how much electricity the household needs on a daily basis and the percentage of wattage the PV system can produce. The PV system produces no electricity at night and when the sun is not shining; for this reason, most systems maintain a connection to the power grid.
- **Building codes**: Although changing quickly, some municipalities' building codes are less than welcoming of PV installations. Homeowner associations may impose restrictions too.
- **Scheduling the installation**: The best time to install solar photovoltaic panels is the same time as roof installation. If retrofitting, the panels should be installed when the roof is replaced; this saves the trouble and expense of dismantling and reinstalling the solar installations in order to install a new roof.

Solar panel roof installation

A solar-powered neighborhood. Premier Gardens, Sacramento, CA

Solar panel ground installation

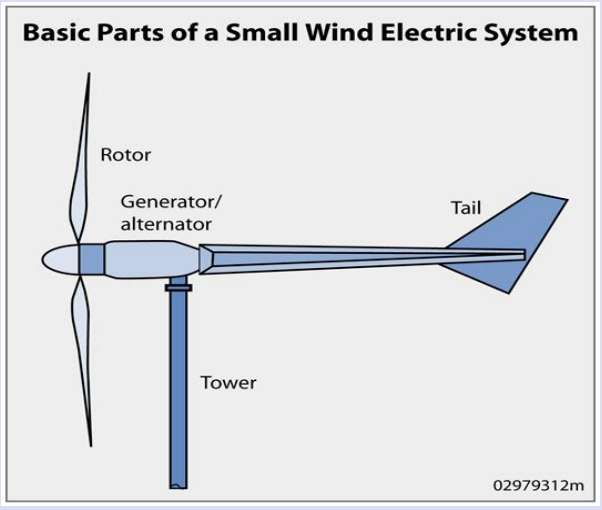
Photos National Renewable Energy Lab, www.nrel.gov

Small Wind Turbine Power In Brief

12-Step Process

1. Assess electricity consumption and costs
2. Reduce energy use where possible
3. Estimate or measure wind resources
4. Select turbine model, size, tower height, and site
5. Research incentives, rebates, and credits
6. Obtain zoning approval
7. Complete utility interconnection agreement
8. Obtain building and electrical permits
9. Order turbine and tower
10. Hire Certified Small Wind Installer
11. Installation
12. Commission the turbine

Adapted from "Siting, Sizing and Other Considerations for Distributed Wind," Trudy Forsyth, National Renewable Energy Laboratory



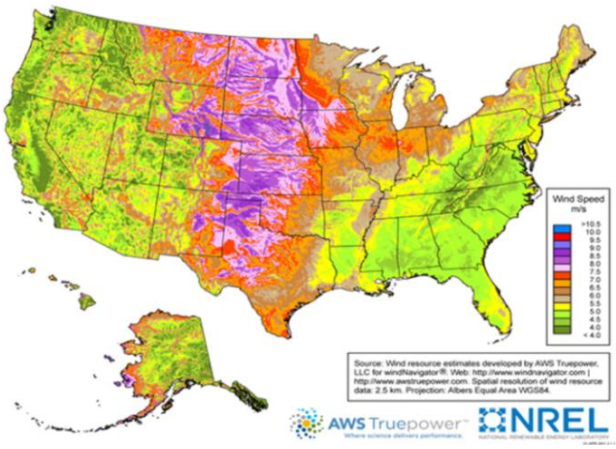
7 Criteria—Is Wind Power Right for You?

1. Good wind resource
2. One acre or more in a rural location
3. Zoning and building codes allow
4. Can quantify energy needs
5. Comfortable with long-term investment
6. Monthly electricity bills are $150 or more
7. Remote location without access to grid

Adapted from EnergySavers.gov

Information Sources

- NREL In My Backyard
  www.nrel.gov/eis/imby
- Small Wind Certification Council
  www.smallwindcertification.org
- Wind Powering America
  www.windpoweringamerica.gov
- American Wind Energy Association
  www.awea.org
- Wind Estimator by Zip Code
  www.solar-estimate.org



NREL Wind Map

Average wind velocity at a height of 80 meters

National Renewable Energy Laboratory (NREL): Wind Maps
www.nrel.gov/wind/ resource_assessment

Wind Power

Nostalgic and iconic, skeletal iron windmills for pumping water once dotted the American landscape. Today's new generation of small wind turbines adapt the old technology for a new and increasing use—generating electricity. Although more prevalent on a utility-wide scale, residential systems are a viable choice for generation of electricity off the grid. Advances in system design are lowering wind speed requirements and decreasing size and space needs. Small wind turbine systems are a renewable-energy solution for cold climates that have an abundance of wind and a dearth of sunshine.

Like solar photovoltaic systems, most small wind turbine systems aim for energy efficiency—replacing a portion of power drawn from the grid—not energy self-sufficiency. And, like photovoltaic systems, wind turbine can produce excess electricity to sell back to the grid. Let's begin by looking at the basic function of a small wind turbine system.

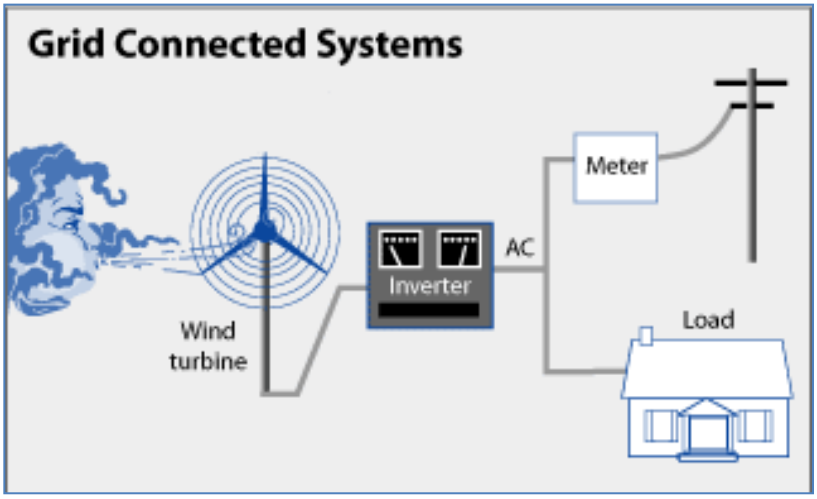
System Terminology

Some wind power terms you should know

- **Anemometer**: device for measuring wind speed
- **Blades**: the rotating arms; most turbines have 3 blades
- **Controller**: a device that makes numerous calculations to ensure operational safety like stopping when winds are too fast
- **Cut in speed**: wind velocity at which the system starts to produce electricity
- **Generator**: turbine component that converts mechanical energy in electricity
- **Nacelle**: (na-SELL) structure that houses the gear box, rotor shaft, and generator
- **Rotor**: the spinning parts of the turbine—blades and hub
- **Start-up speed**: wind velocity at which the rotor starts turning
- **Sweep**: area, in square feet or meters, encompassed by the rotor
- **Upwind**: turbine that faces into prevailing winds
- **VAWT**: vertical axis wind turbine
- **Wire run**: the distance from the turbine to the house or batteries
- **Yaw**: the alignment between the wind direction and the rotor

How Wind Turbines Work

When the wind makes the turbine blades turn, the rotor captures the resulting kinetic energy. The rotary motion drives the generator, which uses electromagnetism to produce electricity. An internal gearbox increases the rotational speed between the rotor and the generator. A yaw controller moves the rotor to align with wind direction. The current travels through electrical wires, the wire run, from the turbine to the inverter which converts the direct current (DC) into alternating current (AC) allowing for household use, battery storage, or selling back (net metering) to the grid.



A wind turbine produces direct current that must be converted by an inverter to alternating current for household use and transmission back to the power grid. Diagram U.S. Department of Energy, Energy Efficiency and Renewable Energy, www.energysavers.gov.

Installing a Small Wind Turbine

- **Location and siting:** Selecting the best location for a small wind turbine requires consideration of resources, space, and system configuration.
  - Variations in wind—velocity and frequency—can exist on the same property. For example, the windward side of a hilltop usually has more constant wind currents than a gully. The location should be upwind from buildings, trees, and hills. In order to assure an unobstructed wind stream in the future, an easement from neighboring properties can prevent construction that might block or divert winds.

