REGREEN

ASID & USGBC

Residential Remodeling Guidelines

Second Edition

REGREEN Residential Remodeling Guidelines 2008

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www.regreenprogram.org

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Preface

ASID

The American Society of Interior Designers (ASID) is a community of people—designers, industry representatives, educators, and students—committed to interior design. Through education, knowledge sharing, advocacy, community building, and outreach, the Society strives to advance the interior design profession and, in the process, to demonstrate and celebrate the power of design to positively change people's lives. Its more than 40,000 members engage in a variety of professional programs and activities through a network of 48 chapters throughout the United States and Canada.

ASID endorses the following principles of environmental stewardship:

- Advocacy for safe products and services: Interior designers should advocate with their clients and employers the development of buildings, spaces, and products that are environmentally benign, produced in a socially just manner and safe for all living things.
- Protection of the biosphere: Interior designers should eliminate the use of any product or process that is known to pollute air, water, or earth.
- Sustainable use of natural resources: Interior designers should make use of renewable natural resources, including the protection of vegetation, wildlife habitats, open spaces, and wilderness.
- Waste reduction: Interior designers should minimize waste through the reduction, reuse, or recycling of products and encourage the development and use of reclaimed, salvaged, and recycled products.
- Wise use of energy: Interior designers should reduce energy use, adopt energy-conserving strategies, and choose renewable energy sources.
- Reduction of risk: Interior designers should eliminate the environmental risk to the health of the end users of their designs.

ASID believes that, whenever feasible, interior designers should endeavor to practice sustainable design. Interior designers should meet present-day needs without compromising the ability to meet the needs of future generations.

Of the Society's 20,000 practicing interior designers, 6,500 practice primarily in the commercial field and 4,000 practice primarily as residential designers. The remaining 9,500 work in both commercial and residential design. Professional members of ASID must pass rigorous acceptance standards: they must have a combination of accredited design education and/or full-time work experience and pass a two-day accreditation examination administered by the National Council for Interior Design Qualification (NCIDQ).

ASID Industry Partners include nearly 3,000 member firms with more than 8,000 individual representatives, uniting the professional designer with manufacturers of design-related products and services.

The Society's membership also includes more than 12,000 students of interior design. ASID has more than 300 student chapters at colleges, universities, and design schools with two-year and four-year programs throughout the United States and a "virtual" chapter through Rhodec International.

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USGBC

The built environment has a profound impact on our natural environment, economy, health, and productivity. Breakthroughs in building science, technology, and operations are now available to designers, builders, operators, and owners who want to build green and maximize both economic and environmental performance.

The U.S. Green Building Council (USGBC) is coordinating the establishment and evolution of a national consensus effort to provide the industry with the tools necessary to design, build, and operate buildings that deliver high performance inside and out. Council members work together to develop industry standards, design, and construction practices as well as guidelines, operating practices and guidelines, policy positions, and educational tools that support the adoption of sustainable design and building practices. Members also forge strategic alliances with industry and research organizations, federal government agencies, and state and local governments to transform the built environment. As the leading organization that represents the entire building industry on environmental building matters, USGBC's unique perspective and collective power enable our members to effect change in the way buildings are designed, built, operated, and maintained.

USGBC's greatest strength is the diversity of its membership. USGBC is a balanced, consensus nonprofit organization representing the entire building industry, comprising more than 12,000 companies and organizations. Since its inception in 1993, USGBC has played a vital role in providing a leadership forum and a unique, integrating force for the building industry. USGBC programs are distinguished by several features:

- Committee-based

The heart of this effective coalition is the committee structure, in which volunteer members design strategies that are implemented by staff and expert consultants. USGBC committees provide a forum for members to resolve differences, build alliances, and forge cooperative solutions for influencing change in all sectors of the building industry.

- Member-driven

Membership is open and balanced and provides a comprehensive platform for carrying out important programs and activities. USGBC targets the issues identified by its members as the highest priority. In annual reviews of achievements, USGBC sets policy, revises strategies, and devises work plans based on members' needs.

- Consensus-focused

USGBC members work together to promote green buildings and, in doing so, help foster greater economic vitality and environmental health at lower costs. The various industry segments bridge ideological gaps to develop balanced policies that benefit the entire industry.

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The REGREEN Residential Remodeling Guidelines have been made possible only through the efforts of many dedicated volunteers, staff members, and others in the ASID and USGBC community.

The scope of the REGREEN guidelines emerged from conversations occurring among a variety of residential building experts convened at the Pocantico Conference Center of the Rockefeller Brothers Fund, April 27–29, 2007. The REGREEN guidelines were developed by a technical committee comprising of both ASID and USGBC members and invited experts. This resource reflects the views of the authors and not necessarily those of other conference participants or of the Rockefeller Brothers Fund, its trustees, or its staff.

Developement of the REGREEN Residential Remodeling Guidelines was managed and implemented by ASID and USGBC staff and included review and suggestions by many technical advisors. We extend our deepest gratitude to all of our Steering Committee members who participated in the development of the REGREEN Residential Guidelines, for their tireless volunteer efforts and constant support of ASID and USGBC's shared vision for this project.

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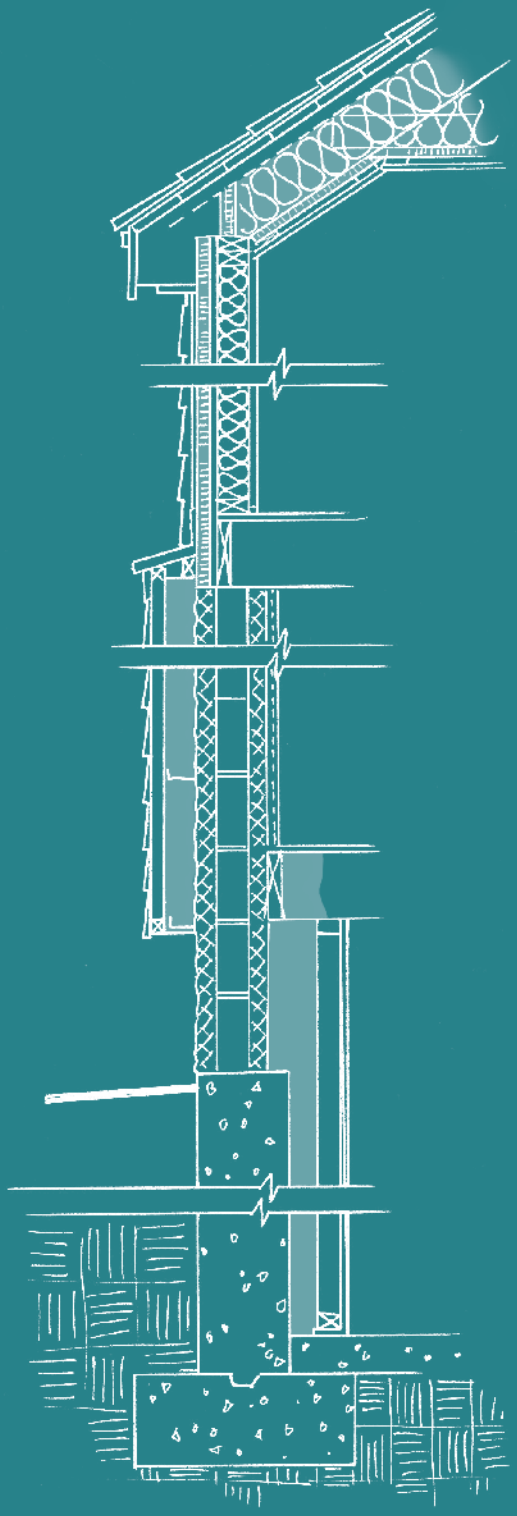
Introduction



Background

Green remodeling is the design and construction of projects that reduce the environmental impacts of remodeling, including energy, water, and materials consumption; waste generation; and harmful emissions, both indoors and out.

Although the principles that govern green residential remodeling are shared with all other design and construction projects, more than a few aspects are unique to green remodeling:

- **Range of projects**. Residential remodeling covers everything from painting a room to refitting a kitchen to gutting a whole house down to the framing and then rebuilding.
- **Existing conditions**. In new home construction we generally have just the site to consider, but in residential remodeling there are existing conditions that range from room configuration to hazards such as mold, lead, and asbestos.
- **Custom work**. Whether in design or construction, just about every residential remodeling project is custom, with very little opportunity for the sorts of economies of scale that occur in production building.
- **Professional-client relationship**. Remodeling professionals almost always have a client; "spec" remodeling projects are rare. The closer relationship with homeowners requires skills and perspectives not generally required for new construction projects.
- **Occupants.** Remodeling professionals must plan and often conduct their work based on the health, safety and schedules of real people. Even if the work requires that the home be vacated, the timing and duration of such a period must be very carefully orchestrated.
- **Sequenced or staged projects.** Many residential remodeling projects are phased or sequenced projects ("we want to do the bathroom and then the kitchen"), and this can make for challenging orders of operation in both design and construction, often requiring innovation and improvisation by remodeling professionals.
- **Integration.** A cornerstone of all types of green building is systems integration, and residential remodeling adds a new dimension to this integration: integrating the old or existing with the new.

Those unique aspects of residential remodeling mean that a best-practices guide, rather than a rating program, is appropriate.

This program and best-practices guide to green residential remodeling have been developed through a partnership between the American Society of Interior Designers (ASID) Foundation and the U.S. Green Building Council (USGBC).

Whole-House, Systems-Thinking Approach

It is easy and tempting to boil down green building to simply product selections and glide over or even ignore the challenges of green building as a process. The REGREEN Program and the REGREEN Residential Remodeling Guidelines are about products and process, about synergies and unintended consequences. In green building, it is rarely a single product or building component or a collection of attributes that results in a building's being labeled "green." Green building is almost always about how systems work together to reduce environmental impacts. In the REGREEN guidelines, systems thinking and integration are encouraged by the cross-listing of strategies by project and environmental category, as well as by the "potential issues" section. In the electronic version of the REGREEN guidelines, electronic links emphasize the systems nature of green residential remodeling.

A Focus on Professional Integration

Let's be frank: getting interior designers, architects, engineers, builders, and trade contractors all on the same page is not easy and is not an everyday occurrence. Yet that is exactly what the REGREEN Program and guidelines do. Content, resources, and case studies tie together best-practice design and construction, and all building professionals are included. Green residential remodeling does not just suggest professional integration at all levels and across all disciplines; it requires it.

And although the target audience of the REGREEN guidelines is building professionals—interior designers, architects, remodelers, and the trades—it should come as no surprise that savvy homeowners and do-it-yourselfers have already shown strong interest in this resource. They want green remodeling integration, too.

Green versus "Good" Design

One of the challenges in developing resources for green building is deciding how to address what constitutes green design and construction versus what constitutes good design and construction. What is the relationship between the two? The REGREEN Program and guidelines work from this perspective: you can have a quality project that is not a green project, but you cannot have a green project that is not also a quality project. Good design and construction are the foundation of green design and construction. For example, you can't have just efficient lighting; it must also be effective lighting. Similarly, beauty is an integral part of green design and construction; the beauty of a building or project is the starting point for durability, one of the most important attributes in green building.

Dealing with Climate and Site

A very significant aspect of building green is designing and constructing for the climate and site. The REGREEN guidelines handle this aspect of green residential remodeling in three ways:

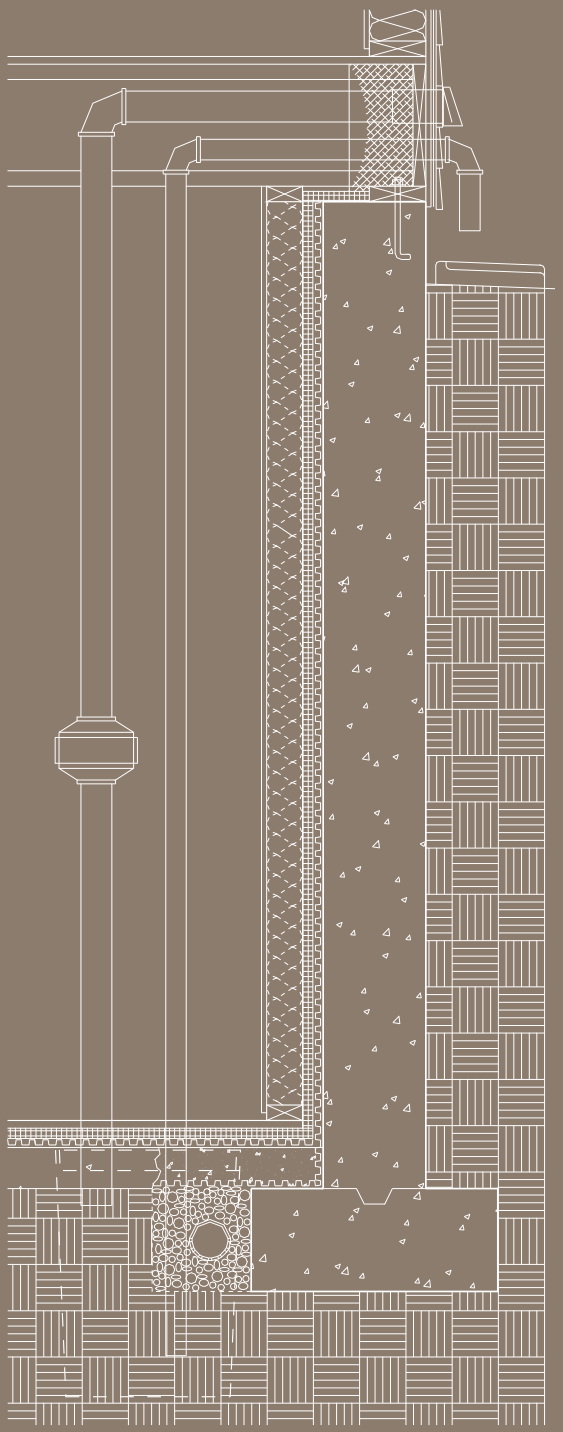
- **Strategies.** Certain strategies suggest varying degrees of implementation, depending on climate—for example, additional insulation or better-performance windows in colder climates.
- **References and Resources.** Many of the sources of additional information yield climate- and site-specific guidance.
- **Case Studies.** Although by no means a comprehensive approach to climate and site, the case studies provide examples of how green residential remodeling can be expressed in types of projects in particular climates and on particular sites.

What the REGREEN Guidelines Are, and What They Are Not

- **The REGREEN Guidelines are comprehensive, but not stand-alone.** The Gguidelines depend heavily on vetted links to additional information on specific topics. Given the nature of green building and the depth and breadth of residential remodeling in particular, the guidelines have to depend—as do you, the user—on connecting with the best resources for more extensive coverage of techniques, strategies, and materials.
- **The REGREEN Guidelines are PDF-based resources, for now.** It was clear to the developers of the Guidelines that electronic resources would offer some significant advantages in covering green residential remodeling. Such a resource would allow for different avenues of initial approach to green residential remodeling, making systems integration and systems thinking natural and easy—and would accommodate evolution and constant improvement to the REGREEN Program. But although the goal is to publish an electronic resource with learning programs to support the use of the guidelines, today it is only available in PDF form. Refer to www.regreenprogram.org for new program updates.

How to Use the Guidelines

The guidelines are organized primarily by project type focusing on the ten most common remodeling projects.



- **The REGREEN Guidelines is project-based, not project-specific.** These guidelines can provide guidance on green remodeling for a variety of projects (ten to date) but it cannot give definitive guidance on a specific project. If you are unsure how a particular method, material, or design feature fits into your project, use the principles of green design and construction in these guidelines.
- **The REGREEN Guidelines is primarily single-attribute product selection guidance.** We simply do not have comprehensive, multi attribute tools today to compare and weigh recycled-content and recyclability, locally sourced and low-emitting materials, manufacturing and maintenance environmental impacts. In these guidelines we have used different proxies for reduced environmental impact rather than a full life-cycle analysis; those products meeting the various criteria are referred to as "environmentally preferable." You will need to accomplish your own balance of various product attributes in weighing the value of one production selection strategy versus another. Look at the the product considerations resources on www.regreenprogram.org to augment the product strategies in the REGREEN Guidelines Strategy Library.
- **The REGREEN Guidelines is not a rating system.** The developers of these guidelines have dovetailed as much as possible with the content and resources of the LEED for Homes Rating System (www.usgbc.org), but not to the extent that any sort of rating or certification can be applied to green residential remodeling projects completed using these Gguidelines. Where applicable, we have referenced standards and certifications used by the LEED for Homes Rating System, including the following:
  - Energy ratings – HERS, EPA Energy Star
  - Water efficiency criteria – EPA WaterSense
  - Material selections – Forest Stewardship Council (FSC) wood certification, GREENGUARD Children and Schools, Green Seal
  - Indoor air quality – ASHRAE 62.2

Here Is the Primary Way to Use the Guidelines

1. Start green

Take a look at the following section, "Green from the start," and use this as a way to approach every green remodeling project. Don't be shy about using the glossary, even if it is just to make sure that the REGREEN authors are using a term the same way that you do.

2. Pick a project type

Each of the ten project types has three major elements:

Integrated predesign issues. Many of the most significant opportunities for reducing the environmental impact of a residential remodeling project, or any building project for that matter, lie in the decisions made at the very start of a project. The Integrated predesign issues ask important questions—by project type—that may challenge some assumptions of either the building professional or the client.

Project scope and strategy lists. For each project, the most important green remodeling strategies that apply to the project are listed around an illustration of such a project. Space limitations dictate that some relevant strategies may not be individually expressed in a given project type; the user may be directed to another project type for a list of additional strategies. The strategy lists are organized by building system or sequence—an order that represents how a remodeling professional (or informed client) typically thinks about a project.

Project case study. Many of us in the building profession understand and internalize principles and practices best when they are expressed through an actual project. For each of the ten project types, a representative green remodeling project is captured through photos; comments from the designer, builder and client; and discussion of key elements of design and construction.

But be careful how much you read into each of the case studies. They cannot capture all of the relevant strategies. They do not necessarily represent the final word or "platinum" perspective; they are guidance, not guilded. You are likely to get as much from the "Lessons Learned" as you are from the "Project Features" section of each case study. The case studies were selected based on a long list of attributes; they can only be improved by having lots of company as the REGREEN Program grows and evolves.

3. Follow Individual Strategies into the Strategy Library

There are nearly 200 write-ups of green remodeling strategies in the Strategy Library. The Strategy Library is organized at by environmental topic, so while you are following up on one strategy, say, on water efficiency, you will see other water efficiency strategies that may be relevant to this or another remodeling project you are involved with. The strategy write-ups include the following:

A general description of the strategy. What it entails and what it means in terms of reduced environmental impact.

Potential issues. This section may cover positive synergies that can be achieved by considering other strategies along with the one at hand, possible unintended consequences of the strategy to be aware of, and issues related to cost, feasibility, or other implications of the strategy.

Related strategies. Each strategy links to other strategies that are related in terms of synergies, unintended consequences, or likely partner strategies.

References and resources. It is not possible in such short write-ups to provide a lot of detail on the strategies. You are directed to some of the best resources for additional guidance on each strategy.

Details and images. Photographs and architectural details further illustrate particular strategies or make critical detailing clear. The title of the detail or image links to a larger view in the image appendix. Where many images refer to a single strategy, all titles are listed, but only one thumbnail is shown.

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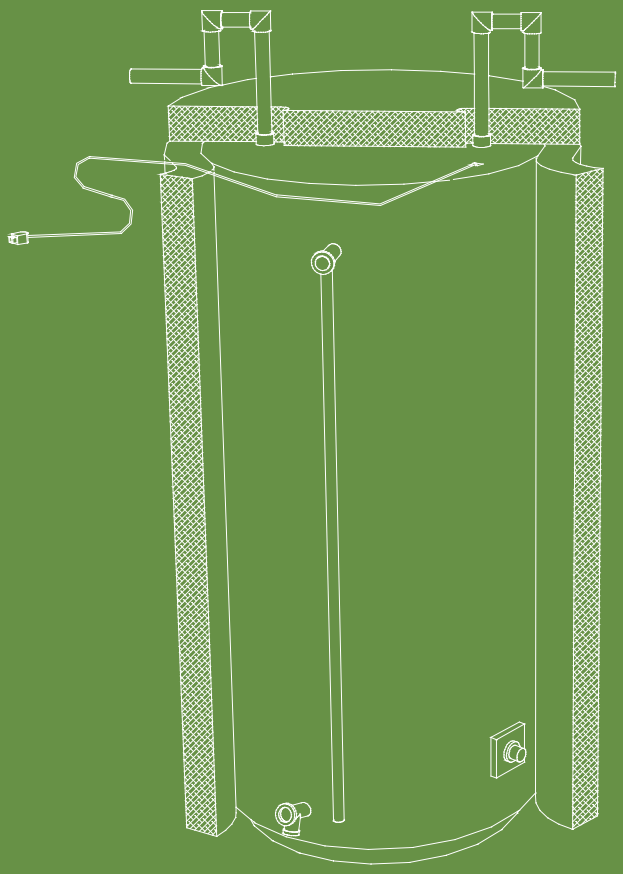
Users of the guidelines can, of course, simply browse the Strategy Library using its table of contents. Many experienced green remodeling professionals will use the guidelines in this way as a sort of brainstorming checklist to remind them of opportunities to consider.

Green From the Start

The start of every remodeling project—weather a single-room renovation or a whole-house gut-rehab—take comprehensive project planning with the major players.

No less important for the green remodeling project, comprehensive green project planning follows these steps:

- Client Interview
- Building Assessment
- Systems-Integrated Team Building
- Cost-Benefit Analysis
- Code and Zoning Issues Management



Client Interview

It is important to begin every project with a "guided discovery" process with the client, asking both open-ended and pointed questions to determine the reasons for renovating in the first place. This process gives the client opportunities to express desires, issues, and concerns and to develop goals, ensuing strategies, and budgets that are aligned with these desires, needs, and expectations. This important up-front process also allows for the design and building professionals to identify issues of which the owners may not be aware.

Here are some representative questions for this client interview:

- What precipitated the desire for a remodel?
- What do thethe owners like about the house?
- What things about the house no longer work for their needs or lifestyle?
- What results do they expect from their renovation?
- Is their house moldy, dusty, dry, or damp?
- How long are they planning to live in the house?
- What compromises have they made due to existing problems?
- Are health issues driving their remodeling project?
- What are their attitudes toward the operations, maintenance, and cleaning of their home?
- Are they happy with the quality of finishes and furnishings, and what are they looking to keep and upgrade?
- Is increased water efficiency a goal?
- Does the house provide them with the desired amount of daylight and sunshine?
- Do their utility bills seem inappropriately high?
- Are there hot or cold spots in their house?
- Do they have to wait a long time for hot water to reach certain fixtures?
- What thermostat setting do they use in the summer and winter?

This guided discovery process provides another opportunity—setting expectations and identifying cause-and-effect outcomes. Energy retrofits can improve both energy performance and thermal comfort, but sometimes increased comfort comes at the price of reduced overall energy improvement. If exhaust fans are required to ensure a healthy, comfortable interior, for example, homeowners need to be aware of the energy costs of those fans. It's important that the owners know just what they must do to maximize the benefit of the green investment they will make in the project.

Building Assessment

The foundation of green remodeling is performance-based systems integration: understanding and then capturing how the structure, finish, furnishings, and mechanical systems work together to make a home safe, healthy, efficient, and durable. The six elements to assess are:

- Building-site interfaces
- Home performance
- Mechanical systems
- Interior spaces
- Materials
- Hazards

Building-site interfaces. The way that sunlight, water, and wind move across or off the home's shell can augment or challenge home performance and levels of comfort. Surface water and groundwater movement can be assessed for proper drainage; trees and adjacent structures can be assessed for desired shading or solar access potential and natural ventilation strategies. Site conditions should also be placed in the larger context of climate, with recommendations for both building envelope and HVAC solutions honoring both opportunities and constraints that climate conditions bring to the project.

Home performance. The building envelope and mechanical systems are the two major elements to be assessed on a home performance audit.

The building envelope components that manage water, air, and heat must be continuous and complete. Many existing homes have gaps or a lack one or more of these barrier systems.

A combination of visual inspections and testing (blower door, infrared technology, moisture meters) can help identify deficiencies in the water, air, and thermal barrier systems, providing you with the information you need to repair, relocate, or create continuous protection systems.

We try to keep our building envelopes from getting wet, and we try to help them dry if—or more likely when—they do get wet. Vapor profiles of building assemblies are assessments of a roof or wall's ability to dry to the inside, the outside or both. Assessment is accomplished be evaluating the air, water , and vapor permeability of individual components and the assembly as a whole. It's often not necessary for this assessment to be quantitative; knowing the relative permeability of assembly components can be enough to gauge drying potential.

There are building assessment tools that green remodeling professionals can use. The LEED for Homes Durability Evaluation Form (from Credit 2 in the Innovation and Design Process section) is one example and the Building Profile Worksheet listed in the guidelines' appendices is another.

Mechanical systems. These include heating, air-conditioning, fresh air ventilation, plumbing, and electrical wiring and equipment. Forced-air HVAC systems can be tested using a duct blaster to identify duct defects. Furnaces, boilers, and gas water heaters can be inspected and tested for combustion safety. Hot water pipes can be identified and tested to determine how long it takes for heated water to reach fixtures. Finally, wiring, switching, lighting, and other equipment can be assessed for potential improvements, such as lamp or fixture replacement.

Interior space. In tandem with the assessment of the building structure itself is the determination of how well the layout of the home is working. Current use of space, reorganization of space, and ease of navigation through the home are all a part of this assessment. The placement of furniture and equipment establishes patterns of movement that should support the activities, health, and safety of the home occupants and not interfere with improved efficiency, comfort, air quality, and noise acoustics.

Every existing home also comes with a substantial inventory of furniture, equipment, and hundreds of furnishing and accessory items—flooring, lighting, window treatments, and artwork, to name a few. Assessment and inventory of these existing goods must be done to ensure that the proposed floor plan maximizes the space and traffic flow relationships throughout the house and balances replacement and refurbishing.

Materials. There are two sides to this assessment: evaluating materials that should *not* become waste because of their reuse potential, and evaluating materials that are not only waste but hazards.

In selective or complete dismantling of a home, or "deconstruction," skilled labor is used as an alternative to the wrecking ball. It can preserve for reuse everything from floor joists to the kitchen sink, from the front door to the light fixtures. Every brick, stick of lumber, or salvaged architectural detail removed from the waste stream saves valuable landfill space, conserves production energy, and can potentially add beauty and historical value to the renovation of the home.

Hazards. These can be mold, water leaks, poor indoor air quality, lead-based paint, radon, asbestos, and structural defects. Some can be assessed by straight visual inspection; others require testing. All are important to the health of the building, the occupants, and the remodeling project.

Systems - Integrated Team Building

One of the most important aspects of green remodeling is assembling a project team whose members understand the importance of systems integration and how their jobs might be a little different because of this approach.

For example, designers must work with the builder to integrate mechanical systems with the structure, keeping ducts and equipment within conditioned space. The head carpenter may need to work out some sequencing details with the insulation contractor to ensure that the air and thermal barriers are complete and continuous, especially at challenging locations, such as behind the tub on an outside wall. The painting contractor needs to understand that substituting a different quality of caulk or paint is not acceptable because of the effect on indoor air quality or the moisture performance of the exterior wall assembly. This type of coordination or systems integration almost always requires three things:

- A team leader who keeps the clients' goals and big picture in mind and who, on his/her own or working with the client's, assembles a project team capable of systems - thinking.
- High-quality floor plans, drawings, specifications, and contractor scopes that fully support the project goals.
- Training, whether it is obtained through a trade association's green certification process or simply by having team members work their way through the REGREEN guidelines.

Green remodeling expertise, including systems integration, can reside in a single person or be spread throughout the team. Not every project team will require a green remodeling consultant, but the benefits of including such expertise may quickly exceed the costs.

Cost-Benefit Analysis

Cost-benefit analysis is an important part of the "guided discovery" process that takes place with the client. Green remodeling professionals have a special opportunity to show how systems integration can actually improve cost-benefit outcomes and provide greater overall value, particularly in the long term. Examples:

- Improvements to the thermal performance of the building envelope can result in downsizing or even eliminating HVAC components, generating a breakeven or even an improved cost-benefit ratio on these elements of the remodel.
- The building and interiors assessment and guided discovery in the client interview shifts the remodeling project from a major addition to (primarily) a reconfiguration of existing space.
- The building and interiors assessment and guided discovery shift the project from an inappropriate gut rehab on a failing structure to the overall more valuable deconstruction and complete rebuilding of the home.

Green remodeling clients are very likely already attuned to a discussion of cost-benefit that includes an expanded definition of value. But using the systems-integration approach to augment the discussion of cost-benefit can move the discussion from "I have heard that building green costs a lot more" to "It's great that building green delivers so much more value."

Code and Zoning Issues Management

Certain green building features and lifestyle choices can be limited or restricted by municipal codes or neighborhood covenants. Some neighborhoods forbid clotheslines as an undesirable look, for example, preventing homeowners from implementing one of the simplest ways to save energy. Getting approval to install solar panels may be difficult in some areas, particularly historic districts. Although the building code may allow advanced framing techniques, the local building inspector may feel otherwise. Green remodeling professionals must be proactive during the planning phase of a project and not reactive during the construction phase when features of the project involve code and zoning issues.

■ ■ ■

The benefits of using the Green from the Start approach in large remodeling projects are probably pretty clear at this point. What many professionals may fail to realize is that every remodeling project will benefit from this approach, and not doing so can be risky in even the smallest projects. Consider these two examples:

- **Interior finishes.** What a designer specifies can have an effect on the performance of the building assembly, the indoor air quality, and the health of the family. If a designer specifies an impermeable wall covering in a hot, humid climate, moisture condensing on the back of the wall covering could result in mold growth on the paper facings of the gypsum board and even rot if the wall is a wood-framed assembly.

- **Window replacement.** As the existing window unit is pulled from the wall, it is discovered that the wall has no building paper or housewrap; there will be no way to weatherlap the flashing of the new window unit to the old assembly. If a building assessment had been conducted during comprehensive planning, the client and remodeling professional might have worked out a more satisfactory result, such as combining the window replacement with some level of recladding.

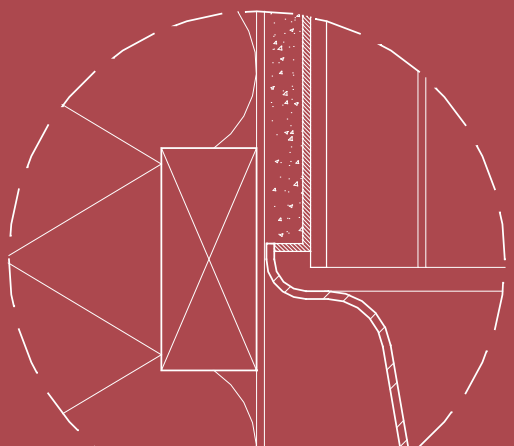
■ ■ ■

Comprehensive project planning is critical to green remodeling and interior design; it can mean a green start that leads to a green finish.

Projects

The ten project types in the next section of the guidelines contain project-specific planning issues. Keep these things in mind:

- Green your projects and your business in steps. Make every project better than the last, but don't try to do everything at once. It can be like trying to drink from a fire hose—you will drown before you slake your thirst.
- Get professional assistance when you need it. You may need quite a bit of help when you are starting, and less and less as you gain experience. Sources for this guidance include local green building and remodeling programs, nonprofit energy efficiency organizations, independent consultants, and experienced green remodelers and design professionals who can serve as mentors.
- Training is critical. Attend green building and remodeling classes before you start your first project and attend classes and conferences whenever you can. And don't forget to train your staff, your trade contractors, and even your vendors to ensure that you get the consistently high performance needed to make your projects green.



Kitchen Remodel

Today's kitchens are often the most active and multipurpose rooms in the home. This can mean that the kitchen provides the most opportunities for "greening" the home. From lighting and appliances to plumbing fixtures and interior finishes, the kitchen is packed with ways to optimize form and function while minimizing environmental impact. For design professionals, the greatest challenge and opportunity of the "new" kitchen can be creating a design that most effectively addresses all of the kitchen's activities without doubling its size. Green kitchens don't have to be sized like a ship's galley, nor do they have to accommodate table tennis.

Integrated Predesign Issues

Function

What does the client want and what does the client need?

The main way that environmental impact is expressed in the function of a kitchen is efficient use of space. The primary functions of a kitchen are work space (both food prep and paperwork), food storage (dry goods and refrigerated items), entertaining (the kitchen is increasingly a place where visitors congregate), and dining. Get a full understanding of just how the client currently uses both the kitchen and related or adjacent spaces and which of the functions the client might want to add to the new kitchen space. These considerations are critical to the efficient use of space within the new kitchen and the home at large.

Existing Conditions

What functional or performance problems exist in the kitchen space that could be addressed at the design level, early in the project?

A project assessment should include examination of the following performance issues, in addition to user function issues:

- Water leaks—building envelope (outside) and plumbing (inside)
- Air leakage
- Environmental hazards: lead, asbestos, radon, interior humidity, mold, CO
- Thermal comfort
- Acoustical comfort
- Structural deficiencies
- Ventilation and exhaust and electrical hazards

Scope

Are there other remodeling projects that should be considered at the time of a kitchen remodel?

For example, a project scope does not include the insulation and air sealing of the opaque areas of the building envelope (walls, roof, foundation), but individual project conditions such as the type of exterior cladding, its service life, and the climate could influence the importance of improving the envelope's thermal performance as part of the kitchen remodel. A green remodeler or interior designer integrates current and future projects in deliberations on the scope of the project with the client.

Conversely, it is easy for a kitchen redesign to result in "pulling out all the stops" to "maximize resale." A green remodeler or designer needs to help the client maintain a focus on personal needs and wants, not what market analysis tells them about what other people want.

Size

Can the kitchen remodel utilize the existing kitchen space, does it require expansion of the kitchen into adjacent interior space, or will it involve additional new space that expands the building envelope?

Satisfying certain "kitchen" functions (for example, dining and storage not related to food or food prep) may mean less overall renovation or avoiding an addition without loss of kitchen function.

There is often a temptation to make the kitchen space bigger and to add more "bells and whistles"—a second dishwasher, a larger refrigerator, a wine chiller, etc. The importance of such features should be carefully weighed because the space requirements and energy costs are significant. Even more difficult may be decisions about storage—including countertop space for everyday or occasional-use appliances and concealed storage for small appliances and dry goods.

Layout and Space Planning

How will the kitchen plan strike a balance between utility, aesthetics, and resource efficiency (especially energy and water use)?

Comprehensive space planning converts the needs expressed by the client into the action - plan for the whole team. Because tradespeople may mean different things by the term "layout," the whole team needs to be involved in development of floor plans, elevations, and supporting documentation to ensure that the design is optimized across disciplines. Ensuring the health, safety, and enjoyment of occupants in the space while minimizing environmental impact, requires special attention to several components:

- Glazing, in terms of both location and total square footage. Windows and skylights can provide views, connection with nature, natural daylighting, passive solar heat gain, and ventilation. But glazing often increases a room's energy load and involves penetrations in the building envelope that must be properly managed. The tendency, especially in kitchens, is to "overglaze" rather than strategically place or select the type of glazing for optimal energy performance, views, and overall indoor environmental quality.
- Plumbing layout. Long runs for hot water result in significant energy and water inefficiencies as well as the inconvenience of long wait-times for hot water. Layouts that place plumbing in exterior walls result in increased heating and cooling loads, as well as potential indoor air quality problems through moisture intrusion, so should be avoided.
- Space conditioning layout. Keep supply registers or radiant and convective elements away from refrigerators.
- Lighting design. the location and type of electric lighting can improve kitchen function, appearance, and energy performance. Provide an optimal mix of task and ambient lighting. Avoid layouts and lighting designs that force recessed lights into the building envelope.
- Appliance location. Keep heating appliances—stoves, ovens, and dishwashers—away from refrigerating units. Provide adequate air space around these appliances.
- Kitchen exhaust location. Ensure that kitchen exhaust fans will be able to readily exhaust to the outside.
- Universal design. Universal design and design for aging in place mean that occupants will need to do less remodeling later, eliminating the associated material use and waste.

strategies

Project Scope

Included:

- Finishes – trim, flooring, countertops, paint
- Furnishings – cabinets, chairs
- Appliances – dishwasher, refrigerator, range and (oven/cooktop), microwave
- Windows
- Fixtures and plumbing

Not included:

- New space or exterior recladding. See Major Addition
- Building envelope and framing. See Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit
- New heating, cooling or water heating. See Deep Energy Retrofit, Gut Rehab
- Renewable energy. See Deep Energy Retrofit

Strategies by Building System

General Design and Construction Strategies

- Ensure durability **IDP1**
- Manage noise **IDP4**
- Design with air quality in mind **IDP5**
- Design for sustainable lifestyle **IDP6**
- Employ universal design **IDP7**
- Design for storage **IDP10**
- Provide pantry **IDP11**
- Design practical and usable kitchen recycling system **IDP12**
- Manage construction and demolition waste **MR107**
- Control spread of pollutants **IEQ158**
- Install track-off mats at exterior doors **IEQ161**

Building Envelope

- Upgrade or replace existing windows and doors **EA56, EA57, EA59**
- Isolate attached garages **IEQ165**
- Use FSC-certified wood **MR118**

Plumbing

- Reconfigure plumbing to distribute domestic hot water efficiently **EA77**
- Install low water–use kitchen faucet **WE41**
- Install on-demand hot water recirculation system **EA78**
- Install under-sink water filtration system **IEQ175**
- Includeplumbing access panel **MR123**

Find strategy descriptions by number in the Strategy Library starting on page 61.

HVAC

- Install effective kitchen ventilation IEQ166
- Provide appropriate venting of all combustion-based heating and water-heating equipment IEQ168
- Make sure ducting is clean EA71

Lighting and Electrical

- Provide daylighting EA83
- Provide appropriate mix of color-correct ambient and task lighting EA84
- Install energy-efficient electric lighting EA85
- Provide shading of skylights as needed EA61

Appliances

- Install energy-efficient refrigerator EA93
- Choose energy-efficient dishwasher EA94
- Install energy-efficient cooking appliances EA95
- Consider energy toll of small appliances EA96
- Manage phantom loads EA98

Wall and Ceiling

- Install environmentally preferable interior sheathing MR126
- Use nonpaper-faced gypsum board in moist areas IEQ183
- Limit use of wallcoverings in high moisture areas IEQ184
- Use low- or zero-VOC interior paints and finishes IEQ185
- Use appropriate sheens for paints and finishes MR130
- Use low- or zero-VOC construction adhesives, caulking, and sealants IEQ187
- Consider tile and tile trim pieces with recycled content MR132

Floors and Flooring Products

- Consider reuse of existing flooring and subflooring MR133
- Refinish wood floors using environmentally preferable processes and products MR137
- Choose hard-surface flooring IEQ180
- Consider flooring made from certified or reclaimed wood MR135
- Consider flooring made from natural or rapidly renewable materials MR136
- Avoid carpeting in high moisture areas or where spills could occur IEQ179

Furniture and Fittings

- Choose furniture and fittings that will not absorb moisture IEQ188
- Select compact furniture that incorporates storage MR146
- Consider reusing clean existing cabinetry or buying salvaged MR140
- Select cabinets made from greener materials MR148
- Evaluate use of cabinetry and furniture made from particleboard or MDF MR145
- Install environmentally preferable countertops MR149
- Select materials that are easy to clean MR156

Use

- Set water temperature no higher than necessary EA82
- Use environmentally preferable cleaning materials and strategies IEQ196
- Properly maintain equipment EA90
- Install CO and smoke alarms IEQ164
- Educate homeowner for green living EA103, EA104, EA105

case study

Location: Santa Cruz, California
Homeowners: Laura Alderman and Gary Garcia
Interior Designer: Lydia Corser, Eco Interiors
General Contractor: Rory Howland, Howland Construction
Area affected: 250 ft^2

"I'm a big believer in the idea of timelessness. When there is good, pleasing design, it stays in place for a long time—people don't want to change it." – Lydia Corser

Kitchen before

Overview and Scope

The owners of this 1,200-square-foot, 1948 house in Santa Cruz, California, had an overall plan: remodel their home in a way that would allow them to live out their lives in one place. Because of mold and moisture issues, they had already upgraded the house envelope. Next they wanted to design a kitchen that would last forever, add a guest bathroom, and create a private master bath. The clients were looking for a way to redesign within the existing space of their concrete masonry home and were sold on the idea of building green.

Design Approach

The tiny kitchen was poorly laid out and poorly furnished, but it adjoined a large mudroom. Reconfiguring the floorplan to subdivide the mudroom allowed the designer to expand the kitchen and add a guest bathroom without an addition or significant relocation of walls. Because the owners wanted to grow old in the building, every effort was made to ensure accessibility in the open plan. And although this project did not include a photovoltaic or graywater system, the remodel did include prewiring for a future PV system and preplumbing for graywater.

Team and Process

Considering whether to hire a pro, the do-it-yourself homeowners were drawn to the unique materials in the Eco Interiors green showroom, and to Lydia's deep green approach. Lydia and Rory (the contractor Lydia recommended and the homeowners ultimately used) are Build It Green trained and certified. Their common green building background allowed them to easily form a team, recommending and implementing a wide range of green features that the clients would not have considered on their own.

"It is valuable having someone certified for Kitchen and Bath (Lydia is a Certified Master Kitchen and Bath Designer®) and also being an evangelist for green—a lot of people tout green, but is it really green? Where do you draw the line?"

– Laura Alderman

Concrete countertop with natural wax finish

"You have to be on top of the communication to come in at the right time in the process and make your case when the client is listening and open."

– Lydia Corser

Built-in eating area

Bamboo and FSC-certified maple cabinets

Finance

The owners originally wanted to add a granny apartment to their garage, but the price estimate led them to a remodel instead. Ultimately, the remodel cost 30% to 60% more than they budgeted —about the cost of the new construction estimate. What drove the cost up was the additional work orders and add-ons, not the green features. Because the owners had decided to move out for the work, they took the opportunity to do additional upgrades on the house.

Lessons and Trade-offs

The clients wanted to go green all the way and made few compromises.

The house is likely to achieve the first green building award in the City of Santa Cruz Green Building Program, meeting133 to 135 of the 137 points available to this project (the program total for remodeling projects is 464). The designer's one regret is the high-VOC finish on the hardwood floors throughout the house, which was the owners' one nongreen choice.

By System

Extra Features

- Prewired for photovoltaic panels
- Preplumbed for graywater system

HVAC

- Kitchen range hood exhausted directly outdoors

Lighting

- Ambient lighting: airtight, insulation-contact-rated, recessed fluorescent cans
- Task lighting: under-cabinet fluorescent lights and over-table light fixtures made from 100% recycled cast aluminum
- Meets California's Title 24 requirements for lighting efficiency

Appliances

- Energy-efficient dishwasher, clothes washer and dryer—beyond Energy Star minimum
- High-efficiency water heater

Wall and Ceiling Finishes

- Zero-VOC paint

Floors and Flooring Products

- Natural linoleum flooring

Furniture and Fittings

- Bamboo cabinetry with natural low-VOC finish and prefinished plywood bodies of FSC-certified maple with formaldehyde-free, soy-based adhesive
- Cabinets with recycled plastic content
- Concrete countertops with locally produced natural wax finish

Bathroom Remodel

The greatest opportunities for greening a bathroom remodel come from managing water, but in two very different ways: managing incoming use (in pipes) and outgoing flows (both liquid and vapor). Green bathrooms need the highest-performing faucets, showerheads, and toilets. But they also need walls designed and constructed to handle both liquid water and high humidity, and exhaust fans that efficiently and quietly move water vapor out of the space. The bathroom is also a good place to invest in durable surfaces, ones that stand the test of time both aesthetically and functionally.

Integrated Predesign Issues

Function

What does the client want and what does the client need?

Bathroom remodeling may be taken on for different reasons: a water leak or moisture intrusion problem that results in the need for structural repairs, a desire to make the bathroom more functional or convenient, the need to accommodate a growing family, a change in health or mobility of a family member, a desire to improve the bathroom appearance, or a desire to upgrade appliances and fixtures.

The bathroom represents an important opportunity to weigh the desire for more glamorous amenities that may seldom be used (such as a Jacuzzi or a steam shower) against a desire for a more practical, more convenient, and more resource-efficient space.

Existing Conditions

What functional or performance problems exist in the bathroom that could be addressed at the design level, early in the project?

- Is there a moisture and/or mold problem that drives the project?
- Have mechanical, electrical, or structural issues arisen that necessitate the bathroom remodel?
- Is the bathroom insufficient in size and layout to function well for the homeowners?
- Have health or mobility issues arisen that necessitate the reconfiguring and outfitting of the bathroom to meet those new needs?

Scope

Are there other remodeling projects that should be considered at the time of a bathroom remodel?

Any opportunity to improve the home's building envelope should be considered at the time of a bathroom redesign and remodel.

The project might include extensive replumbing and rewiring; if any future remodeling projects are being considered, evaluate whether those other projects might be affected by the bathroom remodel and plan accordingly.

Designing for reduced mobility with aging can allow homeowners to live in their homes longer. Selection of taller (ADA-compliant) toilets, wheelchair-accessible sinks and cabinets, and framing to allow later installation of grab bars can be smart and sustainable choices.

Size

Can the bathroom remodel utilize the existing bathroom space or will it require additional space?

Reconsidering the bathroom function to address new needs and wants might be done by reconfiguration of existing space, expansion into adjacent space, or new construction. Rethinking the way existing bath and adjacent space's are being used could minimize the amount and extent of remodeling required and the materials involved.

Layout and Space Planning

How will the bathroom plan strike a balance between utility, aesthetics, and resource efficiency (especially energy and water use)?