- Most home systems are guyed, so room must be allowed for affixing the guy wires. As a rule of thumb, the radius of guy wires should be half to three-quarters of the tower height. Room should be allowed to lower a tilt-down tower for maintenance. The tower should be tall enough so that the bottom of the rotor blades stands at least 30 feet above any obstacle within 300 feet of the tower.
- The shorter the distance between the tower and the house or batteries, the wire run, the better. The longer the wire run, the more electricity lost to wire resistance.

- **Rooftop systems**: Most wind turbine installers do not recommend installation of a wind turbine on a house rooftop. The turbine rotation produces low-frequency vibration that can transmit a low groaning sound throughout the house. Furthermore, most house roofs cannot sustain the weight of the apparatus or added wear and tear.

- **Vertical systems:** Vertical access wind turbines (VAWTs) may provide a solution for urban settings where a tower installation is not possible or practical.

- **Building codes**: Electrical and building inspectors want to make sure that the structure is safe and complies with standards for connection to the power grid. Although it may not be a local requirement, it may facilitate the permitting process if the installer follows the National Electrical Code (NEC) Article 690. The Code addresses equipment and wiring safety for small renewable energy system installations.

- **Local covenants and ordinances**: Many communities have covenants or regulations concerning structures that might mar the aesthetic appeal of the community, cause a noise nuisance, or exceed a height limit. As concern for energy efficiency grows, communities may be more willing to make provisions in the regulations for renewable energy systems. A homeowner should research local regulations before launching an installation. Discussing installation plans with neighbors may be the most diplomatic way to avoid their future objections.

- **Capital outlay**: As with solar photovoltaic installations, the homeowner must balance electricity needs and costs against the cost of the wind turbine installation. In areas where the cost of electricity is quite low, the payback period may exceed the life of the equipment. Tax incentives and rebates may help defray the costs somewhat.

- **Credits and incentives:** The 30 percent federal tax credit that applies to solar photovoltaic systems is also available for wind turbine installations; the credit is available through 2016. States, communities, and utility companies may also offer financial assistance, rebates, or incentives. Refer to the Database of State Incentive s for Renewables and Efficiency at ***www.dsireusa.org***.

- **Wind velocity and frequency:** Sunlight angles are easy to observe and do not change. Wind on the other hand is more impressionistic. Measurement with an anemometer at turbine height is the most accurate measurement method.

- **Sizing**: Selecting the right size of system involves several variables starting with the household's energy usage. Installers can help the homeowner select the right size of system based on electricity needs and local wind patterns. According to the U.S Department of Energy, a 1.5-kilowatt system in a location with an average wind speed of 14 miles per hour will produce 300 kilowatt hours per month.[6]

- **Certified products**: The Small Wind Certification Council certifies small wind turbine products that meet or exceed the requirements of the AWEA Small Wind Turbine Performance and Safety Standard. Find certified products information at ***www.smallwindcertification.org***.

- **Certified installers**: The North American Board of Certified Energy Professionals (NABCEP) certifies small wind turbine installers and salespeople. A searchable directory of certified professionals is available at ***www.nabcep.org/installer-locator***. In April 2011, NABCEP announced plans to offer a company accreditation in addition to its program of professional certifications.

[6] *Small Wind Electric System Turbines*, U.S. Department of Energy, Energy Efficiency and Renewable Energy, www.energysavers.gov/your_home/electricity

Discussion Question

What type of system—solar photovoltaic or wind turbine—is the best option for your area?

The Next Chapter

So fat the course has focused mostly on new home construction. But many of the systems and discussed are also adaptable to existing homes. In the next chapter we will look at retrofitting, remodeling, and renovating to green existing homes.

Green 200.5: Greening Existing Homes

Perhaps the biggest challenge for U.S. homeowners lies in greening existing homes, which accounts for almost 90 percent of the housing stock. The median year of construction for U.S. housing stock is 1974[7] and 8 out of 10 were built before the 1992 launch of the Energy Star rating program. Consequently, most existing homes were designed with standards from a time when resources seemed unlimited and improving indoor air quality meant opening a window. Of the approximately 130 million homes in the United States, it is estimated that more than 86 percent—about 112 million—need energy retrofits.

Does this mean that a home has to be new to be green? Does upgrading an existing home make economic sense? Many homeowners think that green features must be built into a new home from the ground up, therefore older homes can't be greened. But many of the green options we've learned about in this course are adaptable for existing homes. Greening an existing home, however, involves challenges that new construction avoids.

Let's begin by looking at why homeowners tackle the greening process and what real estate professionals need to know.

What Do You Need to Know?

Knowledge of the options for greening a home, whether working with buyers or sellers, reinforces the real estate professional's role as a trusted advisor. Buyers look to the real estate professional for guidance on upgrade possibilities and valuing of green features. Sellers on the other hand want the real estate professional to recognize the efforts they have made to green their homes and reflect these aspects in the marketing and showing of the home.

Whether working with clients or customers on the purchase or sale of an existing home, real estate professionals can provide a valuable service by calling attention to retrofitting, remodeling, and renovating options that will enhance value or improve the home's green possibilities. Knowledge of how to go about greening an existing home also helps real estate professionals network with designers, contractors, energy raters, and other professionals.

[7] *American Housing Survey*, 2009, U.S. Census Bureau, www.census.gov/hhes

Why Green an Existing Home?

Homeowners have different motivations for greening their homes. For some it's all about cost-benefit; they want to know how quickly green upgrades will pay off and enhance property value. Health concerns such as improving indoor air quality motivate others. Some are interested in greening their homes for overall comfort, aesthetics, enhancing the quality of life, or just keeping up with the latest green trends. Regardless of the motivation, the real estate professional can provide a valuable service by helping buyers and sellers see the green potential of existing homes.

- **Energy efficiency**: As we have seen through this course, energy efficiency motivates many home greening efforts. Escalating energy prices are accelerating the push to future-proof homes by enhancing both energy efficiency and self-sufficiency.
- **Comfort and functionality**: Overall comfort of the home's indoor environmental quality (IEQ) may involve improvements in HVAC systems, system controls, acoustics, lighting, or aesthetics. Upgrading outdoor "rooms" like decks, outdoor kitchens, and porches both relieves pressures on the interior systems of a home and increases the amount of living space. Simply increasing the functionality of interior spaces, like finishing a basement, may be a motivator and an opportunity for green upgrades.
- **Health**: Improving indoor air quality (IAQ) for health reasons is a major motivator for making green improvements. Environmental regulations have developed to ban the use of harmful substances, like lead paint and previously unrecognized hazards like radon have come to light. New home construction avoids these issues but many existing homes predate these findings and are susceptible to air quality and health issues.
- **Replacement of offgassing or harmful materials**: Removal of materials that offgas or present hazards, like lead paint or asbestos, can be an opportunity for replacement with green-certified materials; refer to the chart on page 129 for a list of certified products. Indoor air quality issues in relation to building materials are presented beginning on page 105.
- **Repairs**: Major repairs—like replacing the roof, furnace, appliances, or floor coverings—can be opportunities for making choices to replace the old with new energy-efficient systems.
- **Water management and conservation**: Reducing the amount of water consumed by the home and landscaping is a common objective

of green retrofits. Water management could also include the addition of rainwater harvesting capability.

- **Market value**: Upgrading an existing home with green features may preserve and increase market value. Green homes tend to sell faster and closer to list price.
- **Building code compliance**: As building codes evolve, an older home may gradually fall out of compliance, for example, with minimum energy-efficiency requirements. Existing homes may be grandfathered under older building codes, but unless retrofitted they gradually become obsolete and lose substantial market value.
- **Sustainability**: Market value and cost savings do not dominate every green home feature choice. As we learned in *Green 100: Real Estate for a Sustainable Future*, the next generation of homebuyers, the millennials, believe in green living as a core value. They will seek out communities and homes that support their values as well as the real estate professionals who are attuned to sustainability issues.

Greening Challenges

When it comes to greening an existing home, the foremost question homeowners, and buyers, ask is, “Is the expense worth it?”