Comprehensive space planning converts the needs expressed by the client into the action - plan for the whole team. Because tradespeople may mean different things by the term "layout," the whole team needs to be involved in development of floor plans, elevations, and supporting documentation to ensure that the design is optimized across disciplines.

strategies

Project Scope

Included:

- Interior sheathing and walls
- Windows
- Wet wall design (water management)
- Plumbing fixtures and accessory items
- Domestic hot water system
- Ventilation
- Finishes – trim, flooring, tub and shower surfaces, paint
- Cabinetry
- Laundry room (with living or finished space below)

Not included:

- New space or exterior recladding. See Major Addition
- Building envelope and framing. See Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit
- New heating, cooling or water heating. See Deep Energy Retrofit, Gut Rehab
- Renewable energy. See Deep Energy Retrofit

Strategies by Building System

General Design and Construction Strategies

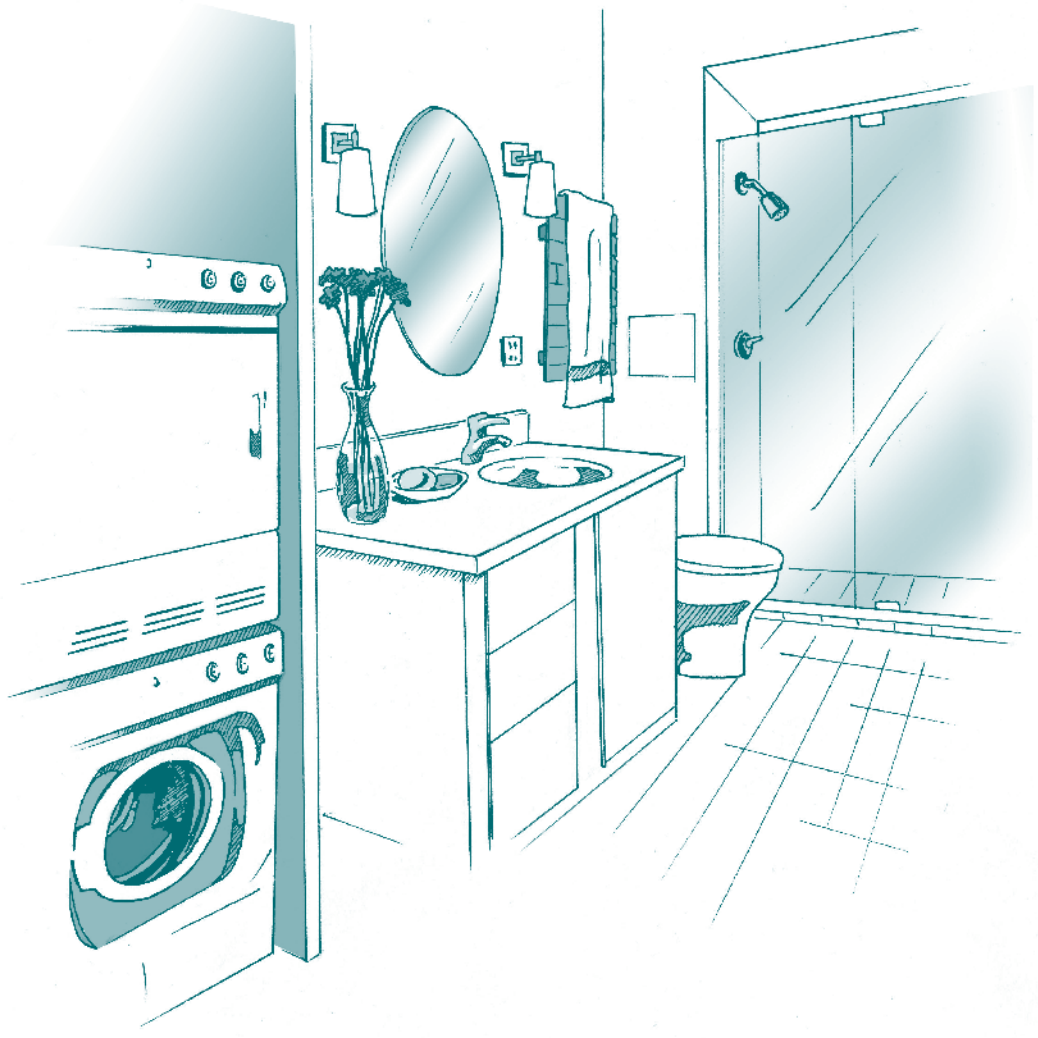
- Ensure durability IDP1
- Manage construction and demolition waste MR107
- Manage noise IDP4
- Design with air quality in mind IDP5
- Design for sustainable lifestyle IDP6
- Employ universal design IDP7
- Design for storage IDP10
- Control tspread of pollutants IEQ158

Building Envelope

- Properly detail window sills in wet areas IDP26
- Ensure that window and skylight installation includes proper air sealing and flashing IDP27
- Use FSC-certified wood MR118

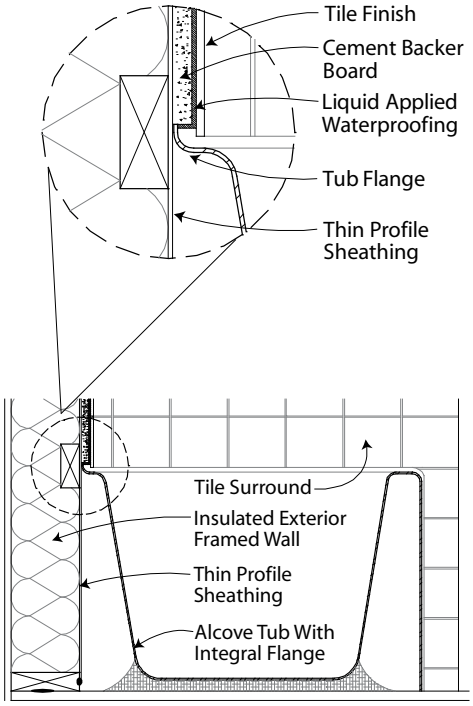
Lighting and Electrical

- Provide daylighting EA83
- Provide appropriate mix of color correct ambient and task lighting EA84
- Install energy-efficient electric lighting EA85
- Manage phantom loads EA98



Find strategy descriptions by number in the Strategy Library starting on page 61.

Tub Surround Detail



The tub-tile surround transition is a difficult yet critical water management detail.

Note the use of materials impervious to bulk water throughout and the free-draining space between the tub and bottom course of tile. This same detail can be applied to the shower basin-tile surround transition, creating a durable, easy-to-clean, and easy-to-maintain bathing area.

Plumbing

- Replace toilets with high-efficiency toilets **WE42**
- Install low - water–use showerheads **WE43**
- Install water-conserving bathroom faucet aerator **WE44**
- Install water filter on showerhead **IEQ176**
- Include plumbing access panel **MR123**
- Choose efficient hot tub or spa **EA97**
- Choose high-efficiency water heater **EA79**
- Consider environmental preferability of piping material **MR122**
- Reconfigure plumbing to distribute domestic hot water efficiently **EA77**

Laundry

- Install readily - accessible single-throw shutoff valve **MR124**
- Install drain and drain pan for clothes washer located over finished space **MR125**
- Select high-efficiency, H-axis clothes washer **EA92**
- Provide air-lock dryer vent **EA72**
- Minimize dryer duct length and number of turns **EA73**
- Provide line drying options for laundry **EA106**

HVAC

- Install effective bath ventilation **IEQ167**
- Make sure ducting is clean **EA71**

Wall and Ceiling Finishes

- Frame for installation of future grab bars **MR128**
- Install environmentally preferable interior sheathing **MR126**
- Use nonpaper-faced gypsum board in moist areas **IEQ183**
- Limit use of wallcoverings in high moisture areas **IEQ184**
- Consider tile and tile trim pieces with recycled content **MR132**
- Use low- or zero-VOC interior paints and finishes **IEQ185**
- Use appropriate sheens for paints and finishes **MR130**
- Use low- or zero-VOC construction adhesives, grouts, caulking, and sealants **IEQ187**

Floors and Flooring Products

- Consider reuse of existing flooring and subflooring **MR133**
- Avoid carpeting in high moisture areas **IEQ179**
- Choose hard-surface flooring **IEQ180**

Furniture and Fittings

- Choose furniture and fittings that will not absorb moisture **IEQ188**
- Consider reusing clean existing furnishings and fixtures or buying salvaged **MR141**
- Evaluate use of cabinetry and furniture made from particleboard or MDF **MR145**
- Select materials that are easy to clean **MR156**
- Purchase best, most durable furniture possible within given budget **MR143**
- Select cabinets made from green materials **MR148**
- Install environmentally preferable countertops **MR149**

Use

- Set water temperatures no higher than necessary **EA82**
- Use environmentally preferable cleaning materials and strategies **IEQ196**
- Consider using bulk-product dispensers for body care products **MR157**
- Educate homeowner for green living **EA103, EA104, EA105**

case study

Location: Clearwater, Florida
Homeowner and Environmental Consultant: Debra Lynn Dadd
Homeowner and Amateur Builder: Larry Redalia
Area affected: 40 ft^2

"Storage was a challenge in this small bathroom, as there just wasn't space to put a cabinet or a spacious vanity. Our solution was to pare down the essentials that needed to be stored in the bathroom and then be creative." – Debra Lynn Dadd

Bathroom before

Overview and Scope

With a 5-by-8-foot bathroom combining 1960s décor with original features from 1940, the homeowners hoped to renovate eventually when they could budget it. They ended up acting faster upon discovering that mold in the bathroom was the cause of their recent respiratory and sleep problems. A house inspection team uncovered the mold infestation and recommended taking the bathroom down to the studs for full remediation. The couple took advantage of the problem to create a visually appealing, nontoxic, and mold-resistant bathroom within the existing space. While also keeping in mind future resale, they tailored the bathroom to meet their needs.

Design Approach

The old bathroom had no ventilation, causing consistently high humidity, and leaks from the bathroom's corroded galvanized steel pipes had saturated the floor around the tub and toilet areas, damaging the floor and subfloor. The couple's highest priority was to create a durable bathroom that would stay mold-free. This meant proper detailing and rethinking plumbing, ventilation, and finishes. They also wanted a nontoxic bathroom with as many additional environmental features and materials as their budget would allow – all within the existing small space. They chose a bathroom theme celebrating water and nature as works of art, and a style befitting an average suburban home, making it suitable for resale.

Team and Process

Taking one year to complete the project, the couple hired skilled contractors to do the mold remediation, plumbing, and electrical work but did the finish work themselves. An extra toilet in the house and a shower in their rental property nearby gave them the flexibility to take whatever time they needed. Concerned about future leaks, they made sure to research correct tile shower installation. Larry first installed cement backerboard underlayment on walls and floor (avoiding paper-faced greenboard, which should not be used behind tile). He then used nontoxic, thin-set mortar to hold the tile and applied nontoxic grout and grout sealer to finish the job. Their research on tile shower installation led Larry to follow the methods and materials of Ontario Tile Setters (www.debraslist.com/greenbathroom/showerpan.pdf).

"Read and understand the directions thoroughly before starting such a project."
– Larry Redalia

Skylight in shower stall

"Home improvement stores will often give you an excellent deal on slightly - damaged or opened cartons, but you need to ask for it first."

– Debra Lynn Dadd

Space-saving sink and vanity

Durable shower pan, under construction

Durable shower pan, finished

Wall tile-marble detailing

Finance

Debra and Larry had not budgeted for this emergency bathroom remodel. Although their insurance paid for basic mold remediation, including full containment and negative pressurization of the bathroom, it did not cover the cost of updating fixtures, furnishings, or finishes. By performing much of the design and construction themselves, the couple could budget more for materials and consider durability and style, in addition to affordability, in purchase decisions. They also shopped architectural salvage yards to acquire, at lower cost, quality materials such as handmade tile.

Lessons and Trade-offs

The homeowners found they had to make some compromises to meet their budget for the project. Although they used nontoxic finish products, and prioritized durability in aspects such as plumbing and tiling, the couple passed on other, less affordable features, such as recycled-content tile and organic cotton towels. Because Larry performed so much of the actual work, he was less prepared for the unknown than a professional may have been. While mixing the mortar for the tiled shower pan, for example, Larry discovered—too late—that the instructions he had didn't match the included illustrations.

By System

HVAC

- Ventilation ducted to outdoors

Plumbing

- Low-flow fixtures for sink, toilet, and shower
- Low-flow showerheads designed for efficiency (not retrofitted with flow-restrictors)

Lighting

- Natural lighting provided by skylight over shower

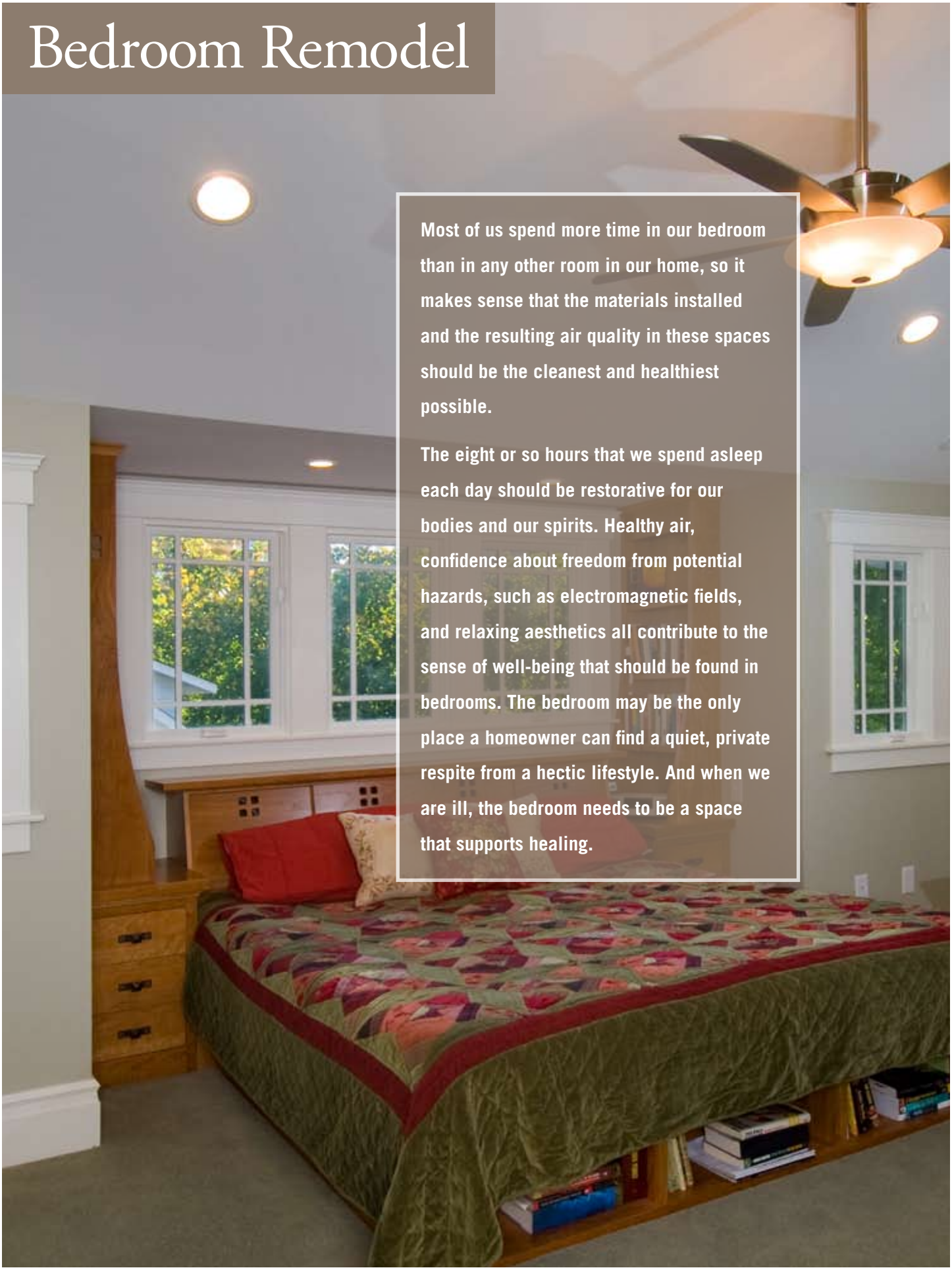
Finishes

- Tile floor and tile walls throughout the bathroom, with unique tiling pattern in shower area
- Durable marble baseboard
- Breathable (natural-colored) clay plaster finish
- Nontoxic grout and grout-sealer
- Waterproof detailing

Use

- Nontoxic (natural) body care products
- Nontoxic cleaning products

Bedroom Remodel



Most of us spend more time in our bedroom than in any other room in our home, so it makes sense that the materials installed and the resulting air quality in these spaces should be the cleanest and healthiest possible.

The eight or so hours that we spend asleep each day should be restorative for our bodies and our spirits. Healthy air, confidence about freedom from potential hazards, such as electromagnetic fields, and relaxing aesthetics all contribute to the sense of well-being that should be found in bedrooms. The bedroom may be the only place a homeowner can find a quiet, private respite from a hectic lifestyle. And when we are ill, the bedroom needs to be a space that supports healing.

Integrated Predesign Issues

Function

What does the client want and what does he client need?

The remodeling and renovation of any interior space can be driven by many factors: the desire to create more usable spaces; the desire to replace worn-out furniture or equipment; the need to create a healthier environment for those with allergies, asthma, or other sensitivities; or the desire to improve aesthetics alone. Regardless of the driving force behind the renovation, several things need to be kept in mind through the early design and decision-making process.

Because our bedrooms play such an integral role in our health maintenance—in providing a good night's sleep, offering a quiet retreat from our hectic lives, and allowing a healing space for our bodies and spirits—it is important to keep health issues at the top of the list in our bedroom design choices.

Existing Conditions

What functional or performance problems exist in the bedroom space that could be addressed at the design level, early in the project?

- Does the existing bedroom have problems caused by moisture intrusion from the adjacent bathroom or other water-compromised areas of the house such as crawl space, or poor perimeter drainage?
- Is the air quality in the existing bedroom compromised by offgassing from VOCs in finishes, or other potential harmful chemicals that may be released from building products or components, such as flame retardants, heavy metals, plasticizers, or biocides?
- Does the bedroom need improved air quality during the nighttime hours?
- Are windows in poor shape and in need of replacement, and do they still open for fresh air?

Scope

Are there other remodeling projects that should be considered at the time of a bedroom remodel?

The project may present an opportunity to make other improvements in the home at the same time.

Size

Can the bedroom remodel utilize the existing bedroom space or will it require additional space?

Additional space may be a driver with a bedroom remodel, but homeowners should consider this carefully. Bedrooms may become repositories for "stuff," giving homeowners the feeling that they need more space. But by taking the time to reduce that accumulated stuff—too much clothing, too many shoes—the need for new space may be reduced or even eliminated. Also, a more clutter-free bedroom allows for a cleaner and healthier space.

strategies

Project Scope

Included:

- Wiring and appliances
- Additions, upgrades and improvements to main HVAC system
- Wall, ceiling, and woodwork finishes
- Flooring
- Window treatments
- Furniture
- Mattress and bedding
- Lighting
- Accessories

Not included:

- New space or exterior recladding. See Major Addition
- Building envelope and framing. See Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit
- New heating, cooling, or water heating. See Deep Energy Retrofit, Gut Rehab
- Moisture management. See Gut Rehab, Major Addition, and Deep Energy Retrofit
- Renewable energy. See Deep Energy Retrofit

Strategies by Building System

General Design and Construction Strategies

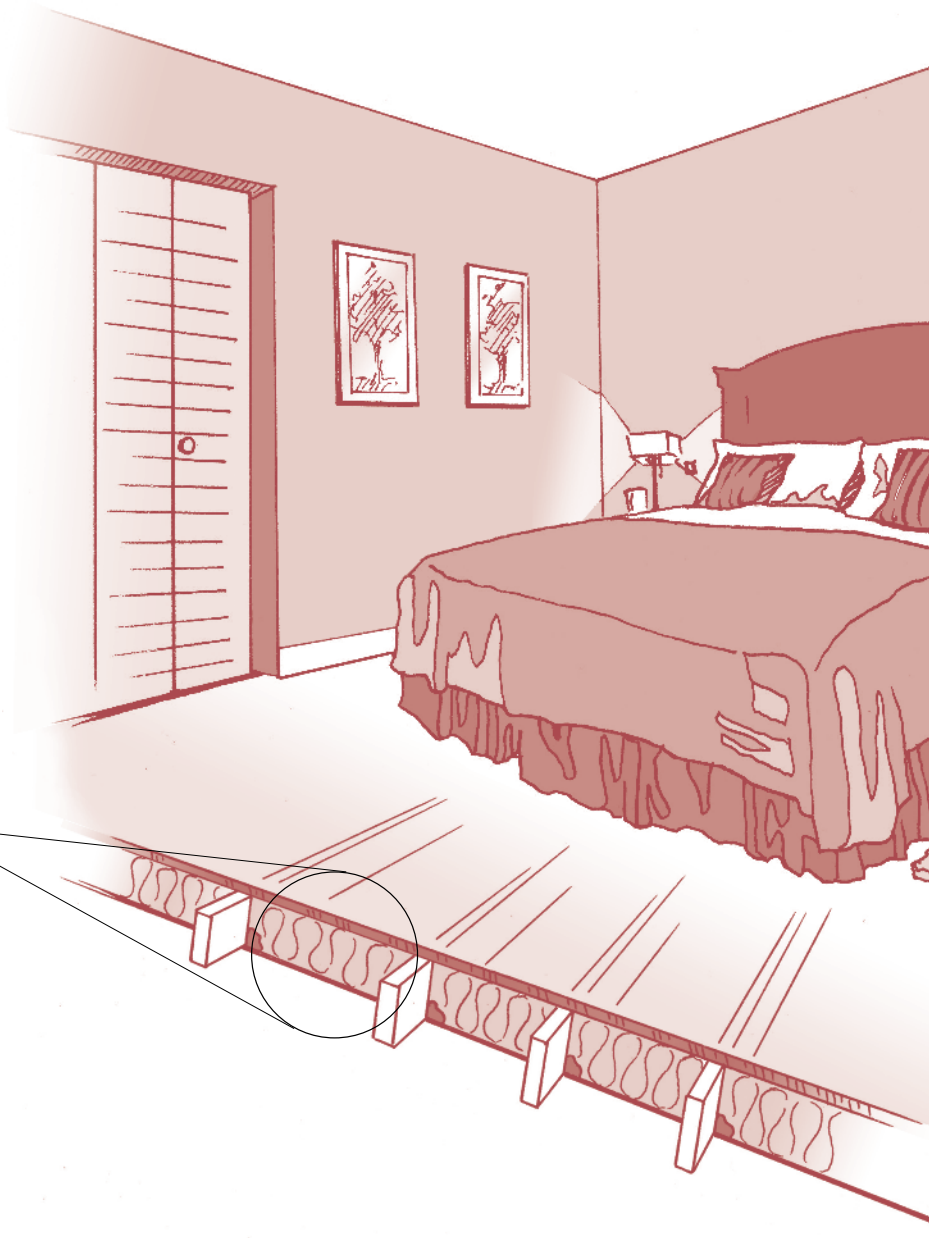
- Ensure durability **IDP1**
- Manage noise **IDP4**
- Design with air quality in mind **IDP5**
- Design for sustainable lifestyle **IDP6**
- Manage construction and demolition waste **MR107**

Building Envelope

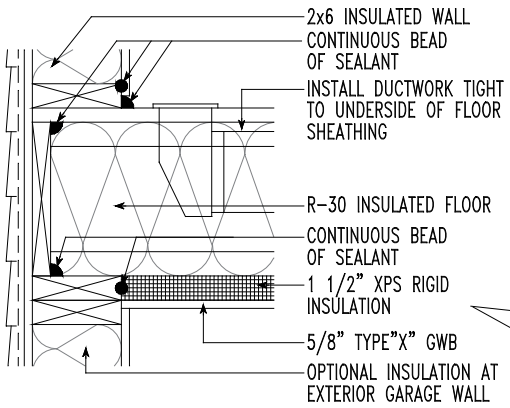
- Isolate attached garage **IEQ165**
- Control spread of pollutants **IEQ158**
- Use FSC-certified wood **MR118**

HVAC

- Provide for forced-air system pressure relief **IEQ170**
- Provide fresh air as part of ventilation system **IEQ171**
- Make sure ducting is clean **EA71**



Attached Garage Air Sealing Detail



This detail shows how to achieve proper isolation (continuous air and thermal barrier) between an attached garage and any adjacent living space.

Find strategy descriptions by number in the Strategy Library starting on page 61.

Lighting and Electrical

- Provide daylighting EA83
- Use prudent avoidance with electromagnetic fields IEQ177
- Provide appropriate mix of color-correct ambient and task lighting EA84
- Install energy-efficient electric lighting EA85
- Provide controllable interior shading IEQ178
- Manage phantom loads EA98

Wall and Ceiling

- Install environmentally preferable interior sheathing MR126
- Select environmentally preferable interior doors MR127
- Use low- or zero-VOC interior paints and finishes IEQ185
- Consider natural finishes MR131
- Use appropriate sheens for paints and finishes MR130
- Consider alternative wallcovering products MR129
- Limit use of VOC-emitting wallcoverings IEQ186

Floors and Flooring Products

- Consider reuse of existing flooring and subflooring MR133
- Select wood subflooring that is FSC-certified and low/no-formaldehyde MR134
- Choose hard-surface flooring IEQ180
- Consider flooring made from certified or reclaimed wood MR135
- Consider flooring made from natural or rapidly renewable materials MR136
- Refinish wood floors using environmentally preferable processes and products MR137
- Use area rugs instead of wall-to-wall carpeting IEQ182
- Choose environmentally preferable carpet and rug products MR138
- Select carpet cushion that does not contain brominated flame retardants MR139

Furniture and Fittings

- Consider cleaning existing furniture or purchasing salvaged or antique furniture MR142
- Purchase most durable furniture possible within given budget MR143
- Select solid furniture made from green and safe sources MR147
- Select furniture from suppliers that practice fair and safe manufacturing processes MR150
- Minimize use of plush and porous materials IEQ191
- Choose environmentally preferable fabrics MR152
- Choose furniture finished with least-toxic products IEQ189
- Select furniture that is easy to clean IEQ192
- Select window treatments with health considerations in mind IEQ193
- Select mattress and bedding with attention to health issues IEQ194
- Choose interior accessories with care IEQ195
- Support local artisans as well as indigenous peoples MR153
- Select upholstered furniture with care MR151
- Avoid fully upholstered furniture where moisture may be problem IEQ190

Use

- Use environmentally preferable cleaning materials and strategies IEQ196
- Educate homeowner for green living EA103, EA104, EA105

case study

Location: Valley Village, California
Homeowners: Mary Cordaro and Scott Jones
Certified Bau-Biologist and Environmental Consultant: Mary Cordaro, Industry Partner member of ASID
Area affected: 200 ft²

"One of the things I always teach is that you are not going to have a healthy bedroom without good perimeter drainage." – Mary Cordaro

Bedroom before

Overview and Scope

This bedroom, along with the rest of the 1950s house, has undergone a slow transformation to an all-natural space, free of allergens and synthetic chemicals. Through a series of renovations that began in 1990, Mary Cordaro has updated her home according to recent advances in building science and the principles of Bau-Biologie (German for " building with life"). Because Bau-Biologie focuses on the bedroom, where people spend the majority of their time, Mary has concentrated her renovation efforts on her own bedroom. The last major change, in 2002, involved swapping environmentally friendly synthetic finishes for natural finishes. The allergen-free bedroom now includes organic bedding materials in addition to natural finishes, and attention has been given to minimizing electromagnetic fields (EMFs).

Design Approach

Renovation of the house is a work in progress. Renovations in the 1990s did away with the décor from the 1970s. In the bedroom, green shag carpeting was replaced with maple hardwood flooring and a synthetic, zero-emitting floor finish. As the Bau-Biologie principles evolved and more durable and easy-to-apply natural finishes became available, Mary replaced synthetic finishes with newly available natural finishes. She keeps a running list of changes to be made as time and finances allow.

Team and Process

Mary is part of a cross-disciplinary team of independent consultants and contractors who worked together on her house, as well as on other projects in the Los Angeles area. The team includes an HVAC installer trained in building science, an electrician with special training in reducing EMFs, a natural painting crew, a building science and Bau-Biologie environmental inspector who ensures that there are no water intrusion or moisture issues, and Mary, the Bau-Biologie project manager and materials specialist.

"It makes such a huge difference to be in an environment that is as free as possible from the pollutants most homes have—in indoor air, but also from the outdoors. We live in a very smoggy urban environment, so this is a great house to try to make as healthy as possible under the worst conditions." – Mary Cordaro

Reclaimed Japanese reed screen

"I'm not worried about durability with natural finishes—we don't wear shoes in the house, and the flooring finish I would now use is just as durable as many green, synthetic, water-based finishes. It also allows for touching up high-traffic areas without sanding and refinishing the whole room." – Mary Cordaro

Bio-based paint

Organic flame retardant-free bedding

Personal space HEPA air filtration

Finance

Although natural finishes are becoming more available, affordable, and manageable, they still tend to be more expensive to purchase and apply than a synthetic equivalent. Rather than compromising on natural finishes, however, the homeowners chose to do renovations room by room over time, as finances permitted.

Lessons and Trade-offs

Because of the long-term nature of this retrofit, Mary experienced the blessing and curse of hindsight throughout the process. As new products became available and Bau-Biologie principles evolved, Mary identified things that she would have done differently. Early in the process, she reinsulated the attic with a new insulation material that turned out to be friable. This creates a lot of dust when changes are made to HVAC and lighting, all located in the attic; cotton or cellulose insulation would be her preferred materials today, installed in the ceiling of the attic to create a conditioned attic. Similarly, the team initially used water-based, zero-emitting paints and floor finish but would now choose only natural finishes.

By System

Wiring

- Shielded and grounded cables
- Minimal EMFs, both low-frequency and high-frequency (radio), and no Wifi
- Bed shield for any remaining EMF levels

HVAC

- Forced-air system installed airtight for energy efficiency, positive pressure, fresh air dilution, and filtration.
- Room high-efficiency particulate air (HEPA) and carbon filter with shielded cable for low EMFs
- Whole-house HEPA and carbon air filtration system

Wall and Ceiling Finishes

- Naturally pigmented mineral and bio-based paint for walls, ceilings, and woodwork

Floors and Flooring Products

- Solid maple hardwood flooring
- Water-based clear acrylic finish with low VOCs

Furniture and Fittings

- Mattress foundation made of FSC-certified wood
- Mattress made of organic cotton and wool and natural latex instead of inner springs
- Organic bedding materials free of flame-retardant chemicals and synthetic materials
- Linens made from hemp, silk, and organic cotton
- Basswood wood blinds
- Antique (reclaimed) Japanese reed screen

Living and Working

In most homes, the traditional living space configuration—kitchen, dining room, living room, den—has already beed reconfigured for more contemporary lifestyles and shared rather than separate functions: work spaces in the kitchen or living room, entertainment in the den, dining in the kitchen. When remodeling green, the goal is to rework existing spaces for new or combined functions rather than add new spaces.

Integrated Predesign Issues

Function

What does the client want and what does the client need?

What motivates the desire or need to reconfigure the living and working spaces in the home? Have lifestyle and work requirements changed to necessitate the repurposing of a space to allow for the performance of multiple tasks in a designated room? Can these lifestylemand work needs be met without additional rooms and square footage? Instead, can an existing room be redesigned to be multipurposed and more?

Is there a desire to keep better connected with family members throughout the day? Can a single, well-thought-out room allow for parents and children to work and play independently but in the same space?

Is there a need to replace or upgrade flooring and/or furnishings, driven by personal changes, or is this a home with new owners?

Existing Conditions

What functions or performance problems exist in the home's general living spaces that could be addressed at the design level, early in the project?

Are there rooms in the home that are underutilized and do not fit with the family's current lifestyle, such as a separate living room that sits vacant, or a formal dining room that is used once a year?

Is thermal discomfort, inadequate lighting, poor indoor air quality, or poor acoustics driving the decision to remodel?

Scope

Are there other remodeling projects that should be considered at the time of the living and working space remodel?

Designing a new multiple-use living and working space is an excellent opportunity to examine daily patterns of activity, and to determine how fully all areas of the house are being used.

Size

Can the living and working space merge other rooms of the home to create a more usable space without adding square footage?

An evaluation of room use combined with an assessment of how well existing rooms might accommodate combined uses will reveal which room can best meet the new combination of uses or which rooms can be reconfigured or even joined for multipurpose living and working space.

Layout and Space Planning

Is the reconfiguration designed for flexible or more permanent long-term combined uses?

Does the plan for reconfiguration cover anticipated future uses of spaces (based on an aging-in-place approach or a general "marketability" of the new spaces and combined functions)?

Integrated infrastructure

Does the plan integrate passive design and active mechanical and electrical infrastructure?

Has the proper consideration been given to the electrical and mechanical configuration of the new multifunctional space—plug load, lighting, space conditioning, ventilation—and its integration with natural ventilation, daylighting, and fenestration?

strategies

Project Scope

Included:

- Wiring
- Furnishings
- Lighting
- Electronic equipment
- Floor finishes

Not included:

- New space or exterior recladding. See Major Addition
- Building envelope and framing. See Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit
- Interior wall finishes. See Bedroom
- New heating, cooling or water heating. See Deep Energy Retrofit, Gut Rehab
- Renewable energy. See Deep Energy Retrofit
- Windows and exterior door. See Gut Rehab

Strategies by Building System

General Design and Construction Strategies

- Ensure durability **IDP1**
- Manage noise **IDP4**
- Design for sustainable lifestyle **IDP6**
- Optimize interior layout **IDP8**
- Design for storage **IDP10**
- Manage construction and demoliton waste **MR107**
- Plan future wiring and cabling needs **MR121**
- Use FSC-certified wood **MR118**
- Control spread of pollutants **IEQ158**

HVAC

- Provide fresh air as part of ventilation system **IEQ177**
- Provide for additional ventilation and air-conditioning needs in certain activity areas **IEQ172**
- Make sure ducting is clean **EA71**

Find strategy descriptions by number in the Strategy Library starting on page 61.

Lighting and Electrical

- Provide daylighting **EA83**
- Design appropriate mix of color-correct ambient and task lighting **EA84**
- Install energy-efficient electric lighting **EA85**
- Provide adaptable lighting for multiuse spaces **EA87**
- Manage phantom loads **EA98**
- Provide controllable interior shading **IEQ178**

Equipment

- Manage phantom loads **EA98**
- Select energy-efficient Energy Star–rated office equipment **EA99**

Floors and Flooring Products

- Consider reuse of existing flooring and subflooring **MR133**
- Select wood subflooring that is FSC-certified and low/no-formaldehyde **MR134**
- Choose hard-surface flooring **IEQ180**
- Consider flooring made from certified or reclaimed wood **MR135**
- Consider flooring made from natural or rapidly renewable materials **MR136**
- Refinish wood floors using environmentally preferable processes and products **MR137**
- Use area rugs instead of wall-to-wall carpeting **IEQ182**
- Choose environmentally preferable carpet and rug products **MR138**
- Select carpet cushion that does not contain brominated flame retardants **MR139**

Furniture and Fittings

- Consider cleaning existing or purchasing salvaged or antique furniture **MR142**
- Purchase the best, most durable furniture possible within given budget **MR143**
- Select ergonomic furniture and office equipment **MR144**
- Select solid furniture made from green and safe sources **MR147**
- Select furniture from suppliers that practice fair and safe manufacturing processes **MR150**
- Select upholstered furniture with care **MR151**
- Avoid fully upholstered furniture where moisture may be problem **IEQ190**
- Minimize use of plush and porous materials **IEQ191**
- Choose environmentally preferable fabrics **MR152**
- Choose furniture finished with least-toxic products **IEQ189**
- Select window treatments with health considerations in mind **IEQ193**
- Choose interior accessories with care **IEQ195**
- Support local artisans as well as indigenous peoples **MR153**
- Provide for paper recycling **MR155**
- Educate homeowner for green living **EA103, EA104, EA105**

case study

Location: Mill Valley, California
Homeowners: Pam and Tim Sowerby
Interior Designer: Victoria Schomer, ASID, LEED AP, Green Built Environments
Area affected: 400 ft²

"I encourage clients to use existing and antique pieces. And when they buy, to buy really good quality long-lasting furniture—not throwaway furniture"

– Victoria Schomer

Living room before

Overview and Scope

Pam Sowerby's house had no office space. She needed a functioning workstation so that she could do computer work at home while taking care of her children. Pam contracted interior designer Victoria Schomer to turn the living room into a multifunctional and healthy space for the family of four. The client's chemical sensitivities made selecting low-emitting materials a necessity.

Design Approach

Pam wanted to be able to work in the room but also use it as a living room for the family and guests. She also needed to have a space for the kids to do homework and play while she was on the computer. Some smaller-scale furniture was chosen to creatively maximize the uses for this limited space. The desk is a self-contained office space that can be closed up to look like an armoire. The coffee table comes with four small matching stools that can be used by the children or pushed under the table for an uncluttered living area.

Team and Process

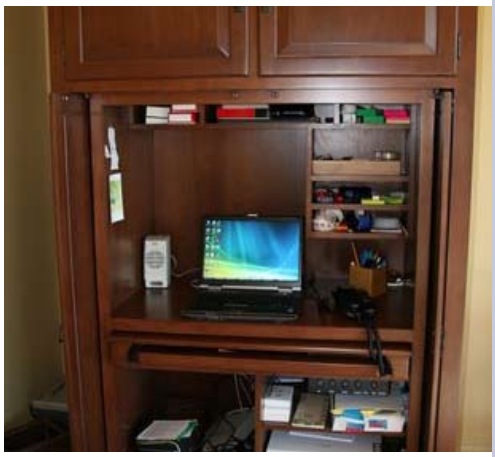
Pam and Victoria have worked together for many years and have developed an effective approach for managing Pam's chemical sensitivities; before any final purchasing decision was made, all furnishings and finishes, including samples of every component going into custom-made furniture, were given to Pam to self-test for a health reaction.

"I had a big exposure about 20 years ago, and ever since then I've been really sensitive. I need to avoid formaldehyde as much as possible; lots of glues, flame retardants on upholstery, I react to. Over the years I also became more concerned with the environment." – Pam Sowerby

Coffee table and children's work station

"I find it's not always so difficult to make an attractive room for someone with chemical sensitivities. A growing number of manufacturers are paying attention to what they're using in their products. Greener, safer furnishings don't always have to be expensive." – Victoria Schomer

Living and working space



Hide-away work station

Finance

Dealing with chemical sensitivities sometimes adds costs. Pam and Victoria had trouble finding a green furniture manufacturer for the kind of desk they desired. They worked around this by ordering the desk unfinished and having a low-emitting finish applied locally. The manufacturer, however, charged the full price for the unfinished product. In general, they focused on purchasing good-quality, durable, and healthy furnishings, and decisions were made slowly to ensure that each purchase would really work.

Lessons and Trade-offs

Furnishings do not always fit the space as anticipated. At first, the filing cabinet appeared too big for the living room. Moving it by the sofa to use as an end table solved the problem. Spending the time to really think about the uses of the room—in particular, how Pam uses a desk—helped them design and furnish the room so that it truly met the needs of the family. During the day, Pam uses the desk for her work, and her children use the coffee table and stools when they want to be close to their mother. On Friday evenings, they close the desk, pull up chairs from the dining room, and seat a church group of ten to 12 people.

By System

Building Envelope

- Existing energy-efficient windows
- No window treatments used or needed

Lighting

- Daylighting
- Compact fluorescent lamps
- Mix of task and ambient light

Wall and Ceiling Finishes

- Low-VOC paint

Floors and Flooring Products

- Existing carpet

Furniture and Fittings

- Self-contained and easily closed desk
- Coffee table with tuck-under seats for children
- Antique desk chair
- Custom sofa and upholstered chair with low-emitting fabrics and components
- Fabrics without surface treatments, self-tested by client for chemical sensitivity
- Kid-friendly (dark, patterned, textured) fabric for durability and minimal cleaning

Equipment

- Energy Star laptop computer

Use

- Shoes off in the house help to keep the carpet clean

Finished Basement

Green from the Start
Green from the Start reminder: the home performance audit and interior space planning are particularly important for this project.

For many existing homes and their households, the finishing of a basement represents one of the easiest and least expensive ways to increase the living space. But the basement can also be one of the most difficult in terms of the building science involved and overall indoor environmental quality. Managing moisture and radon, introducing daylight, and selecting the right materials from insulation to finish flooring are all challenging. And, surprisingly, changing the way in which the attic performs may be the key to changing the way the basement performs, in terms of energy efficiency and indoor air quality. Finishing a basement may seem like an ideal do-it-yourself project, but it can also be one for which a bit of up-front professional design or consultation can mean the difference between a problem project and a green, high-performance remodel.

Integrated Predesign Issues

Building Code Issues

Are there building code issues, such as egress requirements or floor-to-ceiling height requirements, that could provide synergy or conflict with energy efficiency or durability strategies?

Finished basement egress requirements can mean designing large window well units (at least 5.7 square feet) that can also increase the livability of the space by introducing daylight. But these window units will have a significant impact on the energy performance of the basement (increasing the wintertime temperature difference from just 20°F for earth-sheltered basement walls to as much as 50°F to 70°F for welled windows). In addition, window well units must be properly detailed for water management so that they don't introduce a moisture problem along with the safety and daylighting benefits.

Finished floor-to-ceiling height requirements can make it difficult to prevent moisture transmission from the basement slab into the new living space or properly address thermal comfort and condensing surface issues if, as is very likely, the existing basement floor has no thermal insulation or capillary break material beneath it. Although the energy lost through the basement slab to the soil below is relatively minor in the overall energy performance of the basement, a lack of thermal insulation can contribute to thermal comfort problems to promote condensation, to support mold and dust mites. Determine whether the finished floor-to-ceiling height permits the addition of rigid insulation, a sleeper assembly, or both.

Basement as Healthy Living Space

Not all basements can become space for living. But when possible, and if the project is well - thought - out, a basemnt can provide valuable square footage for a family room or functions other than sleeping. But because basements are below grade, by nature they have higher moisture levels. Creating a healthy, light-filled environment in a basement presents many challenges. The first step should be a professional home performance audit. Moisture control can be addressed through judicious attention to all wall and floor details to keep moisture away. Choose the driest area in the basement to make a livable room. Address ventilation and humidity separately from the whole house mechanicals if needed. When furnishing, avoid porous materials, such as carpet, fabric, and upholstered goods, as much as possible. Be attentive to other toxic items that might be stored in the basement that can affect the living space. And consider that acoustical issues might arise when living space is near mechanical systems.

Soil Gases

Has the unfinished basement been assessed for soil gas problems, including radon?

The list of potentially hazardous materials that can be in, on, or even under older homes is dishearteningly lengthy—lead, mold, asbestos, persistent pesticides, coal dust, creosote, etc. Care must be taken to determine whether these substances are a part of the project, and if so, are they best handled professional removal or complete encapsulation.

Moisture Problems and Potential

How might increases in the energy efficiency of the building envelope shift existing moisture loads from an equilibrium to a moisture problem?

Energy flow through building assemblies dries them out. So when finished basements are made more energy-efficient and the energy flow through basement wall and floor assemblies is reduced, moisture issues that were being handled by the basement assemblies can turn into moisture problems. Assess moisture management at the site level (gutters and downspouts, finished grade sloped away from the structure on the entire perimeter), in the wall assemblies (damp proofing and footer drainage), and in the floor (free-draining fill and capillary break beneath the slab). The latter two can be assessed by visual inspection during heavy precipitation events, with moisture meters, and with the ASTM D4263 Plastic Sheet test (www.astm.org) or the more-sophisticated ASTM F1869 Calcium Chloride test (www.astm.org).

Passive Survivability

Do local environmental conditions suggest inclusion of design for passive survivability in the finished basement space?

Passive survivability is "a building's, ability to maintain critical life-support conditions if services such as power, heating fuel, or water are lost" (*Environmental Building News*, May 2006). In many areas of our country, a dedicated area of the basement could be outfitted to sustain its occupants during and after events such as hurricanes, tornadoes, winter storm outages, even nuclear events. Designing passive survivability space into a finished basement may well be a sustainability strategy for many homes.

Existing Mechanical Systems

Are there unsealed combustion or nonpower-vented gas appliances or mechanical equipment in the existing unfinished basement?

Although the plan to finish a basement does not have to involve upgrading existing space heating or domestic water heating equipment, it is something to consider at the predesign stage because of indoor air quality and space implications. Sealed combustion furnaces and boilers/and power-vented gas water heaters are not only more energy efficient, they eliminate dangerous back-drafting potential, usually take up significantly less space than their older, naturally - drafting counterparts, and do not necessarily have to be located adjacent to a chimney or straight-shot chase. Switching to these systems can keep the finished basement safe in terms of indoor air quality and free up spaces and configurations.

The concerns outlined above and described in the following three design issues could be revealed by a professional home performance audit.

strategies

Project Scope

Included:

- Building envelope
- Vapor profile
- Framing
- Floor framing (sleeper assembly)
- Interior finishes
- Furnishings and lighting
- Exterior cladding
- Space conditioning
- Domestic hot water system

Not included:

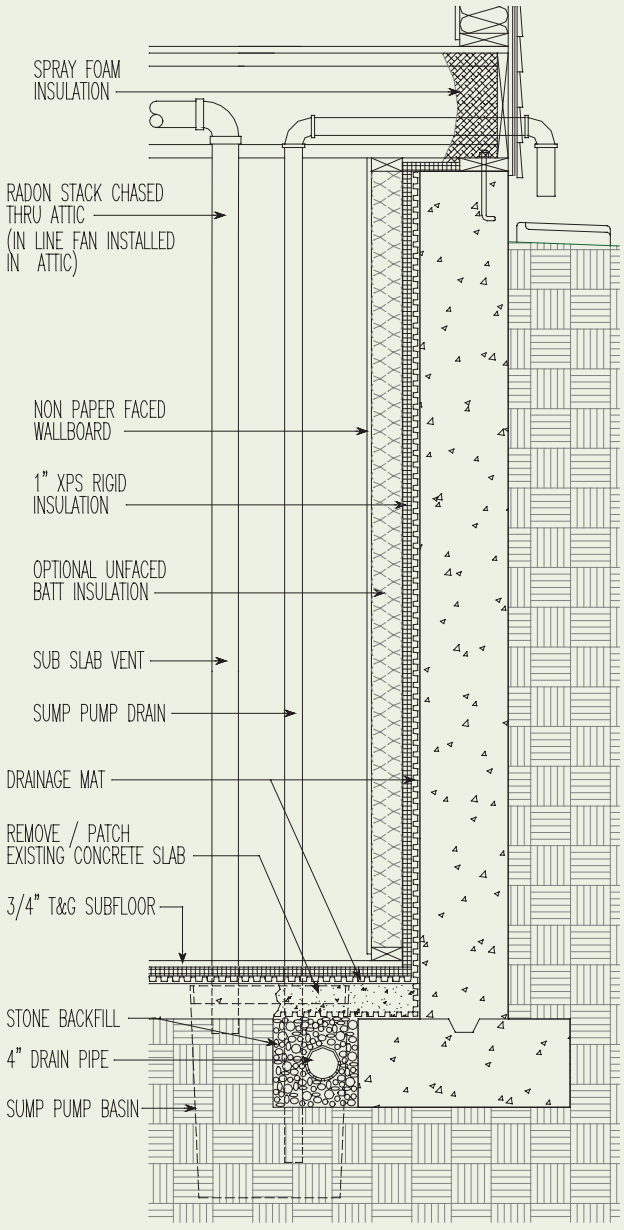
- New space or additional cladding.
  See Major Addition
- "Wet" rooms such as kitchen, bath, or laundry.
  See Kitchen and Bathroom
- Appliances and equipment.
  See Deep Energy Retrofit
- Renewable energy.
  See Deep Energy Retrofit

Strategies by Building System

General Design and Construction Strategies

- Ensure durability **IDP1**
- Conduct home performance audit **IDP2**
- Manage noise **IDP4**
- Design with air quality in mind **IDP5**
- Design for sustainable lifestyle **IDP6**
- Assess vapor profile of new assemblies **IDP25**
- Manage construction and demolition waste **MR107**
- Control spread of pollutants **IEQ158**
- Test for and appropriately handle, hazardous materials **IEQ159**
- Use FSC-certified wood **MR118**

Basement Wall Section at Sump Pump Detail



Technical Illustration: Steve Baczek, AIA

Find strategy descriptions by number in the Strategy Library starting on page 61.

Foundation

- Install radon mitigation system **IEQ163**
- Provide appropriate insect control **IDP23**

Building Envelope

- Upgrade basement floor **IDP20**
- Upgrade exterior basement walls **IDP21**
- Include capillary break between all concrete and sill plates **IDP22**
- Air seal and insulate rim joists **IDP55**

HVAC

- Install appropriate HVAC in finished basement **IEQ174**
- Provide appropriate venting of all combustion-based heating and water-heating equipment **IEQ168**
- Consider stand-alone equipment to address moisture and air quality **IEQ169**
- Install CO and smoke alarms **IEQ164**
- Make sure ducting is clean **EA71**

Plumbing

- Choose high-efficiency water heater **EA79**
- Insulate water heater **EA80**
- Insulate hot water pipes **EA81**
- Set water temperature no higher than necessary **EA82**

Lighting and Electrical

- Provide appropriate mix of color-correct ambient and task lighting **EA84**
- Install energy-efficient electric lighting **EA85**
- Provide daylighting **EA83**
- Manage phantom loads **EA98**

Floors and Flooring Products

- Install appropriate finish flooring in basements **EA181**
- Choose hard-surface flooring **IEQ180**
- Avoid carpeting in high-moisture areas **IEQ179**
- Use area rugs instead of wall-to-wall carpeting **IEQ182**

Wall and Ceiling

- Use nonpaper-faced gypsum board in moist areas **IEQ183**
- Install environmentally preferable interior sheathing **MR126**
- Limit use of wallcoverings in high-moisture areas **IEQ184**
- Use appropriate sheens for paints and finishes **MR130**
- Use low- or zero-VOC interior paints and finishes **IEQ185**
- Use low- or zero-VOC construction adhesives, caulking, and sealants **IEQ187**

Furniture and Fittings

- Evaluate use of cabinetry and furniture made from particleboard or MDF **MR145**
- Choose furniture and fittings that will not absorb moisture **IEQ188**
- Avoid fully upholstered furniture where moisture may be problem **IEQ190**
- Minimize use of plush and porous materials **IEQ191**
- Select materials that are easy to clean **MR156**

Use

- Be attentive to chemicals that might be stored in close proximity to finished basement room **IEQ198**
- Use environmentally preferable cleaning materials and strategies **IEQ196**
- Store all toxic chemicals far away from living space **IEQ197**
- Educate homeowner for green living **EA103, EA104, EA105**

case study

Location: Sandy Springs, Georgia
Homeowners: Carol Anne and Richard Hendrix
Performance Contractor: Matt Hoots, The Hoots Group, Inc.
Area affected: 2,100 ft²

"Any time we are asked to design and build out a basement, we require that moisture control measures be specified and designed into the plans. It is very costly to have to come back at a later date to remediate mold or take care of a foundation leak." – Matt Hoots

Basement before

Overview and Scope

Carol Anne and Richard Hendrix wanted to take advantage of their unfinished basement to better accommodate their three teenagers and visits from their large extended family. The new finished basement includes a bathroom, two bedrooms, a media room, and a kitchenette. The team's focus on high performance provided the Hendrix family with a dry, healthy, and durable finished space that requires minimal additional heating and cooling. Certified as an EarthCraft Renovation, this project achieved 186 points in the system, exceeding the required 100–160 points.

Design Approach

The family wanted the new space—as well as the rest of the home—to be energy-efficient, dry, and free of mold and drafts. Achieving these goals cost-effectively required insulating and air sealing throughout the house before the basement renovation began and addressing moisture issues before any finish work was done. Sound dampening separated basement activity from quieter spaces upstairs.

Team and Process

The Hoots Home Performance division was involved from the very beginning in planning and implementing efficiency improvements, including spraying foam insulation in the attic roof before work began in the basement. These efficiency improvements, along with switching from a single-zone HVAC system to a four-zone system and from a fixed to a variable air volume (VAV) air handler, made it possible to use a dual-fuel heat pump with only a slightly larger capacity than the furnace and air-conditioning units it replaced. Before framing and finishing the basement, the team installed reinforced plastic sheeting on below-grade walls to act as a vapor barrier and

to direct water to a perimeter drain. After the drain system and wall framing were completed, they filled the walls and floor with spray foam insulation. The two crawl spaces were also encapsulated using reinforced plastic sheeting sealed at all seams and caulked to the foundation walls, to create a complete and continuous vapor barrier. R-8 rigid-foam insulation was added to any exposed spaces without framing.

"When remodeling a space and bringing it up to, or exceeding, the code in that area of the house, consider looking at the house as a whole. If you upgrade the HVAC and insulation at the same time, the homeowner can reap the benefit of a better balanced house by maximizing their comfort and the home's energy efficiency."

– Matt Hoots

Before and after

"I wanted the boys to have an inviting area that didn't feel like a basement. Any time you have a basement, there is a chance of it's being damp. They sealed everything, including the storage areas that weren't remodeled, so it won't be damp and moldy." – Carol Anne Hendrix

Before and after

Financing

Recognizing that they would reap long- and short-term savings, the homeowners agreed to spend a significant amount on tightening the house envelope to reduce heating and cooling loads. Doing so allowed them to significantly reduce the size of the new heating and cooling system so that the total cost of both the efficiency improvements and the mechanical system was equivalent to what an additional system would have cost.

Lessons and Trade-offs

This project shows both how increased collaboration can engender innovative solutions and how lack of communication can result in missed opportunities: Everyone knew how the efficiency improvements would lower heating and cooling requirements, but the team missed the opportunity to use more material-efficient framing because the renovation manager purchased materials before the rest of the team could suggest alternatives. Also, there were things that nobody thought to consider. For instance, water pipes that previously went unnoticed in the unfinished space created a noise disturbance in the new bedroom.

By System

Building Envelope

- Air infiltration in house reduced by 40%
- Low-e, double-glazed windows
- Band joist between basement and first floors air sealed and insulated to R-19
- Crawl space walls air sealed and insulated to R-8
- Concrete basement walls air sealed and insulated to R-8
- Framed walls to R-13
- Attic roof insulated to R-19 and all attic vents sealed
- 12-mil reinforced plastic sheeting installed for vapor barrier in crawl spaces and basement, directing water to perimeter drain pipe with two cleanouts
- Borate-treated sill plates to prevent termite damage

HVAC

- Multizone heating and cooling system, with one zone specifically designated for basement
- Variable air volume (VAV) air handler
- Supplies and returns in each room for balanced air flow
- High-efficiency air filter
- New high-efficiency, sealed combustion, dual-fuel heat pump (replacing 20-year-old low-efficiency furnace and air-conditioner), providing 14 SEER (air-conditioning), 8.5 HSPF (heat pump heating), and 96 AFUE (furnace heating) efficiencies
- Additional space conditioned using one air handler
- Low-noise bath exhaust fan, with rigid metal ductwork, vented to outside
- New high-efficiency water heaters for better combustion gas venting

Plumbing

- Low-flow fixtures

Lighting

- Fluorescent fixtures

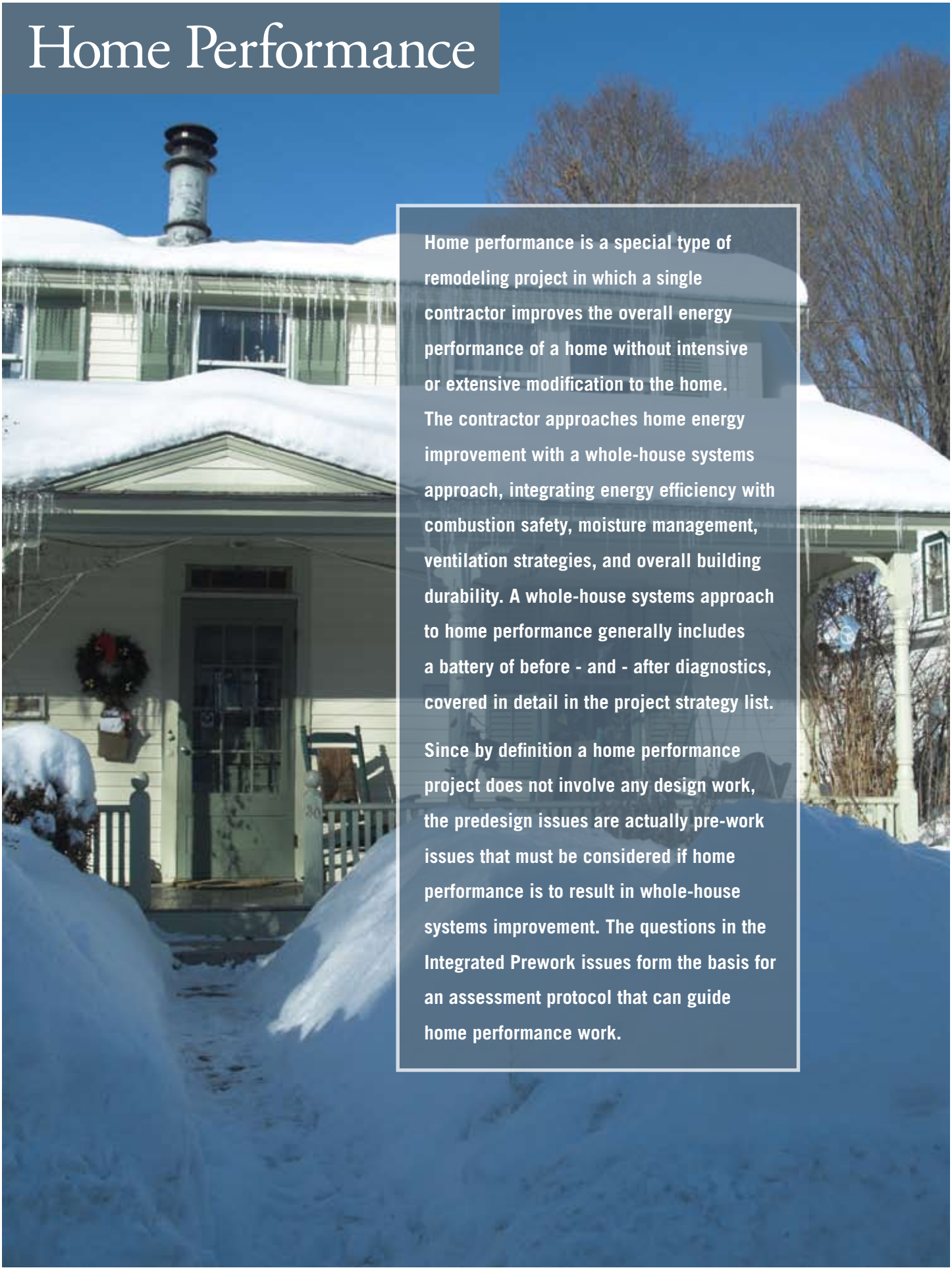
Appliances

- Energy Star refrigerator

Use

- Energy operations orientation and binder provided to homeowner

Home Performance



Home performance is a special type of remodeling project in which a single contractor improves the overall energy performance of a home without intensive or extensive modification to the home. The contractor approaches home energy improvement with a whole-house systems approach, integrating energy efficiency with combustion safety, moisture management, ventilation strategies, and overall building durability. A whole-house systems approach to home performance generally includes a battery of before - and - after diagnostics, covered in detail in the project strategy list.

Since by definition a home performance project does not involve any design work, the predesign issues are actually pre-work issues that must be considered if home performance is to result in whole-house systems improvement. The questions in the Integrated Prework issues form the basis for an assessment protocol that can guide home performance work.

Integrated Prework Issues

Feasibility

Is the home "improvable"?

Some homes may simply not be worth the energy-efficiency improvements, or at least not without certain remedial work first. A home may have structural deficiencies or serious site or plumbing issues that are beyond the scope of the performance contractor.

Existing Problems

What existing performance problems need to be addressed before/during the home performance upgrade?

Mold in a bathroom without an operable window or exhaust fan, clogged downspouts dumping rainwater on the foundation wall, old window sashes stuck in something less than a fully closed position—all of these conditions need to be assessed and addressed to make the home performance project successful.

Unintended Consequences

What performance problems may be initiated or exacerbated as the result of the home improvement upgrade?

A window may quickly lead to rot after the wall in which the window is installed is weatherized. Or a natural draft or atmospherically - ventilated gas water heater that drafted just fine before the home improvement project now backdrafts because the pressure regime of the home has been changed dramatically. A whole-house systems approach to home performance makes use of pre- and post-diagnostics to evaluate building performance changes and anticipate such side effects.

Changing Behavior

What existing performance problems are related not to the building but to occupant habits or behavior?

All sorts of occupant behavior can inadvertently circumvent home performance improvements, including failing to use exhaust fans, windows opening for ventilation during the heating season, incandescent lights leaving on 24/7, and storing cord wood in the basement. An important part of any home performance project is occupant education that enhances rather than erodes building performance.

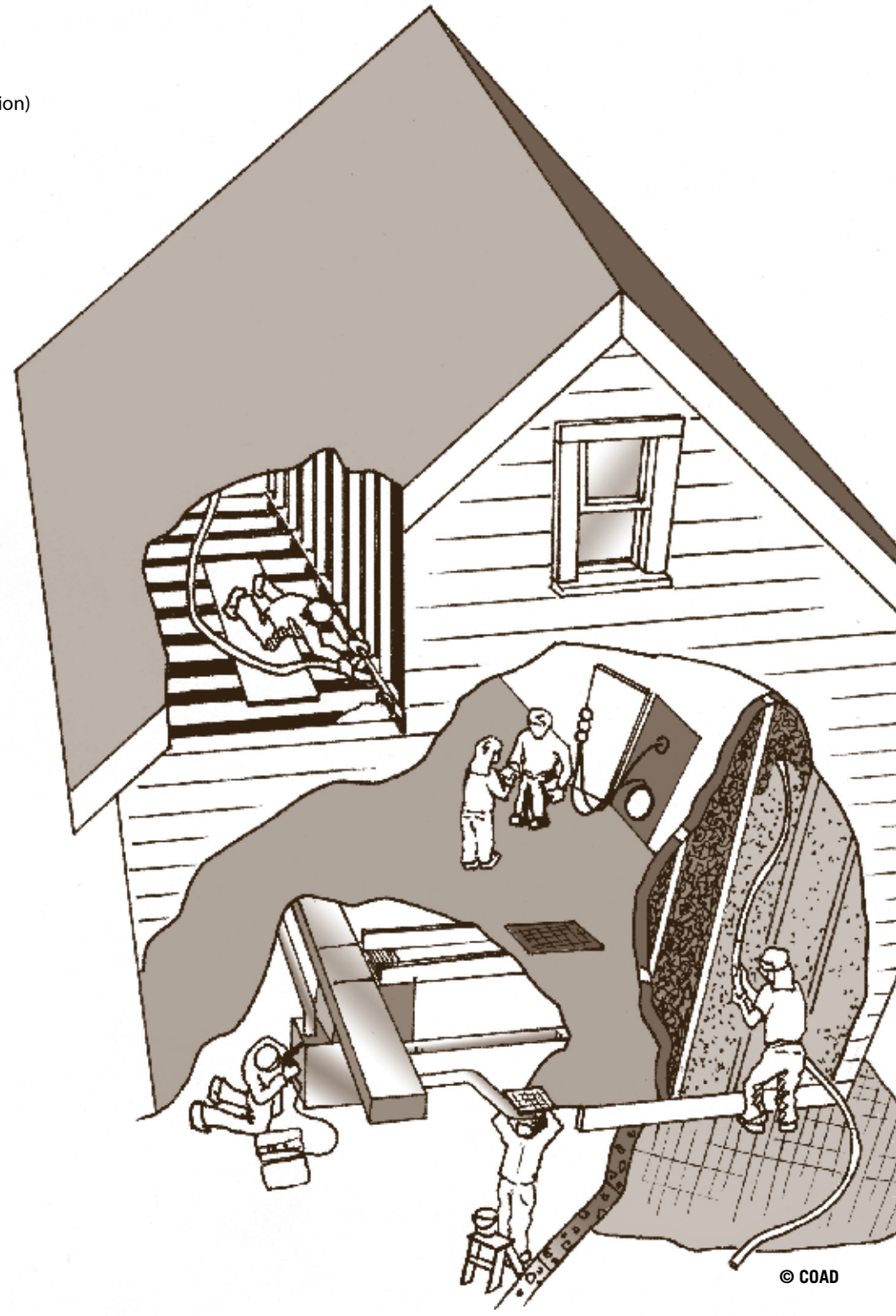
Project Scope

Included:

- Energy testing
- Combustion safety testing
- Insulation
- Air sealing
- HVAC
- Radon testing
- Moisture management (primarily evaluation)
- Homeowner education
- Lighting

Not included:

- "Wet" rooms – kitchen, bath, or laundry. See Kitchen and Bathroom
- Basement (new or retrofit). See Basement
- Interior finishes. See Kitchen, Bedroom
- Landscaping and outdoor water use. See Outdoor Living
- Appliances and equipment. See Deep Energy Retrofit
- Renewable energy. See Deep Energy Retrofit



Find strategy descriptions by number in the Strategy Library starting on page 61.

Strategies by Building System

General Design and Construction Strategies

- Ensure durability IDP1
- Conduct home performance audit IDP2
- Manage noise IDP4
- Design with air quality in mind IDP5
- Design for sustainable lifestyle IDP6
- Manage construction and demolition waste MR107
- Control spread of pollutants IEQ158
- Test for and appropriately handle hazardous materials IEQ159
- Conduct lead-safe work IEQ160
- Provide appropriate insect control IDP23
- Assess vapor profile of new assemblies IDP25
- Use computer modeling to determine heating and cooling loads EA45

Building Envelope

- Optimize energy performance EA48
- Install attic insulation EA49
- Consider radiant barrier in attic EA50
- Conduct blower door test (before and after) EA51
- Conduct room-to-room pressurization EA52
- Conduct infrared imaging (before and after) EA53
- Complete thermal bypass inspection and resolution EA54
- Air seal and insulate rim joists EA55
- Upgrade existing windows EA56
- Upgrade existing exterior door EA57
- Weatherstrip doors and windows EA58
- Use high-recycled-content, formaldehyde-free insulation MR117
- Use low- or zero-VOC construction adhesives, caulking, and sealants IEQ187
- Use FSC-certified wood MR118

HVAC

- Conduct duct tightness test (before and after) in homes with forced-air systems EA68
- Install programmable thermostats EA67
- Properly commission new (or tune existing) HVAC systems EA69
- Properly seal and insulate HVAC distribution system EA70
- Make sure ducting is clean EA71
- Install CO and smoke alarms IEQ164

Plumbing

- Choose high-efficiency water heater EA79
- Insulate hot water pipes EA81
- Insulate water heater EA80

Lighting and Electrical

- Design for effective and color-correct ambient and task lighting EA84
- Install energy-efficient electric lighting EA85
- Manage phantom loads EA98

Use

- Educate homeowner for green living EA103, EA104, EA105

case study

Location: Castro Valley, California
Homeowners: Kathy and Mike Manus
General Contractor: Sustainable Spaces Inc.
Area affected: 1,800 ft²

"We did not want to waste money on hit-and-miss home repairs. Sustainable Spaces' professionals analyzed our home and designed a plan that prioritized solutions to meet our needs while increasing our home's overall energy efficiency. We now have a home that is warm and cozy."

– Kathy Manus

Before: bad ducting

After: hydronic air handler, high-efficiency air filtration and R-6 wireflex duct work.

After: attic reinsulated with cellulose

Overview and Scope

The Manuses' home suffered from a variety of common problems including an uneven heating system that left them uncomfortable on cold winter days, but also high energy costs for the moderate square footage and temperate San Francisco climate. Prior to the renovation, monthly energy bills commonly averaged $350, even with the thermostat below 65°F on cold days. By setting priorities based on an initial comprehensive home-performance evaluation, Sustainable Spaces created a phased plan to maximize the client's return on investment in dollars as well as in health and comfort. The Manus family now has a comfortable home with clean air and significantly lower energy bills.

Design Approach

To address the homeowners' goals and concerns in a practical, cost-effective manner, Sustainable Spaces started with a detailed home performance inspection to evaluate the home as a system, including insulation, outdoor air infiltration, duct leakage, heating and cooling load and systems, moisture issues, water heating, lighting, appliances, and general durability. Based on these findings, the team prescribed a list of priorities targeting those issues that resulted in uncomfortable rooms, unhealthy air, and wasted energy. The project started with building fundamentals— envelope sealing and weatherization, duct system redesign and replacement, additional attic insulation, and a lighting retrofit. By first reducing the home's energy load, they significantly reduced the size of major system improvements, including a new hydronic air handler and air filtration system, a new high-efficiency hot water heater (now the home's primary heat source for domestic hot water and space heating), and a demand recirculation pump for convenience and water conservation. Using energy modeling software to determine the amount and balance of airflow to each room and to design ductwork to ensure that the system is properly balanced, they took the guesswork out of making the home comfortable and efficient. Finally, after completing remediation, every step was tested and commissioned to ensure that the home performed as designed.

Team and Process

Sustainable Spaces takes a holistic approach, evaluating a home's performance as a dynamic, interdependent system in order to identify specific steps to improve indoor air quality, comfort, and energy efficiency while always keeping the homeowners' objectives in mind. A licensed general and solar contractor specializing in home testing and building performance remediation for existing homes, Sustainable Spaces sought first to understand the owners concerns and behaviors. Combined with quantitative data about the home's performance, this allowed Sustainable Spaces to tailor solutions to their goals, budgets, and priorities while creating an efficient, comfortable, and healthy green home.

Home performance audit: testing water heater draft

Before: duct leakage

"Our goal is to work with our clients to create a roadmap for improving their home's performance. We recognize that not everyone can make their home 100% green and zero energy in the first pass. By creating a comprehensive plan, our clients can start down the path toward sustainability and see real results on almost any budget." – *Matt Golden, CEO, Sustainable Spaces*

After: power-vented high-efficiency water heater

Finance

Sustainable Spaces created a roadmap for this project based on multiple phases, focusing first on those items with the biggest impact but within the framework of the client's long-term goals. A phased approach fitted the Manuses' budget while achieving measurable results. By focusing improvements on air quality, comfort, and environmental impact in addition to energy savings, Sustainable Spaces was able to get buy-in from the client for more integrated solutions.

Lessons and Trade-offs

The homeowners originally wanted a tankless hot water heater, but their home performance inspector recognized that large gas bills and poor comfort and indoor air quality were their underlying concerns. Although tankless water heaters can be a good fit in some situations, a systems-based approach revealed that a high-efficiency power-vented storage water heater was more economical and appropriate for the new combined domestic hot water and space-conditioning system.

By System

General Design and Construction

- Home engineered for balanced, comfortable heating
- Air quality improved through duct and envelope sealing
- Airborne pollutants extracted with high-efficiency filtration
- Energy consumption reduced through heating and electrical load reduction

Building Envelope

- Blower door test to identify amount of air leakage; building envelope sealing to achieve compliance with ASHRAE 62.2 requirement for hourly fresh-air exchange
- Noninsulation contact-rated can lights replaced with airtight insulation contact can lights
- 12" of blown-in cellulose installed in attic to achieve R-38 or greater insulation

HVAC

- Duct blaster test to identify amount of duct leakage (before, 360 CFM25; after, 76 CFM25; leakage reduction of 79%)
- Total heating load reduced from 50,600 btu to 38,200 btu, a decrease of 25%
- Ducts replaced with properly designed and installed R-6 wireflex ductwork
- System engineered based on ACCA Manual J load calculations, Manual D (ducts), and Manual S (sizing of equipment)
- System commissioned to ensure airtight ducts, proper static pressure, and proper room-by-room airflow
- Existing furnace replaced with properly sized hydronic air handler
- Energy Star programmable thermostat
- High-efficiency air filtration system
- New high-efficiency, fast-recovery water heater with side taps for hydronic heating
- Insulated hot water pipes
- Demand recirculation pump to conserve water and energy and reduce time for hot water delivery

Use

- Homeowners instructed on proper usage of new equipment
- Programmed thermostat to balance comfort and efficiency

Major Addition

Green from the Start
Green from the Start reminder: the home performance audit and interior space planning are particularly important for this project.

A major addition is any addition of living or conditioned space that requires additional foundation, or adds a floor between the attic and the finished floor below, or adds a floor between the first floor and the foundation. Such additions entail major design and construction decisions that have significant effects on the overall resource and energy efficiency of the home. Some of the predesign issues may seem basic to the experienced remodeling professional, but each question is intended to challenge underlying assumptions.

Integrated Predesign Issues

Reconfiguring Existing Space vs. an Addition

Is it really necessary to add square footage to the home?

The greenest option is usually to adapt existing space in a home to new needs instead of adding new space, so this option should be carefully evaluated before moving ahead.

Size

Is the new space no bigger than needed?

Assuming that all of the possibilities to reconfigure existing space to meet the client's needs have been exhausted and an addition has been identified as the way to go, it can be tough to resist the temptation to "add big," especially since the client may have only one chance to do a major addition on a home. But perhaps the single largest driver of environmental impact is the total square feet of the space—in terms of both material use and operating energy. Time spent up-front ensuring that the space is as efficient as possible can pay big dividends in dollars saved by the client, level of quality in finishing details and materials, and reduced impact to the environment.

Expansion Options

Have all three options—new-footprint addition, tuck-under floor addition, or "raise-the-cap" added floor—been considered:?

Certainly this decision is driven by configuration of the existing home, lot size and configuration, and architectural style. But depending on just what functions the client requires or desires, one may have environmental advantage in terms of improved energy performance, greater resource efficiency, or increased durability.

Flexibility of New Space

Can the new space be used in a variety of ways over time to meet the client's changing needs or the needs of subsequent owners?

The layout of an addition—including wiring, accessibility, and window placement—all can be designed to make the new space more easily reconfigured or repurposed over time. Ideas to consider range from making all interior partitions nonload-bearing to incorporating universal design for aging. Although it's important to design first for existing conditions, future environmental impacts and financial costs of renovation can be minimized by making spaces flexible over time.

Stand-Alone Passive

Can the new space heat and cool itself?

The ability of a space to maintain acceptable thermal comfort is a function of building envelope performance, orientation, site characteristics that influence solar gain, and climate. Downsizing or even eliminating heating and cooling systems can save on both the capital and the operating costs of the addition and have big environmental savings as well. With energy-efficient design, it might make more sense to provide small space-heating and room air-conditioning rather than extending distribution ducts or pipes from existing central systems. An experienced professional engineer or energy consultant and computer modeling are often needed to determine the best approaches.

Getting the Storage-to-Living Space Ratio Right

Is the new space designed to spend energy keeping people or things comfortable?

Let's face it—most people have an awful lot of "stuff,"— a phenomenon that in and of itself poses some green living questions. It is not unusual for up to 50% of new space to be unnecessarily configured as fully conditioned storage space. Design spaces with adequate storage, but configure spaces so that only people and temperature-sensitive "stuff" end up being conditioned.

This can take time with the client, teasing out patterns of use and prioritizing both activities and possessions, but the payoff can be significant in optimized space utilization.

A Durable Building Envelope

Will the new addition last hundreds of years?

This is mostly about moisture management but could include resistance to other stressors, such as insects, sunlight, or wildfire. Care should be taken to evaluate how the addition shelters or increases exposure of the existing structure to rain, snow loading or wind. A low-slope valley that was handling rain and snow marginally well may fail if the addition adds more rain and snow.

Type of Foundation

There are four types of foundation systems—full basement, crawl space, piers, and slab-on-grade. What criteria will be used to make the choice?

In addition to climate, site, soil, and the existing structure's foundation system, there are resource - efficiency issues to consider. A full basement involves the most material and site disturbance, a pier foundation the least of both. An unvented crawl space can increase the total conditioned space but may be more energy - efficient overall and much less subject to moisture problems than a vented crawl space. Make the selection of the addition's foundation system a conscious decision, based on a full evaluation of which system best meets the needs of the client and the environmental impact.

strategies

Project Scope

Included:

- Passive solar design considerations
- Foundation
- High-performance building envelope
- Advanced framing
- Integration and analysis of mechanical needs of new and existing space
- Lighting and electrical

Not included:

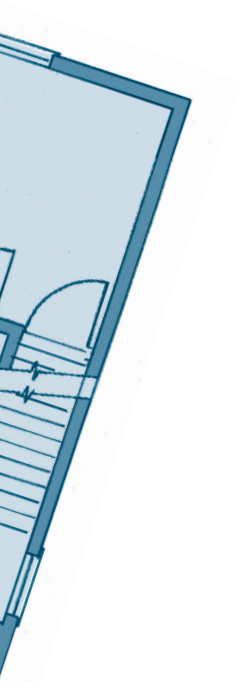
- "Wet" rooms—kitchen, bath, or laundry. See Kitchen and Bathroom
- Basement (new or retrofit). See Basement
- Interior walls. See Gut Rehab
- Interior wall finishes. See Bedroom, Living and Working
- Furniture and fittings. See Bedroom and Living and Working
- Plumbing distribution. See Gut Rehab
- Appliances and equipment. See Deep Energy Retrofit
- Renewable energy. See Deep Energy Retrofit
- Landscaping and outdoor water use. See Outdoor Living

Strategies by Building System

General Design and Construction Strategies

- Ensure durability IDP1
- Conduct home performance audit IDP2
- Optimize energy performance during design IDP3
- Manage noise IDP4
- Design with air quality in mind IDP5
- Design for sustainable lifestyle IDP6
- Employ universal design IDP7
- Optimize interior layout IDP8
- Design sheltered entryway IDP9
- Design for storage IDP10
- Configure for solar access EA100
- Use computer modeling to determine heating and cooling loads EA45
- Evaluate different heat distribution options EA46
- Install track-off mats at exterior doors IEQ161
- Assess vapor profile of new assemblies IDP25
- Include capillary break between all concrete and sill plates IDP22
- Control spread of pollutants IEQ158
- Manage construction and demolition waste MR107

Find strategy descriptions by number in the Strategy Library starting on page 61.



Site

- Minimize site disturbance SS29
- Maintain adequate slope and drainage away from building IDP13
- Make use of trees and landscaping to reduce cooling loads SS30
- Modify landscaping to provide solar access SS31
- Minimize contiguous impervious surfaces and facilitate infiltration SS32
- Design landscape features to minimize heat island effects IDP17
- Use landscape features to shield house SS36
- Use site-chipped or ground clean wood waste as erosion control SS39

Foundation

- Provide proper moisture control at footings, slab perimeter, and foundation walls IDP19
- Install radon mitigation system IEQ163
- Provide appropriate insect control IDP23
- Use bio-based form-release agent or permanent forms MR115
- Use fly ash in concrete MR114
- Insulate floor slab and foundation walls EA47
- Install CO and smoke alarms IEQ164

Building Envelope

- Provide proper moisture management strategies IDP24
- Minimize material use with advanced framing or SIP construction MR116
- Use FSC-certified wood MR118
- Optimize energy performance EA48, EA50, EA51, EA52, EA53, EA54, EA55
- Use high-recycled-content, formaldehyde-free insulation MR117
- Use high-performance windows EA59
- Specify different glazings for different window orientations EA60
- Provide durable, reflective roof MR120
- Install awnings or other exterior window shading system EA62
- Install durable wall cladding MR119

HVAC

- Evaluate different heat distribution options EA46
- Use ACCA Manual's J, S, and D in mechanical system design EA63
- Consider alternatives to conventional refrigerant-cycle air-conditioning EA65
- Provide appropriate controls and zoning for HVAC EA64
- Select high-efficiency HVAC equipment EA66
- Install programmable thermostats EA67
- Make sure ducting is clean EA71
- Install ceiling fan EA76
- Properly commission new (or tune existing) HVAC systems EA69

Lighting and Electrical

- Plan for future wiring and cabling needs MR121
- Provide daylighting EA83
- Use prudent avoidance with electromagnetic fields IEQ177
- Provide appropriate mix for color-correct ambient and task lighting EA84
- Install energy-efficient electric lighting EA85
- Manage phantom loads EA98
- Provide controllable interior shading IEQ178

Use

- Educate homeowner for green living EA103, EA104, EA105

case study

"When adding to a house built so long ago, it is a real challenge to build an addition so it is energy - efficient —and then not show that it is an addition." – Dawn Zuber

House before

Location: Ann Arbor, Michigan
Homeowners: Steve and Linda Norton
Architect: Dawn Zuber, Studio Z, NARI member
Interior Designer: Kimberly Weder, Kimberly Weder Designs
Contractor: Dave Klein, David Klein Construction, Inc.
Area affected: 674 ft^2 added

Overview and Scope

A modest 674-square-foot addition was added to this 1,615-square-foot 1920s Craftsman-style house to make it more functional for Steve and Linda Norton, who had lived in the neighborhood for 20 years. With plans to remain in their house for many more years to come, the couple wanted an addition that would fit their traditional neighborhood and not dwarf their neighbors' homes. The house is not green, the family's decision to make a small addition on a small house with a focus on energy efficiency and durability significantly reduces the environmental impact of the project.

Design Approach

The couple wanted a master bedroom suite, a new family room to supplement the existing tiny living room, and a bit more space, including a separate bathroom for the two growing kids. To make the most of the home's relatively small footprint, the team carefully reconfigured much of the existing space and installed a variety of built-in features. Built-in desks and shelving were added to many of the rooms, and the new master bedroom has a built in bed with integral storage. The existing second-floor bathroom was reconfigured for the children and guests, and the existing master bedroom became a guest bedroom, with a portion of it adapted as a hallway to the new master suite. The existing front porch was enlarged to provide a place for the family to enjoy the outdoors and interact with the neighbors. The high-velocity air-conditioning and radiant floor heating systems were carefully extended so that the existing boiler and air-conditioning equipment could provide for new as well as existing loads. The roof of the addition was designed so that the raised heel trusses, used to improve energy efficiency, would align with the existing roof, despite the differing construction.

Team and Process

The team's goal was to make the small space pleasant and energy - efficient, using durable, low-maintenance finishes. The architect, contractor, and interior designer had all worked with each other before, and this made it easier to pursue alternative construction techniques. The architect took the lead on defining the space, buthaving the interior designer involved early on allowed her to help determine an optimally functional layout.

"If you want to have something you'll really feel good about for a long time, you need to spend a bit more than you planned, to do those things that maybe nobody will ever see but that will extend the life and soundness of your home." –Steve Norton

Office during construction

"There are a lot of ways to interpret what is green. To me it is so frustrating to see people move into enormous McMansions and have rooms they don't use. I remind people you've got to heat and cool and furnish that space."

– Dawn Zuber

Reconfigured living room

Reconfigured master bath

Built-in cabinetry and daylit work station

Finance

The family factored in long-term costs and effort as much as possible, recognizing that any increased first costs for energy efficiency and more durable products with lower maintenance requirements would be paid back in reduced costs and hassle over time. Money that might otherwise have been spent building a larger addition instead went into quality features like the custom built-ins throughout the house.

Lessons and Trade-offs

Especially with new construction approaches, overseeing the details of implementation is critical. On a site visit, the architect noticed that the contractors had rerouted the ducting for the passive radon remediation system, effectively eliminating the stack effect that would pull the radon out; this was explained to the contractors and corrected. The homeowners had a lot of decisions to make and often not enough time to make them. Steve found it hard to get good information to compare the long-term energy costs of different hot water energy systems. In the end they decided to take the hot water off the existing boiler, but he would like to have been more sure of the decision. They made other trade-offs, such as choosing fiber-reinforced cementitious siding and vinyl trim with the thought that the long life and low maintenance requirements of the product would overcome its environmental downsides.

By System

Site

- Wraparound porch extends three-season living space

Building Envelope

- Minimally sized addition
- Engineered I-joists to reduce framing material use
- Two-stud corners for better corner insulation
- Raised heel trusses
- Cellulose insulation
- Low-e, energy-efficient new and replacement windows
- Passive radon abatement system
- Durable, fiber-reinforced cementitious siding

HVAC

- Radiant floor heating system extended with existing high-efficiency boiler
- Air-conditioning ducting extended with existing system

Lighting

- Daylighting from windows, skylights, and light tubes

Plumbing

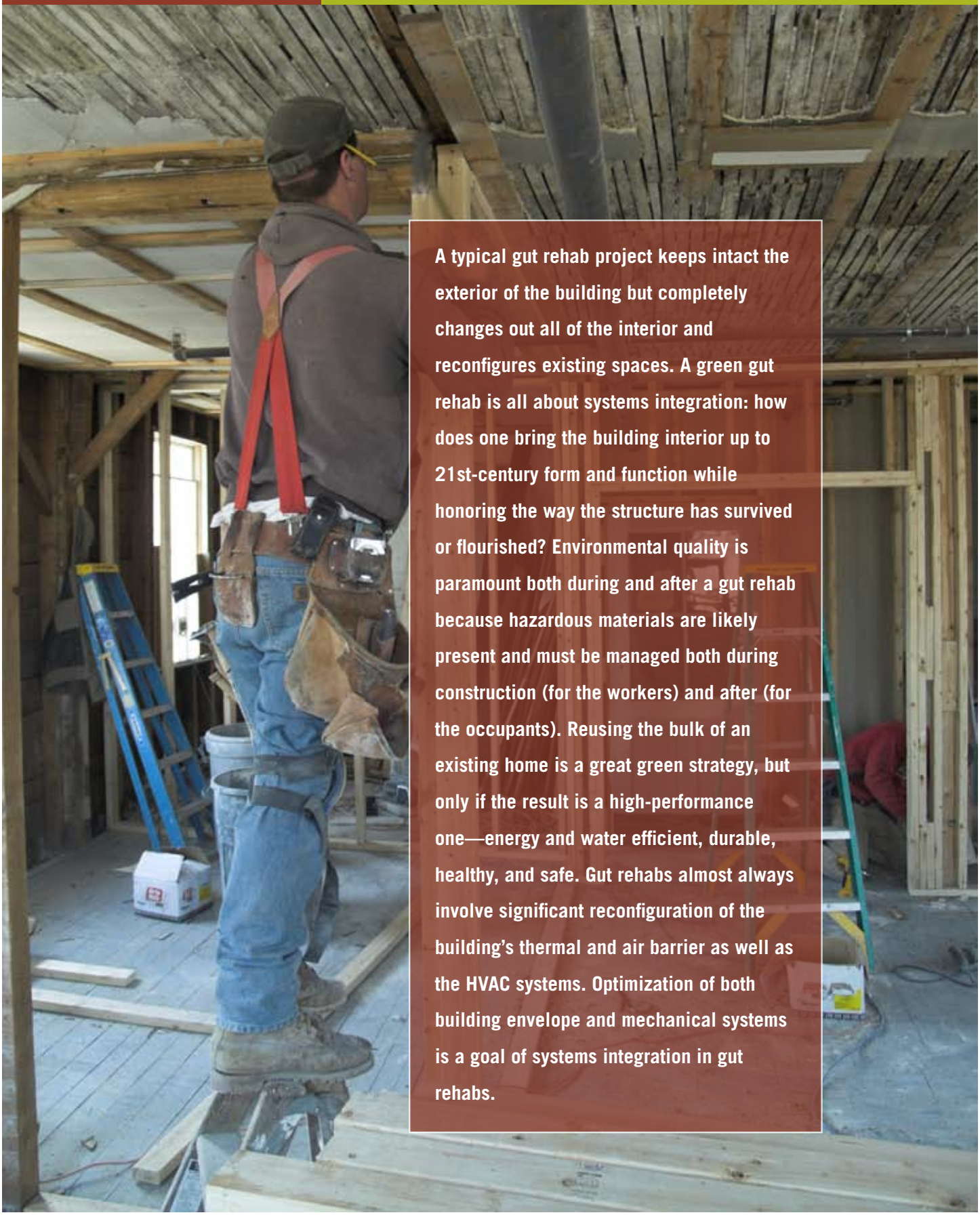
- PEX tubing
- Low-flow toilets

Furnishings and Finishes

- Built-in desks, shelving, and cabinetry to optimize use of space
- Durable wet-plaster finishes
- Durable composite decking for the porch

Gut Rehab

Green from the Start
Green from the Start reminder: the home performance audit and interior space planning are particularly important for this project.



A typical gut rehab project keeps intact the exterior of the building but completely changes out all of the interior and reconfigures existing spaces. A green gut rehab is all about systems integration: how does one bring the building interior up to 21st-century form and function while honoring the way the structure has survived or flourished? Environmental quality is paramount both during and after a gut rehab because hazardous materials are likely present and must be managed both during construction (for the workers) and after (for the occupants). Reusing the bulk of an existing home is a great green strategy, but only if the result is a high-performance one—energy and water efficient, durable, healthy, and safe. Gut rehabs almost always involve significant reconfiguration of the building's thermal and air barrier as well as the HVAC systems. Optimization of both building envelope and mechanical systems is a goal of systems integration in gut rehabs.

Integrated Predesign Issues

Opportunity for Salvage, Deconstruction, Historic Preservation, or Realignment

What elements of existing design or materials have value and can be integrated into the new design of the interior space(s)?

Especially with buildings that have many layers from previous renovation projects, it can be easy to miss the value of the original design and layout or materials. What can be brought back to the surface and incorporated into some aspect of the new design? Certainly not all old or older buildings present the opportunity for reviving historic architectural features, materials, or layouts, but an understanding of the layers and lives of older buildings is a good first step.

A behind-the-walls exploration of both the building and whatever architectural documents that are available may be required to determine what, if any, aspects of the original design or hidden materials may impart special value to the building and its new design.

Existing Hazards

What might the building contain that requires special handling, either in terms of safe removal or complete encapsulation?

The list of potentially hazardous materials that can be in, on, or even under older homes is dishearteningly lengthy—lead, mold, asbestos, persistent pesticides, coal dust, creosote. Care must be taken to determine whether these substances are a part of the project, and if so, are they best handled with professional removal or complete encapsulation?

Existing Energy-Moisture Balance or Conditions

How might increases in the energy efficiency of the building envelope shift existing moisture loads from an equilibrium to a moisture problem?

It is common good practice to eliminate the obvious water leaks in roofs, walls, and foundations before gut rehabbing any structure. But what about the difficult-to-detect, smaller leaks that can turn into a moisture problem when the home is made much more airtight and the building envelope fully insulated? What about masonry systems (concrete block, structural brick wythes, mortared stone veneers) that absorbed and managed a moisture load just fine when uninsulated and air-leaky but fail, or cause connected building elements to fail, when incorporated into an energy-efficient new configuration?

Integration of Mechanical Systems, Interior Layout, Structural Framing

How can new interior layouts, structural framing, and HVAC distribution systems work together to improve rather than degrade thermal comfort and space-conditioning efficiency?

Most gut rehabs provide the opportunity for integration of mechanical systems—particularly plumbing and space conditioning—into new layouts and new or existing structural framing. The performance of the best water heater or boiler can be significantly diminished by inefficient ducting or piping layouts. And the opening up of floor plans so common in today's gut rehabs can make efficient mechanical distribution much more challenging.

The orientation of floor framing, dimensions of interior walls and chases, the location of "wet" rooms (laundry, baths, kitchen), and the location of power units can all combine to help or hurt the ultimate energy performance of the new space. Particularly in terms of interior layout, consider layouts that permit a plumbing core by "backing or stacking" wet rooms and boosting the energy performance of the building envelope so that centralized and simplified HVAC distribution can replace perimeter distribution.

Eliminating Mechanical Systems

Can the building envelope be improved enough to eliminate centralized or active space-conditioning systems?

Depending on climate, one way of breaking through the first cost barrier of dramatic energy improvements is to boost the building envelope performance to such a degree that either all active forms of space conditioning can be eliminated or all centralized space conditioning can be replaced with spot or task heating and cooling. Eliminating central cooling and heating equipment and the distribution systems they require frees up thousands of dollars that may be needed for just such building envelope upgrades.

Climate

What changes to the building envelope and HVAC performance work best for the climate and particular site?

A gut rehab of a two-story home with a basement in Ohio, a split-level coastal home on piers on the coast of Southern California, and a ranch slab-on-grade home in Florida will all involve very different optimal combinations of building envelope and HVAC system changes. The importance of the glazing area and thermal properties of windows, the benefit from higher levels of wall and roof insulation, and the impact of state-of-the-art space-heating and space-cooling equipment will range widely, all based on site and climate. The best way to analyze the options is to use an energy modeling tool, exploring how various changes in building envelope and HVAC performance optimize the remodeled home's performance.

Certification

Is the client seeking LEED for Homes certification?

Because of the extensive alterations involved, a gut rehab is the only residential remodeling project that is included in LEED for Homes Rating System. In LEED for Homes, a gut rehab is held to the same standard as new construction. Similarly, because it is so extensive, a gut rehab may qualify for Energy Star Homes or one of the many local and regional green building programs around the country.

strategies

Project Scope

Included:

- Comprehensive existing hazardous materials management (protection for workers and future occupants)
- Comprehensive building envelope upgrade or redesign (from framing cavity to interior)
- Vapor profile (determination of drying potential and direction)
- Bulk and capillary water management
- Structural loading
- Layout reconfiguration
- Interior walls
- Plumbing distribution
- Mechanical distribution
- Lighting and electrical

Not included:

- "Wet" rooms—kitchen, bath or laundry. See Kitchen and Bathroom
- Basement (new or retrofit). See Basement
- Interior finishes. See Bedroom, Living and Working
- Landscaping and outdoor water use. See Outdoor Living
- Appliances and equipment. See Deep Energy Retrofit
- Renewable energy. See Deep Energy Retrofit

Strategies by Building System

General Design and Construction Strategies

- Manage construction and demolition waste **MR107**
- Ensure durability **IDP1**
- Conduct home performance audit **IDP2**
- Optimize energy performance during design **IDP3**
- Manage noise **IDP4**
- Design with air quality in mind **IDP5**
- Design for sustainable lifestyle **IDP6**
- Employ universal design **IDP7**
- Optimize interior layout **IDP8**
- Design sheltered entryway **IDP9**
- Design for storage **IDP10**
- Assess vapor profile of new assemblies **IDP25**
- Use computer modeling to determine heating and cooling loads **EA45**
- Control spread of pollutants **IEQ158**
- Test for and appropriately handle hazardous materials **IEQ159**
- Conduct lead-safe work **IEQ160**
- Install track-off mats at exterior doors **IEQ161**

Find strategy descriptions by number in the Strategy Library starting on page 61.

Site

- Minimize site disturbance SS29
- Use site-chipped or ground clean wood waste as erosion control SS39

Foundation

- Install radon mitigation system IEQ163
- Install CO and smoke alarms IEQ164
- Insulate floor slab and foundation walls EA47

Building Envelope

- Provide proper moisture management strategies IDP24
- Assess vapor profile of new assemblies IDP25
- Optimize energy performance EA48, EA50, EA51, EA52, EA53, EA54, EA55
- Use FSC-certified wood MR118 or SIP construction MR116
- Use high-recycled-content, formaldehyde-free insulation MR117
- Upgrade or replace existing windows and doors EA56, EA57, EA59
- Specify different window glazings for different orientations EA60
- Install awnings or other exterior window shading system EA62

Interior Walls

- Use FSC-certified wood MR118
- Install environmentally preferable sheathing MR126
- Select environmentally preferable interior doors MR127

HVAC

- Use ACCA Manual's J, S, and D in mechanical system design EA63
- Evaluate different heat distribution options EA46
- Consider alternatives to conventional refrigerant-cycle air-conditioning EA65
- Provide appropriate controls and zoning for HVAC EA64
- Select high-efficiency HVAC equipment EA66
- Properly commission new (or tune existing) HVAC systems EA69
- Install programmable thermostats EA67
- Properly seal and insulate HVAC distribution system EA70
- Make sure ducting is clean EA71
- Discontinue unconditioned basement or crawl space ventilation EA74
- Avoid ozone-depleting refrigerants EA75
- Provide appropriate venting of all combustion-based heating and water-heating equipment IEQ168

Plumbing

- Reconfigure plumbing to distribute domestic hot water efficiently EA77
- Install on-demand hot water recirculation system EA78
- Choose high-efficiency water heater EA79
- Insulate water heater EA80
- Insulate hot water pipes EA81
- Consider environmental preferable piping material MR122

Lighting and Electrical

- Plan for the future wiring and cabling needs MR121
- Provide daylighting EA83
- Provide appropriate mix of color-correct ambient and task lighting EA84
- Install energy-efficient electric lighting EA85
- Avoid recessed lights in insulated ceilings or use insulation-contact fixtures EA86
- Provide appropriate indoor lighting controls as needed EA90
- Manage phantom loads EA98

Use

- Educate homeowner for green living EA103, EA104, EA105

case study

Location: New York City
Homeowners: Alicia and David Basche
Design-Build Team: Robert Politzer, Hanna Purdy, and Nick Moons of GreenStreet Construction, Inc.
Area affected: 3,500 ft²

"I love the expression that in building there's budget, there's time, and there's quality; pick two. And we picked quality and low budget—so we had to let go of time." – Alicia Basche

Interior before

Overview and Scope

As difficult as it is to become homeowners in New York City's perpetually tight housing market, Alicia and David finally managed to purchase a brownstone in Harlem. The trashed and stripped structure needed a complete makeover, including a new roof, windows, insulated exterior walls, interior walls, and all-new HVAC, plumbing, and electrical systems. Despite a tight budget, the experienced green design-build team and actively engaged homeowners created an elegant, daylit townhouse with a spacious kitchen, low-emitting materials, and numerous green amenities.