As we will see, homeowners can choose from a range of options and cost levels from simple steps like weather stripping to the costly and complex processes like a deep energy retrofit. There are many variables that influence the cost–benefit ratio, such as:

- Scope and complexity of the project
- Measurability of results—payback for energy efficiency improvements in HVAC and other thermal remodels are more measurable than IAQ or aesthetic improvements
- Savings on utility costs
- Impact on other home systems

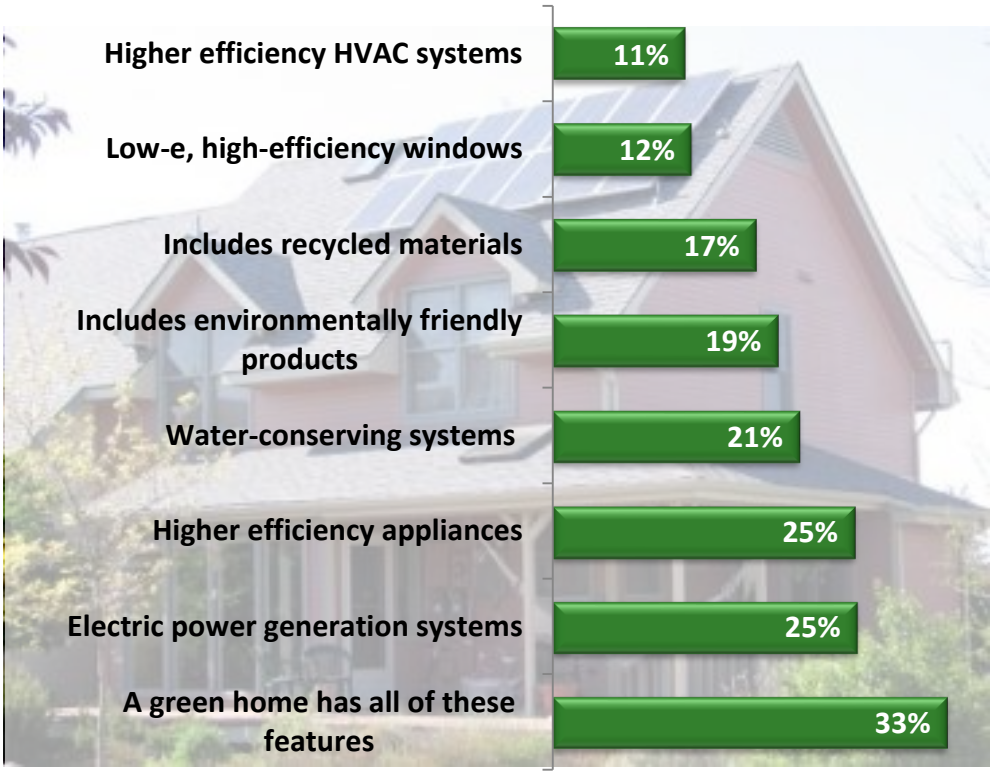
Real estate professionals can help homeowners and buyers see both the tangible and intangible benefits. Direct benefits can be realized in ways such as tax credits and incentives for green construction projects and lower utility bills. Benefits can also be realized in indirect ways such as enhanced comfort, improved health, and well-being. The real estate professional can help an owner or buyer see the green potential of a

home by pointing out ways to increase greenness and suggesting upgrades and fixes that will increase resource efficiency.

Greening Doesn't Have to Be Whole House

A significant number of consumers believe that a green home must address every component of energy, materials, and consumption to be green. But not every element of a home needs to be greened in order to make a difference in the comfort and operation cost.

What Does "Green Home" Mean?



Source: The Shelton Group. EcoPulse 2009. Knoxville, TN: The Shelton Group; 2009.

Integrating New and Old Systems

With new construction everyone on the design and build team is working toward the same goal. Greening an older home, however, is like starting in the middle. Existing homes may have phases of upgrades and reconstruction done at a time when there was less attention to green

building features, fewer choices for green products, and less awareness. Integration of new systems with the old can impact performance in unexpected ways. Correcting or upgrading one component may adversely impact another. For example, sealing air leaks and super-insulating an older home may cut off the ventilation that kept interior moisture levels in balance. In some cases, it may be necessary to repair or remediate conditions before accomplishing green upgrades.

Homes in historic preservation districts may face even higher hurdles in making green upgrades. Covenants and regulations intended to preserve the character and architectural style of a neighborhood may completely preclude upgrades like solar PV installation. Even in these cases, homeowners have retrofitting options (see Checklists for Greening a Home—page 117) that do not compromise historic charm.

Discussion Question

What are the most frequent challenges for greening homes in your area?

Getting Started

Homeowners may be susceptible to greenwashing when looking for quick retrofits. Before adding off-the-shelf green features, the best approach involves a thoughtful analysis of home performance and functionality as well as the homeowner's goals. Questions to consider might include:

- What is the motivation for remodeling and going green?
- What results are expected from the renovation?
- Are health, comfort, or functionality issues motivating the project?
- Can recycled and reclaimable materials be used?
- Is improved water efficiency a goal?
- Does the house provide enough daylight and sunshine?
- Do utility bills seem inappropriately high?
- What is the budget for the project?
- What is an acceptable payback time frame?

Home Improvement Tools from EnergyStar.gov

Tap into these free home improvement tools, hints, DIY guidance, and more at www.energystar.gov

Walkthrough Assessment

With motivations and goals in mind, the easiest way to begin the planning process is with a walkthough assessment. Using online assessment tools, checklists, and DIY testing can help a homeowner focus and prioritize greening efforts.

Check for Air Leaks First

When energy upgrades are the main goal, it's a good idea to start by locating air leaks. Adding extra insulation before locating and sealing air leaks can be counterproductive. Why? It's harder to find air leaks under piles of insulation.

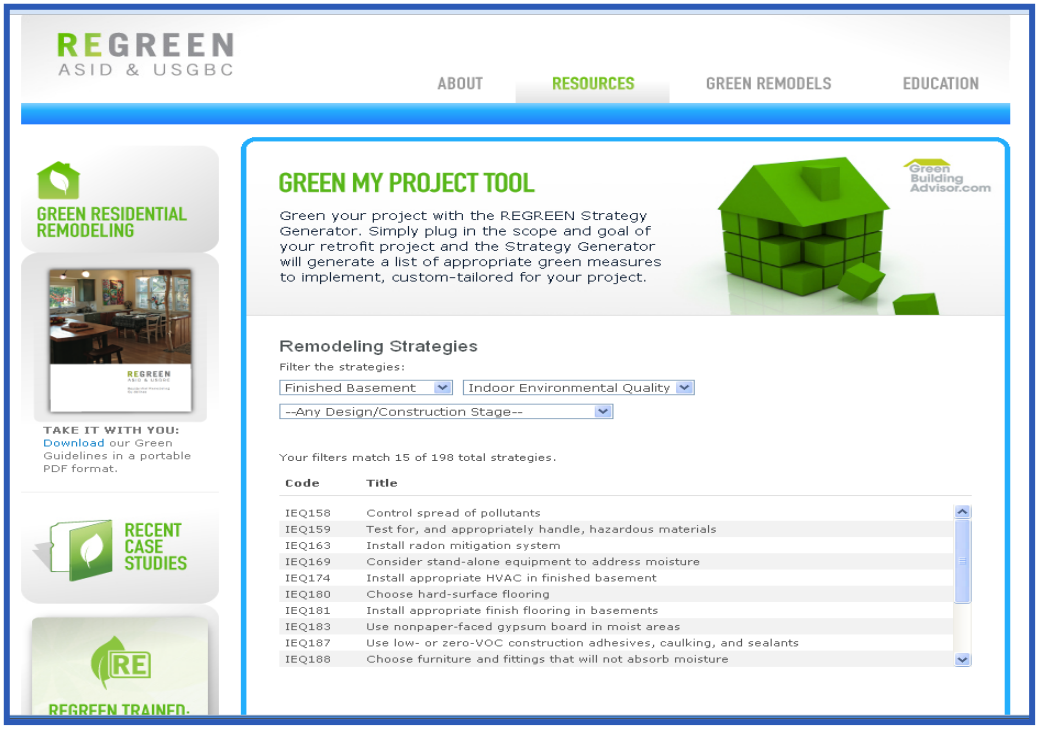
Assessments and Audits

A homeowner could do simple testing, like the DIY energy evaluation procedure described in the previous course, before scheduling professional assessments like a blower door, test infrared scan, or duct blaster test.