Design Approach

Convinced of the value of building green, and with David having suffered lifelong allergies, the couple was invested in creating a healthy and environmentally friendly home. Both the contracting team and the homeowners accepted building green on a budget as a design challenge. The team viewed the whole process through the lens of environmental impact, carefully considering energy efficiency, indoor air quality, and environmentally friendly materials. In selecting each product, the homeowners took care to ask whether a greener product could be found.

Team and Process

The design-build team and the homeowners worked closely together throughout the project. David and Alicia researched green products and materials and did much of the demolition and construction work themselves.

"We had been impressed by building green and being sustainable, but would we really be able to do it in practice? When we told GreenStreet what we had in mind, they said, 'Well, that's what we do.' They were three points on a triangle: Nick was 'we can build it'; Robert was 'we can build it green and I can explain to you how'; and Hanna was 'it's going to be beautiful.'" – David Basche

Preserved brownstone front facade

"Alicia's doing so much research and David being on site every day has kept this project on task. They have really helped us make this project greener for less money."

– Hanna Purdy

Main floor under construction (above)
Remodeled main floor (below)

Remodeled master bath and bedroom

Finance

The homeowners knew it would be a challenge to tackle this extensive gut-rehab on a budget. How to creatively address budget constraints while achieving their aesthetic and green goals was a major component of the conversation from the start. Their answer to budgetary surprises was to pitch in even more of their own labor, rather than compromise on quality. Partly for this reason, the project took two years to complete.

Lessons and Trade-offs

Like many homeowners on a budget, David and Alicia did the demolition work themselves. Although the structure was filled with moldy drywall and trash, it was free of lead paint and asbestos; improper abatement of these hazards can pose ongoing problems.

By System

General Design and Construction Strategies

- 50% deconstruction and construction waste recycling

Building Envelope

- Formaldehyde-free batt insulation
- Modular green roof

Plumbing

- Dual-flush toilets

HVAC

- Whole-house fan and ducted air-conditioning system
- Kitchen and bathroom exhaust
- Radiant floor heating system throughout
- Flat plate hot water radiator
- High-efficiency hot water and space heating

Lighting

- Extensive daylighting
- Compact fluorescent lighting
- Automated controls

Equipment

- Energy Star appliances

Wall and Ceiling Finishes

- Bamboo and natural slate flooring
- Low-VOC, caulks, paints, and adhesives
- Fasteners (not adhesives) to minimize VOCs
- Zero-VOC clay finish made with reclaimed stone, natural pigments, and soy binder

Furniture and Fittings

- Recycled-content countertop

Deep Energy Retrofit

Green from the Start

Green from the Start reminder: the home performance audit and interior space planning are particularly important for this project.

A deep energy retrofit radically improves the energy performance of the existing home. Total household energy reductions of 50% to 90% are achieved by addressing all or nearly all loads—space conditioning, hot water, lighting, appliances, and plug load—and sometimes even transportation. Energy reductions of this magnitude require an intensive and extensive systems approach: the inherent relationships among energy, indoor air quality, durability, and thermal comfort must be honored throughout design and construction. Passive solar design and renewable energy systems are common in these projects.

Integrated Predesign Issues

Existing Conditions

What is the existing total energy profile of the home? Are there moisture problems?

If a client wants to dramatically improve the overall energy performance of the home, then the following assessment tools should be considered for evaluating current energy use:

- Energy bill analysis. Review all bills—electric, gas, fuel oil, cordwood, etc.—covering at least one full year. It's best to analyze energy use over several years.
- An energy feedback or logging device, such as the Energy Detective, to measure electricity usage.
- Blower door testing
- Infrared imaging
- Duct blaster testing

Because moisture management is also critical to the long-term performance and durability of a home, evaluate how the existing building envelope wets and dries and consider how energy improvements being considered will affect moisture management. The best way to do this is to observe the building and site during both a typical and a wind-blown rain event and augment the observations with moisture meter readings of materials.

Scope

How much of the existing structure (and site) will be remodeled as part of the deep energy retrofit?

A deep energy retrofit is likely to involve major modifications to the entire building envelope and the space-conditioning system(s). Here are some predesign principles to consider as you brainstorm just what will and what will not be involved in the whole-house deep energy retrofit.

If heat loss and heat gain are being much more keenly managed, then moisture must be managed as well. Examples:

- A slightly damp basement without perimeter drainage that has never been a problem may become a problem when insulation and air sealing are added to the basement walls and floor.
- A face-sealed wall cladding in a wall with little insulation or air sealing may require back-vented cladding (rainscreen detail) and more comprehensive window flashing details when an aggressive package of wall insulation and air sealing is added.
- A house with neither a dedicated ventilation strategy nor spot exhaust fans in the kitchen and baths may require both when it becomes substantially more airtight.

Start with the site and its first-order role in managing energy and bulk water. Assess the following:

- Existing and potential drainage patterns and strategies.
- Building envelope drying potential based on perimeter plantings—proximity to building, types of root structures, current and mature heights of plantings.
- Existing and potential solar access (addressing views as well as building geometry and existing and planned vegetation and landscaping).
- Site and structure for both ground-mount and rooftop renewable energy systems: PV, solar hot water, and wind turbine.

Also consider:

- What financial instruments, such as tax subsidies, insurance premium reductions, green mortgage programs, and other incentives, might be available that would make major energy retrofits affordable?
- Consider the elimination of one or more space conditioning systems. If heating and cooling loads can be reduced enough, it may be possible to downsize or eliminate heating or cooling systems (or both).
- Achieve compliance with LEED for Homes Innovation and Design Process Credit ID 1"Integrated Project Team" and ID 2 "Quality Management for Durability" (LEED for Homes Program Pilot Rating System, Version 1.11a).
- Can finished products – cabinets, trim, flooring. be "down-graded" for use in a basement, workshop, or auxiliary space?
- Many organic-based or mineral-based site and building materials can be processed for use on site, but it takes planning and sequencing to make sure that the materials are properly processed, stockpiled, and applied. Consider on-site construction waste processing for ground wood, gypsum board, block as mulch, soil amendment and driveway orsidewalk base, respectively.

Sequencing

Are there aspects of the design that lend themselves to sequencing of work to minimize the time that homeowners cannot use the space?

Most of the structure and living spaces are likely to be involved in a whole-house deep energy retrofit, so it is important to assess the needs of the homeowner during construction. Does the homeowner need to occupy the home during the retrofit?

Consider how the work could be sequenced to maximize the utility of the home to the owners over the course of the project.

Start thinking about the structure from the exterior. Exterior—as opposed to interior—retrofits to improve building envelope performance have two distinct advantages:

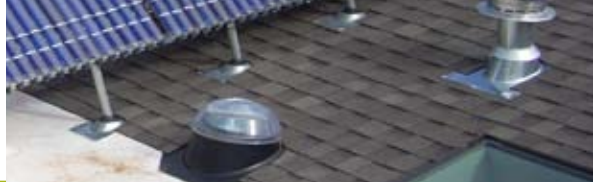
- Potential for better continuity of the air and thermal barriers.
- Significantly less disruption to occupant activities and well-being.

Climate

What changes to the building envelope and HVAC performance work best for the climate and particular site?

A deep energy retrofit of a two-story home with a basement in Ohio, a split-level home on piers on the coast of Southern California, and a ranch slab-on-grade home in Florida will all involve very different optimal combinations of building envelope and HVAC system changes. The importance of the glazing area and thermal properties of windows, the benefit from higher levels of wall and roof insulation, and the impact of state-of-the-art space-heating and space-cooling equipment will range widely, all based on site and climate. The best way to analyze the options is to use an energy modeling tool, exploring how various changes in building envelope and HVAC performance optimize the remodeled home's performance.

strategies



Project Scope

Included:

- Passive solar design considerations
- Comprehensive building envelope upgrade or redesign (from framing cavity to exterior)
- Vapor profile (determination of drying potential/ direction)
- Bulk and capillary water management
- Upgraded and integrated mechanicals
- Space conditioning
- Domestic hot water
- Ventilation—whole - house and spot exhaust
- Lighting
- Renewable energy systems
- Solar water
- Photovoltaic
- Systems analysis or modeling to integrate all of above

Not included:

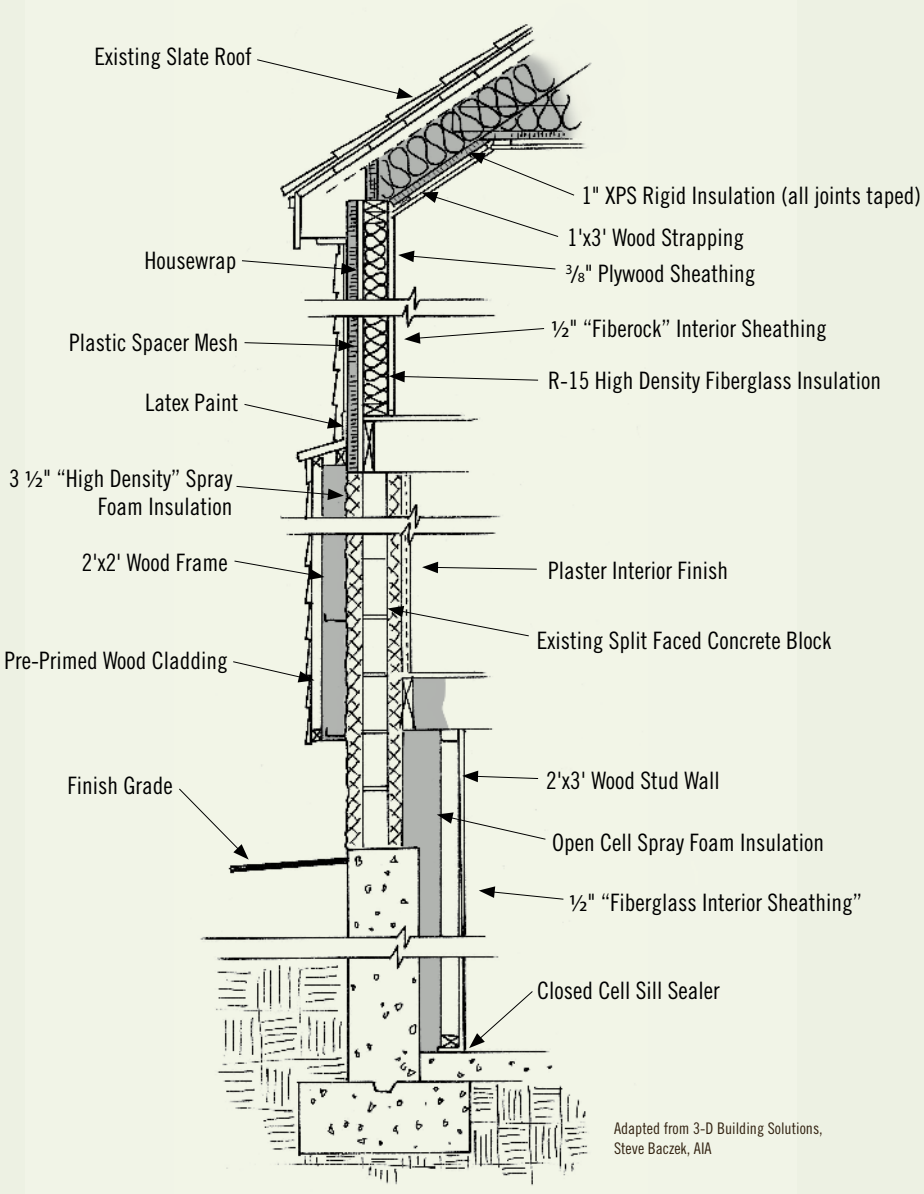
- Interior walls. See Gut Rehab
- "Wet" rooms, kitchen, bath or laundry. See Kitchen and Bathroom
- Interior finishes. See Bedroom, Living and Working
- Landscaping and outdoor water use. See Outdoor Living
- Furniture and fittings. See Bedroom and Living and Working

Strategies by Building System

General Design and Construction Strategies

- Ensure durability **IDP1**
- Conduct home performance audit **IDP2**
- Optimize energy performance during design **IDP3**
- Manage noise **IDP4**
- Design with air quality in mind **IDP5**
- Design for sustainable lifestyle **IDP6**
- Employ universal design **IDP7**
- Design sheltered entryway **IDP9**
- Control tspread of pollutants **IEQ158**
- Manage construction and demolition waste **MR107**
- Use computer modeling to determine heating and cooling loads **EA45**
- Configure for solar access **EA100**
- Provide proper moisture management strategies **IDP24**

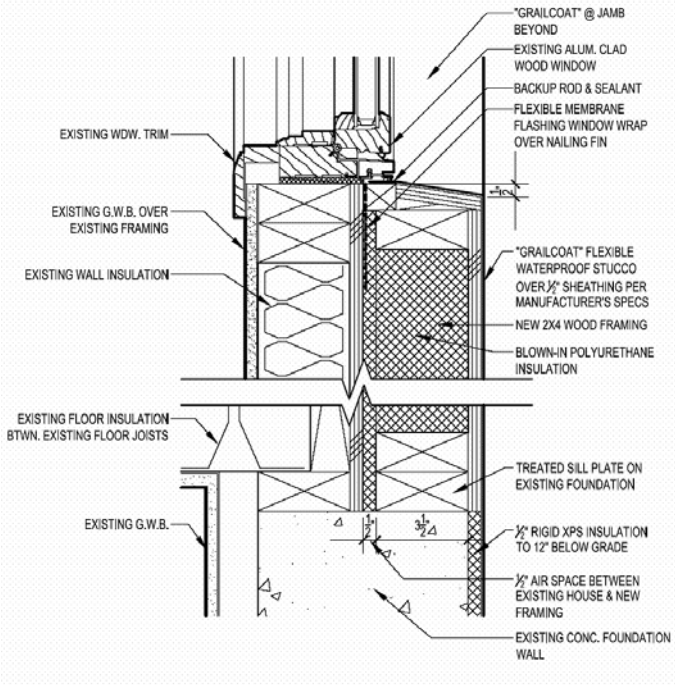
Cold Climate Deep Energy Retrofit Detail



Adapted from 3-D Building Solutions, Steve Baczek, AIA

Find strategy descriptions by number in the Strategy Library starting on page 61.

Wall Section Detail



Wall section from Deep Energy Retrofit case study. See page 152 for a larger view.

- Test for and appropriately handle hazardous materials **IEQ159**
- Conduct lead-safe work **IEQ160**
- Assess vapor profiles of new assemblies **IDP25**
- Ensure that window and skylight installations include proper air sealing and flashing **IDP27**

Site

- Minimize site disturbance **SS29**
- Use site-chipped or ground clean wood waste as erosion control **SS39**

Foundation

- Insulate floor slab and foundation walls **IDP27**
- Install radon mitigation system **IEQ163**

Building Envelope

- Provide proper moisture management strategies **IDP24**
- Optimize energy performance **EA48, EA50, EA51, EA52, EA53, EA54**
- Use high-recycled-content, formaldehyde-free insulation **MR117**
- Provide durable, reflective roof **MR120**
- Replace existing windows **EA59**
- Specify different window glazings for different orientations **EA60**
- Install awnings or other exterior window shading system **EA62**
- Use FSC-certified wood **MR118**
- Install durable wall cladding **MR119**

HVAC

- Evaluate different heat distribution options **EA46**
- Consider alternatives to conventional refrigerant-cycle air-conditioning **EA65**
- Optimize HVAC systems **EA63, EA64, EA66, EA67, EA69, EA70, EA71**
- Discontinue unconditioned basement or crawl space ventilation **EA74**
- Avoid ozone-depleting refrigerants **EA75**
- Provide appropriate venting of all combustion-based heating and water-heating equipment **IEQ168**

Plumbing

- Reconfigure plumbing to distribute domestic hot water efficiently **EA77**
- Choose high-efficiency water heater **EA79**
- Insulate water heater **EA80**
- Insulate hot water pipes **EA81**

Lighting and Electrical

- Plan for future wiring and cabling needs **MR121**
- Provide daylighting **EA83**
- Provide appropriate mix of color-correct ambient and task lighting **EA84**
- Install energy-efficient electric lighting **EA85**
- Provide appropriate lighting controls as needed **EA90**

Equipment

- Select and properly maintain energy-efficient equipment **EA91, EA92, EA93, EA94, EA95, EA99**
- Consider energy toll of small appliances **EA96**
- Manage phantom loads **EA98**

Energy Sources

- Configure for solar access **EA100**
- Consider solar water heating **EA101**
- Consider solar electric (photovoltaic) system **EA102**

Use

- Educate homeowner for green living **EA103, EA104, EA105**

case study

Location: Boulder, Colorado
Homeowners: John and Vicky Graham
Architect: Andy Johnson, DAJ Design
General Contractor: Eric Doub, Ecofutures Building Inc.
Area affected: Remodeled existing 1,000 ft^2; added 700 ft^2

"Most of the choices we made on this project were driven by our desire to be as green and as net-zero as possible while creating our dream home. We hope that our house might inspire others to consider including some of the amazing green building technologies currently available in their own projects." – *John Graham*

Exterior before

Overview and Scope

In deciding to remodel, the owners of this 1,000 square-foot 1970s ranch in Boulder were seeking to both add space and make dramatic energy improvements. Like other houses in the neighborhood, this one had single-pane windows and no insulation in the walls, making it drafty in the winter and "an oven" in the summer. The family had made some improvements five years earlier, replacing windows, adding insulation, and installing radiant-floor heat, but they didn't have the experience to take it as far as they would have liked. This time, wanting more comprehensive improvements, the family hired a contractor with experience in high-performance building. Eric Doub's team retrofitted the existing space for energy efficiency and remodeled it to include a home office in the above-ground space and a play area in the basement. Adding 700 square feet gave the owners a new dining area, expanded the kitchen and great room, and improved solar access and lighting. Financial incentives helped them afford a renewable energy system that will produce more electricity than the home will use. Expected to provide 130% of the home's energy needs, the system will feed excess energy back into the electrical grid and, once plug-in electric vehicles become available, power the family car.

Design Approach

Super - insulating and air sealing throughout the home improve comfort and passive survivability, allowing the home to stay warm without heating for a few days in 0°F, cloudy weather. A project manager knowledgeable in building science best practice was always on site to ensure that proper detailing, critical to a successful energy retrofit, was accomplished. The increased square footage improves the daylighting as well as the livability of the space. An all-electric design allowed the homeowners to cap their natural gas line, which was of particular importance to them because of local environmental degradation caused by natural gas drilling and distribution. Their efforts to be as green as possible extended from the structure to energy supply and to finishes.

Team and Process

With highly committed homeowners, the team was able to push far beyond typical energy retrofits, and explore new approaches to comprehensive efficiency. At the project outset, the contractor and energy designers worked with the homeowners to calculate electrical loads, and used computer modeling to understand heat and energy flows. This critical step in the design process informed all stages of project development. During construction, the homeowners, designers, engineers, and contractor continued to work closely together to ensure project success. For example, when the homeowners asked about thermally retrofitting the exterior of the building to minimize disturbance, the contractor verified with modern building science resources that this approach would work well to create continuous air and thermal barriers.

Finance

With the intention of building their "dream home," the homeowners selected high-quality finishes throughout, pushed energy measures as far as possible, and took full advantage of Colorado's new incentives for renewable energy systems. According to the homeowners, construction costs were comparable to those of other high-end remodels, and with recent reports that local electricity prices may increase 11% in the next year, the projected return on investment keeps getting better.

Lessons and Trade-offs

In a comprehensive retrofit of this sort, it can be easy to miss some of the ways in which the systems interact; even manufacturers may overlook details of advanced energy systems. For instance, the team learned that the evacuated tubes for solar hot water could overheat and break if the power went out on a sunny day. To prevent this, they installed a single solar panel that provides backup power so that the pump can continue to circulate water through the tubes. Despite of their deep-green objectives, the homeowners also had to make some trade-offs. The cost premium for certified wood led them to forgo using FSC-certified wood exclusively in favor of investing more in renewable energy systems.

Evacuated tube solar water array

"It feels great to help our clients future-proof their homes. Not only will their investments in energy efficiency and onsite renewables be more valuable year by year, as energy prices increase but also, as residents, they will be more comfortable and healthier because of the 'build tight, ventilate right' approach."

– Eric Doub

SIP roof assembly

Spray foamed exterior curtain wall

Finished exterior wall

Water-managed, ICF crawlspace foundation

By System

Job Site Processes

- 90% of construction waste diverted through on-site reuse, salvage, and recycling

Site

- Recycled-plastic decking
- Xeriscaping and drip irrigation to be installed

Building Envelope

Existing

- Walls improved to thermally broken R-28: cellulose blown in to existing frame and walls wrapped with new external insulated 2'x4' framed wall
- Roof improved to R-70 by 8" spray-in-place open-cell ½'- lb. foam (SPF)
- Below grade improved to R-17: ½" rigid foam and cotton batts in 2'x4' framed wall added to interior
- Prior installation of 1 ½" gypsum concrete floor with radiant tubes over existing slab
- All-in-one vapor barrier, bubble wrap, and ¼" flexible closed-cell foam added between gypsum and basement slab

Addition

- R-27 walls: 2'x6' frame, faced with 1 ½" resilient channel on interior creating a 7" wall cavity filled with Icynene spray-foam
- R-42 SIP roof with 3.5" SPF in dropped ceiling for R-50 total
- U-0.15 overall window rating
- FSC-certified and engineered lumber
- 6" core ICF crawl space with dropped joists to break thermal boundary; 12" SPF between joists

HVAC

- Operable windows and motorized skylight for ventilation and cooling
- Energy recovery ventilator for continuous ventilation during winter and hot summer days

Plumbing

- Dual-flush toilet
- Direct-from-solar-tank hot water dispenser to reduce energy demand in cooking

Lighting

- Natural daylighting enhanced with four solar tubes, two skylights, and 30% more glazing
- Compact fluorescent lighting

Appliances

- Existing Energy Star washer and dryer, plus clothesline
- New refrigerator and electric oven to eliminate use of natural gas
- Separate switch to eliminate phantom loads from electronics

Interior Finishes

- Low- and zero-VOC paints and stains
- Water-based floor finish
- Clay plaster
- Linoleum tile with low-VOC adhesives
- Formaldehyde-free cabinets
- Concrete and sorghum-based countertops
- Oriented-strand board subfloor
- Natural wool carpet

Energy Sources

- Evacuated tube solar hot water system provides 90%–100% of domestic hot water as well as space heating using in-slab radiant tubes; the system has cloudy cold-snap backup from on-demand 9-kW modulating electric boiler
- Grid connected solar PV (6.15kW installed on new porch and existing roof)
- EPA-approved wood-burning fireplace

Outdoor Living

Outdoor living space can range from a wood-framed deck to a stone patio to a trellised outdoor kitchen. A green outdoor living space expands the square footage of the home with the least amount of materials, connects the home and its occupants to the outdoors and to nature, and can involve landscaping that improves site drainage and reduces outdoor water consumption. Outdoor living space improvements can be a great do-it-yourself project, but the value of professional design is not to be underestimated. And although we tend to think of this space as private and backyard-focused, front space and wraparound front porches that can create a sense of neighborhood are important to consider as well.

Integrated Predesign Issues

Function

What are the planned uses of the outdoor living space?

It can be tempting to jump to the nearly ubiquitous pressure-treated deck option before considering just exactly what functions the outdoor living space or structure will serve.

- Does the outdoor space relieve the pressure to add interior, (and more building-intensive) space?
- Can the landscape around the house help homeowners appreciate nature?
- Does the space offer opportunities for additional storage that does not need to be conditioned?
- Is shielding needed from sunlight, wind, light pollution from nearby development, highway noise, unsightly views, or neighborhood noise? Landscape treatments can help address all these issues.
- What kind of surfaces are desired outdoors? Is a paved area needed for extra car parking or a basketball hoop? Are there young children for whom soft surfaces are desired? Would the homeowners consider alternatives to lawn?
- Can an outdoor kitchen shift cooking from conditioned space during peak cooling periods, thus saving energy?
- Can semioutdoor spaces (covered porches, for example) reduce the need for larger entertaining space indoors?
- Could the new outdoor living space become additional indoor space at some time in the future?

Existing Conditions

Are there existing features or conditions that are important to preserve?

- Will the new outdoor living space protect existing trees, vegetation, and natural habitats and encourage new healthy ones?
- Will the new outdoor features alter or compromise existing light conditions inside the home?
- Will the new outdoor space affect the house or site water management\? With any changes of site features, care should be taken to avoid creating new drainage problems, while solving existing drainage problems.
- Is there an existing structure—a carport or breezeway, say—that might be creatively incorporated into new outdoor living space?

strategies

Project Scope

Included:

- Patios
- Decks—attached and unattached
- Trellis
- Lawn area
- Landscaping
- Porous pavement
- Rainwater catchment

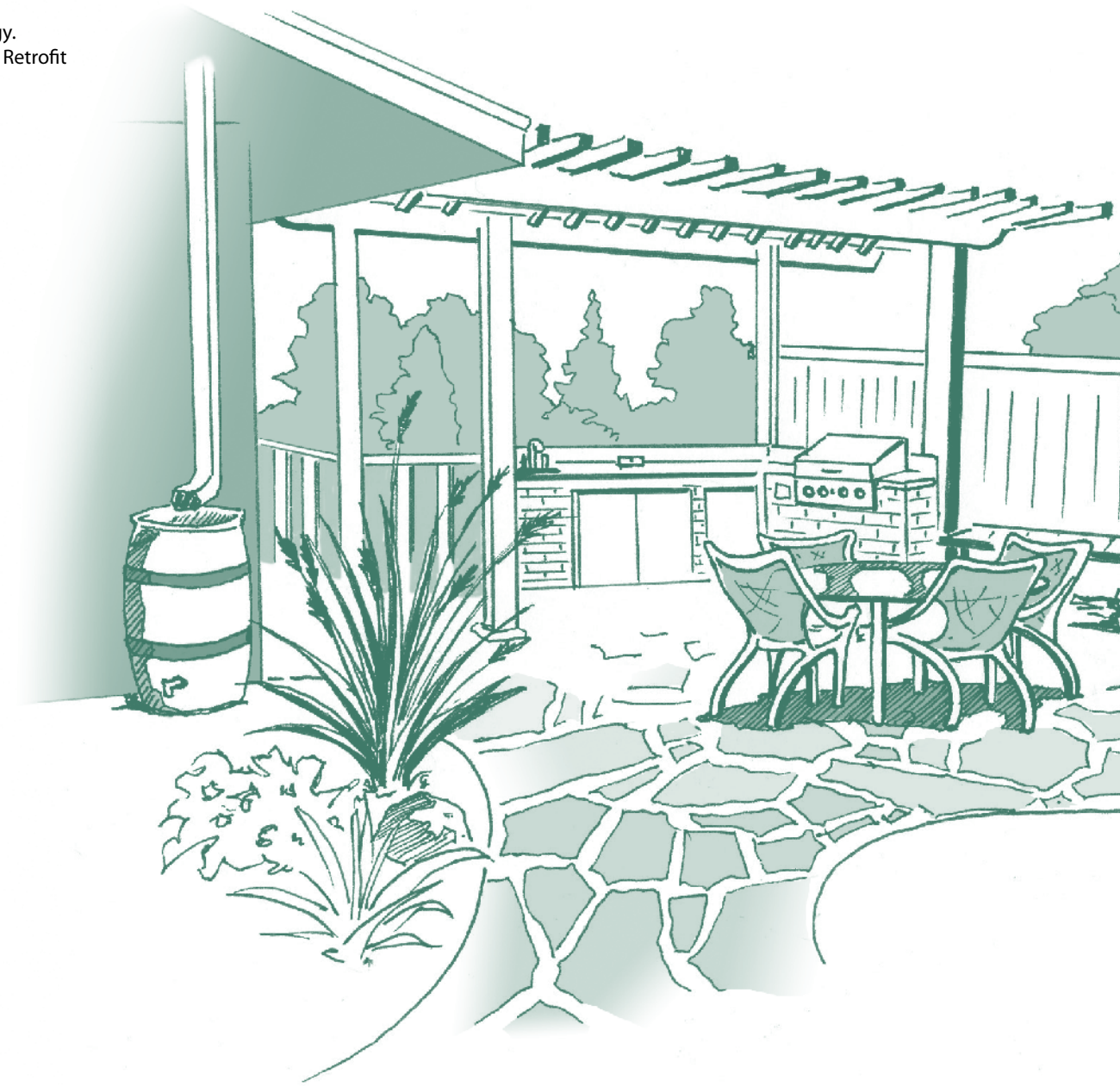
Not included:

- Storage sheds
- Garages
- Playhouse
- Renewable energy.
  See Deep Energy Retrofit

Strategies by Building System

General Design and Construction Strategies

- Ensure durability IDP1
- Manage noise IDP4
- Design with air quality in mind IDP5
- Design for sustainable lifestyle IDP6
- Maintain adequate slope and drainage away from house when creating outdoor living areas IDP14
- Design landscape features to minimize heat island effects IDP17
- Design landscape to encourage outdoor activities IDP16
- Design to minimize outdoor water use IDP18
- Design to support connection with nature IDP15
- Install track-off mats at exterior doors IEQ161



Find strategy descriptions by number in Strategy Library starting on page 61.

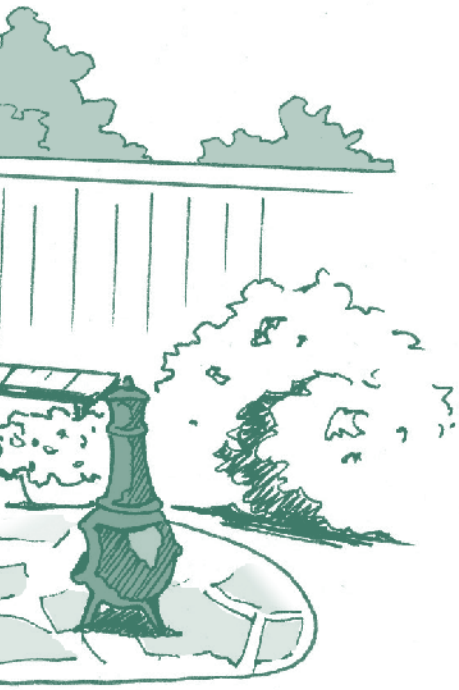
- Manage construction and demolition waste MR107
- Control spread of pollutants IEQ158
- Clean-up and dispose of pressure-treated sawdust and shavings appropriately IEQ162

Site

- Make use of trees and landscaping to reduce cooling loads SS30
- Minimize site disturbance SS29
- Modify landscaping to provide solar access SS31
- Minimize contiguous impervious surfaces and facilitate infiltration SS32
- Provide porous pavement SS33
- Reduce lawn area SS34
- Provide wildlife habitat SS35
- Use landscape features to shield house SS36
- Provide rainwater collection system WE40
- Provide for edible plants in landscape design SS37
- Landscape to minimize chemical use SS38

Outdoor Structures

- Consider reuse of existing materials MR108
- Consider patio rather than wooden deck MR109
- Use environmentally preferable patio materials MR113
- Properly detail connection between deck and house IDP28
- Use naturally rot-resistant, responsibly produced wood for decks MR110
- Use FSC-certified wood MR118
- Use recycled-content plastic or composite decking boards MR112
- Choose less harmful pressure-treated lumber MR111
- Clean - up and dispose of pressure-treated sawdust and shavings appropriately IEQ162



Lighting and Electrical

- Install energy-efficient electric lighting EA85
- Select outdoor lighting to minimize light pollution EA88
- Provide appropriate outdoor lighting controls as needed EA89
- Manage phantom loads EA98

Equipment

- Choose efficient hot tub or spa EA97

Furniture and Fittings

- Choose environmentally friendly outdoor furniture and accessories MR154

Use

- Use environmentally preferable cleaning materials and strategies IEQ196
- Store all toxic chemicals far away from living space IEQ197
- Educate homeowner for green living EA103, EA104, EA105, EA106

case study

Location: Austin, Texas
Homeowners and designers: Grace Riggan and Joshua Bowles
Area affected: ¼-acre lot

"To develop a garden is an important part of how you live—no matter where you live. It isn't just that you're sitting out there instead of using the AC. The garden can be a real cultural exchange—it opens you up to the community." – Grace Riggan

Garden before

Overview and Scope

Over the past ten years, Grace Riggan and Joshua Bowles have transformed their yard from a crabgrass-and-cement lot into an urban oasis. The house's meditation room opens out onto a deck that overlooks the garden. Hidden from the road by a large wall made of salvaged stone, the garden provides a haven for both wildlife and humans. Native plants attract birds and butterflies, mature pecan trees provide food for everyone, and numerous cacti and agave species are found along the meandering paths. Located in an older neighborhood one mile from downtown, the garden recently won the City of Austin's "Green Garden Award."

Design Approach

As children, both Grace and Joshua loved spending time on their grandparents' small farms, and they wanted the design of their home to recall the way in which household activities flowed smoothly from the farmhouse to porch to farm. The open-air deck and lightly conditioned meditation room provide both a thermal and a psychological transition that, according to Grace, allows them to set the house thermostat on a more conservative setting. The curved and gated stone wall, patterned fon Mexico's walled gardens, provides total privacy and encloses the entire yard while remaining inviting on a human scale. A wide variety of details, from the protected fence-top water trough for visiting birds to the hand-planed and unfinished cedar plank deck floor, make the garden both an environmental and an aesthetic accomplishment.

Team and Process

Other than a stand of large pecan trees in the back, the original site was aesthetically unappealing. Eager to make the space their own, the couple started at the edges of the property, replacing weeds and pavement with native drought-tolerant plants. The design of the garden emerged bit by bit as they worked; the many limestone boulders they salvaged from job sites were piled near the sidewalk for months before they started to build a wall. Over the years, the couple's many outdoor projects helped them befriend the neighbors.

"When we started, we didn't really think of ourselves as gardeners, but we couldn't wait to interact with the site. I started trying to break up the dirt and plant native plants. The process of letting it unfold, learning as you go—that's how you become a part of the garden, building it around you in a natural order." – Grace Riggan

Unfinished, hand-planed cedar deck

Landscape screen

"There isn't any outdoor lighting. We've been trying to get rid of the light. It drove us crazy that we never could have real darkness in the city." – Grace Riggan

Meditation room with reclaimed cypress Shoji screens

Lush native hand-watered plants

Finance

Although the garden may look extravagant, it was not an expensive renovation. Instead, changes were made gradually, with everything in the garden done out of pocket. Grace attributes the organic look and feel of the space to this slower timeframe.

Lessons and Trade-offs

Addressing water conservation was one of the trickiest aspects of the project. In the dry Austin climate, even native cacti used for xeriscaping need some watering to look their best. The couple did not find an irrigation system that they were confident would not eventually waste water through leakage. Currently, Grace waters by hand with a hose, using rainwater from a 1,500-gallon rainwater collection system. Although its eight-foot diameter tank fills to capacity from just two to three inches of rain, it occupies a lot of space. The couple is still looking for better ways to manage trade-offs between water - efficiency, use of space, and convenience.

By System

Site

- Paving reduced significantly
- Paving stones on paths
- Minimal lawn area
- Existing pecan trees maintained for shade and food for humans and wildlife
- Plants and safe watering hole provided for wildlife
- 1,500-gallon rainwater collection system
- Rocks used for private seating nooks throughout garden

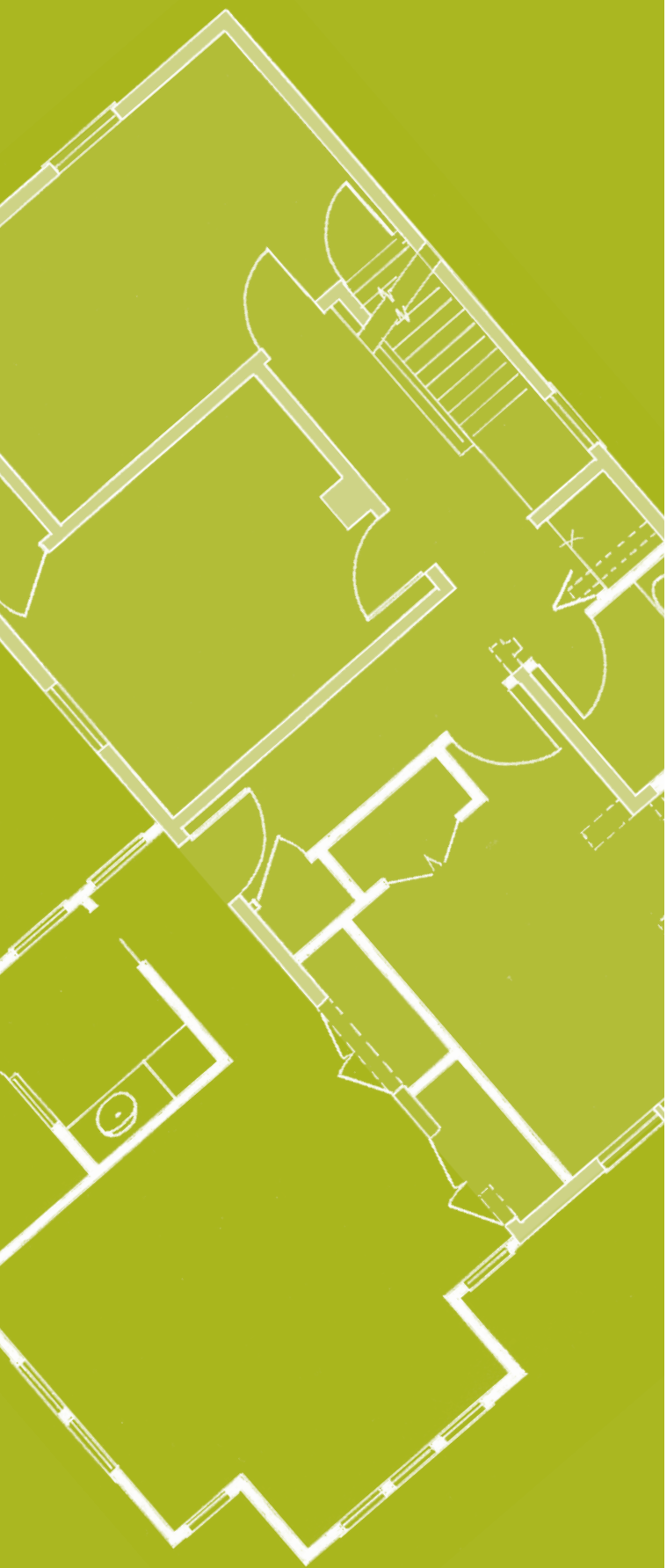
Structure

- Cedar deck, hand planed, without finish
- Garden shielded from road by stone wall made of salvaged boulders
- Cedar and steel fence
- Meditation room separated from deck by shoji screen of reclaimed cypress separates
- Gates and landscape screen of regional, planed, white oak, with no sealant

Lighting

- No lighting outdoors

Strategy Library



Innovative Design Process (IDP)

General Design and Construction Strategies

1. Ensure durability
2. Conduct home performance audit
3. Optimize energy performance during design
4. Manage noise
5. Design with air quality in mind
6. Design for sustainable lifestyle
7. Employ universal design
8. Optimize interior layout
9. Design sheltered entryway
10. Design for storage
11. Provide pantry
12. Design practical and usable kitchen recycling center

Site

13. Maintain adequate slope and drainage away from building
14. Maintain adequate slope and drainage away from house when creating outdoor living areas
15. Design to support connection with nature
16. Design landscapes to encourage outdoor activities
17. Design landscape features to minimize heat island effects
18. Design to minimize outdoor water use

Foundation

19. Provide proper moisture control at footings, slab perimeter, and foundation walls
20. Upgrade basement floor
21. Upgrade exterior basement walls
22. Include capillary break between all concrete and sill plates
23. Provide appropriate insect control

Building Envelope

24. Provide proper moisture management strategies
25. Assess vapor profile of new assemblies
26. Properly detail window sills in wet areas
27. Ensure that window and skylight installations include proper air sealing and flashing
28. Properly detail connection between deck and house

Sustainable Sites (SS)

Site

29. Minimize site disturbance
30. Make use of trees and landscaping to reduce cooling loads
31. Modify landscaping to provide solar access
32. Minimize contiguous impervious surfaces and facilitate infiltration

33. Provide porous pavement
34. Reduce lawn area
35. Provide wildlife habitat
36. Use landscape features to shield house
37. Provide for edible plants in landscape design
38. Landscape to minimize chemical use
39. Use site-chipped or ground clean wood waste as erosion control

Water Efficiency (WE)

Site

40. Provide rainwater collection system

Plumbing

41. Install low-water-use kitchen faucet
42. Replace toilets with high-efficiency toilets
43. Install low-water-use showerheads
44. Install water-conserving bathroom faucet aerator

Energy and Atmosphere (EA)

General Design and Construction Strategies

45. Use computer modeling to determine heating and cooling loads
46. Evaluate different heat distribution options

Foundation

47. Insulate floor slab and foundation walls

Building Envelope

48. Optimize energy performance
49. Install attic insulation
50. Consider radiant barrier in the attic
51. Conduct blower door test (before and after)
52. Conduct room-to-room pressurization testing
53. Conduct infrared imaging (before and after)
54. Complete thermal bypass inspection and resolution
55. Air seal and insulate rim joists
56. Upgrade existing windows
57. Upgrade existing exterior door
58. Weatherstrip doors and windows
59. Replace existing windows
60. Specify different window glazings for different orientations
61. Provide shading of skylights as needed
62. Install awnings or other exterior window shading system

HVAC

63. Use ACCA Manual's J, S, and D in mechanical system design
64. Provide appropriate controls and zoning for HVAC
65. Consider alternatives to conventional refrigerant-cycle air-conditioning
66. Select high-efficiency HVAC equipment
67. Install programmable thermostats
68. Conduct duct tightness test (before and after) in homes with forced-air systems
69. Properly commission new (or tune existing) HVAC systems
70. Properly seal and insulate HVAC distribution system
71. Make sure ducting is clean
72. Provide air-lock dryer vent
73. Minimize dryer duct length and number of turns
74. Discontinue unconditioned basement or crawl space ventilation
75. Avoid ozone-depleting refrigerants
76. Install ceiling fan

Plumbing

77. Reconfigure plumbing to distribute domestic hot water efficiently
78. Install on-demand hot water recirculation system
79. Choose high-efficiency water heater
80. Insulate water heater
81. Insulate hot water pipes
82. Set water temperature no higher than necessary

Lighting

83. Provide daylighting
84. Provide appropriate mix of color-correct ambient and task lighting
85. Install energy-efficient electric lighting
86. Avoid recessed lights in insulated ceilings or use insulation-contact fixtures
87. Provide adaptable lighting for multiuse spaces
88. Select outdoor lighting to minimize light pollution
89. Provide appropriate outdoor lighting controls as needed
90. Provide appropriate indoor lighting controls as needed

Equipment

91. Properly maintain equipment
92. Select high-efficiency, H-axis clothes washer
93. Install energy-efficient refrigerator
94. Choose energy-efficient dishwasher
95. Install energy-efficient cooking appliances
96. Consider energy toll of small appliances
97. Choose efficient hot tub or spa
98. Manage phantom loads
99. Select energy-efficient Energy Star–rated office equipment

Energy Sources

100. Configure for solar access
101. Consider solar water heating
102. Consider solar electric (photovoltaic) system

Use

103. Provide homeowner's manual of green features and O&M practices
104. Complete client education
105. Practice energy-efficient, healthy lifestyle
106. Provide for line-drying options for laundry

Materials and Resources (MR)

General Design and Construction Strategies

107. Manage construction and demolition waste

Site

108. Consider reuse of existing materials
109. Consider patio rather than wooden deck
110. Use naturally rot-resistant, responsibly produced wood for decks
111. Choose less harmful pressure-treated lumber
112. Use recycled-content plastic or composite decking boards
113. Use environmentally preferable patio materials

Foundation

114. Use fly ash in concrete
115. Use bio-based form-release agent or permanent forms

Building Envelope

116. Minimize wood use with advanced framing or SIP construction
117. Use high-recycled-content, formaldehyde-free insulation
118. Use FSC-certified wood
119. Install durable wall cladding
120. Provide durable, reflective roof

Lighting and Electrical

121. Plan for future wiring and cabling needs

Plumbing

122. Consider environmental preferable piping material
123. Include plumbing access panel
124. Install readily accessible, single-throw shut-off valve
125. Install drain and drain pan for clothes washer located over finished space

Walls and Ceilings

126. Install environmentally preferable interior sheathing
127. Select environmentally preferable interior doors
128. Frame for installation of future grab bars
129. Consider alternative wallcovering products
130. Use appropriate sheens for paints and finishes
131. Consider natural finishes
132. Consider tile and tile trim pieces with recycled content

Floors and Flooring Products

133. Consider reuse of existing flooring and subflooring
134. Select wood subflooring that is FSC-certified and low-formaldehyde
135. Consider flooring made from certified or reclaimed wood
136. Consider flooring made from natural or rapidly renewable materials
137. Refinish wood floors using environmentally preferable processes and products
138. Choose environmentally preferable carpet and rug products
139. Select carpet cushion that does not contain brominated flame retardants

Furniture and Fittings

140. Consider reusing clean existing cabinetry or buying salvaged
141. Consider reusing clean existing furnishings and fixtures or buying salvaged
142. Consider cleaning existing furniture or purchasing salvaged or antique furniture
143. Purchase best, most durable furniture possible within given budget
144. Select ergonomic furniture and office equipment
145. Evaluate use of cabinetry and furniture made from particleboard or MDF
146. Select compact furniture that incorporates storage
147. Select solid furniture made from green and safe sources
148. Select cabinets made from greener materials
149. Install environmentally preferable countertops
150. Select furniture from suppliers that practice fair and safe manufacturing processes
151. Select upholstered furniture with care
152. Choose environmentally preferable fabrics
153. Support local artisans as well as indigenous peoples
154. Choose environmentally friendly outdoor furniture and accessories

Use

155. Provide for paper recycling
156. Select materials that are easy to clean
157. Consider using bulk-product dispensers for body care products

Indoor Environmental Quality (IEQ)

General Design and Construction Strategies

158. Control spread of pollutants
159. Test for and appropriately handle hazardous materials
160. Conduct lead-safe work
161. Install track-off mats at exterior doors
162. Clean - up and dispose of pressure-treated sawdust and shavings appropriately

Foundation

163. Install radon mitigation system
164. Install CO and smoke alarms

Building Envelope

165. Isolate attached garages

HVAC

166. Install effective kitchen ventilation
167. Install effective bath ventilation
168. Provide appropriate venting of all combustion-based heating and water-heating equipment
169. Consider stand-alone equipment to address moisture
170. Provide for forced-air system pressure relief
171. Provide fresh air as part of ventilation system
172. Provide for additional ventilation and air-conditioning needs in certain activity areas
173. Provide for additional air filtration
174. Install appropriate HVAC in the finished basement

Plumbing

175. Install undersink water filtration system
176. Install water filter on showerhead

Lighting and Electrical

177. Use prudent avoidance with electromagnetic fields
178. Provide controllable interior shading

Floor and Flooring Finishes

179. Avoid carpeting in high-moisture areas
180. Choose hard-surface flooring
181. Install appropriate finish flooring in basements
182. Use area rugs instead of wall-to-wall carpeting

Wall and Ceiling Finishes

183. Use nonpaper-faced gypsum board in moist areas
184. Limit use of wallcoverings in high-moisture areas
185. Use low- or zero-VOC interior paints and finishes
186. Limit use of VOC-emitting wallcoverings
187. Use low- or zero-VOC construction adhesives, caulking, and sealants

Furniture and Fittings

188. Choose furniture and fittings that will not absorb moisture
189. Choose furniture finished with least-toxic products
190. Avoid fully upholstered furniture where moisture may be problem
191. Minimize use of plush and porous materials
192. Select furniture that is easy to clean
193. Select window treatments with health considerations in mind
194. Select mattress and bedding with attention to health issues
195. Choose interior accessories with care

Use

196. Use environmentally preferable cleaning materials and strategies
197. Store all toxic chemicals far away from living space
198. Be attentive to chemicals that might be stored in close proximity to a finished basement room

Innovative Design Process (IDP)

General Design and Construction Strategies

1. Ensure durability

All Projects

Durability applies to design, materials, and construction. It means combining these in such a way that the project responds to forces that challenge its durability—water, wind, ultraviolet radiation, pests, use and abuse, natural disasters. It is also about designing a project with lasting aesthetics and utility.

Ensuring durability involves quality assurance (of design and material's selection) and quality management (construction). To ensure durability, carry out a durability evaluation, such as that called for in the LEED for Homes program, or use the building assessment form (appendix).

Potential Issues

Designing for durability is about integrating energy efficiency with indoor air quality, energy efficiency with moisture management, and materials selection with all three. In remodeling, all of these need to be integrated with the existing home.

Related Strategies

IDP5, IDP9, IDP13, IDP19, IDP24, IDP25, MR119, MR120, MR124, IEQ166, IEQ167

References and Resources

"Read This Before You Design, Build, or Renovate" www.buildingscienceconsulting.com/resources/mold/ (particularly the introductory section, "The Building Connection")

LEED for Homes Innovation and Design Process Credit 2 www.usgbc.org/ShowFile.aspx?DocumentID=2267

2. Conduct home performance audit

Basement, Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

Both private home performance specialists and whole-house weatherization programs conduct comprehensive home energy analyses that include all areas of performance—moisture flows, thermal comfort, indoor air quality, combustion safety, and durability. This type of assessment represents systems thinking and systems integration and ensures that energy improvements do not result in negative unintended consequences. It also ensures that energy improvements take into account *all* loads—space heating, space cooling, ventilation, water heating, appliances, and plug loads—and climate and site factors so that the package of energy improvements is customized as well as optimized.

Potential Issues

Each building must be evaluated for the cost's and benefit's of managing different energy loads and the loads evaluated for their impact on overall building performance (health and safety, durability). And although the number of building professionals trained in this type of home assessment is growing, the demand is quickly outstripping the supply of qualified professionals so one certification covers systems-integrated, building science-based residential building assessment.

Images: Home Performance Testing During an Audit (3 images)

Related Strategies

IDP25, EA45, EA48, EA53, EA54, EA63, EA74, IEQ171

References and Resources

Saturn On-line Training for the Building Technician, www.srmi.biz/Online_Training.htm

BPI Building Professional Certification, www.bpi.org/contractor/cert.htm

"Combustion Safety Test for Vented Appliances," www.bpi.org/documents/Gold_Sheet.pdf

"Weatherization Plus – Next Generation," www.waptac.org/sp.asp?mc=what_overview_history

"Iowa Weatherization Program – Weatherization Standards," www.regreenprogram.org

Insulate and Weatherize, Bruce Harley, Taunton Press

3. Optimize energy performance during design

Major Addition, Gut Rehab, Deep Energy Retrofit

Computer modeling for energy efficiency is the best way to determine how design elements affect the energy efficiency of the project. The computer model determines how all elements of the home interact, from the foundation, walls, and attic to the mechanical equipment. Energy models allow the user to determine the overall efficiency of the home, predict energy bills, and even see how energy - efficient a home is compared with code.

Energy modeling allows users to determine the effectiveness of all envelope and mechanical equipment. Many professionals use energy modeling to prioritize energy-related decisions, especially when they are dealing with a tight budget. For example, is it better to spend $1,000 on increased insulation in the attic or a more efficient heat pump?

Integrated energy design is also a process that involves the mechanical system designer working in concert with the designer or remodeling contractor. Working together often creates opportunities to optimize heat distribution (with baseboard hydronic radiators or forced-warm-air registers, for example) when extra investment is made in high-performance windows and superinsulated wall sections. This integrated energy design also creates an opportunity to ensure that the design provides space for ducting, plumbing chases, and equipment.

The most popular modeling programs are REM/Rate, TREAT, and ENERGY-10. The IRS Energy-Efficient New Homes Tax Credit also includes a list of certified energy modeling programs.

Whole-house green remodeling projects should set a HERS rating target value (such as that just established by the City of Boulder, Colorado, for residential remodeling of a 25 HERS rating) and design to meet the target.

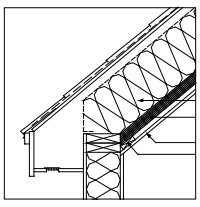
Potential Issues

Optimizing energy performance is very site- and climate-specific; if you don't model all the existing and potential loads in the home, it is very difficult to optimize the home's new performance. Integrated energy design practices often are win-win strategies that improve overall performance and/or improve cost-benefit ratios. Keep in mind that managing energy intensively requires that moisture and its movement be evaluated and managed with equal intensity.

ASHRAE is working on climate-specific deep energy retrofit protocols for homes. The schedule for this work is uncertain, but USGBC and ASID will incorporate the protocols into REGREEN when they become publicly available. For more information on carbon neutral existing home retrofits, see the ACI website reference (listed below).

Occupant behavior has a huge impact on actual energy usage in any home. Clear communication and a homeowner's manual can go a long way toward ensuring that the house will be managed for the optimal energy performance designed and built into the project.

Detail: Roof Retrofit Insulation and Interior Roof Retrofit



Related Strategies

IDP1, IDP2, IDP25, IDP31, EA45, EA48, EA63, EA100, EA101, EA102

References and Resources

REMrate, www.archenergy.com/products/rem/

TREAT, www.treatsoftware.com/treat_intro.html

Energy-10, www.sbicouncil.org/store/e10.php

IRS Allowed Energy Models, www.natresnet.org/programs/taxcredit_software/directory.aspx

"ACI Summit: Moving Existing Homes Toward Carbon Neutrality," www.affordablecomfort.org/event/aci_summit_moving_existing_homes_toward_carbon_neutrality

4. Manage noise

All Projects

Noise can be an indoor environmental quality problem. Along with the direct impacts of noise, such as impaired hearing, problems such as elevated blood pressure and heart rate, cardiovascular constriction, sleep loss, depressed learning rates, and the production of stress hormones are now being attributed to noise. Sources of noise can be external (traffic, jets) or internal (children, furnace).

Construction: Strategies include installation of layers of sound-control materials in floors, ceilings, or walls; offset wall studs or resilient channel (hat-track) furring on framing members; cellulose or mineral wool cavity-fill insulation even in interior walls; sound-control wall panels; cork or other sound-control underlayment in floor systems; carpeting or cork flooring; vibration-control brackets for mechanical equipment and ducting; minimal duct elbows and constrictions; and of equipment with low sound ratings (often listed in sones for exhaust fans and dBA for appliances).

Appliances: Kitchen appliances can be a significant source of unwanted noise in homes. When selecting refrigerators, dishwashers, and other appliances, look for noise ratings, which are usually listed in the logarithmic decibel-A scale (dBA). Appliances vary considerably in noise ratings. The quietest dishwashers have noise ratings below 45 dBA, which is almost unnoticeable in a kitchen if there is conversation.

Getting quantitative information on sound levels of appliances is very difficult. Most manufacturers do not provide dBA sound ratings for their appliances. It is common to see reference to a "sound control package" or a qualitative description of sound levels, but consistent metrics are needed to gauge noise from appliances. The best source for this information may be *Consumer Reports*.

Finishes: Hard, monolithic surfaces (high-density wood composite paneling, gypsum board, ceramic tile) do not absorb sound; softer, variegated surfaces (carpet, cork, loosely woven materials) help manage it.

Potential Issues

Some sound-control measures can add significant cost to a remodeling project. Sound-control measures can also add thickness to a wall system, taking away usable floor area. In many cases, there is good synergy between managing air leakage and managing noise generated outside the home.

Related Strategies

IDP3, EA54, EA56, EA92, EA93, EA94, MR138, IEQ165

Resources and References

"Building Green…Quietly: Noise Pollution and What to Do About It,"
www.buildinggreen.com/auth/article.cfm?fileName=100101a.xml

Noise Pollution Clearinghouse,888/200-8332,
www.nonoise.org

Rutgers Noise Control Technical Assistance Center,
www.envsci.rutgers.edu/org/rntac/tech.shtml

National Council of Acoustical Consultants, 973/564-5859,
www.ncac.com

5. Design with air quality in mind

All Projects

Considerations related to indoor air quality should be taken into account during the design phase of just about all remodeling and interior design projects: ventilation, materials selection, filtration, etc. EPA's Indoor Air Quality division has developed a model (I-BEAM) that can be used for both new construction and renovation to address IAQ during both the design and the construction phases.

Potential Issues

The EPA resource covers both new construction and renovation so the user must keep this in mind if applied to just renovation.

Related Strategies

EA71, EA74, MR137, MR145, MR147, MR152, IEQ163, IEQ165, IEQ166, IEQ167, IEQ171

Resources and References

"EPA IAQ Building Education and Assessment Model"
www.epa.gov/iedweb00/largebldgs/i-beam/text/renovation_new_construction.html#CR3.3.2

6. Design for sustainable lifestyle

Kitchen, Living & Working, Outdoor Living

As part of a remodeling project, incorporate features that will facilitate environmentally responsible living. Specific measures can include incorporating recycling receptacles, providing convenient storage for bicycles, providing storage for locally produced food, providing composting receptacles in the kitchen and a sturdy composting bin outdoors; and storage spaces that will encourage organization while discouraging the accumulation of belongings that are never used.

Potential Issues

It is very likely that green remodeling clients will be fully attuned and open to guidance from their designer or remodeler on a sustainable lifestyle that augments the project's sustainable focus. But the homeowners may need to be directed to information resources.

Related Strategies

IDP7, IDP10, IDP11, IDP12, EA105, IEQ196, IEQ197, IEQ198

References and Resources

www.greenhomeguide.org/

7. Employ universal design

Bathroom, Kitchen, Major Addition, Gut Rehab

The relationship between universal and sustainable design is a strong one. Remodeling to maintain a home's functionality as the owners age or as owners change is resource efficient.

Potential Issues

Care should be taken on exterior walls to maintain thermal performance if new blocking replaces insulation—yet another good argument for considering the addition of exterior rigid insulation as a part of any bathroom remodel. Making finished first-floor levels the same or nearly the same as finished grade mean's that sheltered entryways become that much more important.

Related Strategies

IDP3, MR109, MR128

Resources and References

"Residential Remodeling and Universal Design"
www.huduser.org/publications/destech/resid.html

"Universal Design"
www.extension.iastate.edu/housing/elderly/udha-ud.html

8. Optimize interior layout

Major Addition, Gut Rehab

Whenever a remodeling project involves potential reconfiguration of interior spaces, consider how the layout could be modified to better utilize space (including storage), benefit from passive solar heating, more effectively circulate conditioned air (in some cases obviating the need for distributed heat), and reduce the length of hot-water piping runs. Part of the long-term trend of ever-larger houses is driven by the fact that Americans have more possessions than ever before, and storage space is needed for those belongings; that storage can be more efficient, allowing comfortable living with fewer square feet of living space. Reconfiguration of

house layout can significantly improve the potential for passive solar energy to heat a home or for small space-heating or air-conditioning systems to work effectively without a full distribution system.

Potential Issues

Air circulation in a building is complex, especially when passive solar heat gain and thermal mass are factored in; a designer knowledgeable in passive solar design should be consulted if the home will rely on natural air circulation to maintain comfort.

Related Strategies

IDP10, EA46, EA77, EA84

References and Resources

The Not-So-Big House, Sarah Susanka, Taunton Press, 1998
www.notsobighouse.com/

9. Design sheltered entryway

Major Addition, Deep Energy Retrofit, Gut Rehab

Providing a sheltered entry to a home can reduce heat loss and gain, provide protection from UV and water exposure, and provide a place to leave wet shoes and outerwear. There should also be adequate space for hanging coats and storing outdoor shoes. In cold climates, the entry should be an airlock mudroom large enough that homeowners will close one door before opening the next—whether coming in or going out.

Potential Issues

Providing a sheltered entry requires a significant amount of space, which can be challenging in a compact home; the space can also be costly to build.

Related Strategies

IDP1, IDP3, IEQ161

References and Resources

"Remodeling with the Sun"
www.homeenergy.org/archive/hem.dis.anl.gov/eehem/97/970508.html

10. Design for storage

Kitchen, Bathroom, Major Addition, Gut Rehab

Maximizing all opportunities for storage means less square footage. In small bathrooms in particular, design additional storage by framing in interior wall cavities for medicine cabinets and small shelves. There are lots of incidental bathroom items that are appropriate for the 3 ½- to 4-inch-deep storage space that interior framing cavities provide. Choice of a sink with cabinet over a pedestal will also give more storage.

Potential Issues

A really tight bathroom will appear even less spacious with cabinetry. Another approach is to assess adjacent rooms or the hallway into which the tight bathroom opens for storage potential.

Related Strategies

IDP8

References and Resources

The Not-So-Big House, Sarah Susanka, Taunton Press, 1998
www.notsobighouse.com/

11. Provide pantry

Kitchen

A pantry that is accessible from the kitchen can provide space-efficient and cost-effective storage space for food and kitchen utensils. Kitchen pantries can be very small—as little as 3 square feet in floor area—or a full walk-in room. Effective implementation of a pantry can reduce the number of cabinets needed, and because doors are not needed on each shelf inside a pantry, overall material use and construction cost can be reduced.

Potential Issues

Pantries cannot be accommodated in every kitchen layout, and where they can be built, their effective integration often requires significant design experience.

Related Strategies

IDP8

References and Resources

The Not-So-Big House, Sarah Susanka, Taunton Press, 1998
www.notsobighouse.com/

12. Design practical and usable kitchen recycling center

Kitchen

Ideally, a kitchen recycling center includes stations or bins for paper, plastic, metal, and compost. It can also make an in-sink garbage disposal unnecessary. The space for a kitchen recycling center can be incorporated into the new cabinet layout or into pantry, mudroom, or other adjacent space. Instead of a trash compactor, a dedicated recycling center in the kitchen or utility room will help homeowners practice environmentally responsible lifestyles. Make sure that a recycling setup correlates with the municipality's recycling program. Another option is to design an in-house composting system. Worm bins and other techniques are available that can make composting possible in nearly any setting. Outdoor compost containers, into which compost collected in most kitchen composting systems is dumped, must be well - designed to provide air flow and keep animals out.

Potential Issues

Space for a comprehensive recycling center can be challenging, especially to make the space easily accessible so that all household members use it. Make homeowners aware that composting involves more work than in-sink garbage disposals. They must be committed to

monitoring and maintaining the composting system or it will fail. Outdoor compost bins need to be carefully designed to exclude raccoons, rats, or other problem animals.

Related Strategies
IDP8

References and Resources
Good Green Kitchen, Jennifer Roberts

"Kitchen Recycling Center"
www.toolbase.org

"Composting Guide – Composting Fundamentals"
vegweb.com/composting/systems.shtml

"Garbage Disposals and Trimming Your Waste"
www-erights.prod.consumerreports.org/cro/appliances/kitchen-appliances/garbage-disposers/garbage-disposers-204/overview/?resultIndex=10&resultPageIndex=1&searchTerm=traps

Site

13. Maintain adequate slope and drainage away from building

Major Addition
To direct roof runoff and rainfall away from the foundation, grade the surrounding ground to maintain at least a 5% percent slope (6 inches in 10 feet) away from the foundation. Although porous backfilling should be used along the foundation, a relatively impervious layer of soil near the surface will help direct rainwater away from the house.

Another approach to manage bulk water load around the structure is to install a subsurface "shed roof" (see Figure 16, page 14 in the reference cited below).

Potential Issues
A 5% slope can be challenging, particularly given existing finish grade constraints. After surface water has been moved away from the structure, consider the advantages of on-site infiltration as opposed to stormwater system management of this load.

Related Strategies
IDP1, IDP19, SS32

References and Resources
"Read This Before You Design Build or Renovate"
www.buildingscienceconsulting.com/resources/mold/

14. Maintain adequate slope and drainage away from house when creating outdoor living areas

Outdoor Living
The surface grade around a house is very important to prevent water (and winter snowmelt) from draining toward the house foundation, where it can cause moisture problems. With patios, decks, walkways, gazebos, and other outdoor living spaces and landscaping features, maintain a surface grade away from the house, especially with patios that extend right up to the house. If there are no gutters to collect rain from the roof, provide a different surface treatment at the roof dripline to minimize splashback into the house; a band of crushed stone with subsurface drainage away from the house is often a good option.

Potential Issues
A 5% slope can be challenging, particularly given existing finish grade constraints.

Related Strategies
IDP1, IDP19, SS32

References and Resources
"Read This Before You Design Build Or Renovate"
www.buildingscienceconsulting.com/resources/mold/

15. Design to support connection with nature

Outdoor Living
Research into "biophilia" shows that views of and contact with nature can improve our health and well-being. Along with incorporating natural features outdoors, design features and decorations indoors can help homeowners achieve a connection with nature. For starters, provide visual connection with the outdoors with: large window areas facing natural features. Outdoors, provide patios, decks, or porches so that homeowners can enjoy outside living during good weather. Indoors, provide places for potted plants or even small indoor gardens. Decorate with art that represents or shows off relaxing natural scenes.

Potential Issues:
With indoor plantings and potted plants, be aware that mold, mildew, and insect pests can become problems, particularly if plantings are overwatered. On the other hand, these same natural features can be used to improve solar shading and even support bulk water management.

Related Strategies
SS29, SS35, SS36, EA83, MR109

References and Resources

"Biophilia in Practice: Buildings That Connect People with Nature," www.buildinggreen.com/auth/article.cfm?fileName=150701a.xml

Buildings for Life: Designing and Understanding the Human-Nature Connection, Stephen Kellert, Island Press, 2005.

16. Design landscapes to encourage outdoor activities

Outdoor Living

The growing incidence of obesity among children is but one piece of evidence that children today are spending far less time outdoors. Landscapes around homes can be designed to encourage outdoor activities by people of all ages. Although conventional lawns are not ecologically responsible, there are ways to create environmentally sound lawns, as well as play surfaces covered with wood shavings or other safe surface materials.

Potential Issues

Lawns provide an inherent tension with landscape design. On the one hand, conventional lawns are often chemical- and water-intensive and require pollution-spewing mowing. But their value as healthy play spaces (assuming few if any chemical additives) and their ability to absorb stormwater, can outweigh the negatives. A good compromise is often a modest lawn area in a landscape that includes more natural areas.

Related Strategies

SS34, SS35, SS38

References and Resources

Last Child in the Woods, Richard Louv
www.thefuturesedge.com

17. Design landscape features to minimize heat island effects

Strategy included in: Major Addition, Outdoor Living

The urban heat island effect is a localized warming that occurs in urban areas because of the large areas of dark surfaces absorbing solar energy. This not only increases air-conditioning loads in urban areas but also exacerbates smog generation. Reflective (high-albedo) roofing materials and pavement surfaces as well as vegetative plantings can help minimize this heat island effect. With roofing materials, look for products certified as Energy Star, which mandates a minimum reflectivity. With pavements, start by minimizing pavement area (minimizing driveway width, limiting parking area), but also look for lighter-colored paving materials, such as concrete grid-pavers instead of asphalt.

Potential Issues

This issue is of less concern in nonurban areas, particularly in cold climates.

Related Strategies

IDP3, SS30

References and Resources

"What Can Be Done?"
www.epa.gov/hiri/strategies/index.html

18. Design to minimize outdoor water use

Outdoor Living

It is remarkable that Kentucky bluegrass and related turfgrass varieties are almost ubiquitous from coast to coast. We are designing landscapes in Phoenix and Las Vegas that require the same amount of water as landscapes in Hartford and Seattle. A far more responsible (and affordable) approach is to design landscapes that are adapted to the local climate. In more arid or drought-prone areas, use xeriscaping (low-water-use landscaping). Where landscape irrigation is required, use water-conserving irrigation equipment (including drip - irrigation technology), advanced irrigation controls that will prevent overwatering (when the ground is already wet or when rainfall is expected), and consider innovative options such as graywater, harvested rainwater, or treated wastewater piped from sewage - treatment plants. Planting drought-tolerant landscapes or providing alternative water sources may enable landscape to remain healthy during drought's and if outdoor watering restrictions are imposed.

Potential Issues

Some municipal regulations and subdivision covenants that mandate lawn watering. These can make responsible landscaping difficult.

Related Strategies

SS34, WE40

References and Resources

EPA WaterSense Program, www.epa.gov/watersense

California Urban Water Conservation Council, www.cuwcc.org

Foundation

19. Provide proper moisture control at footings, slab perimeter, and foundation walls

Major Addition

Foundations are one of the most significant moisture sources in many homes. Moisture can wick through concrete slab floors and foundation walls, then evaporate indoors—often with no visible wetness. Preventing moisture entry through the foundation requires proper foundation design, quality workmanship, and exterior drainage. Accepted foundation design for moisture control typically includes tamped, crushed stone under a foundation slab, a layer of durable polyethylene (protected from abrasion with insulation or sand), a

capillary break between the footing and foundation wall, a damp-proofing layer on the foundation exterior, and a drainage layer outside the foundation wall, including geofabric to keep silt out of the drainage layer and drainage pipe.

Potential Issues

The addition foundation must be integrated with the existing foundation, both structurally and in terms of moisture management. Be prepared to add perimeter foundation drainage to the existing structure if changes in surface and soil water movement alter the performance of the existing foundation.

Related Strategies

IDP1, IDP25, IEQ163

References and Resources

"Understanding Foundations", www.buildingscienceconsulting.com/resources/foundations/Understanding_Foundations.pdf

20. Upgrade basement floor

Basement

A high-performance basement floor manages bulk water, capillary water, and water vapor while improving comfort in a basement living space. Floor insulation is not to reduce energy loss through the floor but to elevate the surface temperature for thermal comfort and lower the relative humidity at the surface to manage dust mites, mold, and mildew. Unless you are replacing the existing basement concrete slab or the basement does not have one, it is very likely that a capillary break and insulation will be needed on top of the existing basement slab.

Wet floor. If there is liquid water on the basement floor, you need to manage the site drainage. If exterior work gives access to the footing, install an exterior perimeter drainage system that drains to daylight, a storm sewer, or a drywell. Otherwise, install an interior perimeter drainage system, sump pit, and pump.

Damp floor. If you see efflorescence (white powder on the surface of the basement slab), or if you conduct a plastic sheet test (ASTM D4263) and the plastic is wet on the side against the foundation wall, do one of two things: Make sure that anything placed on the basement floor is highly vapor permeable so that the whole assembly can dry to the interior. Or install a layer directly against the concrete floor that prevents all vapor transmission to the space above and can manage water that condenses on its back side.

New concrete slab. If there is adequate headroom in the basement, moisture management and insulation can be accomplished by casting a new concrete slab on top of the existing. Provide a suitable moisture barrier, then a layer of insulation, then the concrete slab. Follow recommended practices for detailing the slab.

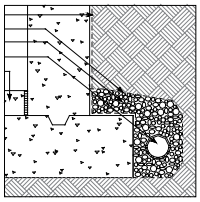
Potential Issues

Moisture and radon exposure must be assessed and a plan for their management developed before any attempt can be made to convert a basement into living space. See the integrated predesign issues for the basement.

Head height is a common problem in finishing off a basement floor. One option is to dig out to gain the head height, which also provides the opportunity for improving moisture management and insulation of the basement slab.

Details: Foundation Water Management

- **Crawl space foundation with piers**
- **Inside-outside perimeter drainage**
- **Inside-outside perimeter drainage with mat**
- **Inside perimeter drainage retrofit**



Related Strategies

IDP1, IDP22, IDP25, IEQ179

References and Resources

"Read This Before You Design Build Or Renovate" www.buildingscienceconsulting.com/resources/mold/

21. Upgrade exterior basement walls

Basement

A high-performance exterior foundation wall is well - drained, damp proofed, and well insulated, and is constructed of durable materials that will not degrade under the expected conditions. If the exterior surface of the existing foundation walls can be accessed, that is generally the best location for added insulation (bringing the thermal mass of the foundation wall into conditioned space), and a mechanism to manage moisture—a coating on the outside of the wall, free-draining material next to the wall, and perimeter drainage at the outside of the footer. See the strategy under major addition for constructing high-performance new foundation walls.

Unfortunately, with most basement finishing projects, it is not possible to access the outside of the walls, so any modifications have to be done to the interior.

Wet walls. If you see liquid water, you need to manage liquid water. Assuming the outside of the foundation wall cannot be accessed through excavation, drainage has to be provided on the interior. Create a free-draining space to allow water to drain down the wall and into an internal drainage system at the perimeter of the basement floor; this should drain to an air-tight sump pit and pump.

Damp walls. If you see efflorescence (white powder on the surface of the masonry wall), or if you conduct a plastic sheet test (ASTM D4263) and the plastic is wet on the side against the foundation wall, moisture is likely seeping through the wall and evaporating on the interior. Take one of two approaches: Make sure that anything placed on the foundation walls is highly vapor permeable so that the whole assembly can dry to the interior. Or install a continuous water and vapor barrier facing a free-draining space next to the wall, and then make sure that every component of the basement assembly to the interior of this barrier is vapor permeable. This is particularly important if perimeter metal or wood stud walls are planned for the finished basement.

Mud sill or rim joist moisture or rot. If either the mud sill or the rim joist at the top of the foundation wall is high in moisture content (above 18% by weight) or actually degraded, you need to identify and eliminate the source of the problem. It could be improper site or building perimeter drainage, water wicking up into the wood assembly from direct contact with the foundation wall, or condensation from a poorly insulated or air-sealed assembly. Replace compromised wood framing with nontoxic rot-resistant material, such as TimberSil or wood-plastic composite materials that have the required design values and an evaluation service report (ESR) number.

Cold walls. Insulate and air seal, paying the most attention to the portion of the foundation wall that is above grade and the first 4 feet below grade. Air-sealing details at the top of the wall and its transition to the wood framing assemblies above are critical, particularly if a free-draining air space is part of the new exterior wall finished assembly.

Durable walls. Use materials that tolerate moisture and separate them from materials that can wick moisture by using capillary breaks such as concrete, wood, and gypsum drywall. This will most likely entail upgrading to a high-performance basement floor first (See 20, Upgrade basement floor) and then upgrading the basement walls.

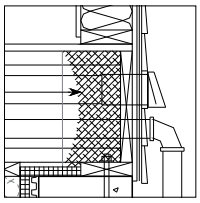
High interior relative humidity. The best way to manage moisture is to keep it out, but in an existing basement with walls drying to the interior, you are very likely going to need to manage it from the inside with active dehumidification.

Potential Issues

Moisture and radon exposure must be assessed and managed before any attempt can be made to convert a basement into living space. See the integrated predesign issues for the basement.

Paper-faced interior sheathing products should in general be avoided in basement wall assemblies.

Detail: Basement Moisture and Energy Management



Related Strategies

IDP1, IDP19, IDP22, IDP25, IEQ183

References and Resources

"Read This Before You Design Build Oor Renovate."
www.buildingscienceconsulting.com/resources/mold/

22. Include capillary break between all concrete and sill plates

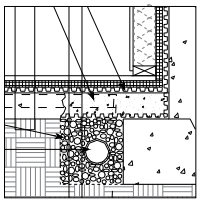
Basement, Major Addition

It is becoming common practice for closed-cell foam sill sealer or similar material to be installed between all concrete and framing on exterior foundation walls (usually purposefully as an air-sealing detail and incidentally as a capillary break). But just as this material serves as a capillary break on exterior walls, it does the same for interior walls. To keep water from rising into interior framing, a capillary break is needed between all bottom plates and concrete foundation walls or floors.

Potential Issues

Some minor adjustments in stud lengths may be necessary to have interior walls with sill sealer line up properly with existing exterior wall heights. It is possible to raise and brace exterior walls to insert a sill sealer or capillary break material, but the moisture flow potential from foundation to exterior above-grade wall must be weighed against the cost of such a strategy.

Detail: Basement Moisture and Energy Management



Related Strategies

IDP1, EA47

References and Resources

"Read This Before You Design Build or Renovate."
www.buildingscienceconsulting.com/resources/mold/Read_This_Before_You_Design_Build_or_Renovate.pdf

23. Provide appropriate insect control

Major Addition

The foundation provides the interface between the ground and the house, and this is the most common

point of entry of wood-destroying insects, especially subterranean termites, though carpenter ants and powderpost beetles can also be problems. Keep all untreated wood 12 inches above soil (most building codes require 8 inches) and keep vegetation at least 2 feet from foundation walls. A variety of strategies can be used to manage the threat posed by insects: nonwood building systems, metal shields or screens, sand barriers, borate or sodium silicate-treated wood, and newer bait management systems.

Potential Issues

Some jurisdictions still require chemical treatments around houses for termite control. If this is the case, use the least-toxic chemicals available. The use of exterior foam insulation on foundation systems can require both inspection zones and metal shields, depending on the intensity of the insect risk exposure.

Image: Borate Insect Treatment of Framing

Related Strategies

IDP1, EA47

References and Resources

Integrated Pest Management (IPM) Practitioners Association, www.efn.org/~ipmpa/keydocs.html

Common Sense Pest Control, William Olkowski, Sheila Daar, and Helga Olkowski, Taunton Press, 1991

Bio-Integral Resource Center, www.birc.org

Building Envelope

24. Provide proper moisture management strategies

Major Addition, Gut Rehab, Deep Energy Retrofit

Keeping moisture out of a house is critical to ensuring its long-term durability, particularly in wetter climates. Many of the strategies required for moisture management involve the building envelope. These include providing a substantial roof overhang, ensuring that window and door flashing is properly installed, sealing any roof and wall penetrations including chimneys and vent stacks, providing a house-wrap weather barrier or asphalt-impregnated paper (tar paper), providing a rain screen detail (an air space behind siding that provides a drainage plane and allows siding to dry off between wettings), providing an air barrier in the insulated envelope (on the interior and/or the exterior), and selecting both interior and exterior finishes that fit the vapor profile. (Note that vapor diffusion and bulk water movement are quite different; a material that blocks bulk water movement might or might not retard moisture diffusion.)

Potential Issues

The key, particularly in remodeling, is to manage energy and moisture with equal intensity. Heat flow dries assemblies out, and decreasing the heat flow through an assembly (with insulation and air sealing) requires superior moisture management. A wall that tolerated a small leak under a window may fail when upgraded insulation and air sealing prevents the moisture from evaporating.

Penetrations into existing walls and roofs raises the issue of just how flashing systems for the penetrations will properly function if the existing assemblies do not have weather-resistive barriers in place. Consider removing enough exterior cladding to integrate a new penetration with the assembly.

Related Strategies

IDP1, IDP3, IDP25, IDP27

References and Resources

"Read This Before You Design Build or Renovate," www.buildingscienceconsulting.com/resources/mold/Read_This_Before_You_Design_Build_or_Renovate.pdf

25. Assess vapor profile of new assemblies

Basement, Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

There is a long-standing tradition in building to focus on the vapor permeability of just one component in building assemblies—that of the "vapor retarder" or "vapor barrier." But *all* of the components in an assembly, both individually and collectively, determine how water vapor moves or does not move through an assembly. The relative vapor permeability of *all* components in an assembly should be assessed, and the designer should ensure that there is at least one path for drying (to the interior, the exterior, or both). This aspect of assembly moisture performance is called the vapor profile. In other words, how an assembly is designed to dry is just as important as how it is designed to keep from getting wet. This is particularly important when a portion of the wall, roof, or foundation assembly already exists and new components are being added. Vapor profiles are also important to consider when closed-cavity insulation fill is used to upgrade the thermal performance of wall and roof assemblies.

Potential Issues

Elements of building assemblies are selected for more than just their vapor permeability. This one property must be balanced with many other considerations, such as flammability, thermal conductivity, ease of installation,

long-term durability, cost, and appearance. The builder, architect, and specifier should all be aware of exactly why each component of an assembly has been selected and not make substitutions without reassessing the impact of any substitution on the overall performance of the assembly, including the vapor profile.

In general, avoid components with very low vapor permeabilities unless the climate and assembly requires it. Examples include vapor retarders with a vapor permeability less than 1 perm in very cold climates and average interior relative humidity greater than 30%, or brick veneer walls where solar-driven moisture is likely.

Image: Drip-Through Deck Grating on Gutterless Eaves

Related Strategies
IDP1, IDP3, EA48, EA49, MR129, IEQ184

References and Resources

"Understanding Vapor Barriers," www.buildingscience.com/documents/digests/bsd-106-understanding-vapor-barriers/?topic=/designguidance/buildingscienceanddesign/enclosuredesignprinciples/main_topic

26. Properly detail window sills in wet areas

Bathroom

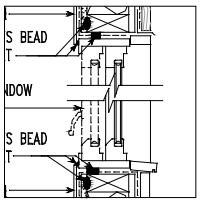
A tub or shower surround is a tough place to put a window (though there are plenty of them in both new and existing homes), and it can be hard to balance the aesthetic and daylighting gains with moisture management challenges. If a window of any kind either must stay or go into the wet area of the tub or shower surround, it has to be detailed per the drawing below.

- The sill must be water impermeable, such as marble or Corian, not tiled with grout joints unless the grout is epoxy-based.
- The sill must be pan-flashed or sealed as if it were an exterior sill. (Two people taking one shower each day for 8 minutes is equivalent to approximately 1,000 inches of driving rain a year.)
- Select a more moisture-tolerant frame material, such as plastic or fiberglass, not wood or metal-clad.

Potential Issues

If possible, keep windows and skylights out of the tub or shower surround.

Details: "Wet Room" Window
· High sill shower window
· Low sill shower window



Related Strategies
IDP1, IDP24

References and Resources See accompanying details.

27. Ensure that window and skylight installations include proper Air Sealing and flashing

Bathroom, Deep Energy Retrofit

Water and air leakage problems at windows and skylights are all - too - common and cause a multitude of structural and indoor air quality problems. Water leaks can be highly damaging and very expensive for remodeling contractors—not to mention inconvenient with weekend call-backs. Air leaks can result in significant heat loss, costing homeowners hundreds of dollars per year. Follow practices recommended by building scientists to properly flash and seal all wall and roof penetrations.

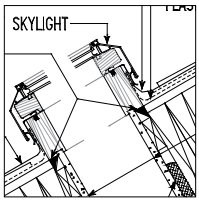
Potential Issues

If the existing roof or wall assembly has no weather-resistive barrier (concealed drainage plane), how do you integrate the flashing of the new unit to the existing exterior of the assembly? Without a weatherlap, the unit flashing will do little to protect the overall assembly. If this assembly is not significantly protected by an overhang or roof, consideration may have to be given to stripping the exterior cladding so that a true weatherlapped flashing approach can be achieved.

Also, although skylights and roof windows can add important daylight to homes, they can be significant sources of unwanted solar heat gain. Hire an energy designer or mechanical engineer to carry out computer modeling to determine the optimal size and location of skylights.

Details: Bay Window and Skylight Air Sealing and Insulation

- **Air sealing at bay window**
- **Air sealing at skylight head and sill**
- **Air sealing at skylight jamb**



Related Strategies
IDP1, IDP24, EA54

References and Resources See accompanying detail.

28. Properly detail connection between deck and house

Outdoor Living, Major Addition

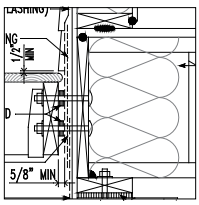
The connection between a house and the deck is critically important for structural stability and long-term moisture management and durability. Improperly detailed, the deck connection can channel water into the ledger plate and rim joists of the house, causing rot, which in turn can weaken the deck connection to the house, risking catastrophic failure. Additionally, the copper-based preserved wood that has largely replaced CCA (chromated copper arsenate) is corrosive to steel; special fasteners must be used to reduce risk of failure. The detail below shows proper flashing for connections for a deck that should help ensure a long life both for the deck and the house.

Potential Issues

A deck is a significant investment in materials; consideration should be given to whether the functions of a deck can be provided with another outdoor living space option, such as a patio.

The shear forces exerted on the fasteners with free space between the deck ledger and existing structure may require engineered or strength-specified fasteners. An alternative approach would be to have the deck ledger bear on posts so that the deck and house fasteners are facing only tear-out and not shear forces.

Detail: Deck Attachment at Band Joist



Related Strategies
IDP1, IDP24, MR110, MR111, MR112

References and Resources

"Deck2 Wall Spacer,"
www.screw-products.com/deck2wallspacer.htm

Sustainable Sites (SS)

Site

29. Minimize site disturbance

Major Addition, Gut Rehab, Deep Energy Retrofit, Outdoor Living

Any addition involved site disturbance, but through careful planning and job - site supervision, that disturbance can be kept to a minimum. Carefully control the impact area by designating vehicle parking farther from the site and storing building materials inside a garage or other protected area. Existing trees should be protected by fencing off an area that includes, at a minimum, their drip line (a line extending down from the outermost perimeter of the crown); it is important to avoid not only direct damage to tree trunks but also compaction of soil by construction vehicles or storage of materials, which can smother tree roots. On undisturbed sites, protect native vegetation. Consider providing incentives for excavation contractors to protect the site (or penalties for damage). Where damage is unavoidable, existing desirable plants can be dug up and relocated. Best practices should be followed to control erosion of topsoil from the site, including—as needed—silt fencing, berming, wood chip entry pads, and use of straw bales to filter runoff. Ensure that equipment being used by excavation contractors is not leaking fuel or hydraulic fluid.

Potential Issues

Many remodeling job sites are tight spaces that require careful planning to keep materials moving on and off the site easily without risk of theft. Minimizing site disturbance starts with project planning and then translates into sound job site management.

Related Strategies
SS39

References and Resources

"The Low Risk Site Handbook for Erosion Prevention and Sediment Control,"
www.vtwaterquality.org/stormwater/docs/construction/sw_low_risk_site_handbook.pdf

Erosion Control Technology Council, www.ectc.org

30. Make use of trees and landscaping to reduce cooling loads

Major Addition, Outdoor Living

Shade trees can dramatically reduce cooling loads in houses or additions. Efforts should be made to protect trees existing, and new trees should be planted to provide future shading and protection. On the south side of a house where passive solar heating is being used, tall deciduous trees can allow the low wintertime sunlight to reach south-facing windows and solar features yet block the summer sun, which is higher in the sky. On west walls, it may make sense to incorporate trellises, arbors, and planting beds for tall annuals to provide shading of west-facing windows (where summertime heat gain is the biggest problem).

Potential Issues

In arid areas—where shading can be most beneficial—the moisture requirements for trees may be significant; select trees that are adapted to the climate and will require a minimum amount of irrigation.

In temperate regions, deciduous trees can provide summertime shading and then solar access after they drop their leaves. Care must be taken in selecting deciduous trees, however, because species vary widely in the amount of shading they provide, both in leaf and bare.

Related Strategies

IDP3, SS31

References and Resources

"Conserving Energy with Landscaping,"
www.ext.vt.edu/pubs/envirohort/426-712/426-712.html

31. Modify landscaping to provide solar access

Major Addition, Outdoor Living

To provide solar access to a house, it is often necessary to remove or prune trees on the south, east, or west. A solar site assessment tool can be invaluable in identifying trees that should be removed or pruned. Removing trees from immediately around a house can also help with air circulation, which can improve durability.

Potential Issues

Removing trees to provide solar access can increase cooling loads.

Related Strategies

IDP3, SS30, EA100, EA101, EA102

References and Resources

"Conserving Energy with Landscaping,"
www.ext.vt.edu/pubs/envirohort/426-712/426-712.html

"Passive Solar Home Design,"
www.eere.energy.gov/consumer/your_home/

32. Minimize contiguous impervious surfaces and facilitate infiltration

Major Addition, Outdoor LIving

Runoff from roofs, sidewalks, driveways, and other impervious surfaces can contaminate surface waters and lead to downstream flooding and erosion. Far better, from an environmental standpoint, is allowing that stormwater to soak into the ground and recharge underground aquifers. To maximize infiltration and limit runoff, try to avoid impervious surfaces outdoors, limit contiguous impervious surfaces (in other words, provide permeable drainage areas between sidewalk and other impervious surfaces), use porous paving materials (open-matrix concrete grid pavers, specialized honeycomb substrates for gravel or turf, or pervious mixes of concrete or asphalt), and provide vegetated infiltration swales, rainwater gardens, or other landscape features where stormwater can collect and infiltrate.

Potential Issues

Porous paving requires specialized management; in northern climates, for example, applying sand or salt in winter can clog the pores in these surfaces.

Make sure that whatever strategies you employ to keep water on site comply with local stormwater management policies and regulations.

Related Strategies

IPD1, IDP24, SS39

References and Resources

"EPA Stormwater Best Management Practice Design Guide,"
www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121a.pdf

33. Provide porous pavement

Outdoor Living

Designing outdoor surfaces around buildings to allow rainwater to infiltrate the ground rather than running off and overwhelming storm sewers achieves several important benefits: it helps recharge underground aquifers, reduces contamination of surface waters with pollutants that are picked up in stormwater runoff, reduce's the risk and frequency of downstream flooding, and (in many urban areas) reduce's combined sewage overflow (CSO) events, in which sewage treatment plant capacity is overwhelmed during storms and raw sewage ends up in surface waters. Porous pavement around houses is one important way to increase on-site infiltration. Options include porous grid pavers, pervious concrete, porous asphalt, and specialized turf and gravel systems in which a matrix supports these porous materials and prevents vehicles from compacting the ground. Porous pavements should be considered for driveways, walkways, pathways, sidewalks, patios, and emergency - access alleys.

Potential Issues

Porous pavements often require more maintenance than impervious surfaces because plants are able to grow through them. In cold climates with snow and ice, porous pavements may become clogged with sand or damaged by plowing.

Related Strategies

SS32, MR109

References and Resources

Porous Pavements, Bruce Ferguson, CRC Press, 2005, www.buildinggreen.com/biblio/item.cfm?itemID=1362

Center for Watershed Protection, www.cwp.org/

"Permeable Pavement," toolbase.org/Technology-Inventory/Sitework/permeable-pavement

34. Reduce lawn area

Outdoor Living

Conventional lawns carry significant environmental burdens, needing chemical applications (fertilizers, pesticides), requiring irrigation in many parts of the country, causing runoff, and nessitating sewage treatment burden. Mowing emits far more air pollution per unit of gasoline burned than driving cars. Increasingly, homeowners wanting to minimize environmental impacts (and save money) are seeking ways to minimize lawn area, replacing it with naturalized plantings, wildlife habitat, small meadows with native plants, and in arid areas, xeriscapes with cacti and other desert plants that require little or no added water. When outdoor living spaces and landscape features are being considered, address with homeowners whether there are opportunities to reduce lawn area—and integrate such landscaping into outdoor living features.

Potential Issues

The cost of converting lawn to native plant habitat can be significant, but the cost of maintaining natural habitat is typically lower than the cost of maintaining lawns. Lawns contribute less to heat island effects than pavement and so it is better to "grass" than "pave" if other more sustainable site coverage options cannot be employed.

Related Strategies

SS35, SS37

References and Resources

How to Get Your Lawn off Grass, Carole Rubin, Sally Wasowski, and Lorraine Johnson, Harbour Publishing, 2002

"Reducing Lawn Area," www.recycleworks.org/greenbuilding/sus_lawnarea.html

35. Provide wildlife habitat

Outdoor Living

Certain plantings can attract birds, butterflies, and other wildlife, helping to support local biodiversity and ecological balance while also providing enjoyment to homeowners. Look for native plants that are adapted to the area, will not require irrigation, and are not invasive species.

Potential Issues

Some fruit-bearing plants can cause track-in problems in homes. Use care in selecting and locating plants so that berries or fruits won't be tracked inside on shoes, increaseing cleaning needs.

Related Strategies

IEQ161

References and Resources

National Wildlife Federation Wildlife Habitat Program, www.nwf.org/backyard/

Welcoming Wildlife to the Garden, Catherine J. Johnson, Susan McDiarmid, Edward R. Turner Hartley and Marks Publishers 2004

The Natural Habitat Garden, Kenneth Druse, TimberPress, 2004

36. Use landscape features to shield house

Major Addition, Outdoor Living

Noise, street lighting, commotion from neighbors, unpleasant views, wind, and excessive sunlight can be problems at some houses. Landscaping features, including earthen berms, walls, and plantings, can provide important shielding. Work with landscape architects or landscape contractors to figure out solutions to provide such shielding when it's needed.

Potential Issues

Shade tree plantings can severely reduce the potential to benefit from passive solar heating and daylighting. Consider the impact of various deciduous trees versus evergreens when balancing passive solar with shading strategies, given that deciduous trees vary significantly in their bare-branch shading percentage.

Related Strategies

IDP3

References and Resources

Site Planning for Solar Access: A Guide to Residential Developers and Builders, Erley and Jaffe, DIANE Publishing, 1997

37. Provide for edible plants in landscape design

Outdoor Living

When topography and sun exposure allow, consider planting edible plants instead of or in addition to ornamentals. Locally grown food may be healthier than store-bought produce, and the transportation energy in getting produce onto the table is greatly reduced.

Growing one's own provides a high level of personal satisfaction and supports a greener lifestyle.

Potential Issues

Although home-grown vegetables and fruits can be safer and healthier than store-bought produce, heavy use of pesticides, fertilizers, and irrigation can eliminate those health benefits and increase local environmental burdens. Be aware that soils on some sites have been previously damaged by heavy chemical use.

Related Strategies

IDP6

References and Resources

National Gardening Association, www.garden.org/ediblelandscaping/

Edible Landscaping and Gardening, www.efn.org/~bsharvy/edible.html

38. Landscape to minimize chemical use

Outdoor Living

Conventional lawns in many parts of North America require heavy applications of fertilizers and pesticides (as well as irrigation water and regular mowing). Low-maintenance turf grasses are available for many regions, including buffalo grass for dry, sunny applications and native fescues for cooler, cloudier locations. Beyond turf, there are many native landscaping practices that are environmentally responsible. Locally adapted prairie plants, woodland flowers, trees, and dryland succulents and cactuses make sense in certain climates. When conventional lawns are required, select a seed mix that will be as hardy as possible and require minimal additives.

Potential Issues

Native landscapes may be more difficult to establish—though they are usually less expensive to maintain.

Related Strategies

SS34

References and Resources

Washington Toxics Coalition, www.watoxics.org/homes-and-gardens

39. Use site-chipped or ground clean wood waste as erosion control

Major Addition, Gut Rehab, Deep Energy Retrofit

Chipped or ground clean wood waste can be put in woven "socks" and placed as a drive pad at site entrances to reduce soil erosion and keep runoff from the streets and sewers.

Potential Issues

Clean wood waste means no pressure-treated, wood-composite, or wood materials laminated with nonwood material. Check to make sure that local regulations permit the use of engineered wood waste for mulching and soil erosion control.

Image: Clean Wood Waste for Site Erosion Control

Related Strategies

SS32, MR107

References and Resources

"Toolbase Construction Waste," www.toolbase.org

"Construction Waste Management for Residential Builders and Sub-Contractors," www.packer2000.com/ (click on "Residential")

Water Efficiency (WE)

Site

40. Provide rainwater collection system

Outdoor Living

Capturing rainwater from the roof for landscape irrigation makes a great deal of sense in areas where water is—or may become—limited. A very simple rainwater harvesting system consists of a rain barrel positioned at the corner of a house into which the roof downspout flows. Rainwater is collected in gutters and directed to the downspout, which channels that water into the rain barrel. A hose feeding from the base of the barrel is used for landscape watering. More sophisticated rainwater harvesting systems can provide filtration and purification so that water can be used indoors, even for drinking. The storage tank (whether a simple barrel or large cistern) should be covered to keep out animals, children, and sunlight.