What to Do Next?

How do the results of the preceding questionnaire, goal setting, assessments, and testing translate into actions? The U.S. Green Building Council and American Society of Interior Designers provide an informative online Regreen Strategy Generator that helps consumers transform goals into action plans. Go to ***www.regreenprogram.org/resources/strategy-generator***.

Green remodeling strategy generator



Green Homeowners Insurance

Can insurance coverage take into consideration the extra effort to build or remodel green?

There are two types of policies: one for homes that are already green and another type for repairing conventional homes with green materials. Policies for green-certified homes typically receive a discount on premiums, whereas green replacement policies usually charge an additional premium.

- **Green certified homes**: Homes that are already certified green, such as LEED certification, may be eligible for reduced premiums on homeowners insurance. Insurers reason that homeowners who make the effort to certify and maintain a green home are more likely to take better care of it. Policy holders should, however, confirm that their policies cover replacement to the same green level so that, in the event of a loss, they won't have to pay out of pocket to meet the same standards or pay the inspection fees for recertification.

- **Conventional homes**: The other type of green homeowners policy pays to replace damaged or lost property with green materials and systems such as Energy Star appliances.
- **Net metering liability coverage**: In the case of net metering, the utility company may require additional liability insurance for incidents that harm workers or equipment as a condition of completing the interconnection agreement. The interconnection agreement may require proof of insurance and indemnification. In the case of energy cooperatives, the agreement may require that the utility company be named as an additional insured on the homeowners policy.

Recycle the Whole House?

An existing home represents a substantial investment of embodied energy in its construction including the land it occupies. Recycling a building saves on the energy invested in constructing it—transportation and production of building materials—as well as the energy required to demolish and dispose it plus the energy and materials not consumed to build a new home.

Going Green at the Beach*

The Recyclable House†

** PorterWorks, Inc., "Going Green at the Beach," www.goinggreenatthebeach.com. Photo reprinted with permission by Northwest Property Imaging, www.nwpimaging.com.*

† Reprinted with permission of Henderson, H. The Recyclable House. Chicago Reader, July 24, 2008.

Deconstruction, Not Demolition

When you think about it, the most recyclable product in the world is buildings. Deconstruction is the sustainable alternative to demolition. By deconstructing, instead of demolishing, elements of an existing building, the materials such as wood, millwork, stone, wallboard, and bricks can be

salvaged for reuse. That means that all of the salvaged materials, up to 80 percent of some buildings, are diverted from landfills.

Indoor Air Quality Issues

Improving indoor air quality (IAQ) for health reasons motivates many existing home green upgrades. There are three basic strategies for improving indoor air quality:

- **Source control**: remove the problem element, like replacing cabinetry that emits formaldehyde.
- **Ventilation**: lower the concentration of pollutants or emissions by increasing fresh air flow.
- **Air cleaners**: use a mechanical air cleaner—tabletop or whole room/house—to lower the level of pollutants.

Older homes built before hazards like the ones listed below were identified may have IAQ issues that new homes avoid. Let's take a look at common air quality issues for existing and older homes.

- **Offgassing**: Offgassing from materials and combustion sources can trigger asthma, respiratory conditions, and allergic reactions. It is also linked to multiple chemical sensitivity syndrome. In many cases the sources are identifiable and replacing the material or appliance removes the source of the issue. Common sources include paints, finishes, adhesives, floor and wall coverings, cabinetry, and carpets or combustion fumes from furnaces and ovens.
- **Lead paint**: Sometimes found in older homes, lead paint has serious health consequences for both children and adults if ingested as chips or dust or in drinking water. Lead paint that is in good condition does not present a hazard unless it is disturbed during repairs or renovations. However, ingesting or inhaling paint chips or dust can impair children's' brain and nervous system development and slow growth. It can cause hypertension, reproductive problems, memory and cognitive impairment, and other conditions in adults. Since April 2010, federal law requires that contractors performing renovation, repair, and painting projects that disturb more than six square feet of lead paint in homes, child care facilities, and schools built before 1978 must be trained and certified to follow specific work practices to prevent lead contamination. Homeowners can find Lead-Safe Certified contractors at ***www.epa.gov/lead/pubs/leadinfo***.

- **Asbestos**: Now linked to lung cancer and pulmonary disease, asbestos was once commonly used in buildings materials such as fireproofing, soundproofing, and floor tiles. When asbestos-containing materials are damaged or disturbed by repair, remodeling, or demolition activities, microscopic fibers become airborne and can be inhaled into the lungs, where they can cause significant health problems. If the asbestos material is in good shape and will not be disturbed, the best course of action can be to do nothing. If it is a problem, the options are to repair it by sealing (encapsulation) or covering (enclosure) or remove it altogether. Asbestos-containing materials cannot be identified by sight; an inspection by a qualified asbestos professional is required. An asbestos professional should be hired if the material must be repaired or removed. The federal government presents training courses for asbestos professionals and some states and local governments also provide training and certification.
- **Radon**: The naturally occurring breakdown of uranium in soil emits radon, which is a radioactive gas linked to lung cancer. It is emitted into the air, water, and soil and can seep into any type of building through cracks in basement and crawlspace walls or through well water. The highest risk tends to be where people spend the most time—in the home. The only way to detect radon is testing. Inexpensive EPA-approved radon test kits are available at home supply stores as well as online. As noted earlier in the course, new homes can be constructed with radon reduction measures in place. For older homes, lowering radon levels requires installation of measures such as barriers and venting. If a homeowner plans to finish a basement to convert it into living space, radon testing should be a first step. Homeowners can check with the state radon office for names of qualified or certified radon professionals.

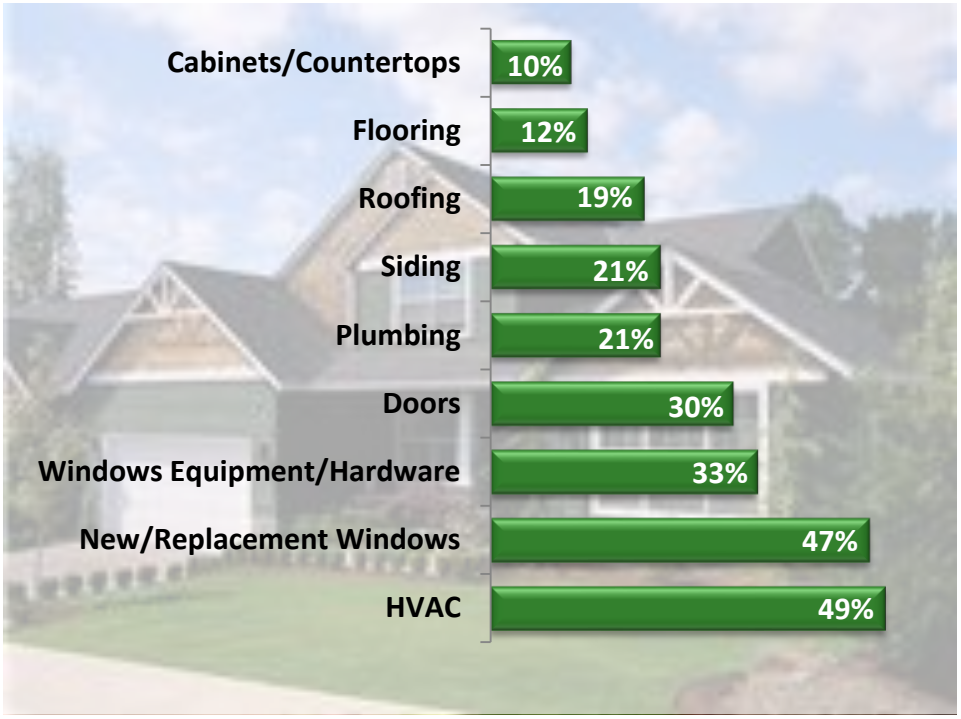
Sick Building Syndrome

Sick building syndrome and building-related illnesses, although usually associated with commercial buildings, can occur in homes when, for example, drywall or insulation emits formaldehyde fumes. The source of symptoms—headaches, congestion, and faintness—may be difficult to pinpoint but symptoms go away when the person leaves the building. The conditions are linked to inadequate ventilation, indoor and outdoor chemical contaminants, and biological contaminants like bacteria in ducts and humidifiers. Increasing ventilation rates and air distribution may alleviate some of the problem. Identifying contamination sources usually requires professional indoor air quality investigation. Once identified the source of problems can be removed.