Potential Issues

The quality of the water harvested can be highly variable, largely depending on the type of roofing material. The system generally must be covered to prevent the water storage from becoming mosquito habitat. Some local jurisdictions and water districts do not permit on-site collection of rainwater; check with local authorities to determine the legality of your rainwater harvesting plans.

Related Strategies

SS37

References and Resources

The Rainwater Harvesting Community, www.harvesth2o.com

Plumbing

41. Install low-water-use kitchen faucet

Kitchen

Standard kitchen faucets have a flow rate of 2.5 gallons per minute (gpm). This can be reduced with a low-flow faucet aerator to 2.0 or 1.5 gpm, but low flow rates may be frustrating in a kitchen because of the need to fill pots. Often more practical are devices to control the water flow such as flip-type aerators that allow the user to quickly cut the water flow without altering the hot-cold mix.

Another option is a hands-free faucet with foot or knee photoelectric controls to reduce waste. Although fairly expensive upgrades, both options offer convenience and water/energy savings.

Potential Issues

Savings from user-activated faucet controls have not been substantiated to date. Because kitchen faucet water consumption is fairly insignificant relative to a home's overall water use, kitchen faucet water efficiency is a relatively low priority.

Related Strategies

IDP6

References and Resources

www.epa.gov/watersense/

www.h2ouse.org/

42. Replace toilets with high-efficiency toilets

Bathroom

In most existing homes, toilet flushing is the single largest water user. The older the existing toilets, the more important their replacement with new, water-efficient models. Federal law mandates that new toilets can use no more than 1.6 gallons per flush (gpf); while many older toilets use 3.5 gpf and even as much as 7 gpf. There are now dozens of toilets on the market that offer superb flush performance, yet use at least 20% less water than 1.6 gpf models. These high-efficiency toilets (HETs) include pressure-assist toilets that use as little as 1.0 gpf, gravity-flush toilets that consume 1.28 gpf, and dual-flush toilets that offer two flush volumes (depending on whether solid or liquid wastes are being flushed). Dual-flush toilets are now required by law in Australia and very common throughout Europe. To ensure that a toilet will provide satisfactory flush performance, choose a model that has been put through third-party MaP (maximum performance) testing and is rated in grams; look for MaP test results of 350 grams or higher or toilets that meet the new EPA WaterSense program requirements.

Composting toilets may also be an option for major addition projects.

Potential Issues

Federal law on low-flow toilets applies only to the manufacture of new toilets, so be careful not to reinstall a toilet that uses more than 1.6 gpf or purchase a salvaged toilet that uses more than 1.6 gpf. Techniques that reduce water use in these older units (bricks or dams in the toilet tank) can be problematic because the unit is not flushing with the volume for which it was designed.

When the 1.6 gpf federal standard was introduced in 1994, many manufacturers simply modified the flush valve to reduce the flush volume without modifying the toilet bowl and drain line; this resulted in poor performance, giving low-flush toilets a bad reputation. Today's EPA WaterSense-approved models pass a flush performance test .

Older, less efficient toilets should be recycled, but recycling outlets for toilets are not available in all areas of the country.

Related Strategies

IDP6

References and Resources

EPA Water Sense Program, www.epa.gov/watersense/pp/het.htm

California Urban Water Conservation Council, www.cuwcc.org

"Toilet Recycling," www.h2ouse.org/tour/bath.cfm (click on "Toilet", then on "Disposal & Recycling")

"Composting Toilets," www.cityfarmer.org/comptoilet64.html

43. Install low-water-use showerheads

Bathroom

Older showerheads often use 3 to 5 gallons per minute (gpm); federal law now requires that new showerheads use no more than 2.5 gpm. For a green bathroom remodel, choose a showerhead that uses less than the 2.5 gpm maximum; excellent showerheads are available that use as little as 1.5 gpm. Note that many of the early low-flow showerheads atomized the water into a fine mist that resulted in very unsatisfactory showers—both because the tiny droplets did not effectively wet the skin and because the droplets cooled off quickly, so the shower felt cool (or the water had to be set at a higher temperature). Better-quality showerheads today maintain large droplet size to provide satisfactory wetting and heat retention yet use significantly less water.

Although EPA is working with private industry to establish a performance-based test for low-flow showerheads, it will be a while before this comes to fruition, particularly since anecdotal results on low-flow showerheads as part of the EPA Residential Water Efficiency Benchmarking study show completely different preferences for the same two model. Consideration

should be given to showerheads mounted on a sliding arm, since the distance between the showerhead and the bather is proving to be a significant determinant of shower experience satisfaction, particularly at lower flow rates.

Potential Issues

Custom shower systems that have multiple showerheads or rain-panel components increase total water consumption far above the 2.5 gpm limit for single showerheads. Some use as much as 20 gpm and require two drains in the floor. Avoid the temptation to install these wasteful systems.

Related Strategies

IDP6

References and Resources

EPA Water Sense Program,
www.epa.gov/watersense/pp/showerheads.htm

REGREEN Product Selection Resources,
www.regreenprogram.org
(Also, type in "adjustable height showerheads" into any web browser)

44. Install water-conserving bathroom faucet aerator

Bathroom

Kitchen faucets usually need to deliver fairly close to the allowable 2.5 gallons per minute (gpm) of water—to fill pots for example—but bathroom faucets often do not. In many homes, 1.0 gpm or even as little as 0.5 gpm is adequate for washing hands, brushing teeth, or shaving. Simple screw-on aerators are available that reduce flow to the desired level. Determine with the homeowners what flow rate is desired and specify the proper aerator; the aerators are inexpensive and can easily be swapped out later if the flow rate seems either higher or lower than desired.

Potential Issues

The lower the flow rate of a faucet, the longer it will take to get hot water at the tap. For example, with a flow rate of 0.5 gpm, ¾-inch copper piping, and 50 feet of distance from the water heater, it can take more than 2.5 minutes to get hot water, whereas with a 1.5 gpm faucet, the wait time will be less than a minute. There are other ways to deal with the wait time (see Related Strategies), but if the wait time is not dealt with, a very low-flow faucet may prove unsatisfactory.

Related Strategies

IDP6

References and Resources

EPA Water Sense Program,
www.epa.gov/watersense/pp/bathroom_faucets.htm

Energy and Atmosphere (EA)

General Design and Construction Strategies

45. Use computer modeling to determine heating and cooling loads

Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

To properly size and optimize the performance of heating, ventilation, and air-conditioning equipment in conjunction with building envelope performance, computer modeling is critical. When the house envelope is being buttoned up, an addition is increasing the total square footage of the house, or mechanical equipment is being upgraded, it is very important to understand the heating, air-conditioning, and sometimes ventilation loads fairly precisely, and only computer simulation can provide such estimations. Through careful computer modeling, mechanical equipment can be properly sized, to prevent the inefficiencies (and higher pollution) that result from frequent on-off cycling of equipment.

Potential Issues

Occupant behavior has a huge impact on actual energy usage in any home. Clear communication and a homeowner's manual can go a long way toward ensuring that the house will be managed for the optimal energy performance designed and built into the project.

Images: Retrofit Insulation Strategies

- **Interior Rigid Insulation (taped seams for air seal) on Walls**
- **Interior Rigid Insulatin and Air Sealed (taped seams) on Ceiling**
- **Exterior Wall Air Sealed and Insulated with Spray Foam, Reclad**
- **Exterior Wall Spray Foam Insulation**

Related Strategies

IDP2, IDP3, EA51, EA63

References and Resources

REMRate, www.archenergy.com/products/rem/

TREAT, www.treatsoftware.com/treat_intro.html

Energy-10, www.sbicouncil.org/store/e10.php

46. Evaluate different heat distribution options

Major Addition, Deep Energy Retrofit

Although some house additions necessitate expansion of the heating and air-conditioning distribution systems, building envelope improvements often allow the distribution systems—as well as the heating and cooling equipment—to be downsized or reconfigured to be more efficient, centralized, and simplified. With very significant improvements to the envelope, in fact, it may be possible to totally eliminate central distribution systems and rely instead on simple space-heating and space-cooling equipment. A space-heating system could be short sections of baseboard electric resistance heat (the lowest first-cost option), a through-the-wall-vented gas wall heater or visible-flame gas fireplace, or a wood stove or pellet stove. Room air conditioners or mini-split air-conditioners can provide space cooling.

Along with sizing of heat loads and the potential to shrink or eliminate distribution systems, also consider how the same forced-air distribution system can be used for multiple needs in a highly energy-efficient house. Typically, larger ducting is required for air-conditioning than for space heating, and both of these needs are greater than for ventilation, but significantly shrinking the heating and cooling loads may make it possible to have one duct system serve all three needs; hire a knowledgeable mechanical engineer to address this issue.

With both forced-air and hot-water (hydronic) distribution systems, carefully plan where they will be installed and whether they should be insulated. Try to avoid running any distribution lines outside the conditioned building envelope. If any distribution components are in unconditioned or partially conditioned space, provide high-quality, durable insulation appropriate to the pipes or ducts. All ducting should be sealed with duct mastic to minimize losses, and ducts should be pressure tested as part of the commissioning process (using a Duct Blaster or comparable equipment) to detect leaks.

Potential Issues

Clients may resist the idea of eliminating distributed heat or air-conditioning. Use computer modeling to demonstrate that the proposed space-heating alternatives will indeed do the job.

Related Strategies

IDP3, EA66

References and Resources

REMRate, www.archenergy.com/products/rem/

TREAT, www.treatsoftware.com/treat_intro.html

Energy-10, www.sbicouncil.org/store/e10.php

Foundation

47. Insulate floor slab and foundation walls

Major Addition

In most climates, foundation walls should be insulated. The most common insulation for foundation walls is extruded polystyrene (XPS), though high-density (minimum 1.5 pounds per cubic foot) expanded polystyrene (EPS) can also be used, as can rigid mineral wool or rigid fiberglass. Computer modeling should be used to determine appropriate insulation levels. Foundation walls can also be insulated on the interior, as long as proper care is taken to deal with moisture management. On the interior, if basement space is to be finished, a wall - system is built and insulated with sprayed polyurethane (closed-cell or open-cell) or a fiber insulation, such as fiberglass, mineral wool, or cellulose. Insulated concrete forms (ICFs) and insulated precast concrete wall systems provide integral insulation. With slab-on-grade applications and basement floor slabs (when the basement is to be finished and heated), it is also important to insulate under the slab.

Potential Issues

Proper moisture control is critically important with interior insulation of foundation walls. Code issues can arise for insulation and air-sealing materials left exposed that will not pass fire barrier ratings.

Image: Furred Out and Spray Foamed Basement Walls (vapor-permeable polyurethane)

Related Strategies

IDP21, IDP25, EA45

References and Resources

Renovating Your Basement, www.buildingscienceconsulting.com/resources/foundations/renovating_your_basement.pdf

"Upgrading below Grade," www.pathnet.org/sp.asp?id=23716

Building Envelope

48. Optimize energy performance

Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

Energy efficiency is the single most important priority in green building. All remodeling projects, but most importantly those involving a substantial portion of the

building envelope, should optimize the overall energy performance of the home. This means that *all* loads—heating and cooling, domestic hot water, appliances, and lighting—should be evaluated; the right combination of energy improvements is going to be very site- and climate-specific. Information on these loads should be gathered prior to the start of design and can involve something as simple as utility bill analysis (see EPA Energy Star Home Energy Yardstick) or performance testing and energy modeling.

Potential Issues

Clients may have their own idea of just what their green remodeling project will emphasize. The green remodeling professional may need to educate his or her client about to the importance of energy efficiency in green building. Utility bill analysis, performance testing, energy modeling results can all strengthen the remodeling professional's hand in these discussions. Include any applicable energy efficiency tax incentives, rebates, subsidies, special-term financing and homeowner's insurance premium advantages.

Keep in mind that managing energy intensively requires that moisture be managed more intensively as well.

ASHRAE guidance for deep energy savings for remodeling projects should be available late in 2008.

Related Strategies

IDP2, IDP3, EA51

References and Resources

"Energy-efficient Improvements for Remodeling Projects – Training Modules,"www.toolbase.org

"City of Boulder Green Points Program – 2008," www.bouldercolorado.gov/files/ord_7565.pdf

"Home Energy Yardstick," www.energystar.gov/

49. Install attic insulation

Home Performance

While many people think that we generally have or add more insulation in the attic than other locations because "heat rises," it's only hot air that rises. The actual increased (Δ T) at the top floor ceiling varies quite a bit based on a number of factors. But the main reason we do attic insulation to a greater degree is that it's the easiest. The biggest decision is likely to be just how much to add to the attic.

Be careful with standard simple payback or even net value payback calculations—neither take into account the unpredictability of energy cost increases. Rising energy prices demand that we maximize every energy improvement option that presents itself.

Potential Issues

Given that air-permeable insulations (fiberglass, cellulose) require six-sided containment to achieve their full benefit, higher-density insulation should be considered as a top layer in the attic and/or baffles should be installed at the eaves to protect attic insulation from windwashing by way of soffit venting (see EPA Energy Star Thermal ByPass Checklist). Address all thermal bypasses in the attic as insulation is added.

If roof insulation is added on top of the existing roof, the fascia detail can be tricky. See the detail with this strategy.

Image: Spray Foam Insulation at Roof Line for Conditioned Attic

Related Strategies

IDP25, EA45

References and Resources

"Insulation," www1.eere.energy.gov/consumer/tips/insulation.html

"Recommended Levels of Insulation," www.energystar.gov/

"Home Energy Solutions," (Energy Trust)- www.energytrust.org/TA/hes/weatherization/attic.html#at37

50. Consider radiant barrier in attic

Home Performance, Deep Energy Retrofit, Gut Rehab, Major Addition

Attic radiant barriers can reduce (primarily) cooling load's by reflecting radiant energy or by not reradiating as much energy because of the material's low emissivity.

Potential Issues

Radiant barriers must face an air space to be effective, and their effectiveness depends on keeping the surface clean and free of dust or other materials.

Related Strategies

EA48

References and Resources

"Radiant Barriers," www.eere.energy.gov/consumer/your_home/

"Radiant Barrier Fact Sheet," www.ornl.gov/sci/roofs+walls/radiant/index.html

51. Conduct blower door test (before and after)

Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

A blower door test uses pressure differences and air flow created by a large calibrated fan to estimate the air tightness of the entire structure; it can be used for room-

to-room pressure testing as well. The blower door and associated diagnostic tests can be done in less than 1.5 hours. Before and after testing is important in evaluating energy improvements in existing homes.

Potential Issues

This test require a block of time during which the testing crew must have full access to the home and occupants must stay either in or out of the structure.

Image: Blower Door Test Set-Up

Related Strategies

IDP2

References and Resources

"Blower Door Testing,"
www.pct.edu/wdce/wtc/pdf/Blower-Door-FINAL.pdf

52. Conduct room-to-room pressurization testing

Basement, Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

Individual rooms can develop significant pressure differences with doors closed—a situation that can lead to interstitial moisture problems in exterior walls. Room-to-room pressure testing is done by turning on the air handler, closing all interior doors to the room, and using a two-station handheld manometer to see whether the lack of return-air pathway pressurizes the room compared with the rest of the house or the common areas without doors. The general threshold for room-to-room pressurization is 3 Pascals.

Potential Issues

Solving room-to-room pressurization issues in existing homes typically involves either trimming doors by at least 1.5 inches or cutting offset transfer grilles just above the bedroom doors. The former may not be acceptable to the homeowners and is rarely sufficient and the latter is an invasive operation, particularly if load-bearing walls are encountered.

Related Strategies

IDP4, IEQ170

References and Resources

"Specifications for the Low-Income Weatherization Program, Version April 2007,"
www.cted.wa.gov/DesktopDefault.aspx?alias=cted&lang=en&tabID=513&wversion684=Production#Specs

53. Conduct infrared imaging (before and after)

Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

Infrared imaging is a compelling tool for identifying "invisible" conductive heat loss, air leakage, and moisture problems.

Potential Issues

IR imaging requires a temperature difference (Δ T) and associated heat flow, but the cameras have become sensitive enough that even a Δ T of 15°F is enough for meaningful results. IR imaging can be a useful tool when tied to final payment of trade contractors for insulation and air sealing.

Images

- **Tough-to-Insulate Cathedral Ceiling**
- **After-the-Fact Infrared Image of Cathedral Ceiling**

Related Strategies

IDP2, EA54

References and Resources

"Selecting an Infrared imaging System,"
www.homeenergy.org/archive/hem.dis.anl.gov/eehem/93/930712.html

54. Complete thermal bypass inspection and resolution

Basement, Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit

Air leakage can represent 24% to 40% of the total heat loss in older homes. But just as importantly, air leakage can move significant amounts of moisture with it. Years of testing and field experience indicate that addressing certain typical large air leakage sites, or thermal bypasses, can give the most bang for the air-tightening buck. EPA Energy Star has compiled the most common air leakage and thermal discontinuities into its thermal bypass checklist; use the checklist to track, evaluate, and eliminate heat loss and gain associated with air leakage.

Potential Issues

Some of the bypasses will be easier to get to than others. The contractor and the client will need to work out just how aggressive to be.

Images
· Thermal Bypass: Duct Chase
· Spray Foam to Insulate and Air Seal

Related Strategies
IDP2, IDP24

References and Resources

"Air seal and insulate with Energy Star," www.energystar.gov/

"EPA Energy Star Thermal Bypass Checklist," www.energystar.gov/

55. Air Seal and insulate rim joists

Basement, Home Perfromance, Major Addition, Gut Rehab

In a home with a full basement or crawl space, the first-floor rim or band joist is one of the major places of conductive heat loss and air leakage. Given that this area of the home is going to be covered up, it is doubly important to insulate and air seal before finishing a basement. Fiberglass or cellulose insulation cannot serve as a continuous air barrier; a combination of rigid insulation and caulking or sealant is required, or a spray polyurethane foam insulation should be used that provides a very complete air seal.

Potential Issues

The quantity of spray foam required is small enough that you may not be able to engage a spray polyurethane foam contractor or a spray foam company foam the rim joist at a reasonable cost. But this area is large enough to make it unreasonable to foam "by the can." So-called froth paks can fit the bill, however. If spray foam is used for the band joist, note that building codes generally require that this material not be left exposed to living space; it must be covered by a noncombustible material, such as gypsum board.

Image: Spray Foam Insulation at Rim Joists

Related Strategies
EA47, EA54

References and Resources

"EPA Energy Star Thermal Bypass Checklist," www.energystar.gov/

"A Do-It-Yourself Guide to Energy Star Home Sealing," www.energystar.gov/

56. Upgrade existing windows

Kitchen, Home Performance, Gut Rehab, Deep Energy Retrofit

The greatest gain in performance is obtained by sash or whole-window-unit replacement, but when circumstances don't allow this approach, substantial improvement in energy performance and window unit durability can be achieved with exterior, airtight, low-e storm windows. Although storms are not The National Fenestration Research Council certified, research has shown that they significantly improve single-pane window performance and, when installed on the exterior, also shield the existing sashes from bulk water and UV degradation.

Storm windows, particularly airtight ones, can substantially reduce noise reduction from exterior sources (traffic, neighbors).

Potential Issues

Historic homes make improvements of window peformance challenging regardless of the approach.

Be aware of the potential for continued lead paint exposure from old painted windows, sash, or trim. The low-e coating on most storm windows is an exposed hard coating on the interior surface that can be damaged by aggressive cleaning. Homeowners should be advised to clean the storm's interior only when absolutely necessary and to avoid excessive use of cleanser's and rubbing.

Image: Air-tight, Low-e Triple-Track Storm Window

Related Strategies
IDP4, IEQ193

References and Resources

"Windows," www1.eere.energy.gov/consumer/tips/windows.html

"Windows, Doors, and Skylights," www.eere.energy.gov/consumer/your_home/

"Creating Windows of Energy-Saving-Opportunity," www.homeenergy.org/archive/hem.dis.anl.gov/eehem/97/970908.html

57. Upgrade existing exterior door

Kitchen, Home Performance, Living and Working

Air sealing minor leakage areas, such as windows and doors, does not typically give a big boost to an existing home's air tightness but it can have a disproportionate impact on thermal comfort. Go for the biggest leaks on windows and doors, using qualitative information from "smoke-stick" testing around door and window joints and margins.

Potential Issues

If you have not addressed the big air leaks first (see EPA Energy Star Thermal Bypass Checklist, above), there will be little to gain from buttoning up all the doors and windows.

Related Strategies

EA54

References and Resources

"Storm Doors,"
www.eere.energy.gov/consumer/your_home/

"ECM: Building Envelop: Install Storm Doors,"
www.hud.gov/offices/pih/programs/ph/phecc/strat_B4.cfm

58. Weatherstrip doors and windows

Home Performance

Air sealing minor leakage areas, such as windows and doors, do not typically give a big boost to an existing home's air tightness but they can have a disproportionate impact on thermal comfort. Go for the biggest leaks on windows and doors, using qualitative information from "smoke-stick" testing around door and window joints and margins.

Potential Issues

If you have not addressed the big air leaks first, (see EPA Energy Star Thermal Bypass Checklist above) there will be little to gain from buttoning up all the doors and windows.

Image: Interior Trim Removed to Insulate and Air Seal Sash Pockets after Sash Replacement

Related Strategies

EA54

References and Resources

"Caulking and Weatherstripping,"
www.eere.energy.gov/consumer/your_home/

59. Replace existing windows

Kitchen, Gut Rehab, Deep Energy Retrofit

Replace existing windows and doors with climate-appropriate high-performance products. In general, about one third of a window's performance comes from the glazing, one third from the frame, and one third from the spacer system. The three primary performance properties of windows are U-factor (thermal conductivity or the amount of heat that a material conducts), solar heat gain coefficient (SHGC, how much of the sun's heat energy is transmitted through the glazing), and visual transmittance (VT, the percentage of visible light transmitted through the glazing). The National Fenestration Research Council has a standardized test procedure to report these properties, and the Efficient Windows Collaborative provides climate-specific guidance on glazing selection. The following shows the best-performance climate-specific window properties.

Metric	CC/IRC Climate Region			
	Northern Climate Zone 5–8	North Central Climate Zone 4	South Central Climate Zone 3	Southern Climate Zone 1–2
U-Factor	≤ 0.30	≤ 0.32	≤ 0.32	≤ 0.55
SHGC	Any	≤ 0.40	≤ 0.30	≤ 0.30

Note that these U-factor and SHGC recommendations assume that the same glazing is used on all orientations of a house. If different glazings are used on different orientations, as many green designers recommend, the optimal SHGC may be higher for south-facing windows, particularly in more northern climates. Many green designers also recommend selecting even higher-performance windows with triple glazing and two low-e coatings in northern climates, in which case the U-factor could be as low as 0.20. VT numbers should be as high as possible, regardless of U-factor and SHGC numbers.

Potential Issues

Historic homes make improvements of window peformance challenging regardless of the approach.

It can be challenging from a manufacturing standpoint to achieve low U-factor, high SHGC, and high VT with a window that still works well for passive solar gain.

Specifying different glazing properties for different orientations is important; see 60, "Specify different window glazings for different orientations."

Not many building professionals or even building code officials follow code requirements for design pressure (DP) ratings for windows, but they are an important indication of the durability and airtightness of windows. Select windows with DP ratings. Also, the more airtight

the window, the better the acoustical separation of the inside and the outside of the home.

Bay and bow windows: These are popular replacement windows, but their projection moves the drainage plane, air barrier, and thermal barriers out of the plane of the exterior wall. Care must be taken to properly flash the shed roof of the projecting unit and to air seal and insulate the head and sill of the unit. The R-value of the window unit "ceiling" and "floor" should be equivalent to that of the wall into which the window unit is installed. This usually means rigid insulation several inches thick and well-fitted caulk and/or spray-foam sealant at all margins.

Roof windows or skylights are a popular component of many remodeling projects but require in their sizing, location, and performance properties to prevent unwanted solar gain and glare. The geometry of the installation (roof angle, curb and well design) has a big impact on skylight performance.

Related Strategies
IDP24, EA45, EA48

References and Resources
Efficient Windows Collaborative, www.efficientwindows.org/

The National Fenestration Research Council, www.nfrc.org/

"SkyVision free software," www.irc.nrc-cnrc.gc.ca/ie/lighting/daylight/skyvision_e.html

60. Specify different window glazings for different orientations

Major Addition, Gut Rehab, Deep Energy Retrofit,
Because solar radiation (sun angle and intensity) is very different on different orientations, it makes a great deal of sense to "tune" glazings by orientation. On south-facing windows, where wintertime solar heat gain is generally desirable, it makes sense to install windows with high solar heat gain coefficient (SHGC) and low-e. On east and west windows, controlling summetime unwanted solar heat gain is important, so here it makes sense to install windows that have lower SHGC values and higher R-values (lower U-values). On north windows, maximizing the R-value is important and SHGC is not a significant concern.

Potential Issues
Without the The National Fenestration Research Council label, it is nearly impossible to distinguish the different glazings of otherwise identical windows, so there is risk of mixing up windows intended for particular orientation. To avoid this problem, some designers or builders design slightly different window sizes for the different orientations.

Related Strategies
EA48

References and Resources
Efficient Windows Collaborative, www.efficientwindows.org

Residential Windows, John Carmody et al., www.efficientwindows.org/books.cfm

61. Provide shading of skylights as needed

Bathroom, Working and Living
Skylights and roof windows can cause significant overheating, especially when mounted on south or west roofs. The highest sunlight penetration through glazing occurs when the rays of the sun are normal (perpendicular) to the glazing plane. During the hot summer months, roof-mounted glazing is usually much closer to normal, especially on south-facing and west-facing roofs, than vertical (window) glazing, so solar gain is a significant concern. Some skylights have integral blinds—typically mounted between the panes of glass—that can be opened and closed to control heat gain. Some skylights are available with electrochromic glazing that allows users to tint the glass with a push of a button (a small amount of electric current tints a coating on the glass and maintains that tint as long as the current remains). Exterior shading systems are also effective but not widely available in the North American market.

Potential Issues
Skylights with integral blinds or screening are more expensive than standard skylights, and electrochromic skylights are much more expensive.

Related Strategies
EA83

References and Resources
Efficient Windows Collaborative, www.efficientwindows.org/

The National Fenestration Research Council, www.nfrc.org/

"SkyVision free software," www.irc.nrc-cnrc.gc.ca/ie/lighting/daylight/skyvision_e.html

62. Install awnings or other exterior window shading system

Major Addition, Gut Rehab, Deep Energy Retrofit
In hot, sunny regions, it often makes sense to provide awnings, overhangs, or other shading devices on west-, east-, and south-facing windows. The type and configuration of shading system depend on the location, because much of the overheating potential from west- and east-facing windows comes from the side rather than overhead. A good energy designer should provide input on the shading system and design, including the relationship between glazing choices and shading.

Potential Issues
An improperly designed and implemented overhang or awning may block too much daylight and reduce beneficial passive solar heating.

Related Strategies
IDP1, IDP3

References and Resources

"LBL Shading Strategy,"
windows.lbl.gov/daylighting/designguide/section5.pdf

"FSEC Window Orientation and Shading,"
www.fsec.ucf.edu/en/consumer/buildings/homes/windows/

"Awnings in Residential Buildings: The Impact on Energy Use and Peak Demand,"
www.awninginfo.org/images/stories/documents/pdf/energystudy22007.pdf

HVAC

63. Use ACCA Manual's J, S, and D in mechanical system design

Major Addition, Gut Rehab, Deep Energy Retrofit

Standards developed by the Air Conditioning Contractors of America (ACCA) should be used for calculating energy loads (Manual J), for mechanical system sizing (Manual S), and for duct design (Manual D). Someone involved in the project—the architect, the builder, the HVAC contractor, the HERS rater or energy professional—should conduct these ACCA standards.

Correct sizing is essential to maximizing HVAC energy efficiency. Significant improvements to the building envelope will reduce load demands dramatically and require smaller HVAC systems. Too frequently, HVAC equipment is oversized, using too much energy and creating the need for advanced controls. A properly - sized system will reduce energy demand, provide more comfort, and rely less on operator programming and advanced controls.

Ensure proper sizing and installation by following the Energy Star/ACCA Quality Installation Standards (www.acca.org/quality/).

Work with the designer, builder, and contractor to ensure that the installation of the HVAC equipment leaves enough space for proper airflow, and be accessible for routine maintenance.

Potential Issues

Some training may be required to effectively use the design tools.

When replacing HVAC equipment but leaving the existing ducts, use Manual J to ensure correct sizing.

Related Strategies
IDP3, EA45

References and Resources

"ACCA Quality Installation,"
www.acca.org/quality/

"HARDI Architect, Builder & Remodeler Good Practice Guide,"
www.hardinet.org/pdf/GdPractGuide2.pdf

64. Provide appropriate controls and zoning for HVAC

Basement, Major Addition, Gut Rehab, Deep Energy Retrofit

Controls for HVAC equipment can be just as important as—or even more important—than the efficiency of equipment. During the heating season, for example, setting back thermostats by 10 degrees for eight hours each night can reduce total heating energy consumption by about 7%. (Note, however, that the degree of setback varies by heating system type size and deep setbacks may pose comfort problems; consult a certified HVAC contractor.) Programmable thermostats often provide both nighttime and daytime setbacks, with the option for different set points on weekends, when usage patterns are different. Similar savings can be achieved with daytime setback of air-conditioning systems. (Note, however, that refrigerant-based cooling systems are even more sensitive to setback recovery, particularly for right-sized systems.) Some new products allow homeowners to conveniently bring the house into setback mode when they leave (see www.GreenSwitch.tv).

Separate control of different spaces in a house provides another option for savings. Zoning allows homeowners to keep bedrooms cooler in winter or leave unused rooms largely unconditioned. Traditionally, hydronic systems can be more easily separated into zones than forced-air systems, but retrofit forced-air zoning systems have advanced tremendously, and some level of zoning is possible with almost all distribution systems.

Potential Issues

Not all HVAC controls are appropriate for all applications. Some of the most advanced European controls for boilers, for example, which regulate boiler temperature according to outside temperature, do not work well with usage that involves significant temperature setback. During swing seasons in the fall and spring, lower boiler temperatures will result in very long recovery times to bring a space up to comfortable conditions.

Note that setback thermostats for heat pumps are very different from those for boilers or furnace-based heating systems.

Related Strategies
EA48, EA66

References and Resources

Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-efficient Economy, 2007, www.aceee.org

Residential Energy, John Krigger, Saturn Resource Management, 2004

"Thermostats and Control Systems," www.eeregov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12720

65. Consider alternatives to conventional refrigerant-cycle air-conditioning

Major Addition, Gut Rehab, Deep Energy Retrofit

Instead of central or room air-conditioners that rely on Rankine-cycle compressors and refrigerants, other options may be available. One is to use a whole-house fan or attic fan to move a large volume of air through a house at night (through open windows) when the outside air is cool, then close up the house during the day to keep it cool. In dry climates, evaporative coolers (swamp coolers) can provide very energy-efficient cooling by evaporating water into the occupied space. Direct, indirect, or all-indirect evaporative cooling systems allow evaporative cooling to work while adding less moisture to the indoor air (or none at all, in the case of the Coolerado system; see www.coolerado.com). Another option that uses compression air-conditioning is to provide ice storage so that the compressor can operate at night during off-peak hours (see www.ice-energy.com).

Potential Issues

Nontraditional cooling strategies often require more involvement by homeowners. For example, nighttime whole-house ventilation requires opening windows and knowing to operate this system only when the outside air is cooler than the indoor air. Such information should be clearly communicated to homeowners.

Related Strategies

EA66, EA76

References and Resources

"Evaporative Cooling," ateam.lbl.gov/Design-Guide/DGHtm/evaporativecooling.htm

"Residential-scale ice-storage system for space cooling," www.adsabs.harvard.edu/abs/1981tcs..meetQ..14H

66. Select high-efficiency HVAC equipment

Major Addition, Gut Rehab, Deep Energy Retrofit

The efficiencies of heating and air-conditioning equipment have dramatically improved in recent years. Top-efficiency gas furnaces and boilers have AFUE ratings of 95% or higher. The best oil-fired equipment exceeds 90% AFUE. Central air-conditioning systems are available with SEER performance above 15 (the minimum allowable is now SEER 13), and room air-conditioners are available with EER performance above 12 (the minimum ranges from 8.5 to 9.8, depending on size). As described under 65 "Consider alternatives to conventional refrigerant-cycle air-conditioning," some cooling options are much more efficient than the best refrigerant-cycle systems.

Air-conditioning efficiency ratings are achieved only if the indoor and outdoor cooling components are properly - matched. The mismatched installation of a 13 SEER-rated air-conditioning system could pull performance down as low as 8.5 SEER. Be sure to use a qualified, licensed HVAC contractor who references the ARI Contractor Guide (www.aridirectory.org/) to ensure properly matched system components.

Consider installing an air-to-air heat exchanger (HRV) for fresh air and moisture control to maximize heating energy.

High-efficiency heat pumps can significantly reduce furnace run times in many climates, lowering natural gas demands and maximizing efficiencies.

Potential Issues

The importance of equipment efficiency drops when heating or cooling loads are reduced. If there is a limited budget, rather than spending the money to upgrade the heating and cooling equipment, it often makes more sense to reduce heating and cooling loads by putting money into envelope improvements. Or upgrade only the HVAC motor to a variable-speed motor.

Related Strategies

EA65

References and Resources

American Council for an Energy-efficient Economy, www.aceee.org

"HARDI Architect, Builder & Remodeler Good Practice Guide," www.hardinet.org/pdf/GdPractGuide2.pdf

67. Install programmable thermostats

Bedroom, Basement, Major Addition, Gut Rehab, Deep Energy Retrofit,

During the heating season, setting back thermostats by 10 degrees for eight hours each night can reduce total heating energy consumption by about 7%. (Note, however, that the degree of setback varies by heating system type and size and deep setbacks may pose comfort problems; best to consult a certified HVAC contractor.) Programmable thermostats often provide both nighttime and daytime setbacks, with the option for different set points on weekends, when usage patterns are different. Similar savings can be achieved with daytime setback of air-conditioning systems. (Note, however, that refrigerant-based cooling systems are even more sensitive to setback recovery, particularly for right-sized systems.) Some new products allow homeowners to conveniently bring the house into setback mode when they leave (see www.GreenSwitch.tv).

Potential Issues

Setback thermostats for heat pumps are very different from those for boilers or furnace based heating systems; consult the heat pump manufacturer or contractor about proper operation. With radiant - floor heat distribution, the thermal lag results in long recovery times, so set back settings should be adjusted accordingly (consult radiant floor designer or installer).

An important element of programmable thermostats is their simplicity and ease of operation. Programmable thermostats will not be used or not be used properly if they are complex and nonintuitive.

Related Strategies

EA103, EA104, EA105

References and Resources

"Programmable Thermostats,"
www.energystar.gov/

www1.eere.energy.gov/consumer/tips/thermostats.html

68. Conduct duct tightness test (before and after) in homes with forced-air systems

Basement, Home Performance, Deep Energy Retrofit

A duct blaster test uses pressure differences and air flow created by a calibrated fan to estimate the air tightness of forced-air duct systems. If a home has a duct distribution system, its performance can effect energy efficiency, thermal comfort, and indoor air quality. Before-and-after testing is important in evaluating energy improvements in existing homes.

Potential Issues

During this test, the home will be without space conditioning for approximately one-half to one hour.

Image: Duct Blaster Test Set-Up

Related Strategies

EA51, EA63

References and Resources

"Minneapolis Duct Blaster Operation Manual,"
www.energyconservatory.org/download/dbmanual.pdf

"Energy Star/ACCA Quality Installation Standards,"
www.energystar.gov/

69. Properly commission new (or tune existing) HVAC systems

Basement, Major Addition, Home Performance, Gut Rehab, Deep Energy Retrofit

Mechanical equipment should be inspected, tested, and tuned up after installation. Both forced-air and hydronic distribution systems must be properly balanced to ensure even distribution of hot air, chilled air, or ventilation air. Test the controls to make sure that they are functioning properly. Existing equipment should be tuned up on a regular basis (typically annually) to ensure that it is operating at top efficiency. At least annually, but sometimes as often as every three months, air filters for furnaces, air-conditioners, heat pumps, and ventilation systems should be inspected or replaced.

Have air-conditioning systems checked thoroughly for refrigerant leaks that will emit gases into the atmosphere. Should your system require extensive service or replacement, insist that proper EPA regulations be met and all refrigerants are properly recovered and disposed of. Refer to ACCA Quality Maintenance Guidelines (under development).

Potential Issues

Improperly balanced forced-air distribution systems can cause leakage through the ducts or depressurize the house, drawing in radon and other hazardous soil gases.

Related Strategies

EA48, EA103

References and Resources

"Energy Star/ACCA Quality Installation Standards,"
www.energystar.gov/

"HARDI Architect, Builder & Remodeler Good Practice Guide,"
www.hardinet.org/pdf/GdPractGuide2.pdf

70. Properly seal and insulate HVAC distribution system

Home Performance, Gut Rehab, Deep Energy Retrofit

With forced-air distribution for heating and cooling systems it is not uncommon for duct losses to reduce overall efficiency by 30%. With hydronic heating, uninsulated pipes running through unconditioned or partially conditioned spaces can lower efficiency and pose failure problems. Both ducting and hydronic piping should be kept within the insulated envelope and kept out of exterior walls whenever possible. All ducting should be properly sealed with mastic designed for duct sealing, and any ducts that extend through unconditioned or partially conditioned space should be insulated to, or preferably beyond, code minimums. Test the air tightness of ducting after sealing and insulating using a Duct Blaster or comparable duct

testing equipment. Hydronic piping that extends through unconditioned or partially conditioned space should be fitted with pipe insulation providing a minimum of R-3.

Potential Issues

Unless you have an energy-conscious HVAC contractor, it can be hard to keep the focus on HVAC strategies such as this one. Consider bringing an energy professional, such as a HERS rater, on board for systems integration of HVAC strategies.

Fiberglass ductboard and poorly sealed metal ducts insulated with fiberglass can release fibers into the household air. Avoid fiberglass duct insulation unless that insulation is coated to prevent fiber shedding.

Related Strategies

EA48

References and Resources

"HARDI Architect, Builder & Remodeler Good Practice Guide,"
www.hardinet.org/pdf/GdPractGuide2.pdf

71. Make sure ducting is clean

All Projects

Ensuring that air-distribution ducts (for heating, cooling, and ventilation systems) are clean is an important priority in maintaining a healthy indoor environment. This is particularly important following construction or remodeling work. Procedures for cleaning ducts depend on the type of duct; the easiest to clean are sheet metal ducts that are insulated on the outside. When ducts are cleaned, they should also be pressure-tested using a Duct Blaster system.

Potential Issues

Cover registers and any other duct openings during renovation; this can be done using plastic and duct tape or with a specialized product, such as Speedi-Boot (www.speediboot.com).

Ducts should be cleaned only by trained professionals; improper cleaning can release particulates and other contaminants into the household air, causing rather than solving problems.

Image: Duct Protection during Renovation

Related Strategies

IEQ158

References and Resources

"Should You Have the Air Ducts in Your Home Cleaned?,"
www.epa.gov/iaq/pubs/airduct.html

National Air Duct Cleaners Association, www.nadca.com/

www.energyconservatory.com/products/products2.htm

72. Provide air-lock dryer vent

Bathroom

The vent used to exhaust hot, moist air from drying clothes can be a major source of air infiltration when the dryer is not operating. Install a dryer vent cap that protects against air infiltration.

Potential Issues

The dryer vent cap should not unduly restrict exhaust air flow or lint will collect and drying performance will drop (and energy use increase).

Related Strategies

EA106

References and Resources

"Heartland Dryer Vent Closure,"
www.energyfederation.org/consumer/default.php/cPath/86_742_110

Consumer Guide to Home Energy Savings, 9th Edition, ACEEE, 2007, www.aceee.org

73. Minimize dryer duct length and number of turns

Bathroom

It is the duct length and number of turns that determine resistance to air flow. Use only smooth, rigid metal ducting for dryer exhaust and keep the length of the run and number of turns to a minimum. To add a booster fan, follow the dryer manufacturer instructions for length and number of turns that exceed the dryer's capacity to efficiently exhaust.

Potential Issues

There are very few structures or climates for which clothes dryer exhaust should be vented inside conditioned space. The energy saved during the winter is offset by the increased moisture risk, particularly in rooms or parts of rooms where the exhaust originates. As a rule, do not vent clothes dryer exhaust internally.

Related Strategies

IEQ158

References and Resource

"In-line Fans,"
www.toolbase.org

"Energy Note: Buying and Using Clothes Washers and Dryers,"
www.oregon.gov/ENERGY/CONS/RES/docs/appntwas.pdf

74. Discontinue unconditioned basement or crawl-space ventilation

Basement, Gut Rehab, Deep Energy Retrofit

In more humid climates, including most of the United States east of the Mississippi River, summertime ventilation of basements and unconditioned crawl spaces has been found to introduce more moisture than it removes. Therefore, in most situations, it is advisable to keep windows and ventilation ports to these spaces closed.

Potential Issues

The general recommendation to seal unconditioned basements and crawl spaces during the summer months may not apply in all situations. Consult an engineer or other building professional with experience in building science. Some building codes still require basement and crawl space ventilation, so it may be a challenge to convince local building officials that such requirements are based on bad science; ask for exemptions to these requirements, citing the extensive field research on unvented crawlspaces done by organizations such as the Building Science Corporation or Advanced Energy Corporation.

Related Strategies

IDP124

References and Resources

"Conditioned Crawlspace Construction, Performance and Codes,"
www.buildingscienceconsulting.com/resources/foundations/

Advanced Energy Corporation Knowledge Library,
www.advancedenergy.org/buildings/knowledge_library/crawl_spaces/

75. Avoid ozone-depleting refrigerants

Deep Energy Retrofit, Gut Rehab, Basement

Chlorofluorocarbons (CFCs) were phased out in the 1990s after they were clearly implicated in depletion of Earth's stratospheric ozone layer, which protects us from high-energy ultraviolet radiation. CFCs were mostly replaced with HCFCs, which are less damaging to ozone but still a problem. Now, most of the HCFCs are being eliminated, by international treaty, and replaced with ozone-safe HFCs, hydrocarbons such as pentane, and other compounds. Refrigerants used in air-conditioning equipment are still largely dependent on HCFC refrigerants, including R-22, though some products are now coming onto the market that use nonozone-depleting HFC refrigerants. In selecting air-conditioning equipment, look for products using ozone-safe refrigerants—or no refrigerants at all.

Potential Issues:

Central air-conditioning systems are increasingly available with ozone-safe refrigerants, but window air-conditioners are several years behind in replacing HCFCs, so finding alternative products will be more difficult.

Non-HCFC refrigerants may lower the overall energy efficiency of air-conditioning equipment to some extent. This lower efficiency can be compensated for by using better heat exchangers and ECM motors, but those features raise costs. Some ozone-safe refrigerants are also fairly potent greenhouse gases (compounds that contribute to global warming by trapping heat in the atmosphere). The U.S. Green Building Council recommends considering both the ozone-depletion potential (ODP) and the global warming potential (GWP) of refrigerants when selecting cooling equipment.

Related Strategies

EA65, EA76

References and Resources

"What You Should Know about Refrigerants When Purchasing or Repairing a Residential A/C System or Heat Pump,"
www.epa.gov/ozone/title6/phaseout/22phaseout.html

76. Install ceiling fan

Bedroom, Living and Working, Major Addition, Finished Basement

Ceiling fans provide an inexpensive way to reduce air-conditioning needs in homes by helping people feel comfortable at higher air temperatures. Air flow from a ceiling fan increases evaporation and allows homeowners to be comfortable at air temperatures of 82°F or sometimes even higher raising the temperature "comfort window" in a room.

Potential Issues

A ceiling fan requires adequate ceiling height; check local building code requirements. Advise homeowners to turn off ceiling fans when they leave a room because the fan does not cool a room (it actually raises the air temperature slightly because of waste heat from the motor) but rather helps people maintain comfort at higher air temperatures. Also, advise homeowners that energy savings from the use of ceiling fans will be achieved only if the thermostat is turned up so that the air-conditioner comes on less.

Related Strategies

EA103, EA104

References and Resources

"Ceiling Fans,"
www.energystar.gov/

Acceptable Residential Refrigerants Based on Ozone-Depletion Potential and Global Warming Potential Ratings

Refrigerant	Combined LCGWP+ LCODP Score	System Refrigerant Charge	Size Equipment	Leakage Rate	Life
R410A	152	2 Ton	3.7 Lb/Ton	1.5%	15 Years
R410A	151	3 Ton	3.0 Lb/Ton	2.0%	15 Years
R410A	151	4 Ton	3.0 Lb/Ton	2.0%	15 Years
R410A	121	5 Ton	3.0 Lb/Ton	2.0%	15 Years

Source: U.S. Green Building Council

Plumbing

77. Reconfigure plumbing to distribute domestic hot water efficiently

Kitchen, Basement, Deep Energy Retrofit

To optimize hot water plumbing runs use a: pipe diameter no larger than is required for the flow, design runs no longer than are needed, minimize the number of hard angle bends, and do not plumb in the exterior building envelope. "Home-run" plumbing systems, in which individual runs of PEX tubing are made to each fixture from a central manifold with the tubing diameter optimized for the flow-rate of the fixture, are one approach for optimizing hot water distribution. Long distances from the water heater to the kitchen sink waste water. Long waits for hot water can be reduced with an on-demand recirculating system that uses a small, user-controlled pump to bring hot water to the sink quickly and returns water in the pipe to the water heater.

Potential Issues

Not all kitchen spaces may lend themselves to optimal plumbing distribution for energy and water efficiency.

Image: PEX Plumbing for Efficient Distribution of Hot Water

Related Strategies

IDP3, EA48

References and Resources

"Hot Water Delivery – Systems and Construction Practices," www.awwa.org/waterwiser/references/pdfs/RES_HW_Klein_G_Hot_Water_Delivery_Systems_and_Constructi.pdf

"Tech Set 1: Resource Efficient Plumbing," www.toolbase.org

78. Install on-demand hot water recirculation system

Kitchen, Bathroom

Significant energy and water can be wasted running water down the drain while waiting for hot water to make it from the water heater to the point of use. On-demand recirculation systems have been shown, in retrofit, to change user behavior and reduce resource use. The cold water line is used as a return so that cooled hot water is moved back to the water heater by a high speed pump that runs only when activated and just long enough to get the up-to-temperature hot water to the point of draw.

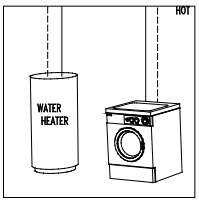
Potential Issues

The recirculation pump must be properly sized to the pressure drop of the runs, and the user must adjust to the activation system. If the cold water line is used as the return, some cold water can be wasted when a user draws water to drink that has been warmed when acting as the return line.

Note: The term on-demand is also often used to refer to tankless water-heating systems. With hot water recirculation systems, "on-demand" indicates that the hot water recirculation pump runs only when a user hits the activation button and hot water is demanded.

Image: On-Demand Recirculation Pump for Hot Water

Image: Typical On-Demand Recirculation System



Related Strategies

IDP3, EA77

References and Resources

"Benefits of Demand-Controlled Pumping," www.cuwcc.org/res_hot_water/Home_Energy_Magazine_Sept-Oct-2006.pdf

79. Choose high-efficiency water heater

Basement, Home Performance, Gut Rehab, Deep Energy Retrofit

A water heater can be one of the two or three largest energy users in a home. It is important to select a high-efficiency model, whether electric or gas-fired, whether storage or tankless. The energy performance of storage-type water heaters is determined by the amount of insulation around the tank, the efficiency of the heat exchanger, and (with gas water heaters) the burner configuration and efficiency. With gas-fired tankless (demand) water heaters, models with electronic ignition are significantly more efficient than models with pilot lights; some models include very high-efficiency heat exchangers and condensing technology. Electric- demand water heaters are not recommended for whole-house applications because of the very large power demand (typically 40 to 60 amps at 240 volts).

Finally, probably the most efficient way to heat hot water is by using the sun. "Consider solar water heating strategy".

Potential Issues

With gas-fired water heaters, choose sealed-combustion models to prevent risk of spilling combustion gases into the house.

Tankless (demand) water heaters have been gaining a lot of attention recently, and they can make sense in the right situation. Because demand water heaters do not store hot water, there is no stand-by heat loss, which accounts for in much of the efficiency loss with storage-type water heaters. For whole-house applications, only gas-fired models are viable because electric models require too much power (typically 40 to 60 amps at 240 volts). Whether a demand water heater makes sense for a family depends in part on their hot water usage patterns. If family members turn on the hot-water tap frequently for short periods of time (a quick hand-washing dozens of time per day, for example), the gas burner will never reach full efficiency before it shuts off, and the frequent cycling on and off will waste energy. Combining domestic water heating and space heating in a tankless water heater in colder climates may result in an overall lower level of energy efficiency compared with the most efficient alternatives—condensing efficiency gas-fired furnaces and boilers.

If domestic water heating is combined with space heating, be sure that a switch to a tankless water-heating system does not reduce overall system efficiency.

Image: One Approach to Efficient Water Heater: Gas Tankless

Related Strategies

EA77, EA101

References and Resources

"Selecting a New Water Heater," www.eere.energy.gov/consumer/your_home/

"Consumer Guide to Home Energy Savings: Water Heating," www.aceee.org/consumerguide/waterheating.htm

80. Insulate water heater

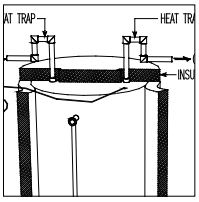
Basement, Home Performance, Deep Energy Retrofit

Insulating storage-type water heaters reduces standby heat loss, improving overall energy efficiency. If the water inside the tank is 130°F and the air temperature of the space in which it sits is 70°F, there is a larger temperature differential driving heat loss from the tank than between inside and outside temperature's for all but the coldest of winter nights. Water heater blankets are available from weatherization supply companies and from some utility companies. Most are fiberglass with plastic backing. Convective flow of hot water from the water heater can be stopped with a "heat trap" valve or a loop in the pipe above the water heater. Be sure to also insulate hot water pipes leading from the water heater (see 81 "Insulate hot water pipes").

Potential Issues

With gas-fired natural draft water heaters, air flow beneath the water heater must not be blocked because that air flow is needed for combustion. Follow the manufacturer's instructions for insulation.

Improving Efficiency of Existing Water Heater



Related Strategies

EA81

References and Resources

Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-Efficient Economy, 200, www.aceee.org

Residential Energy, John Krigger, Saturn Resource Management, 2004

"Insulate Your Water Heater Tank for Energy Savings," www.eere.energy.gov/consumer/your_home/

81. Insulate hot water pipes

Basement, Home Performance, Gut Rehab, Deep Energy Retrofit

To slow the cooling of hot water in piping, all hot water pipes should be insulated. This will increase the likelihood that water in the pipes will be warm when the tap is turned on, thus reducing water waste and limiting the time of operation of a water heater. If all hot - water pipes cannot be insulated easily, concentrate the first 6 to 8 feet of pipe from the water heater; insulate elbows and fittings in addition to straight runs.

Insulate cold - water pipes in areas with high summertime humidity to prevent condensation of moisture on the pipes (which can promote mold growth and decay of cellulosic materials).

Potential Issues

Select a durable pipe insulation material that can withstand the highest temperatures that will be experienced. Some low-cost pipe insulation does not hold up well in the long term. Pipe insulation must be tight-fitting to be effective, and although elbows and angles are harder to insulate, their greater surface area makes them that much more important to properly insulate. Because hot water pipes in existing slabs can not be insulated, replumbing around these pipes should be considered in some types of homes and climates.

Related Strategies

EA80

References and Resources

Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-Efficient Economy, 2007, www.aceee.org

Residential Energy, John Krigger, Saturn Resource Management, 2004

82. Set water heater temperature no higher than necessary

Kitchen, Bathroom, Basement

Even though 120°F water is hot enough for most households, and water temperatures above 125°F can cause severe burns, the manufacturer setting may be as high as 140°F. Setting the water heater's thermostat to 120°F can improve safety and conserve energy. According to Energy Efficiency and Renewable Energy, each 10°F reduction in water temperature saves 3% to 5% in energy costs for water heating and also slows corrosion in the water heater and pipes, helping the water heater continue to operate efficiently.

Potential Issues

A dishwasher without a booster heater may require water temperatures between 130°F and 140°F.

Related Strategies

EA103, EA104, EA105

References and Resources

"Lower Water Heating Temperature for Energy Savings," www.eere.energy.gov/consumer/your_home/

Lighting

83. Provide daylighting

Kitchen, Major Addition, Deep Energy Retrofit

If natural daylight can satisfy ambient lighting requirements, only task lighting will be needed during daytime hours, and electric ambient lighting will be needed only at night or during very dark days.

Additions and significant house renovations (gut - rehab and whole-house deep energy retrofits), may offer the potential for daylighting. Windows, skylights, and tubular skylights can be used to bring natural light into a space during the daytime. Select glazing systems carefully to meet or exceed the energy performance of the rest of the house or addition. With large glazing areas for daylighting, select glazing options that will minimize the increased cooling loads. Light-colored walls and ceilings can help distribute daylight more deeply into a house.

Potential Issues

Poorly implemented daylighting can lead to overheating of a space or an increase in air-conditioning loads. South-facing and low-slope roof windows are particularly problematic because the angle permits a high percentage of the sunlight to be transmitted. Careful placement of skylights and glazing selection can minimize this problem. "Glazing strategies".

Image: Solar Tube for Daylighting

Related Strategies

IDP3, EA60

References and Resources

"Understanding High Performance Lighting: Room-by-Room Designs," www.ibacos.com/hpl5.html

84. Provide appropriate mix of color-correct ambient and task lighting

Kitchen, Bathroom, Deep Energy Retrofit

Lighting design should be an element of all residential remodeling projects. Distinguishing between ambient and task lighting needs is a critical part of effective and energy-efficient lighting design. Ambient lighting should be provided by daylight during the daytime if at all possible, with fluorescent lights for overcast days and night. Indirect fluorescent lighting is quite effective. Task lighting delivers light more precisely where it is needed and can be provided more efficiently with recessed compact fluorescent lamps (CFLs) or LED light fixtures.

Potential Issues

Although very attractive from an energy-efficiency standpoint, fluorescent lamps contain the toxic metal mercury, which can escape into the environment after disposal, particularly if municipal solid waste is incinerated. Burned-out fluorescent lamps should always be disposed of properly, through facilities that capture the mercury and recycle the components.

When recessed downlights are installed in an insulated ceiling, use insulation-contact fixtures (IC-rated) that can be properly sealed to prevent air leakage and moisture migration into the attic space.

Related Strategies

EA103, EA104

References and Resources

"Understanding High Performance Lighting: Room-by-Room Designs," www.ibacos.com/hpl5.html

85. Install energy-efficient electric lighting

Kitchen, Bathroom, Home Performance, Deep Energy Retrofit

The new federal energy bill bans incandescent light bulbs by the year 2012. Fluorescent lighting has come a long way in the past several decades, with high-quality lamps offering excellent color rendering, color temperatures that match incandescent lighting, and silent, flicker-free operation. Attractive fixtures are available in many designs (sconce, recessed, surface-mount, indirect cove) for straight-tube and compact fluorescent lamps that work well with most kitchen designs. Energy Star–rated lighting fixtures and lamps ensure good performance in various areas, including color rendering, harmonic distortion, start-up time, long life, and energy-efficiency. Although still relatively new, LED lighting is quickly emerging as a viable alternative to incandescent and, in certain applications, fluorescent lighting. LED lighting today is most practical for task and under-the-counter lighting, though as efficacy improves, LED ambient lighting will become increasingly practical.

Potential Issues

Natural daylighting can be used to reduce the need for electric lighting.

Install low-mercury fluorescent lamps to reduce the potential for postdisposal mercury release.

Not all compact fluorescent bulbs are dimmable—take care in specifying and installing.

Green remodelers and interior designers will have to stay current with the changes as technologies and commercialization of new lighting products develop.

Related Strategies

EA83

References and Resources

"Light Bulbs and Fixtures," www.energystar.gov/

"The Low-down on Mercury in Fluorescent Lamps," www.informinc.org/fact_P3fluorescentlamps.php

"Dimmable Compact Fluorescent Lamps Fact Sheet," www.pge.com/includes/docs/pdfs/res/rebates/lighting/dimmercflflyer.pdf

86. Avoid recessed lights in insulated ceilings or use insulation-contact fixtures

Kitchen, Bedroom, Major Addition

Recessed light fixtures installed in insulated ceilings are a very common source of heat loss through air leakage. When possible, use surface-mounted ceiling fixtures or track lighting to avoid penetrating the insulated ceiling plane. When recessed cans cannot be avoided, specify insulation-contact fixtures that seal fairly tightly and allow insulation to be packed against them. To improve energy performance, select fixtures designed for compact fluorescent lamps (CFLs) or LED lighting. The most energy-efficient recessed lights available today are LED lights.

Potential Issues

Insulation-contact recessed light fixtures are more expensive than standard recessed cans. Cost is also higher for CFL fixtures than for incandescent, and higher still for LED fixtures.

Related Strategies

EA54, EA85

References and Resources

Builders Guide to Home Lighting, www.lrc.rpi.edu/programs/lightingTransformation/residentialLighting/buildersguide/introduction.asp

The Lighting Pattern Book for Homes, Russell Leslie and Kathryn Conway, Lighting Research Center, Rensselaer Polytechnic Institute, 1996 (2007 online)

87. Provide adaptable lighting for multiuse spaces

Living and Working

In spaces that have varied uses, such as a living room that also serves as a home office, lighting needs may change throughout the course of the day and evening. One approach is to install a variety of light sources, such as recessed can lights for directional light, wall sconces and cove lighting for ambient light, and task lighting to illuminate an office desk. Daylighting can also play a role during daytime uses of the space. Another option is to let homeowners rely on movable lamps by providing plenty of wall receptacles, some of which can be switched to aid in controllability.

Potential Issues

None.

Related Strategies

EA83, EA84

References and Resources

Lighting Research Center at RPI, www.lrc.rpi.edu/

88. Select outdoor lighting to minimize light pollution

Outdoor Living

Light escaping from our buildings and the outdoor spaces around them has brightened the night sky so much that stars are scarcely visible in many parts of the country. Along with the aesthetic concerns and impact on astronomy, light pollution can affect health by keeping people up at night, and it can alter wildlife behavior and plant growth. In coastal areas, sea turtles that come ashore to lay eggs are confused by light pollution and sometimes return not to the sea but toward the lights. Rare moths swarm to outdoor lights and die rather than finding mates. And the flowering patterns of some plants are altered by artificial outdoor lighting. All outdoor lighting should be provided with full-cutoff fixtures (which prevent direct-beam light from exiting the fixture at an angle above the horizontal). Motion-sensing controls can turn outdoor lights on only when that light is actually needed. The International Dark Sky Association has a certification program for outdoor light fixtures that will minimize light pollution.

Potential Issues

Although safety is often cited as a justification for high outdoor light levels, studies show that good nighttime visibility involves more than lumen levels; in fact, too much light can reduce visibility.

Related Strategies

IDP3, IDP6

References and Resources

International Dark Sky Association, www.darksky.org

89. Provide appropriate outdoor lighting controls as needed

Outdoor Living

Lighting outdoors is often provided primarily for security and to provide illumination when entering or leaving a house. For these applications, effective lighting controls that utilize motion sensors are often appropriate. The lights turn on when motion is sensed. Outdoor lighting that is controlled by motion sensors should use lamps that come on instantly, operate at cold temperatures (especially in cold climates), and reach full brightness almost instantly; LED lighting and cold-cathode fluorescent lamps are the best energy-saving options for such lighting. Incandescent lamps are more satisfactory than standard CFLs in most motion-sensor-controlled outdoor lighting applications.

Potential Issues

Some energy-saving lighting, including compact fluorescent lamps (CFLs), take time come up to full brightness, especially when cold, and may not work well for motion-sensor-controlled outdoor lighting.

Related Strategies

EA88

References and Resources

Lighting Research Center Outdoor Lighting Handbook, www.lrc.rpi.edu/researchAreas/outdoor.asp

90. Provide appropriate indoor lighting controls as needed

Major Addition, Gut Rehab, Deep Energy Retrofit

Indoor lighting controls for the home include dimmers, timers, and motion detectors. A whole-house lighting control system is the most sophisticated form of indoor lighting control, consisting of zone controllers, a programmable central controller, dimming processors, remote controllers, and tie-ins to the Internet, phone system, or security system.

Potential Issues

Care must be taken in mixing controlling technology and some types of non-dimmable compact fluorescent lamps and bulbs.

Related Strategies

EA85

References and Resources

"Builder's Guide to Home Lighting: Controls," www.lrc.rpi.edu/searchpublications.asp

"Introduction to Lighting Automation for the Home," www.aboutlightingcontrols.org/education/papers/homeautomation.shtml

Equipment

91. Properly maintain equipment

Kitchen

Instruct homeowners on proper cleaning and maintenance needs of appliances and equipment.

Refrigerators should be maintained by periodically vacuuming the coils annually, preferably more frequently. Removing dust from the heat-exchange coils can significantly improve energy performance. With older refrigerators, it is usually necessary to pull the refrigerator out into the room to clean the coils in the back. Most newer refrigerators have more accessible coils. Nonfrost-free refrigerators and freezers have to be periodically defrosted to maintain efficient operation. Ovens should be cleaned of accumulated spilled food to ensure safe, efficient operation.

The dishwasher food scrap basket—if there is one—should be emptied regularly.

Potential Issues

None.

Related Strategies

EA103, EA104, EA105

References and Resources

Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-Efficient Economy, 2007 www.aceee.org

"HARDI Architect, Builder & Remodeler Good Practice Guide," www.hardinet.org/pdf/GdPractGuide2.pdf

92. Select high-efficiency, H-axis clothes washer

Bathroom

The efficiency of clothes washers has improved dramatically in recent years as horizontal-access (H-axis, front-loading) washers have become more common. H-axis washers use about half as much water (with the most efficient using only a third) than conventional (V-axis top-loading washers) because the drum does not have to be filled to ensure that clothes are adequately wetted in the wash cycle: in an H-axis washer, the clothes are dipped into water in the bottom of the drum. H-axis washers also typically spin a lot more rapidly than V-axis washers, so they extract a lot more water and the clothes require less drying energy. At a minimum, look for an Energy Star–labeled clothes washer; the current Energy Star standard requires a modified energy factor (MEF) of 1.72 and a maximum water factor (WF) of 8.0. The Consortium for Energy Efficiency lists three different tiers for clothes washers. The maximum MEFs and minimum WFs for these tiers are as follows: Tier 1, MEF 1.8 and WF 7.5; Tier 2, MEF 2.0, WF 6.0; Tier 3, MEF 2.2, and WF 4.5. Select the highest tier possible to minimize water and energy use. A list of Tier 1, 2, and 3 clothes washers is available from the Consortium for Energy Efficiency.

Potential Issues

Horizontal-axis clothes washers are typically more expensive than vertical-axis models. And H-axis clothes washers vary widely in their acoustical performance; check *Consumer Reports* on this and other performance issues.

Image: High-Efficiency H-Axis Clothes Washer

Related Strategies

IDP4, EA106, MR124, MR125

References and Resources

Consortium for Energy Efficiency, www.cee1.org

Energy Star, www.energystar.gov/

93. Install energy-efficient refrigerator

Kitchen

Select a refrigerator that meets or exceeds Energy Star standards. In general, bottom-freezer refrigerators are the most efficient, followed by top-freezer models; side-by-side models are the least efficient. Alos, compare the estimated annual kWh consumption and percentage-savings ratings on the yellow EnergyGuide labels. Features such as through-the-door ice makers and water dispensers typically lower energy performance, so carefully evaluate whether they are needed.

Potential Issues

The energy ratings for refrigerators, including Energy Star standards, are based on the size and configuration. A small non-Energy Star refrigerator may use less energy than a larger side-by-side model with an Energy Star rating. Don't get a larger refrigerator than is needed. If an older refrigerator will be retained, ensure sufficient air flow around condenser coils; new refrigerators are designed to ensure adequate air circulation. Follow manufacturer's instructions for installation.

Related Strategies
IDP3

References and Resources
"Refrigerators,"
www.cee1.org/resid/seha/refrig/refrig-main.php3

94. Choose energy-efficient dishwasher

Kitchen
Most of the energy used by dishwashers heats the water. Therefore, water-conserving dishwashers are the most energy-efficient. Dishwashers vary considerably in water and energy use.

Dishwashers that rely on condensing technology for drying should introduce less moisture into a kitchen, thus helping avoid potential moisture problems and reducing air-conditioning loads. Also, dishwashers that heat water directly, rather than by way of an open element, may be among the most efficient.

Potential Issues
Modern dishwashers have booster heaters that heat the incoming hot water to 140°F or higher, which is considered necessary for optimal washing performance. These booster heaters use considerable electricity, which may cause problems with net-zero-energy homes or homes that are off-the-grid and powered by solar electricity.

To minimize use of the electric booster heater in a dishwasher, it may make sense to keep the water heater temperature higher than generally recommended (i.e., 140° rather than 120°F).

Related Strategies
IDP3

References and Resources
"Dishwashers,"
www.energystar.gov/

www.cee1.org/resid/seha/dishw/dishw-main.php3

95. Install energy-efficient cooking appliances

Kitchen
Convection ovens are more energy-efficient than standard models because the cooking temperature can be reduced or the cooking time shortened. The most efficient cooktops are induction models that transfer electromagnetic energy directly to ferrous metal cooking pans, but most induction cooktops are quite expensive. Gas ovens are less energy-efficient than electric ovens because much greater airflow through the oven is required. Gas ovens also use considerable electricity (300 to 500 watts) whenever the oven is operating as a safety feature. Microwave ovens provide a more efficient method of cooking and reheating because the food is heated directly, rather than the air in the oven. For very small portions of food, toaster ovens may be more energy-efficient than full-size ovens.

Potential Issues
Gas ovens and cooktops release combustion products into the house, so proper venting is essential. Many indoor air quality experts recommend against gas cooking equipment for this reason. Electric ovens can be more precisely controlled than gas ovens, and some electric cooktops, especially induction and halogen, respond as rapidly as gas cooktops.

Related Strategies
IDP3, EA105

References and Resources
"Consumer Guide to Home Energy Savings: Cooking,"
www.aceee.org/consumerguide/cooking.htm

96. Consider energy toll of small appliances

Kitchen, Living and Working
The energy consumption of extra consumer appliances, or plug loads, can be significant. In deciding how to outfit a kitchen, include only those appliances and features considered necessary to meet the homeowners' needs. Reconsider extras like a second dishwasher, second freezer, wine chiller, ice maker, and refrigerator water dispenser. For appliances and features deemed necessary, seek the most efficient.

Potential Issues
Phantom loads (or vampire loads)—the electricity consumed by many pieces of equipment even when turned off—can be significant now that many consumer appliances are kept plugged in.

Related Strategies
IDP3, EA105

References and Resources
Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-Efficient Economy, 2007, www.aceee.org

"Small Appliances,"
www.consumerenergycenter.org/home/appliances/small_appl.html

"Home Electronics,"
www.energystar.gov/

97. Choose efficient hot tub or spa

Bathroom
Although hot tubs and spas are not remotely green because of their considerable water consumption, if one is desired, choose the most resource-efficient model. A hot tub that is kept filled with water should be well insulated, including a tightly fitting, well-insulated cover. The least-toxic approach for keeping it clean should be employed.

For water treatment in this case, look into UV or ozone treatment in place of heavy chlorination. With spas and whirlpool bathtubs that are filled for each use, keep the size as small as possible for the given needs.

Potential Issues

Again, the big issue with spas or hot tubs is energy use. Look for other solutions to meet the homeowners' needs.

Related Strategies

IDP3, EA105

References and Resources

"Energy Efficiency Fact Sheet: Hot Tub and Pool Conservation Tips," www.energy.wsu.edu/documents/building/res/spatips.pdf

98. Manage phantom loads

All Projects

Many televisions and other entertainment equipment, as well as office equipment and devices with AC adapters that plug into the wall, continue to use power even when turned off. At average electricity rates today, every 1 watt of phantom load (1 watt being consumed 24/7) uses about 10 kWh per year and costs homeowners about $1 per year. Thus, a television or computer monitor using 10 watts when off would consume about 100 kWh per year, costing $10. To reduce this source of energy consumption, there are several options: 1) the equipment can be plugged into power strips that can easily be switched off when equipment is not being used; 2) certain outlets can be controlled with wall switches to facilitate easy on and off (though accidentally switching off equipment in use can cause problems); or 3) a specialized system can be installed to provide radio-frequency control of selected features, as is possible with the GreenSwitch (www.greenswitch.com).

Advise homeowners to consider both the standby and the operating power consumption of new electronic equipment. Though there is a lot of variability, for comparable-size screens, LCD models are usually more energy-efficient than CRT (standard picture-tube models using cathode ray tubes), and plasma models are usually less efficient than CRTs. Digital recording devices, such as TiVo, tend to draw significant power (25 to 35 watts) even when not recording, and they are typically left on 24/7 to be ready for preset recording. Internet connection equipment, including cable modems and wireless routers, are significant electricity users in many homes, often surpassing even televisions. Plug these devices into power strips so that homeowners can switch them off at night and when not home. Note that with voice over Internet protocol (VoIP) telephone systems, cable modems cannot be turned off without losing phone service.

Potential Issues

Most appliances or electronic devices with clocks need to be reset if AC electricity is interrupted; homeowners should be advised of this issue when a switched circuit is being considered to manage phantom loads.

Related Strategies

EA96, EA105

References and Resources

www.GreenSwitch.tv

Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-Efficient Economy, 2007, www.aceee.org

"Off Is a Three-Letter Word," www.homeenergy.org/archive/hem.dis.anl.gov/eehem/96/960715.html

99. Select energy-efficient Energy Star–rated office equipment

Living and Working

Buy only Energy Star–certified office products. Along with lower operating energy use, most Energy Star office equipment will go into a power-saving sleep mode, and phantom loads when equipment is turned off are very low.

Potential Issues

Energy-saving features, such as sleep mode, can be deactivated by users; encourage homeowners not to change settings to disable energy conservation features.

Related Strategies

IDP3, EA105, MR155

References and Resources

"Office Equipment," www.energystar.gov/

Consumer Guide to Home Energy Savings, 9th Edition, American Council for an Energy-Efficient Economy, 2007, www.aceee.org

Energy Sources

100. Configure for solar access

Addition

During predesign and design of any remodeling project (but particularly major additions), carefully consider orientation and the potential for solar energy features, including passive-solar heating, daylighting, solar water heating, and photovoltaic (PV) power production. This strategy should start with a careful site assessment to determine solar (various site assessment tools are available for carrying out such analysis). To the extent possible, configure the space to benefit from sunlight and control unwanted heat gain. With passive solar heating, this will involve window placement, potential for heat storage within the space, and an interior layout that facilitates natural circulation of solar-warmed air.

Potential Issues
With daylighting, care should be taken to avoid unwanted solar heat gain that can result from roof-mounted skylights and west-facing windows. Solar water heating and PV arrays are typically roof - mounted, requiring an unobstructed south-facing roof.

Related Strategies
IDP3, SS31, EA45, EA83

References and Resources
National Renewable Energy Laboratory, www.nrel.gov

"Passive Solar Design," www.eere.energy.gov/consumer/your_home/

Solar Today, American Solar Energy Society, www.ases.org

101. Consider solar water heating

Major Addition, Home Performance, Gut Rehab, Deep Energy Retrofit
Renewable energy systems can make a tremendous difference in improving the environmental performance of a house. Beyond passive solar design and daylighting, solar water heating is often the most cost-effective renewable energy system for residential applications. The many types of solar water heaters including flat-plate collector systems with closed-loop antifreeze collector fluid, drainback systems, evacuated-tube systems, passive thermosiphon systems, and integral-collector-storage systems (batch solar water heaters). Some active solar water heaters use integral photovoltaic (PV) panels to power the pumps, obviating the need for sophisticated controls.

Potential Issues
Most solar water-heating systems are fairly expensive, particularly in retrofit situations.

Related Strategies
IDP3, SS31, EA45, EA79, EA104

References and Resources
American Solar Energy Society, www.ases.org

Solar Energy Industries Association, www.seia.org

National Renewable Energy Laboratory, www.nrel.gov

102. Consider solar electric (photovoltaic) system

Major Addition, Home Performance, Gut Rehab, Deep Energy Retrofit
Photovoltaic (PV) power systems use available sunlight to generate electricity. PV systems work by moving electrons; there are no moving parts. Very small systems provide walkway lights or limited backup power needs. Larger PV systems are designed to feed electricity into the power grid (through net - metering). Others are stand - alone, providing power only to the house and not connected to the utility grid. These standalone systems require battery banks to store power for when the sun is not shining. With batteries, control systems, an inverter to operate AC equipment, and panels, a PV system for a home can cost several tens of thousands of dollars.

Potential Issues
PV systems are expensive; be careful not to spend your "greening budget" on high-profile items like PV systems at the expense of more cost-effective energy conservation improvements. A licensed electrician who has experience with PV power systems should be hired for design and installation of a PV system, and proper safety procedures must be followed.

Related Strategies
IDP3, SS31, EA45

References and Resources
"BSC Photovoltaic Primer," www.buildingscienceconsulting.com/resources/homeowner.htm

Solar Energy Industries Association, www.seia.org

"Photovoltaic Basics," www1eere.gov/solar/pr_basics.html

Use

103. Provide homeowner's manual of green features and O&M practices

Strategy included in: All Projects
Leading builders today are providing a homeowner's manual when they complete a new house; the same should be provided for a significant remodeling project. This is a place to explain how systems work, collect equipment and appliance owner's manuals, provide photographs showing wall framing before the walls were closed in, list the contractors and subcontractors with contact information, describe special maintenance requirements (such as seasonal cleaning of solar collector panels), and offer safe cleaning recommendations. A lot of effort goes into creating a green addition or remodel; to ensure that the space remains green and healthy, homeowners must practice green O&M practices. In a homeowner's manual, these practices can be described, and lists of specific cleaning products can be provided.

Potential Issues
None.

Related Strategies
IDP6, IDP12, EA104, EA105

References and Resources
"Model Green Homebuilding Guidelines: User Guide-Operation," www.nahbrc.org/greenguidelines/userguide_homeowner_manual.html

104. Complete client education

All Projects

If green remodeling moves the home to higher performance, then the project must also move the occupants to higher levels of performance. Much of the energy savings and many of the improvements to comfort and indoor air quality initiated by building improvements need to be supported by changes in occupant behavior. Exhaust fans need to be turned on, lights need to be turned off, regular maintenance needs to be scheduled for major equipment. The weatherization community may have taken the lead on client education, but all green remodeling professionals can learn from their examples.

Potential Issues

Any template homeowner education manual will need to be customized by the green remodeling professional, perhaps even by project type. But having a master document from which to draw means that issues are less likely to be missed and the homeowner left with something that has their stamp on it.

Related Strategies

EA103, EA105

References and Resources

"Home Energy Guide,"
California Energy Commission. Publication #400-99-003 (compliant with Title 24 requirements)

CMHC "Homeowner's Manual,"
www.cmhc-schl.gc.ca/en/

The Energy Efficiency Manual, Donald Wulfinghoff, Energy Institute Press, 2000

105. Practice energy-efficient, healthy lifestyle

All Projects

Homeowners should be encouraged to alter their lifestyles in ways that reduce energy use and ensure that a home will be as healthy as possible. Specific recommendations to save energy include properly setting back thermostats, limiting water use, closing windows reducing operation of air-conditioning or heating systems, closing window blinds to reduce unwanted heat gain, using a ceiling fan to increase summertime comfort without air-conditioning, turning off a ceiling fan when leaving a room, turning off lights when not in a room, and using lighting while keeping ambient light levels lower. Practices to keep houses healthy include wiping feet when entering and/or removing shoes, avoiding overwatering plants, operating bath and rangehood fans when generating moisture or cooking odors, avoiding smoking in or next to the house, and avoiding excessive perfume use.

Potential Issues

When speaking with homeowners about lifestyle and behavioral issues, be careful not to sound preachy, as that can turn people off. Explain the benefits of such actions but leave it up to homeowners to follow these suggestions.

Related Strategies

EA103, EA104

References and Resources

"Sustainable Lifestyles,"
www.greenhomeguide.org/

106. Provide for line-drying options for laundry

Outdoor Living

Clothes drying consumes a significant amount of energy, yet fewer and fewer people today dry clothes on lines. Outdoor clothes lines provide the cleanest, lowest-energy option for drying clothes and provides homeowners with an opportunity to spend time outdoors (which is healthy in and of itself). If outdoor clothes drying is not an option, it is often possible to dry laundry indoors, though space and humidity concerns may be a concern.

Potential Issues

Avoid drying clothes indoors in humid climates or during seasons when humidity levels in a house are elevated. Be aware that covenants in many subdivisions do not permit hanging clothes outdoors.

Related Strategies

IDP3, SS31, EA105

References and Resources

"Project Laundry List,"
www.laundrylist.org/index2.htm

Materials and Resources (MR)

General Design and Construction Strategies

107. Manage construction and demolition waste

All Projects

It makes good environmental sense to minimize solid waste during construction because landfills are filling up, incineration of construction and demolition (C&D) waste generates pollution, and such waste represents lost resources. The first priority should be to minimize the generation of construction waste. This can be done during design by optimizing dimensions to reduce cut-off waste, and it can be done on the job site through careful use of materials. Second, C&D waste materials that are generated on the job site should be sorted and stored

for salvage and reuse or recycling. As part of a waste management plan, research the salvage and recycling options for different materials, and designate storage receptacles accordingly. A local municipal solid waste agency should be able to help you identify these disposal options.

Additionally, it is good practice, and good public relations to recycle consumer materials on the job site, such as glass, plastic, and aluminum beverage containers and paper products. Arrangements can be made to use either the client's recycling containers or designate a crew member to handle municipal recyclables.

Potential Issues

Good waste management plans for remodeling are especially challenging because of the lack of space on the job site, the small quantities of new construction waste material, the often huge amount of demolition waste, and finally, th presence of hazardous waste. Nevertheless, the other hand, remodeling projects present increased opportunities for salvage and reuse.

Images:

- **On-Site Recycling of Clean Wood Waste**
- **Clean Woodwaste from a Remodel**

Related Strategies

SS39, MR108, IEQ158, IEQ159, IEQ162

References and Resources

EPA C&D Waste Management, www.epa.gov/epaoswer/non-hw/debris-new/index.htm

Building Materials Reuse Association, www.buildingreuse.org/

"Construction Waste," www.toolbase.org

Site

108. Consider reuse of existing materials

Outdoor Living

Just as there is tremendous potential to use salvaged materials indoors, outdoor living spaces and landscape features offer lots of opportunity to use salvaged materials outdoors. Patios can be made from salvaged stone or brick. Retaining walls can be made from a wide range of salvaged materials, including railroad ties and pieces of broken concrete slabs (called "urbanite" by some green builders). Outdoor decks and railings can be made from decay-resistant salvaged woods, such as cypress, redwood, longleaf yellow pine, black locust, and various tropical hardwoods.

Potential Issues

Whenever using salvaged wood or concrete, consider contamination. Do not reuse wood that has lead paint or has been treated with persistent pesticides. Determine the source of salvaged concrete slab material and avoid concrete floor slabs from industrial facilities where toxins may have been spilled and absorbed into the concrete. Use creosote-treated timbers only in locations where offgassing from the material will not infiltrate indoor spaces or affect outdoor living areas.

Image: Salvaged Roofing Tiles

Related Strategies

IEQ158, IEQ159

References and Resources

Building Materials Reuse Association, www.buildingreuse.org/

109. Consider patio rather than wooden deck

Outdoor Living

Treated wood has traditionally been one of the least-green materials used in and around homes. Although today's pressure-treated wood is less toxic than its predecessor (chromated copper arsenate or CCA), it may still leach copper compounds that are toxic to many aquatic organisms, and its expected life outdoors is usually no more than ten years, creating a disposal problem. Wood-plastic composite decking and 100% plastic decking should outlast pressure-treated wood, but many homeowners dislike the look and feel of plastic or are concerned about flammability. A greener alternative is a stone or brick patio. Properly designed and installed, a patio will long outlast a wooden deck, and it has none of the flammability concerns of a wood-plastic composite or all-plastic deck. Patios can be very effectively integrated into other landscape features, such as stone walls, stairs, trellises, and garden areas.

Potential Issues

Patios can have hard, uneven surfaces, a potential cause for concern for seniors or young children.

Related Strategies

IDP7

References and Resources

"Reduce Impervious Surfaces," www.recycleworks.org/greenbuilding/sus_imperviousurfaces.html

110. Use naturally rot-resistant, responsibly produced wood for decks

Outdoor Living

Different species of wood vary tremendously in their rot resistance. Some domestic hardwoods, such as black locust, and like tropical hardwoods, such as ipé, teak, and certain mahoganies will significantly outlast standard pressure-treated wood, and they may even outlast plastic decking. The challenge with these woods, especially those of tropical origin, is ensuring that they were produced in sustainably managed forests. A way to help ensure responsibly sourced wood is to specify wood from forests certified according to Forest Stewardship Council (FSC) standards. Some resistant woods may also be available from salvaged sources.

Potential Issues

If using salvaged sources of durable wood, make sure it has not been treated with persistent pesticides or other toxic chemicals.

Related Strategies

IDP28, MR108

References and Resources

"Wood Handbook,"
USDA Forest Products Laboratory,
www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/fplgtr113.htm

"Protecting Wood Fences for Yard and Garden,"
www.treesearch.fs.fed.us/pubs/5700

111. Choose less harmful pressure-treated lumber

Major Addition, Outdoor Living

The most common pressure-treated lumber for decks today uses copper as the active ingredient (either ACQ or copper azole). Other treatments include borates (which are not water resistant) and a new generation of light organic solvent preservatives (LOSPs), whose long-term performance and health concerns are not yet known. The greenest treated-wood option for decking today involves a sodium silicate and heat treatment. The resulting material is nontoxic and highly resistant to insects and decay.

Potential Issues

The greenest option for pressure-treated wooden decks, the process using sodium silicate followed by heat treatment, is not yet widely available in most of the country.

Related Strategies

IDP28, IEQ162

References and Resources

TimberSIL, www.timbersilwood.com

REGREEN Product Selection Resources,
www.regreenprogram.org

112. Use recycled-content plastic or composite decking boards

Strategy included in: Outdoor Living

Wood-plastic composite decking and 100% plastic decking will outlast most treated-wood decking. Some of these plastic-composite and 100% plastic decking products are also made of recycled material. The most common recycled plastic in decking is high-density polyethylene (HDPE). Some of the composite decking products also contain reclaimed wood—typically sawdust or lumber mill wast.

Potential Issues

Some of the manufacturers of wood-plastic composite and plastic decking that once made extensive use of recycled plastic have switched to virgin plastic, so these products are no longer as green as they had been. Flammability of plastics in decking is a growing concern: if a barbeque grill tips over, hot coals can quickly ignite such decks.

Related Strategies

IDP28

References and Resources

California Integrated Waste Management Board's Recycled Content Product Directory, www.ciwmb.ca.gov/RCP/

REGREEN Product Selection Resources,
www.regreenprogram.org

113. Use environmentally preferable patio materials

Outdoor Living

In many respects, patios are far greener than decks. They last longer, the risk of moisture damage to the house is lower, and the materials used in construction are often greener. Look for local stone or salvaged stone or brick to build a patio. Also consider porous materials—either porous grid pavers, the use of free-draining crushed stone between and under stone or brick.

Potential Issues

Locally bought stone may not be local. A lot of the stone being sold in the United States today comes from Brazil and even China. The transportation energy and environmental burdens of bringing in stone from foreign countries outweigh most of the environmental benefits of patios.

Image: Site-Processed Materials

Related Strategies
IDP14, MR108, MR109

References and Resources
California Integrated Waste Management Board's Recycled Content Product Directory, www.ciwmb.ca.gov/RCP/

REGREEN Product Selection Resources, www.regreenprogram.org

Foundation

114. Use fly ash in concrete

Major Addition
Portland cement, which accounts for 12 percent of most concrete, is highly energy - intensive to manufacture, and its production releases significant quantities of carbon dioxide (both from the energy of manufacture and from the chemical process of calcining limestone). In fact, approximately 6% of the world's carbon dioxide emissions results from portland cement production. One way to reduce the environmental burdens of foundations is to use concrete that contains a percentage of fly ash (or other pozzolans, such as blast furnace slag) in place of portland cement. Fly ash is a waste product from coal-fired power plants. Mixes with 15% to 25% Type C or Type F fly ash are fairly common, and mixes as high as 60% are sometimes used.

Ask local or regional departments of transportation what fly ash mixes they have tested and support. Such information can be convincing with the building inspection department, the ready mix supplier, and the concrete contractor.

Potential Issues
The use of fly ash in residential concrete is still relatively new; look for a ready-mix concrete provider who is familiar with fly ash mixes and can advise about any differences in installation and performance.

The different types and grades of fly ash and blast furnace slag can vary widely in quality and quantities. Some of these materials come from manufacturing or energy production activities here in the United States, but increasingly these materials are being imported from overseas because of supply and demand issues.

Related Strategies
EA47

References and Resources
Making Better Concrete, Bruce King, Chelsea Green Publishing, 2006, www.buildersbooksource.com/cgi-bin/booksite/21165.html

"Fly Ash Concrete," www.toolbase.org

115. Use bio-based form-release agent or permanent forms

Major Addition
Standard form-release agents (used to allow formwork to be easily removed from concrete footings and walls after the concrete has set) are made from petroleum. Some of this oil seeps into the ground around the foundation, and some remains on the concrete, where it can contribute to indoor air pollution. A new generation of form-release agents are made from vegetable oils, which biodegrade naturally and are less harmful in indoor air. An alternative to removable concrete forms is insulated concrete forms (ICFs), which are made from polystyrene insulation. They remain in place and provide insulation on both the interior and the exterior of the foundation wall. Although ICFs are most commonly used for foundation walls, they are sometimes used to construct the entire wall of a house or addition.

Potential Issues
Bio-based form release agents generally come at a substantial price premium.

Related Strategies
EA47

References and Resources
REGREEN Product Selection Resources, www.regreenprogram.org

Building Envelope

116. Minimize wood use with advanced framing or SIP construction

Major Addition, Gut Rehab
Conventional wood framing uses 15% to 20% more framing lumber than is structurally required. Extra studs at corners and wall intersections, cripple studs, solid-wood headers (flanked with 2-by plates top and/or bottom), double top-plates, and 16-inch-on-center stud spacing are all overkill, according to proponents of *Advanced Framing*. By switching to 24-inch studs and roof trusses or rafters, switching from a double to a single top plate (and aligning roof trusses or rafters with wall studs), eliminating superfluous studs, and replacing solid-wood headers above windows and doors with engineered (and insulated) headers, builders can reduce wood use and increase insulation performance (because insulation functions at least three times better than wood). Advanced framing also saves money by reducing wood use. Structural insulated panels (SIPs) go beyond advanced framing by eliminating framing lumber altogether for the exterior envelope. SIPs, are panels of oriented-strand board that surround a core of rigid insulation (usually EPS or polyurethane); they insulate

extremely well and if properly installed result in a very tight envelope.

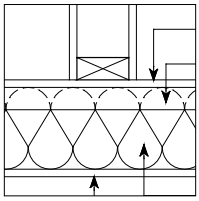
Potential Issues

In going from 16-inch-to 24-inch-on-center wall and ceiling framing, some contractors prefer using 5/8-inch drywall. There is typically a learning curve in moving framers to advanced framing techniques.

Advanced Framing on Interior Partitians

Details: Advanced Framing

- **Ladder blocking**
- **Intersecting wall details (5)**
- **Corner details (8)**
- **Stacked frame elevation**



Related Strategies

IDP3, EA48

References and Resources

Efficient Wood Use in Residential Construction, NRDC, 1998

"Using Wood Efficiently,"
www.buildingscienceconsulting.com/resources/misc/

117. Use high-recycled-content, formaldehyde-free insulation

Major Addition, Gut rehab, Deep Energy Retrofit

All fiberglass today contains at least 25 percent recycled glass, most of which is from the window glass manufacturing industry, but some is from recycled beverage glass. The insulation industry is now the largest user of recycled glass in the country. Cellulose insulation, however, contains a significantly higher recycled content—typically 80% postconsumer recycled newspaper (the remainder being borate and/or ammonium sulfate flame retardants). Most fiberglass insulation uses phenol formaldehyde binders to hold the fibers together. Although most of the free formaldehyde is driven off during a baking process, residual formaldehyde may still be released into a home. Formaldehyde was reclassified in 2004 by the International Agency for Research on Cancer from a probable human carcinogen to a known human carcinogen, raising greater concern about formaldehyde from fiberglass. At least one major fiberglass manufacturer has switched production to a nonformaldehyde acrylic binder. Although polystyrene, polyisocyanurate, and spray polyurethane insulation do not contain significant recycled content, they do not contain formaldehyde. Of the insulation materials available today, only extruded polystyrene (XPS) is still made with an ozone-depleting blowing agent; phaseout is scheduled for 2010.

Potential Issues

Because most of an insulation's environmental footprint is contribution to reduced energy consumption of the building, the material's applied performance should always be considered before other features like high-recycled content.

Related Strategies

EA48, EA49

References and Resources

"Insulation: Thermal Performance Is Just The Beginning,"
www.buildinggreen.com/auth/article.cfm?fileName=140101a.xml

REGREEN Product Selection Resources,
www.regreenprogram.org

118. Use FSC-certified wood

All Projects

A way to ensure that the wood used in remodeling projects or additions was produced in an environmentally responsible manner is to specify products certified by the Forest Stewardship Council (FSC). FSC has established rigorous standards for forest management and a process for third-party certification of those forests and products derived from them.

Potential Issues

Most FSC-certified wood products will be more expensive than noncertified products because of the cost of conducting third-party certifications of forest operations and verifying chain-of-custody certifications of products coming from those forest operations. Obtaining a consistent, ready supply of FSC-certified wood products may also be a problem; supply and distribution of various FSC-certified materials vary widely by region.

A strong second option is to use third-party-certified Sustainable Forest Inititative materials, with a third option being SFI self-certified materials.

Related Strategies

MR134, MR147

References and Resources

Forest Stewardship Council, www.fscus.org

Scientific Certification Systems, www.scscertified.com/

SmartWood Program of the Rainforest Alliance,
www.rainforest-alliance.org/forestry.cfm?id=certification

Sustainable Forestry Initiative, www.sfiprogram.org/

119. Install a durable wall cladding

Major Addition, Deep Energy Retrofit

Siding choices affect the moisture management, long-term durability, and maintenance needs of a house

exterior. With any moisture-permeable siding material (wood, fiber cement, brick), an air space behind the siding is highly recommended. With wood or fiber cement siding, this air space or rainscreen can be provided with strapping that is perpendicular to the siding or a specialized drainage or rainscreen material designed for this application. Properly finished and installed over a rainscreen, wood or fiber cement siding should require far less frequent painting or staining than when installed directly over sheathing. In fire-prone areas, a noncombustible siding, such as fiber cement, can provide important building protection but must be coupled with fire-resistant screening of the air space behind the cladding to be effective.

Properly finishing means priming all cut edges; a factory preprimed cladding is preferred.

Potential Issues

Some of the environmental impact from siding comes from periodic painting or staining, so measures to reduce the need for refinishing can improve the environmental performance significantly. The air space between the cladding and the wall sheathing can implicate the jamb extensions at windows and doors.

Related Strategies

IDP1, IDP24, IDP25

References and Resources

"Siding Question/Rainscreen Question,"
www.buildingscienceconsulting.com/resources/walls/

"Exterior Ventilated Cladding,"
www.uaf.edu/ces/publications/freepubs/HCM-01558.pdf

120. Provide durable, reflective roof

Major Addition, Deep Energy Retrofit

Roofs are exposed to the most stressful conditions of any component of a house: tremendous temperature fluctuations, UV light, rainstorms, and high wind. Their long-term performance in excluding precipitation is critical to the long-term durability of a house, and they can be a source of significant unwanted heat gain. Roofing is also one of the largest components of Construction and Demolition waste today, especially short-lifespan asphalt shingles. A highly durable, 50-year roof is recommended for any green addition or in reroofing a house. To reduce unwanted heat gain, provide a high level of insulation in the ceiling or roof assembly. Also consider a reflective roof with material that is certified by EPA's Energy Star roof program. Although a reflective roof may reduce air-conditioning costs in a home, it also helps reduce the urban heat island effect (the local warming that comes from dark paved areas and buildings).

Potential Issues

If a roof is to be used to collect potable water, its material should not capture or hold contaminants (such as asphalt or fiberglass with a textured surface), and it should not leach contaminants into the water, as can be the case with copper and certain other materials.

Related Strategies

IDP1, IDP24, IDP25

References and Resources

EPA Energy Star roofing products,
www.energystar.gov/

Lighting and Electrical

121. Plan for future wiring and cabling needs

Living and Working, Major Addition, Gut Rehab, Deep Energy Retrofit

Cabling is an important issue in any 21st-century home, but especially in any space that could be used as a home office. Living rooms, too, need to meet more and more needs when it comes to cabling, including sophisticated audio and visual systems. We have seen dramatic changes in the needs for electrical, communications and data cabling in the past two decades—particularly from standard phone lines to ethernet to T-1 and fiber-optic. It is hard to predict what the needs will be in five years; indeed, it is possible that wireless technology will obviate the need for communications and data cabling altogether. To plan for the unknown and minimize the likelihood of expensive cabling upgrades in the future, provide either wiring conduit through which new cables can be run or surface-mounted wiring raceways that are accessible for homeowner modifications. In addition to planning for adaptability, provide plenty of electrical receptacles and communications ports to provide flexibility within the spaces.

Potential Issues

Raceways slightly erode usable floor area. The main issues are height requirements for outlets (off the floor) and universal design.

Image: Baseboard Wiring Raceway with SIP Walls

Related Strategies

IDP7

References and Resources

"Electrical Raceways,"
www.toolbase.org

Plumbing

122. Consider environmentally preferable piping material

Kitchen, Bathroom

Of the most common piping materials used in homes today—copper, CPVC, and PEX (cross-linked polyethylene)—PEX is often considered the greenest. PEX is a plastic containing only carbon and hydrogen atoms, so its manufacture and disposal are relatively clean. Although most copper pipe has a fairly high recycled content, the mining required to produce virgin copper is environmentally damaging, and all copper is highly energy - intensive to produce. Home-run piping systems are becoming increasingly common; they have a central manifold near the water heater with separate PEX tubing lines running directly to each fixture or appliance. This configuration offers the benefit of matching the tubing diameter to the usage of each fixture. The diameter of a tubing line for a bathroom faucet can be kept small (say, ⅜-inch diameter) so that hot water will reach the faucet quickly and losses will be minimized a bathtub will be served by larger-diameter tubing. If copper is used in a more conventional pipe distribution network, the hot water pipes should be insulated to retain heat longer between uses. PEX tubing can be insulated, but because the tubing diameter is matched with the usage and the tubing has lower conductivity than copper, this may not be necessary.