Reseal the Building Envelope

Energy efficiency is profoundly affected by the condition of the building envelope. When it comes to green upgrades for an existing home, the building envelope is often the first target. According to research by McGraw Hill Construction, the top four green improvements all pertain to energy efficiency and involve the building envelope.

Most Frequent Green Upgrades



Source: McGraw-Hill Construction. The Green Consumer: Driving Demand for Green Homes. New York, NY: McGraw-Hill Construction; 2008.

In existing buildings an improperly sealed building envelope may account for significant losses in efficiency. Some of the critical areas to check include:[8]

- Plumbing penetrations through insulated floors and ceilings
- Chimney penetrations through insulated ceilings and exterior walls
- Wiring penetrations through insulated floors, ceilings, and walls

[8] Sources, www.aceee.org/consumerguide/envelope, and www.energysavers.gov/your_home/insulation_airsealing

- Door and window frames
- Mail chutes
- Electrical and gas service entrances
- Cable TV and phone lines
- Outdoor water faucets
- Dryer vent outlets
- Bricks, siding, stucco, and foundation
- Air conditioners
- Vents and fans

Sealing air leaks—what is the best sealant?

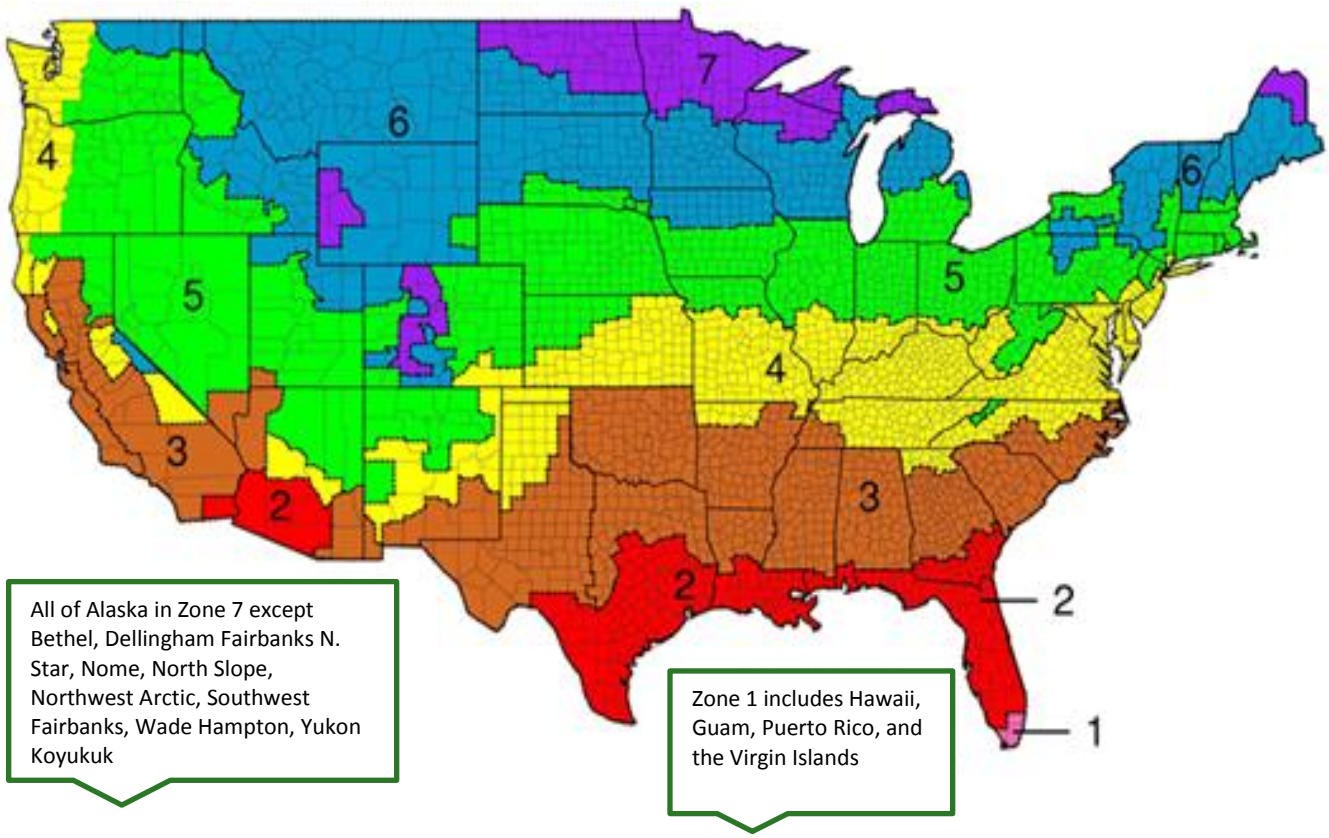
Selecting a sealant for an air leak depends on the size of the crack or hole:

- **Cracks less than ¼" wide**: caulk
- **Cracks more than ¼" wide**: expanding foam sealant or crack filler flexible foam material
- **Larger openings**: rigid foam insulation, fiberglass insulation, roof flashing, or silicone sealant

Believe or not? That handyman's friend, duct tape, isn't a good choice or durable solution for sealing leaky air ducts. Duct tape frays and comes unstuck. Air duct leaks should be sealed with mastic or metal tape, both of which are available a home supply stores.

Recommended levels of insulation for retrofitting existing wood-framed buildings

Cost-effective insulation levels for different climates and locations in the home.



Zone	Add insulation to the attic		Floor
	Uninsulated attic	Existing 3–4 inches of insulation	
1	R-30–R-49	R-25–R-30	R-13
2	R-30–R-60	R-25–R-38	R-13–R-19
3	R-30–R-60	R-25–R-38	R-19–R-25
4	R-38–R-60	R-38	R-25–R-30
5–8	R-49–R-60	R-38–R-49	R-25–R-30

Wall insulation: Whenever exterior siding is removed	
Uninsulated wood frame wall	▪ Drill holes in the sheathing and blow insulation into the empty wall cavity before installing the new siding ▪ Zones 3–4: add R-5 insulative wall sheathing beneath the new siding ▪ Zones 5–8: add R-5–R-6 insulative wall sheathing beneath the new siding
Insulated wood frame wall	▪ Zones 4-8: add R-5 insulative wall sheathing beneath the new siding

Deep Energy Retrofit

Deep energy retrofits are on the extreme end of cost and effort when it comes to making homes more energy-efficient but can achieve 50–95 percent energy savings. The process involves resealing the building envelope, super-insulating, upgrading systems including proper ventilation, and installing energy generation capacity like solar photovoltaic (PV) panels. If a homeowner plans to do major renovations such as replacing a roof or siding, it may be an opportunity for a whole-house deep energy retrofit. The first step is a thorough, professional energy audit to determine which actions will produce the most benefit.

"A deep energy retrofit probably will include changes to the entire building envelope as well as heating and cooling equipment. Moisture must also be carefully managed; this may mean adding perimeter drains in the basement. Exhaust fans in the kitchen and bathroom, or a whole-house ventilation system, where those features are lacking play critical roles too. Plants and roots that are too close to the house may have to be cut back to encourage drying outside and open up the house to get more sun. In some cases, both the site and the structure should be examined with an eye toward adding rooftop- or ground-mounted solar-energy installations, solar hot water collectors, or a wind turbine."[9]

Deep Energy Retrofit Upgrades

- **Building envelope**
  - Super-insulate the slab and foundation, exterior walls, floors, ceiling or roof, and attic
  - Install a durable roof
  - Replace doors and windows with energy-efficient models based on the house's exposure to the sun
  - Install moisture management measures
- **HVAC**
  - Install a programmable thermostat
  - Install high-efficiency heating and cooling systems and heat pumps, where possible
  - Consider alternatives to conventional air conditioning

[9] "Remodel Project: Deep Energy Retrofit," *Green Residential Remodeling*, USGBC and ASID Regreen Program, www.regreenprogram.org/case-studies/remodel-project-deep-energy-retrofit

- Vent combustion appliances
- Install moisture and ventilation balance controls

- **Plumbing**
  - Reconfigure plumbing to distribute hot water efficiently
  - Insulate hot water pipes
  - Install a high-efficiency water heater
  - Consider solar or on-demand water heating
- **Lighting**
  - Increase natural daylighting if possible
  - Install energy-efficient lighting
- **Appliances**
  - Eliminate phantom electrical loads
  - Replace old appliances with energy-efficient models
- **Energy sources**
  - Consider installing photovoltaic modules or a wind turbine

Greening Opportunities

The process of greening an existing home opens the possibilities for choosing many of the environmentally friendly and innovative building products and systems that go into new home construction. Short of tearing down and rebuilding, there's not much that can be done to change a home's site orientation. But almost all of the systems and materials described in this course can be applied in the process of greening an existing home. For example, a kitchen remodel could present opportunities to:

- Choose recycled material countertops and flooring
- Install formaldehyde-free cabinetry
- Use reclaimed or FSC©-certified woods
- Select Energy Star appliances and exhaust fan
- Build in LED down- and task-lighting
- Build in bins for recycling household waste including composting
- Install a greywater reuse system

- Install low-flow faucets and an instant hot water faucet
- Choose low-VOC wall coverings and finishes
- Increase glazing for enhanced daylighting and install double pane windows
- Shade windows, if needed, with an awning
- Install an insulated outside door
- Caulk around window and door frames
- Reclaim and recycle old materials and appliances
- Use Green Seal cleaning products

Discussion Question

What are the greening possibilities for other rooms in the house—the bathroom, family room, bedrooms, or other spaces? What sustainable materials would you use?

The Green Household

Not every green upgrade involves remodeling. Some involve changing habits and making green choices for things we're going to do anyway. A green home can incorporate waste management and recycling plans to make recycling more convenient. Improper disposal of some household hazardous wastes can contribute to environmental pollution and health hazards. Improper disposal methods are actions like pouring leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients down sink drains, into storm sewers, or on the ground.

Don't Pour These Down the Sink

- **Household Products**: wood and metal cleaners and polishes
- **Lawn and Garden Products**: herbicides, insecticides, fungicides, wood preservatives, fertilizer
- **Workshop/Painting Supplies**: adhesives and glues, furniture strippers, oil or enamel based paint, stains and finishes, paint thinners, strippers, and removers, turpentine, photographic chemicals, fixatives and other solvents
- **Automotive Products**: motor oil, fuel additives, carburetor and fuel-injection cleaners, air conditioning refrigerant, starter fluids, transmission and brake fluid, antifreeze
- **Indoor Pesticides**: insecticide sprays, baits, and poisons, insect repellants, rodent poisons, houseplant bug sprays
- For information on safe disposal, go to ***http://earth911.com***

Pet Waste

Pet waste can harbor E. coli, salmonella, toxoplasmosis, and parasites that threaten health when leeched into water. If droppings are not mixed with other materials, the EPA recommends flushing pet waste down the toilet. Local regulations may allow pet owners to dispose of waste in plastic bags and dispose of it in the garbage. Pet waste is not recommended for composting.

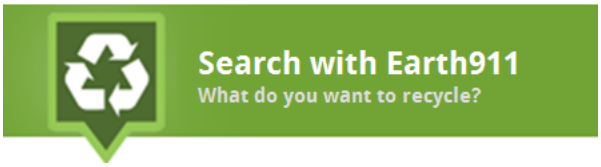
Appliance Disposal

Household appliances and electronics must be disposed of properly to prevent potential health and pollution issues. Appliances with cooling equipment contain refrigerants and other toxic materials that can be released in landfills and contribute to greenhouse gases. Electronics involve a variety of both recyclable and toxic materials requiring professional disposal. Products that require special disposal include:

- Refrigerators
- Freezers
- Dehumidifiers
- Room air conditioners
- Televisions and radios
- Cell phones
- Computers and peripherals
- Fax machines
- CFL bulbs
- Batteries

Many communities have permanent collection facilities or schedule special collection days. Local businesses may provide collection sites to deal with hazardous products requiring special disposal. Knowledge of your area's approach to appliance recycling and disposal issues is a valuable service that you can provide to your customers and clients.

Where can I recycle…?



Earth911.com provides an authoritative guide to where and how to recycle a wide range of products: batteries, construction material, electronics, hazardous materials, household items, and more. The site provides detailed disposal instructions as well as information on local recyclers. Go to ***www.earth911.com***.

Lawn and Garden Care

Watering

- Allow soil to partially dry out between waterings
- Use soaker hoses
- Use outdoor water timer to ensure correct amount and frequency
- Use rain shutoff device
- Water early in the morning to avoid evaporation
- Consider rain harvesting or a greywater system
- Consider rain barrels to collect rainwater and use for irrigation
- Group plants with similar irrigation needs to conserve water

Xeriscaping

Some plant species do not require irrigation beyond that provided by rainfall. Using these plants in landscaping design conserves water. In hot, arid climates, this landscaping practice is called x*eriscaping.* Native plants integrate with the ecosystem, requiring less irrigation and pest control.

Mulch

The process of layering organic materials such as leaves, aged wood chips, compost, or grass clippings around landscaping beds and plants.

- Stabilizes soil temperature and prevents erosion
- Feeds soil and improves root growth
- Prevents weeds
- Conserves water (retains water and reduces evaporation)

Fertilizers and Pest Control

Pest problems may indicate that a lawn or garden is not getting what it needs to stay healthy. Before turning to pesticides, try these steps:

- Select pest-resistant plants
- Remove dead plants and pull weeds
- Use physical controls like traps or barriers; use organic pesticides as a last resort and don't apply them when rain is expected

Fast-release fertilizers are best on heavy (clay) or compacted soils. Use Slow-release nitrogen fertilizers are best for sandy or loose soils.

Compost

The process of converting organic material by natural processes into decomposed matter

- Brown ingredients to provide carbon, such as dead leaves, branches, and twigs
- Green ingredients to provide nitrogen, such as grass clippings, vegetable and fruit waste, and coffee grounds
- Water to provide moisture and help break down organic matter

Apply as mulch to enrich the soil in garden beds, under shrubs, on the lawn, or in potting soil.

Lawn

- Reduce lawn size
- Use a mulching mower
- Use electric equipment non-powered reel mower
- Raise cutting height to 3–3.5 inches

Information Sources

- National Wildlife Association, www.nwf.org
- U.S. Dept. of Agriculture, www.usda.gov
- U.S. Nat'l Arboretum, www.usna.usda.gov
- USDA Horticultural Research, www.ars.usda.gov
- DIY Lawn Care, www.lawncare.net

Discussion Question

What hints can you share for keeping a green household?

Changing Habits

Perhaps the most important ingredient in operating a green home is homeowner education and behaviors. Upgrading systems without changing habits can negate system savings. Simple actions, or inactions, like leaving lights on, not using exhaust fans, over heating or cooling, or not using systems once they are installed, can cancel out the benefits of the systems. There is a learning curve associated with operating and maintaining some of the green systems we've learned about in this course. For the U.S. Green Building Council homeowner education is such a vital part of maintaining a LEED Certified home that it is included in the rating criteria.

Real estate professionals can provide a valuable service, particularly for buyers, by making sure they are aware of the green features of a home and directing them to sources of information on operation as well as service providers.

Checklists for Greening a Home

$ = low cost, low effort, DIY
$$ = medium cost, professional installation recommended
$$$ = high cost, professional installation required

☑	***Building Envelope***		
☐	Weather stripping	$	www.energysavers.gov
☐	Caulk window trim	$	www.energysavers.gov
☐	Repair glazing	$	www.energysavers.gov
☐	Putty around window panels	$	www.energysavers.gov
☐	Remove shrubbery around foundation	$	www.epa.gov
☐	Seal foundation cracks	$$	www.energysavers.gov
☐	Replace outer doors	$$	www.energystar.gov
☐	Reflective exterior paint	$$	www.paint.org
☐	Attic floor and hatch insulation	$$	www.energysavers.gov
☐	Insulate floors above crawlspace	$$	www.energysavers.gov
☐	Install acoustic insulation	$$	www.energysavers.gov
☐	Draft stopper in fireplace chimney	$$	www.energysavers.gov
☐	Blow-in insulation in walls	$$$	www.energysavers.gov
☐	Install double pane windows	$$$	www.energystar.gov
☐	Energy Star windows	$$$	www.energystar.gov
☐	Install a cool or green roof	$$$	www.greenroofs.org/
☐			
☐			

$ = low cost, low effort, DIY
$$ = medium cost, professional installation recommended
$$$ = high cost, professional installation required

☑	***Water***		
☐	Laminar faucets	$	www.toolbase.org
☐	Aerators on faucets	$	www.toolbase.org
☐	Wrap hot water heater and pipes	$	www.energysavers.gov/your_home/water_heating
☐	Dual flush toilet controls	$	www.toolbase.org
☐	Fix leaky faucets	$	www.thisoldhouse.com
☐	Low flow showerhead	$	www.toolbase.org
☐	Circulating hot water pump	$$	www.energysavers.gov/your_home/water_heating
☐	High-efficiency (low flow) toilet	$$	www.toolbase.org
☐	Energy Star water heater	$$	www.energystar.gov
☐	Tankless water heater	$$–$$$	www.energysavers.gov/your_home/water_heating
☐	Install heat recovery system	$$–$$$	www.energysavers.gov/your_home/water_heating
☐	WaterSense appliances and products	$$–$$$	www.epa.gov/watersense
☐	Solar water heater	$$$	www.energysavers.gov/your_home/water_heating
☐	Dual plumbing system for greywater	$$$	www.toolbase.org
☐			
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$ = low cost, low effort, DIY
$$ = medium cost, professional installation recommended
$$$ = high cost, professional installation required

☑	*Energy Efficiency and Lighting*		
☐	Switch to CFL or LED light bulbs	$	www.energystar.gov
☐	Solar garden lights	$	www.solarhome.org
☐	Install dimmers	$	www.energystar.gov
☐	Timers	$	www.toolbase.org
☐	Sensors, motion and occupancy	$	www.toolbase.org
☐	Install a clothesline	$	www.energysavers.gov
☐	Power strips (avoid phantom load)	$	www.energysavers.gov
☐	Energy-monitoring application	$	www.google.com/powermeter
☐	Clean refrigerator coils	$	www.energysavers.gov
☐	Install LED down lights	$$	www.energystar.gov
☐	Tubular skylights	$$–$$$	www.energystar.gov
☐	Energy Star appliances	$$–$$$	www.energystar.gov
☐	Solar water heater	$$	www.solarhome.org
☐	Electric car recharging hookup	$$	www.electricauto.org
☐	Increase glazing for more daylight	$$$	www.wbdg.org/resources/daylighting
☐	Install insulated airtight skylights	$$$	www.energystar.gov
☐	Solar PV generating system	$$$	www.solarhome.org
☐	Solar passive heating	$$$	www.solarhome.org
☐	Small wind turbine generator	$$$	www.awea.org
☐	Net metering	$$$	http://apps3.eere.energy.gov/greenpower/markets/netmetering
☐	Deep energy retrofit	$$$	www.regreenprogram.org
☐			
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$$ = medium cost, professional installation recommended
$$$ = high cost, professional installation required

☑	***HVAC***		
☐	Programmable thermostat	$	www.energystar.gov
☐	Thermal drapes	$	www.doityourself.com
☐	Air filters	$	www.energystar.gov
☐	Duct sealing	$	www.energystar.gov
☐	Cross ventilation upgrade	$$	www.energystar.gov
☐	Dehumidifier	$$	www.energystar.gov
☐	Awnings	$$	www.awninginfo.com
☐	Whole house fan	$$	www.energystar.gov
☐	Condensing furnace	$$$	www.energystar.gov
☐	Ceiling fans (dual direction)	$$	www.energystar.gov
☐	Exhaust fans	$$	www.energystar.gov
☐	Zone control heat and cooling	$$	www.energystar.gov
☐	Heat pump	$$$	www.energystar.gov
☐	Air source pump	$$$	www.energystar.gov
☐	Energy Star furnace, boiler	$$$	www.energystar.gov
☐	Radiant heat	$$$	www.energystar.gov
☐	Radiant floor heat	$$$	www.energystar.gov
☐	Ground source heat pump, geothermal	$$$	www.energystar.gov
☐	Trombe wall or window	$$$	www.energysavers.gov
☐			

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$$ = medium cost, professional installation recommended
$$$ = high cost, professional installation required

☑	***Indoor Air Quality***		
☐	HEPA air filters	$	www.epa.gov/indoorairplus
☐	Low-VOC paint and finishes	$$	www.epa.gov
☐	Remediate lead based paint	$$	www.epa/gov/lead
☐	Radon sealing and venting	$$$	www.epa.gov/radon
☐	Replace offgassing materials	$$$	www.epa.gov/indoorairplus
☐	Remediate mold	$$$	www.epa.gov/mold
☐	Remediate asbestos	$$$	www.epa.gov/asbestos
☐			
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☑	***Materials***		
☐	Low-VOC paint and wall coverings	$-$$	www.paint.org
☐	Deconstruct and recycle old material	$-$$	http://earth911.com/recycling/
☐	CFI Green Label carpet	$$	www.carpet-rug.org
☐	FSC©- and SFI®-certified wood	$$–$$$	www.fsc.org, www.sfi.org
☐	Formaldehyde-free cabinetry	$$–$$$	www.epa.gov
☐	Recycled material countertops and flooring	$$$	www.isfanow.org, www.rfci.com
☐	Reclaimed or recycled materials	$$$	www.epa.gov/mold
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☑	*Lawn and Garden*		
☐	Drip irrigation	$	www.thisoldhouse.com
☐	Irrigation timer, rain shutoff device	$	www.the-organic-gardener.com
☐	Rain barrel or cistern	$	www.epa.gov
☐	Organic, slow-release fertilizer	$	www.the-organic-gardener.com
☐	Compost bin	$	www.the-organic-gardener.com
☐	Mulch	$	www.the-organic-gardener.com
☐	Native plants, xeriscaping	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Group plants by water needs	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Deep root plants	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Reduce grassed lawn size	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Electric or push mower	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Set mower height at 3 inches	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Pest resistant plants, natural repellant	$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Evergreen trees for wind block	$	www.arborday.org
☐	Leafy trees for shade	$	www.arborday.org
☐	Bioswale and rain garden	$$	www.nrcs.usda.gov/feature/backyard
☐	Permeable pavement materials	$$	www.perviouspavement.org/
☐	Solar pool heater	$$	www.builditsolar.com
☐	Outdoor living space upgrade (porch, outdoor kitchen, shaded patio)	$$$	www.epa.gov/epawaste/conserve/rrr/greenscapes
☐	Greywater usage, dual plumbing	$$$	http://greywateraction.org
☐			
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$$ = medium cost, professional installation recommended
$$$ = high cost, professional installation required

☑	*Waste Disposal*		
☐	Recycling bins	$	http://earth911.com/recycling
☐	Compost bins	$	www.howtocompost.org
☐	Recycle building components	$–$$	www.deconstructioninstitute.com
☐	Proper appliance disposal	$–$$	www.epa.gov/ozone
☐			
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Summing Up

- Best-practice green home design happens in four phases: site selection, home design, materials selection, and interior systems and design
- Traditional home construction starts by designing the house and dropping it into the site. The green building process starts with a thoughtful assessment of the site to create a structure that integrates into the environment and takes advantage of positive aspects.
- With green building, the watchwords are functional and compact. Small but functional homes cost less to build and maintain, use less material to construct, and feel cozy and sheltering. Overly large homes contribute to sprawl, require more materials, and consume more energy even if they are energy-efficient.
- Important concepts to keep in mind for selecting green building materials include low toxicity, embodied energy, future recycling—can the material be reclaimed for another use or will it end up in a landfill?
- A successful design process includes everyone, including the homeowner, involved in the planning, design, construction, operation, and maintenance of the home. It works best when all team members understand the issues and concerns of all the other stakeholders, as well as the interconnectivity of systems, and collaborate throughout all phases of the project.
- A tightly sealed building envelope is crucial to energy efficiency because it impacts the energy load for heating, cooling, water heating, and lighting. Moisture and ventilation (fresh air rotation) are also important factors.
- A system may cost more to buy and install, but less to own and operate over the long term. For home buyers, the cost of a home with energy-efficient systems may be higher than a similar conventional home. But the additional amount of mortgage payment may be more than offset by savings on utility bills.
- Energy-efficient home systems can help homeowners withstand the uncertainties of future energy prices. Think of energy-efficient choices as a way to future-proof a home.
- Homeowners have different motivations for greening their homes—health, air quality, environmental concerns, lifestyle choices, or just keeping up with the latest trends. Not every benefit of green choices can be monetized.

- Improving indoor air quality for health reasons motivates many existing home green upgrades. Because they were built before some hazards were identified, older homes may have environmental and air quality issues that new homes avoid.
- Real estate professionals don't need to remember all of the technical details of systems, but they do need to know how the systems interrelate and contribute to the greenness of a home.
- Net zero energy homes are not "homes of the future"; they are being constructed and are on the market now. Escalating energy prices are accelerating the push to make homes energy-efficient and self-sufficient. Cost-effective, affordable technologies exist and are in use now. The simple definition of a net zero energy home is one that produces annually as much electricity as it uses.
- In most cases, both solar photovoltaic and wind-generated power should be regarded as methods for reducing energy bills and carbon footprint, not as a total replacement for power from the grid.
- Net metering allows for a utility repurchase or credits for excess electricity produced. It is an informal term for what happens when a home system generates more electricity than it can use or store. In simplest terms, the excess electricity feeds back to the power grid which causes the meter to spin backward.
- Many of the green options presented in this course are adaptable for existing homes, but greening an existing home, however, involves challenges that new construction avoids.
- An existing home represents a substantial investment of embodied energy in its construction including the land it occupies. Deconstruction is the sustainable alternative to demolition.

- **Next course**
  - ***Green 300: Greening Your Real Estate Business***

- **Earning the Green Designation**
  Refer to page 128 for a map to earning NAR's Green Designation.

Resources

Green REsource Council Member Benefits

Earning the Green Designation

❑ **3 Required Courses**	❑ **Green 100: Real Estate for a Sustainable Future** ❑ **Green 200: The Science of Green Building** ❑ **Green 300: Greening Your Real Estate Business** Courses can be completed in any order but the Green REsource Council recommends the above numerical sequence. Students who take any of the above courses online at REALTOR® University must complete the course within 6 months from purchase. All courses, regardless of format (live or online), must be completed within 1 year.
❑ **Designation Application**	❑ **Upon completion of all required courses, complete the designation application form at www.greenresourcecouncil.org/apply_now** ❑ **Send the completed form to greendesignation@realtors.org or fax it to 312-329-8632** Processing time is 2–4 business days after we receive your course materials from the association that hosted the course.
❑ **Maintain Membership**	❑ **Be a member in good standing with the NATIONAL ASSOCIATION OF REALTORS®** ❑ **Maintain Green REsource Council Membership** Green **RE**source Council membership 1st year: Free (begins upon completion of 2 of the 3 required courses) 2nd year: Prorated through end of calendar year 3rd and following years: $99 Designees must maintain <u>both</u> NAR and Green REsource Council membership in order to use and display the designation.

Building Material Certifications and Ratings

	Wood	Flooring	Cleaning Products	Appliances	Windows	Other
EPA Deisgn for the Environment			✓			
Energy Star				✓	✓	
GREENGUARD®						Indoor air quality
GreenSeal™	✓	✓	✓			Food packaging, paint, paper
FSC©-Certified (Forest Stewardship Council)	✓	✓				Chain of custody, paper, printing
FloorScore	✓	✓				
Carpet and Rug Institute	✓	✓	✓			
NFSC Certified					✓	
WaterSense						Bathroom fixtures, irrigation professionals
AirPLUS				✓		Indoor air quality
Green Globes						Commercial and industrial buildings

Websites

- **Green REsource Council, www.greenresourcecouncil.org**
- National Association of REALTORS®, **www.Realtor.org**

- **Air-Conditioning, Heating, and Refrigeration Institute** www.ahrinet.org
- **American Wood-Preserver's Association** www.AWPA.com
- **California Department of Resources, Recycling, Recovery** www.calrecycle.ca.gov/GREENBUILDING/Toolkit
- **California Energy Commission Consumer Energy Commission** www.consumerenergycenter.org
- **Consortium for Energy Efficiency** (CEE) www.cee1.org
- **Construction Waste Management Database** www.wbdg.org/tools/cwm.php
- **Cool Roofs** www.coolroofs.org
- **Cradle to Cradle® certification** www.mbdc.com
- **Database of State Incentives for Renewables and Efficiency** www.dsireusa.org
- **DIY Lawn Care**, www.lawncare.net
- **Energy Star**, www.energystar.gov
- **EPA Radon Maps** www.epa.gov/radon/zonemap
- **Going Green at the Beach** www.goinggreenatthebeach.com
- **Green Building Pages** www.greenbuildingpages.com
- **Green Building Supply** www.grenbuildingsupply.com
- **Green Seal Standard** www.greanseal.org
- **In My Backyard solar and wind electricity production estimator** www.nrel.gov/eis/imby
- **Lead-Safe Certified contractors** www.epa.gov/lead/pubs/leadinfo
- **National Renewable Energy Lab** www.nrel.gov
- **National Wildlife Association** www.nwf.org
- **Passive House** www.passivehouse.us
- **Regreen Strategy Generator** www.regreenprogram.org/resources/strategy-generator
- **U.S. Department of Energy, Energy Efficiency and Renewable Energy** www.energysavers.gov/your_home/electricity
- **U.S. Dept. of Agriculture** www.usda.gov
- **U.S. Energy Information Administration** www.eia.doe.gov
- **U.S. Nat'l Arboretum** www.usna.usda.gov
- **USDA Horticultural Research** www.ars.usda.gov
- **U.S. Green Building Council** www.usgbc.org
- **WaterSense** www.epa.gov/WaterSense
- **Whole Building Design Guide** www.wbdg.org
- **Zip-Code Insulation Program** www.ornl.gov/~roofs/Zip/ZipHome

Read More

Books

Freed, Erik Corey, and Kevin Daum, *GreenSense for the Home: Rating the Real Payoff from 50 Green Home Projects*, Taunton Press, Newton, Connecticut, 2010

Katz, Barry. *Practical Green Remodeling: Down-to-Earth Solutions for Everyday Homes*, Taunton Press, Newton, Connecticut, 2010

The Complete Guide to Green Building & Remodeling Your Home, Atlantic Publishing Company, Ocala, Florida, 2011

Topel, Avrim and Vicki. *Green Beginnings, The Story of How We Built Our Green and Sustainable Home*, www.booksurge.com, 2008

Venolia, Carol, *Natural Remodeling for the Not-So-Green House: Bringing Your Home into Harmony with Nature*, Lark Books, New York, 2006

Wagner, John, *Green Remodeling*, Creative Homeowner®, Upper Saddle River, New Jersey, 2008

Wells, Walker, et al., *Blueprint for Greening Affordable Housing*, Island Press, Washington, D.C., 2007

Magazines

Builder Magazine
www.builderonline.com

EcoHome Magazine
www.ecohomemagazine.com

Green Builder
www.greenbuildingmag.com

Green Source
www.greensource.construction.com