Potential Issues

Some local jurisdictions are reluctant to approve to PEX tubing for domestic water supply (as opposed to radiant heating systems) because of confusion between PEX and other plastic tubing systems and concerns regarding the leaching potential from soil into PEX tubing in some slab-on-grade applications. Efficient plumbing design (clustering of hot-water draw locations) is the best way to achieve plumbing pipe efficiency, although in remodeling there is certainly less opportunity for plumbing distribution redesign.

Image: PEX Piping Manifold

Related Strategies

EA77

References and Resources

Copper Development Association,
www.copper.org/environment/homepage.html

Plastic Pipe Institute, www.plasticpipe.org

"Piping in Perspective: Selecting Pipe for Plumbing in Buildings,"
www.buildinggreen.com/auth/article.cfm?fileName=160401a.xml

123. Include plumbing access panel

Bathroom

To facilitate inspection and repairs to plumbing components, provide a plumbing access panel in the bathroom, kitchen, and laundry room. The access panel should be located to permit access to as much plumbing as possible—especially for piping that is most likely to require future modification or repairs. Most common are access panels that open into walls with pipes serving showers and baths.

Potential Issues

A plumbing access door that penetrates a wall's air barrier should be well constructed and tightly sealed to prevent it from being a source of air and moisture movement into the wall cavity.

Related Strategies

EA77

References and Resources

(Type "plumbing access panel" into any browser)

124. Install readily accessible, single-throw shut-off valve

Bathroom

Water pressure—both hot and cold—is maintained 24/7 in a clothes washer unless the shut-off valves are closed. This means that if a hose starts to leak or bursts, water will flow unabated. Installing a single-throw shut-off valve in a readily available location means that all water supplied to the clothes washer can be turned, like a light switch, to prevent flooding if a hose leaks or bursts. The single-throw lever turns off both the hot and cold supply in one motion.

Potential Issues

A location for the single-throw shut-off that is handy but not prominent can be an aesthetic issue, depending on the location of the clothes washer.

Image: Single-Throw Clothes Washer Shut-Off

Related Strategies
EA92, MR125

References and Resources
"Read This before You Design, Build, or Renovate", www.buildingscienceconsulting.com/resources/mold/

www.plumbingwarehouse.com/clotherswasherhoseshutoff.html

125. Install drain and drain pan for clothes washer located over finished space

Bathroom
More and more, clients want the laundry room located in a finished space, on the first floor or even the second floor instead of the basement space or in a utility room. This means that the clothes washer is located in and over finished space where a burst or leaking hose or washer drum can cause catastrophic water damage. Installing the clothes washer on a shower pan, plumbed for drainage, is a smart strategy for reducing risk and increasing service life.

Potential Issues
The pan must be sized according to the clothes washer, and it must be in the rough plumbing layout.

Image: Electronic Leak Detection for Clotheswasher

Related Strategies
MR124

References and Resources
"Checklist for Decay Resistance," www.lsuagcenter.com/en/family_home/home/la_house/my_house/Durable/

"Clotheswasher Drain Pan Specifications," www.floodsaver.com/24_Specs.htm

Walls and Ceilings

126. Install environmentally preferable interior sheathing

Kitchen, Bathroom, Basement
Select drywall (wallboard) products with a high recycled content and use taping materials and joint compound without hazardous additives that aid drying and setting. Conventional, paper-faced drywall is a fairly good material from an environmental standpoint (recycled paper facing and low off-gassing of pollutants). Drywall made from flue-gas desulfurization gypsum (a waste product from pollution control equipment on coal-fired power plants) is also available. In high-moisture areas, specify drywall products that are more resistant to moisture, such as nonpaper-faced products (monolithic and fiberglass-faced drywall is available for high-moisture areas). Drywall materials with higher preconsumer recycled content are becoming available. In some cases, interior finish panels can be eliminated altogether by using structure-as-finish components. For example, if the wall is being made from blocks (such as autoclaved aerated concrete, AAC), a natural clay plaster could be applied directly to that masonry surface, eliminating the need for panelized products altogether.

Potential Issues
During remodeling work, protect both workers and homeowners by capturing dust during drywall finishing and using temporary fans to maintain negative pressure (and exhaust the dust) in the space being finished. To avoid contaminating the heating system, seal registers and the ductwork during drywall sanding and finishing.

Recycling opportunities for drywall cut-off waste are generally quite limited; on-site recycling of ground gypsum board as a soil amendment is permissible in many locations.

Low- and zero-VOC joint compound may contain chemical compounds that have adverse health effects for some individuals.

Related Strategies
MR107, IEQ183

References and Resources
ReGreen Reference Guide to Product Considerations, www.regreenprogram.org

127. Select environmentally preferable interior doors

Bedroom, Living and Working
When selecting interior doors, consider salvaged and refinished products that may be available from architectural salvage yards, or existing reuse doors. With new doors, look for the following features: ag-fiber (e.g.,

wheat straw particleboard) core, formaldehyde-free or urea-formaldehyde-free wood components, FSC-certified wood or wood veneers, transom lights to help distribute natural light, and zero-VOC or low-VOC finishes.

Potential Issues

Many of the environmental features described here are not widely available in interior doors, so availability may be an issue. Greener products entail a cost premium.

Related Strategies

EA83, MR108, MR118

References and Resources

REGREEN Product Selection Resources, www.regreenprogram.org

128. Frame for installation of future grab bars

Bathroom

With walls opened to the studs during a remodel, additional blocking can be added for the installation of grab bars or called out for a future installation when health issues necessitate. Take photographs of the framing for future reference before installing drywall.

Potential Issues

Use care on exterior walls to maintain thermal performance as blocking is added that replaces insulation—yet another good argument for considering the addition of exterior rigid insulation as a part of any bathroom remodel.

Related Strategies

IDP7, EA48

Resources and References

"Residential Remodeling and Universal Design," www.huduser.org/publications/destech/resid.html

"Universal Design," www.extension.iastate.edu/housing/elderly/udha-ud.html

129. Consider alternative wallcovering products

Bathroom, Bedroom

In the past, wallpaper was indeed made from paper or natural fiber materials backed with paper. Over time, the need for sturdier wallcoverings for commercial interiors and more cleanable products for bathroom and kitchen applications led to the development of nonbreathable wallcovering made mostly from plastic materials, nearly universally PVC-based. Recent concerns about manufacturing by-products from the PVC industry and growing awareness about the out-gassing characteristics of the plasticizers in PVC-based products have prompted the industry to develop greener wallcovering products. These new products are free of PVCs, plastics and heavy - metals or made from natural and rapidly renewable materials, including wood pulp, cork, grasses, and other plant fibers. Because they are also breathable, they do not act as barriers that trap moisture behind the walls.

Potential Issues

Many wallcoverings create an attractive, durable, and easily - cleaned surface, sometimes more durable than a good wall paint. In areas that will undergo continued contact with furniture and equipment, wallcovering can still be the best option.

Related Strategies

IDP25

Resources and References

"Green from Wall to Wall," www.edcmag.com/CDA/Archives/8f8837e14c697010VgnVCM100000f932a8c0

130. Use appropriate sheens for paints and finishes

Kitchen, Bathroom, Bedroom

In high-humidity areas where walls will frequently be washed, durable paints with high "scrubability" ratings will ensure longer life. In these applications, painters long preferred oil-based enamel paint, but newer high-sheen, water-borne acrylic paints now offer excellent performance. As with all paints, look for low VOC levels.

Potential Issues

Thick layers of higher-sheen paints might act as a vapor barrier and trap moisture behind walls.

Related Strategies

IDP1

References and Resources

"Selecting Healthy and Environmentally Sound Finishes," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/760/C224

131. Consider natural finishes

Bedroom, Living and Working

Natural paints, varnishes, oil finishes, and plasters provide a more natural alternative to conventional petroleum-based finishes, but many of these products may not be available locally. Natural pigments often provide the colors, so options may be somewhat limited. Many of the plant-based paints and oils are produced in Europe, as are some of the lime and clay plasters. Follow manufacturers' instructions for installation and apprise homeowners of care and maintenance requirements.

Potential Issues

Natural finishes tend to be more labor intensive to apply and more expensive. Many natural finishes are not as moisture - resistant as acrylic and polyurethane

finishes. Also, some of the natural, plant-based finishes can contain natural terpenes and other ingredients that chemically sensitive people cannot tolerate.

Related Strategies
EA103, IEQ196

References and Resources
"Selecting Healthy and Environmentally Sound Paints," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/750/C224

132. Consider tile and tile trim pieces with recycled content

Kitchen, Bathroom
Ceramic and porcelain tile with high recycled content is available. Some products are made entirely from recycled glass, others from preconsumer recycled industrial waste (such as tailings from mining operations). Some recycled-content tile comes with unique stories—recycled window glass from a particular building, for example, or a certain type of recycled beverage glass.

Potential Issues
Recycled content tile is available in limited styles and types, although inventories are growing.

Related Strategies
MR156

References and Resources
"Green Buyer's Guide To Stone & Tile," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/642/C225/

Floors and Flooring Products

133. Consider reuse of existing flooring and subflooring

Kitchen, Bathroom
An attractive environmental solution is to refinish an existing floor that has structural integrity and is made from a safe product, such as hardwood or concrete. Attention should be paid to ensure that an older wooden floor being refurbished does not have lead-based paint. New grinding and hardening technology is allowing old concrete slabs to be turned into beautiful, polished concrete floors.

Potential Issues
Existing finished flooring should be assessed for hazardous material content (primarily lead and asbestos), and subflooring should be assessed for its structural integrity. See EPA or HUD resources for managing lead- and asbestos-containing materials in the home.

Image: Birch Flooring Reused

Related Strategies
IEQ159, IEQ160

References and Resources
National Wood Flooring Association, www.woodfloors.org/consumer/maintRenewal.aspx

"Asbestos In Your Home," www.epa.gov/asbestos/pubs/ashome.html#4

"Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work," www.hud.gov/offices/lead/training/LBPguide.pdf

134. Select wood subflooring that is FSC-certified and low/no-formaldehyde

Bedroom
To help ensure sustainable forest management practices have been followed and the wood subflooring emits lower levels of harmful chemicals, use products that have been certified by the Forest Stewardship Council (FSC) and comply with product emissions standards set by California Air Resources Board (CARB). For word-panel subflooring, such as particleboard, select products that do not contain formaldehyde binder per the forthcoming CARB standard for formaldehyde emissions.

Potential Issues
FSC-certified and non-UF particleboard may be difficult to find and likely be priced above standard subflooring.

Related Strategies
MR118

References and Resources
"Formaldehyde in the Home," www.arb.ca.gov/research/indoor/formaldgl08-04.pdf

Forest Stewardship Council, www.fsc.org

135. Consider flooring made from certified or reclaimed wood

Kitchen, Bedroom
Buildings use a considerable amount of lumber. Careful consideration should go into researching the appropriate material for dimensional stability, minimizing use and waste, and determining the source and species of wood (avoiding sourcing endangered wood or wood from a fragile ecosystem).

Reuse of wood is ideal, a green solution, assuming the wood is dimensionally stable and does not have any lead

paint. Sourcing reused or reclaimed wood is another good way to reduce wood use.

For new wood, the high standards in wood production and harvesting practices are overseen by the Forest Stewardship Council. The FSC logo can now be found more often on wood and wood products at major and specialty home improvement stores.

Potential Issues

Ensure that reclaimed woods do not have old lead-based finishes. Some wood certification programs are more stringent than others, and some are backed by chain-of-custody paperwork to guarantee their certification.

Related Strategies

MR118

References and Resources

REGREEN Product Selection Resources, www.regreenprogram.org

136. Consider flooring made from natural or rapidly renewable materials

Kitchen, Bedroom

Products made using fast-growing and underutilized agricultural materials take strain off natural forests. Sheet products made from wheat, recycled waste paper and resins, and paneling made waste sorghum stalks and other plant fiber can make unique and more environmentally benign products.

Bamboo for flooring and paneling is a good use of a very rapidly growing plant product.

Cork and true linoleum are two durable, good substitutes to other mainstream kitchen flooring products. Cork flooring is made from the bark peeled off Spanish oak trees. It gives cushioning under foot and has good sound mitigation qualities. Natural linoleum is made much the way it has been for decades and contains wood and cork flours, colorants, and linseed oil. It is a very durable product that allows for endless design opportunities.

Potential Issues

Watch for formaldehyde content in glues and consider applicability in situations where water might be an issue. Pay attention to manufacturing processes when buying products manufactured overseas. Some products may also have odors that could irritate sensitive individuals.

Related Strategies

MR137

References and Resources

"Navigating the Flooring Ticket," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/802/C220

137. Refinish wood floors using environmentally preferable products

Living and Working, Gut Rehab

Reusing existing wood flooring has many positive environmental benefits, including the opportunity to show off beautiful woods that have been "on location" for years. But attention needs to be paid to how floors are refinished. Start by testing for lead paint and follow accepted practices for stripping or encapsulating it. When sanding and refinishing wood floors, provide active dust collection and seal off adjoining parts of the house and any air distribution registers to prevent contamination. When finishing wood floors with coatings, use low-VOC products, such as water-borne polyurethane.

Potential Issues

Unless proper care is not taken, refinishing older wooden floors can cause significant building contamination problems, posing a health risk to homeowners.

Related Strategies

IEQ159

References and Resources

"Buyer's Guide to Clear Finishes," www.greenhomeguide.com/index.php/knowhow/

138. Choose environmentally preferable carpet and rug products

Bedroom, Living and Working

Choices for greener carpeting and area rugs include the following:

- products made from natural materials, such as wool, cotton, jute, or hemp (but try to avoid wool treated with mothproofing and other pesticides);
- products that do not contain residues from the dyes and finishes used in manufacturing;
- products that do not have surface treatments to repel stains;
- products with low VOC offgassing, documented through independent, third-party testing, such as CRI Green Label Plus, GreenGuard, and FloorScore;
- products with high recycled content and made by companies that recycle old carpeting.

In addition, avoid carpet cushion that may contain brominated flame retardants (BFRs), such as product made from bonded polyurethane foam. Although the amount of BFR has dropped since Pentabromodiphenyl ether went of use in 2005, carpet cushion made from postconsumer recycled polyurethane foam may still contain residual BFR.

Once available only for commercial applications, carpet tile is now being produced in residential styles, patterns,

and textures. Carpet tile allow for easy replacement of small areas necessitated by staining, moisture damage, or wear.

Potential Issues
Examine manufacturer claims carefully; some may exaggerated or mislead. Residential carpet tile is not yet widely available; shopping around may be necessary.

Related Strategies
IEQ179, IEQ182

References and Resources
Carpet and Rug Institute, www.carpet-rug.org

Greenguard Environmental Institute, www.greenguard.org

139. Select carpet cushion that does not contain brominated flame retardants

Bedroom, Living and Working
Flexible polyurethane foam carpet cushion (underlayment) used to contain fairly high levels of brominated flame retardants (BFRs). Although the amount of BFR has dropped since penta BDE went of use in 2005, carpet cushion made from postconsumer recycled polyurethane foam may still contain residual BFR. Because polyurethane foam breaks down over time, these BFRs may be released into the house as dust. Various health concerns have been raised about BFRs, carpet cushion with postconsumer recycled content should be avoided unless the recycled sources are known not to contain BFRs.

Potential Issues
Natural-fiber carpet cushion may be difficult to find or more expensive.

Related Strategies
IEQ182

References and Resources
Carpet and Rug Institute, www.carpet-rug.org

Carpet Cushion Council, www.carpetcushion.org

Greenguard Environmental Institute, www.greenguard.org

Furniture and Fittings

140. Consider reusing clean existing cabinetry or buying salvaged

Kitchen
Should existing or recycled cabinets be in good shape, have a style that you are willing to work with, and can be refinished if needed, reusing cabinets can be a good idea. Some reconfiguring, new finishes, hardware, and sometimes new drawer and door fronts can be practical.

Another good choice for reuse of existing cabinetry is refacing. If the structural integrity and configuration of the existing cabinetry fits the client's needs, cabinet refacing is a good investment for the client and the environment.

Potential Issues
Improperly sized and styled cabinets may compromise good kitchen design. Make sure cabinets are in good shape and free of lead paint, mold, or other toxins.

Iamges:
- **Secondhand Bath Countetop**
- **Retail Architectural Salvage Center**

Related Strategies
IEQ159

References and Resources
Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

www.kitchencabinetrefacing.org/

"Taking a Green Approach to Furniture," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/943/C221

141. Consider reusing clean existing furnishings and fixtures or buying salvaged

Bathroom
Using salvaged cabinetry and plumbing fixtures can reduce the impacts of manufacturing new goods, as well as reduce the amount of material entering landfills. Although it makes sense to salvage and reuse certain bathroom fixtures—such as sink basins, tub and shower surrounds, and bathtubs—older, high-water-use toilets should not be reused; newer, water-conserving models should be used, such as the high-efficiency toilets that use at least 20% less water than the federal maximum of 1.6 gallons per flush.

Potential Issues
Make sure that older sinks can accommodate faucets with modern screw-in aerators to control water flow. With any painted salvaged product coming from a house built prior to the 1970s, test for lead paint.

Related Strategies
IEQ159

References and Resources
Building Materials Reuse Organization, www.buildingreuse.org/

142. Consider cleaning existing furniture or purchasing salvaged or antique furniture

Bedroom, Living and Working

Antique, salvaged, or reused furniture and accessories are a good use of resources but only if these items are clean and in good condition. Not only do salvaged goods reduce the environmental and energy impacts of manufacturing new goods, but they also reduce the burden on landfills. Be careful to avoid bringing furniture that contains dust, mold, or toxic finishes into a newly renovated space. Test painted furniture for lead paint. Thoroughly vacuum and clean any "new" used item outside the home before bringing it into the living space. Use green cleaning products and practices.

Potential Issues

The risk of lead contamination is significant with salvaged materials coming from houses built before the 1970s; always test for lead paint, and if it is found, follow accepted best practices for removal and sealing, or do not install.

Related Strategies

IEQ159, IEQ160

References and Resources

National Lead Information Center, www.epa.gov/lead/pubs/nlic.htm

143. Purchase the best, most durable furniture possible within agiven budget

Bedroom, Living and Working

Purchase tomorrow's antiques today. Well-made, durable furniture is a good financial investment, is less likely to go out of style than cheaper furnishings, and can be passed on for many generations. Examine workmanship and materials carefully and consider warranties, which may be indicative of expected life. With wood furniture, look for FSC certification, indicating that the wood came from well-managed forests.

Potential Issues

Often, within a given furniture budget, it is possible to get better-quality, more durable furniture by finding older, salvaged goods and spending money on reupholstering or cleaning. (See above)

Related Strategies

IDP1, MR118, IEQ159, IEQ192

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman – Associates III

144. Select ergonomic furniture and office equipment

Living and Working

Keeping homeowners healthy means looking beyond VOC emissions and control of mold and other contaminants; also consider posture and support when sitting and sleeping. Select ergonomically designed office furniture and seating for living spaces throughout a house. Select beds that will provide back support.

Potential Issues

In confined spaces that serve multiple uses, such as living rooms that serve as home offices, the same furnishings may serve multiple roles, so paying attention to ergonomics is particularly important.

Related Strategies

IDP6

References and Resources

"Computer Workstations," www.osha.gov/SLTC/etools/computerworkstations/index.html

145. Evaluate use of cabinetry and furniture made from particleboard or MDF

Kitchen, Basement, Bathroom

Conventional particleboard and medium-density fiberboard (MDF) produced with urea-formaldehyde binder is highly susceptible to moisture damage. Liquid water or even high humidity can swell these panel products, and repeated exposure to moisture can cause delamination or decomposition. Avoid cabinets and furniture made from these materials in moist locations; if they must be used, select more moisture-resistant products, such as particleboard and MDF produced with MDI (polyurethane) or phenol-formaldehyde binders. Most plywood and solid wood are significantly more moisture-resistant than standard particleboard and MDF. Sealing can also help to prevent moisture damage.

Potential Issues

Alternatives to urea-formaldehyde particleboard and MDF are more expensive, but in addition to greater moisture resistance, they result in much lower formaldehyde off-gassing.

Related Strategies

IDP5

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

"Taking a Green Approach to Furniture," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/943/C221

146. Select compact furniture that incorporates storage

Kitchen, Living and Working

With the growing trend in business that encourages employees to work from home, more and more manufacturers are providing home office furnishings that are compact and incorporate integral storage. Home office spaces are often shared with other functions, including living rooms, bedrooms, and dens, necessitating compact furnishings, including desks that fold up to look like cabinets.

Potential Issues

Choose office furniture with low-formaldehyde off-gassing.

Related Strategies

IDP10

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

"Taking a Green Approach to Furnitur," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/943/C221

147. Select solid furniture made from green and safe sources

Kitchen, Bedroom, Living and Working

With all furniture but especially in the bedroom, select furniture that will not emit significant awards of formaldehyde. Furniture made with conventional particleboard or medium-density fiberboard (MDF) that is produced with urea-formaldehyde binders should be avoided. More preferable is furniture made from solid wood or from manufactured wood products with soy-based, phenolic, or polyurethane (MDI) binders. Also look for furniture finished with zero- or low-VOC coatings and made with FSC-certified wood and other green materials.

Potential Issues

With furniture made from salvaged wood, testing for residual lead paint is recommended.

Related Strategies

IEQ159

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

"Taking a Green Approach to Furniture," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/943/C221

148. Select cabinets made from greener materials

Kitchen

Some stock and semicustom cabinet manufacturers offer cabinets made from FSC-wood (solid or veneers) with low toxic finishes. In addition, the boxes of the cabinets can be made from marine-grade plywood (not particleboard or interior-grade ply), which will emit less formaldehyde.

Totally custom cabinetry provides the opportunity to select all FSC-wood, potentially all solid wood boxes and drawer faces and doors, and green paints or finishes.

The popularity of kitchen and bathroom cabinets that look like real furniture provides an opportunity to incorporate furniture, antiques, or reclaimed pieces into the design. Certain design styles are easy to keep clean, both by the nature of the style and the materials used to make them. Look for cabinets that can be cleaned using the least toxic products.

Potential Issues

Green cabinetry may be only custom or semicustom which usually means a higher price point.

Related Strategies

MR118

References and Resources

Good Green Kitchens, Jennifer Roberts, Gibbs Smith, 2006

"Where Can I Find Wheatboard Unfinished Cabinets?," www.bayarea.greenhomeguide.com/index.php/knowhow/entry/1311/C221

149. Install environmentally preferable countertops

Kitchen, Bathroom

Examine the merits of using products with a higher environmental toll, such as exotic granite, versus those typically considered not very green, such as plastic laminate. Greener choices would include natural stone, tiles, manufactured solid surfaces (some with recycled content), and wood and plastic laminates with greener substrates. The durability and cleanability of the countertop are important considerations.

Support for the finished countertop should be constructed from green materials as well, such as an exterior-grade plywood, preferably from a certified wood source. When using substrates with any unsafe degree of chemical emissions, seal penetrations and exposed surfaces with an appropriate sealer or paint to block some of those emissions.

Potential Issues

It is difficult to find green countertops at the lower end of the price range, and it is very difficult to dissuade clients

from ordering granite which is often Italian and far from local.

Related Strategies
IDP1

References and Resources
"Green Countertop Know-How,"
www.greenhomeguide.com/index.php/knowhow/

150. Select furniture from suppliers that practice fair and safe manufacturing processes

Bedroom, Living and Working
Because the majority of our furniture and accessories manufacturing continues to be produced outside the United States and Canada, we are more and more separated from the sources of these goods. Finding accurate information about manufacturing processes and factory workers safety and well-being is challenging in our gglobal market. For example, some of the finishes that are safest for homeowners, such as manufactured wood products made with polyurethane (MDI) binders, pose significant risk to factory workers because MDI is highly toxic until fully cured. Purchase from local or U.S. companies with environmentally and socially responsible business practices.

Potential Issues
It is often difficult to be sure that a "U.S.-made" product is derived from U.S.-made components. For example, some particleboard and medium-density fiberboard (MDF) used in furniture making is foreign-made and significantly exceeds U.S. formaldehyde standards.

Related Strategies
MR147

References and Resources
Sustainable Furniture Council,
www.sustainablefurniturecouncil.org

151. Select upholstered furniture with care

Bedroom, Living and Working
Upholstered furniture is made up of an assembly of many different parts. From the hardwood framing and glues to the supporting parts such as webbing and springs to the foams, cushioning, and fabrics, each component can have health and environmental implications.

- Framing should be made from hardwoods, glued or attached with water-based glues. Framing is available from FSC wood, which is certified as coming from well-managed forests.
- Webbing is usually made from jute, and springs are made from steel. Ask the supplier or furniture manufacturer about the sources of these materials.
- Foams used for upholstered goods are typically made from synthetic materials that used to contain potentially harmful brominated flame retardants (BFRs). The BFR of greatest concern, pentaBDE, which went of use in 2005, and today upholstered furniture and bedding manufacturers are using fire barrier layers to achieve fire resistance. Salvaged upholstered furniture and mattresses will likely contain BFRs in the polyurethane foam. When BFRs are present, they may volatize or be released as dust as the foam breaks down over time. One solution with upholstered furnishings is to use products made with organic or "Pure Grow" wool, which is naturally flame resistant.

Potential Issues
It is very difficult to get information on flame retardants used in furniture, especially since fire resistance strategies have changed considerably in recent years; identify companies that have eliminated BFRs or halogenated flame retardants across their product lines.

Related Strategies
MR118, IEQ189

References and Resources
"Furniture, Mattresses, and Flame Retardants,"
www.thegreenguide.com/docprint.mhtml?i=106&s=pbde

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

152. Choose environmentally preferable fabrics

Bedroom, Living and Working
Choices in more environmentally friendly fabrics have grown dramatically over the past half-dozen years. Improvements in sources for raw materials, as well as better manufacturing processes, have provided designers with many durable and attractive fabrics in both natural and synthetic goods. Best choices include fabrics with no residual chemicals or heavy metals and fabrics made from organically grown, rapidly renewable resources such as cotton, hemp, wool, and wool-blends. Greener synthetic fabrics include those made with recycled plastic content. Look for fabric made by companies that closely monitors their overseas manufacturing for best practices.

Potential Issues
Although many greener and more attractive textiles are becoming available, we still need to consider the cultural requirements (irrigation, pesticides) of any plant materials used, manufacturing process and locations, and the fabrics carbon footprint. Recycled polyester fabrics should be low in, or free of, antimony.

Related Strategies
IDP6, IEQ189

References and Resources

"Eco-Tip: Mini-Directory of Green Fabrics," www.treehugger.com/files/2007/02/ecotip_mini_dir.php

153. Support local artisans as well as indigenous peoples

Bedroom, Living and Working

Support sustainability by purchasing art, home decorations, and accessories from local artists and crafts people, and from indigenous peoples who maintain sustainable lifestyles and protect their ecosystems. The use of locally produced goods not only supports local economies but also avoids the added environmental impacts of shipping items from remote locations.

Potential Issues

Most products supporting indigenous peoples must be shipped long distances.

Related Strategies

IDP6

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman – Associates III

www.tenthousandvillages.com

154. Choose environmentally friendly outdoor furniture and accessories

Outdoor Living

Outdoor furniture is a challenge because the weather can quickly degrade many materials. The majority of outdoor furniture sold today is made from virgin plastic. Plastic furniture is resistant to moisture but degrades in sunlight, which significantly reduces the expected life. Greener options include FSC-certified wood furniture and furnishings made from wood and recycled high-density polyethylene (HDPE) composite material.

For clients who want to do outdoor cooking, look for durable products that are designed to withstand the elements, including stainless steel grills and terracotta fire pots.

Potential Issues

Durability is crucial with outdoor furnishings, and care is an important factor. Outdoor furniture should be stored under cover during months when it is not being used.

Related Strategies

IDP1, MR109

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

Use

155. Provide for paper recycling

Living and Working

In a home office or other space in the home where mail is sorted and wastepaper generated, provide a paper recycling receptacle. Additional storage may be required for paper recycling in a garage or utility room, especially for clients who subscribe to newspapers, which generates considerable paper waste.

Potential Issues

Check with the municipal solid waste authority to find out what forms of paper are accepted for recycling. Some areas may not accept boxboard, for example, or may require that corrugated cardboard be separated.

Related Strategies

IDP12

References and Resources

"Setting Up a Home Office: Making Environmental Choices," www.epa.gov/epaoswer/aging/home-off.pdf

156. Select materials that are easy to clean

Kitchen, Bathroom

Some interior finish materials inherently need stronger chemicals to keep them safe and clean. Choosing solid surfaces that do not need regular applications of treatments and sealers will reduce the use of unsafe chemicals.

Potential Issues

Color can play an important role in the maintenance and service life of finish materials, particularly fabrics.

Related Strategies

IEQ196

References and Resources

"Good, Clean Fun: How to Clean Your House without Hurting the Planet," www.grist.org/advice/possessions/2003/03/18/possessions-cleaning/index.html

Unified Green Cleaning Alliance, www.zerowaste.org/ugca.htm

157. Consider using bulk-product dispensers for body care products

Bathroom

Bulk dispensers allow for the purchase of body care products in bulk, reusing plastic containers, and thus reducing the number of plastic bottles thrown away. Many body care products available in bulk—usually found at health food stores and co-ops—are made from healthier ingredients by companies that have progressive policies, including cruelty-free product testing.

Potential Issues

Bigger storage containers for body products require more storage space, which a small bathroom may not have. Investigate nearby or adjacent storage to substitute for bathroom storage of bulk containers.

Related Strategies

IDP10

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

Indoor Environmental Quality (IEQ)

General Design and Construction Strategies

158. Control spread of pollutants

All Projects

During any remodeling project or the construction of an addition, particularly when the house is occupied, it is very important to keep contaminants from the construction site out of the house. Many construction activities, such as concrete grinding, tile and backerboard cutting, pipefitting, drywall finishing, caulking and foam sealing, gluing, and painting can introduce significant quantities of indoor air contaminants. To control such contaminants, first avoid creating them by using zero-VOC paints and finishes, conducting dust-producing activities outside if possible, and capturing pollutants as they are produced (with sanding and drywall finishing, for example). Second, seal off the construction area from the rest of the living space with tightly sealing temporary partitions. Third, operate temporary exhaust fans in the area under construction to maintain negative pressure and keep airborne contaminants from flowing into adjacent interior spaces; alternative, the adjacent living space can be pressurized. And fourth, seal off ducts, air distribution registers, and air inlets for ventilation systems to avoid contaminating ducts and HVAC equipment.

Potential Issues

Most indoor contaminants come from demolition of existing space rather than from new construction activities. Be particularly careful in isolating all demolition activities from the rest of the house. When you use an exhaust fan to depressurize a space, make sure that this negative pressure does not affect the function of whatever gas appliances may be in the space or adjacent to it.

Related Strategies

IDP5

References and Resources

"Indoor Environmental Quality during Construction Projects," www.ehs.uci.edu/programs/ih/IEQinConstruction.html

"Addressing Indoor Environmental Concerns during Remodeling," www.epa.gov/iedweb00/homes/hip-concerns.html

159. Test for, and appropriately handle, hazardous materials

Kitchen, Basement, Home Performance, Gut Rehab

Although some hazardous materials like mold and asbestos are fairly apparent, it is usually a good idea to test for the less obvious potential hazards in an older home. Hazards such as lead paint and persistent pesticides generally cannot be identified without testing, and even visible hazards like mold and asbestos may be hard to identify. Various test kits are available to aid in identification.

Wood trim painted with lead paint can be removed and disposed of, stripped and sealed off-site, or painted with a special lead-encapsulant coating. Asbestos should be encapsulated or removed by a trained asbestos mitigation contractor. Wood contaminated with persistent pesticides, such as chlordane, should be removed and disposed of at a hazardous waste landfill. Mold should be cleaned by someone trained in mold mitigation, or the mold-contaminated materials should be removed and disposed of. Whenever salvaged materials are used in a remodeling project, they should be tested for lead paint before installation and treated appropriately or avoided.

Potential Issues

If not properly dealt with, problems with hazardous materials can be exacerbated by releasing contaminants into the house. Be aware of potential liability exposure when dealing with such hazards such as asbestos, lead paint, and mold.

Related Strategies

IDP5, IEQ160

References and Resources

"Hidden Environmental Hazards for the Home Remodeler," www.montana.edu/wwwcxair/remodel.htm

"Playing It safe: How to Keep Your Ffamily Out of Danger During a Remodel," www.consumerreports.org

160. Conduct lead-safe work

Home Peformance, Gut Rehab

Many older homes still have lead-based paint that can pose a hazard for workers and the occupants. Lead-safe work practices should be followed during any remodeling work, including weatherization projects.

Potential Issues
Follow local regulations for worker protection, risk mitigation, and homeowner notification for any work that could or does involve lead-based paint.

Related Strategies
IDP5, IEQ159

References and Resources
Weatherization Assistance Program, www.waptac.org/

161. Install track-off mats at exterior doors

Kitchen, Major Addition, Gut Rehab, Deep Energy Retrofit
Area rug and track-off mats at doorways are an excellent way to control dirt and pollutants from coming into the home through major entryways. Design entryways to provide adequate space for track-off mats so that people and pets entering scuff their feet several times.

Potential Issues
Track-off mats will get wet, so make provisions for that. The surface beneath the mats should be impermeable and easily washable (such as concrete, stone, or tile), and the mat should be easily removable for cleaning.

Related Strategies
IDP5, IDP9

References and Resources
"The Sensible House Project: Contaminants," www.sensiblehouse.org/tu_hlth_toxics.shtml

162. Clean up and dispose of pressure-treated sawdust and shavings appropriately

Outdoor Living
Sawdust from all but sodium silicate pressure-treated lumber is potentially hazardous and should be collected during construction and properly disposed of. Collect sawdust and shavings and dispose of them through landfilling. Never burn pressure treated scraps.

Potential Issues
Working outdoors, it may be difficult to collect sawdust. When working on a deck, spread a dropcloth beneath to capture sawdust.

Related Strategies
MR107

References and Resources
"Lumber Pressure Treated with CCA," www.dec.ny.gov/chemical/8790.html#epaalt

Foundation

163. Install radon mitigation system

Major Addition, Basement
Retrofit radon mitigation systems depressurize the soil underneath the basement slab either through a sump pit or piping that goes through the basement floor and into a small excavated hole in the soil. Then piping runs either through a chase inside the house through the attic and out the roof or out the side of the house at about first floor level and then extends up to roof level. In either case, an exhaust fan is installed in-line that runs 24/7 to pull soil gases up and out of the conditioned space of the house. If the radon piping is chased through the house, the exhaust fan is installed in the attic; if the radon piping is run outside the house, the fan must be installed outside as well.

Potential Issues
Finding a pathway for the radon piping from the basement to the attic can be challenging. Finding an inobtrusive location on the outside of the house for exterior piping and an in-line fan can be challenging too. With the exterior approach, make sure that the piping is set up in such a way that any condensation in the piping drains back past the fan and does not affect its performance.

Image: Air-Tight Sump with Radon Exhaust System


Related Strategies
IDP5, IDP19

References and Resources
Radon Reduction Techniques for Existing Detached Houses, Document EPA/625/R-93/011, October 1993

EPA, www.epa.gov/radon/index.html

164. Install CO and smoke alarms

Home Performance, Major Addition, Gut Rehab, Deep Energy Retrofit
Many local building codes require the installation of smoke alarms during home renovation projects, but carbon monoxide (CO) detectors should also be installed in homes with any type of combustion equipment or unvented space heaters, or where backdrafting is a potential CO hazard, as in a house with a fireplace, woodstove, or atmospherically vented water heater, boiler, or furnace.

Potential Issues

The type of CO monitor is important as well as its location; follow manufacturer restrictions on CO monitor location.

Related Strategies

EA104

References and Resources

"Basic Information: Carbon Monoxide," www.epa.gov/iaq/co.html

Building Envelope

165. Isolate attached garages

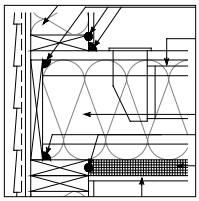
Kitchen, Bedroom

Rooms adjacent to attached garages (most commonly the kitchen and/or the "bonus" room—be it a bedroom, family room, or playroom) have poor insulating and air-sealing details. For health, safety, and energy efficiency reasons, it is imperative that the air and thermal barriers be complete and continuous between the two spaces or that the garage space be depressurized with a high-efficiency exhaust fan or both.

Potential Issues

The garage ceiling and interior wall(s) will already have gypsum board sheathing per the building code, requiring its removal to reinsulate and air seal the shared framing assemblies. Thermal comfort or odor problems from the garage may indicate a need for better insulating but a blower door test will certainly confirm the problem.

Detail: Air Sealing at Garage Ceiling



Related Strategies

IDP5, EA54

References and Resources

"EPA Energy Star Thermal Bypass Checklist," www.energystar.gov/

"6 Steps to a Healthier Garage," www.offroaders.com/tech/healthier-garage.htm

HVAC

166. Install effective kitchen ventilation

Kitchen

A kitchen range hood fan exhausted to the outdoors is a combustion safety requirement when gas kitchen appliances are installed and an odor and moisture control strategy for both gas and electric stoves. The fan should have, at a minimum, an Energy Star rating, which ensures an efficacy of at least 2.8 cfm/watt, a maximum sound level of 2.0 sones, and fluorescent lighting for products with integral lights. Quiet fans are important because homeowners are unlikely to use noisy fans.

It may also make sense to provide whole-house ventilation with an exhaust port in the kitchen. The best whole-house ventilation systems are balanced (two fans with roughly equal incoming and outgoing air flow). In cold climates provide heat recovery to capture heat from the outgoing air flow.

Potential Issues

The negative pressure exerted by some powerful range hoods can be problematic when combined with operation of other equipment, such as clothes dryers and fireplaces or woodstoves. A worst-case depressurization test can be helpful in identifying this problem. One solution is to make sure that all major combustion equipment is sealed combustion or power-vented.

Related Strategies

IDP2, IDP4, IEQ171

References and Resources

Home Ventilating Institute Library, www.hvi.org/resourcelibrary/library.html

"Oversized Kitchen Fans—An Exhausting Problem," www.homeenergy.org/archive/hem.dis.anl.gov/eehem/99/990113.html

167. Install effective bath ventilation

Bathroom

Because so much moisture is produced in a bathroom, ventilation is extremely important. A bath fan should vent to the outdoors rather than attic. Keep duct runs as short as possible with few sharp bends (to minimize pressure drop and loss of effectiveness). Specify a durable fan rated for continuous operation, even though the cost will be higher than the least expensive bath fans available. An energy-efficient fan motor will save energy and money, particularly if the fan will serve whole-house ventilation needs. Size the fan according to the ventilation needs it will be satisfying and the pressure-drop from the ducting; most bath fans should move 50 to 75 cubic feet per minute (cfm). The fan should also be as quiet as possible; a maximum of 1.5 sones is recommended, and below 1.0 sones is preferable. Ducting should be installed to minimize vibration and noise. The most common control for a bath fan is a simple on-off switch next to the light switch; more sophisticated controls provide for automatic operation based on humidity level, automatic shutoff a certain period of time after the lights are turned off, or automatic

operation throughout the day—either continuous or intermittent. The latter control option is called for if bathroom fans are being relied upon to satisfy the home's whole-house ventilation needs.

Potential Issues

The key to ventilating with bath exhaust fans is getting people to use them. They must be quiet and often hard-wired to the light or placed on a mandatory timing cycle.

Related Strategies

IDP2, IDP4, IEQ171

References and Resources

"EPA Energy Star Ventilating Fans," www.energystar.gov/

Home Ventilating Institute, www.hvi.org

168. Provide appropriate venting of all combustion-based heating and water-heating equipment

Gut Rehab, Deep Energy Retrofit

Improperly vented or unvented combustion equipment can introduce combustion gases into a house through backdrafting. Backdrafting most commonly occurs with gas- or oil-fired heating equipment that relies on natural draft for venting the combustion products up a chimney. (Natural draft venting is the process by which lightweight flue gases naturally rise up a chimney due to their buoyancy.) To prevent backdrafting, only sealed-combustion or power-vented combustion equipment should be installed. Most of the high-efficiency furnaces, boilers, and water heaters sold today already incorporate power venting or sealed combustion, but many older models do not. Install a carbon monoxide detector whenever combustion heating and water-heating equipment is installed to warn occupants of combustion gas spillage or malfunctioning power-venting fans.

Unvented combustion heating equipment, such as vent-free gas stoves and gas fireplaces, should never be installed in any house—especially an energy-efficient, tight house. In addition to releasing small quantities of carbon monoxide and other combustion byproducts, unvented combustion devices introduce significant quantities of water vapor, which can cause moisture problems.

Potential Issues

Particularly in tight homes, kitchen range-hood fans (especially downdraft and commercial-style top-venting models), outdoor-venting central vacuum cleaning systems, and woodstoves and fireplaces, can depressurize a house and exacerbate backdrafting. Conduct a worste-case depressurization test as cited below.

Image: Sealed Combustion, Condensing Efficiency Gas Furnace

Related Strategies

IDP2, IEQ166

References and Resources

"Backdrafting: Causes and Cures," www.homeenergy.org/archive/hem.dis.anl.gov/eehem/91/910512.html

"Combustion Safety Test Procedure for Vented Appliances," www.bpi.org/documents/gold_sheet.pdf

169. Consider stand-alone equipment to address moisture

Basement, Living and Working

If moisture problems are limited to only one area of the house, such as a basement or home office, consider a stand-alone dehumidifier. Dehumidifiers are rated by moisture removal capacity and include either integral receptacles to collect water (which have to be regularly emptied) or a drain line that can lead to a floor drain or outdoors.

Potential Issues

Dehumidification is most effectively accomplished with whole-house air distribution systems.

Related Strategies

IDP19, IDP24, IEQ173

References and Resources

EPA Energy Star Dehumidifiers, www.energystar.gov/

170. Provide for forced-air system pressure relief

Bedroom

There are basically five ways to address pressure relief in homes with forced-air HVAC systems when the doors to rooms are closed: dedicated return ducts, operable interior transoms, jump ducts, transfer grilles, or undercutting doors (at least 1.5 inches).

Potential Issues

Negative pressure in a bedroom may be evidence of an improperly balanced forced-air distribution system. Carry out a room-to-room pressurization test to determine the extent of the problem.

Related Strategies

IDP5, EA52, IEQ168

References and Resources

"Transfer Grilles,"
www.buildingscienceconsulting.com/resources/mechanical/

"Pressure Relief: The Hows and Whys,"
www.advancedenergy.org/buildings/svenews/index.html#pressure

"Minimizing Energy Losses In Ducts,"
www.eere.energy.gov/consumer/your_home/

171. Provide fresh air as part of ventilation system

Bedroom

In tight houses, mechanical ventilation is extremely important. In fact, most experts now recommend that nearly all houses have mechanical ventilation. Relying on natural ventilation through operable windows may be fine if there is an adequate pressure differential between indoors and out (created by, a breeze or significant difference in temperature), but during the spring and fall swing seasons, open windows may not provide adequate ventilation. Also, for those with pollen allergies or who live in smoggy urban environments, keeping windows open at all may not be practical. Rely on fresh air either supplied directly to the living areas in a dedicated ventilation system or delivered through the distribution ducts of an HVAC system. With a balanced whole-house ventilation system (in which two fans are used—one to exhaust stale indoor air and another to deliver fresh outdoor air), fresh air should be delivered to locations in the house where homeowners will spend the most time, such as bedrooms and living rooms, and exhaust air should be removed from locations where moisture or pollutants are generated, such as kitchens, bathrooms, and hobby rooms. In cold climates, energy performance of a balanced ventilation system can be improved by using, heat-recovery ventilator (HRV) which recovers heat from the outgoing air stream and transfers it to the incoming fresh air. If an exhaust-only ventilation system is being used (in which fans exhaust air and make-up fresh air is provided naturally), passive inlet ports should be provided in bedrooms and other living areas. Advanced controls are available for mechanical ventilation systems to operate them continually, intermittently, or based on conditions in the home (such as humidity or carbon dioxide levels).

Potential Issues

Properly balancing ventilation systems is important. Improper balancing or use of exhaust-only ventilation, without fresh-air make-up ports, may depressurize the house and draw in radon and other soil gases. Follow the new ASHRAE 62.2 Ventilation standard in high-performance remodeling work.

Related Strategies

IDP5, EA69

References and Resources

"Read This Before You Ventilate,"
www.buildingscienceconsulting.com/resources/mold/

ASHRAE Standard 62.2: Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, ASHRAE

172. Provide for additional ventilation and air-conditioning needs in certain activity areas

Living and Working, Outdoor Living

Home offices with copiers and laser printers, hobby rooms where paints or adhesives are used, and garages or storage areas where vehicles or hazardous substances are stored all may require higher ventilation rates than other areas in a home. Home offices with significant equipment may generate enough extra heat that more air-conditioning is required. Work with a mechanical engineer to determine these additional ventilation and cooling loads. With whole-house ventilation systems, provide for operation at a higher airflow rate in locations where significant pollutants are generated. If a whole-house ventilation system is not being installed, provide separate exhaust fans in these locations, with passive make-up air vents.

Potential Issues

Whenever extra exhaust ventilation is added to a home, install no more cfm capacity than is required to manage the extra contaminant load the activity represents. And whenever exhaust ventilation is added, a whole-house depressurization test should be conducted to determine what happens to any gas appliances or radon if every exhaust component in the home is operating simultaneously.

Related Strategies

IDP5

References and Resources

"Ventilaton and Air Quality in Offices,"
www.epa.gov/iaq/pubs/ventilat.html

ASHRAE Standard 62.2: Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, ASHRAE

173. Provide for additional air filtration

Bedroom

In general, whole-house filtration systems, integrated with air-handling equipment, are more effective than stand-alone room units. Providing stand-alone, room-sized air-filtering equipment might be advised, however, if the house HVAC system does not provide the needed filtration in certain rooms, such as bedrooms. Room air cleaners that use fans to push air through filters or electrostatic precipitators are far more effective than units without fans; avoid the latter. Size air-filtering equipment to room air volume and choose a unit that removes

pollutants with activated carbon and good HEPA filtration. Choose the most energy-efficient unit available.

Potential Issues

Never install air cleaners that generate ozone, which is a dangerous pollutant. Some disreputable companies continue to market ozone generators for standard household use.

Care must be taken in adding higher-efficiency air filters to central forced-air systems; make sure that the pressure drop associated with installation of the air filter can be met by the existing air handler motor, or upgrade the air handler motor to deal with it.

Related Strategies

IDP5, IEQ169

References and Resources

"Guide to Air Cleaners in the Home,"
www.epa.gov/iaq/pubs/airclean.html

"High-Efficiency Whole-House Air Filtration,"
www.toolbase.org

174. Install appropriate HVAC in finished basement

Basement

Many basements need active ventilation and dehumidification much more than they need active space cooling and heating. Make sure that finished basement spaces have both carbon monoxide (CO) monitors and humidistats along with conventional thermostats. If a stand-alone dehumidifier is used, it should be Energy Star–rated. (Note that dehumidifiers with scroll wheels move air more efficiently than those with paddle fans.)

Potential Issues

Be careful about relying upon your space-cooling system to dehumidify, particularly in basement spaces. Check the sensible heat ratio (SHR) of the existing or new air-conditioning system, and where high humidity is a problem, make sure that the SHR is .75 or less. Seek the advice of a qualified mechanical engineer if uncertain about moisture dynamics of mechanical equipment.

Related Strategies

IDP5, EA63, IEQ169

References and Resources

Energy Star,
www.energystar.gov/index.cfm?c=dehumid.pr_dehumidifiers
www.energystar.gov/index.cfm?c=vent_fans.pr_vent_fans

Plumbing

175. Install undersink water filtration system

Kitchen

Undersink water filters remove contaminants from tap water and improve its taste, thus reducing the likelihood that homeowners will buy bottled water (a significant source of packaging waste). There are a number of options for water treatment, including reverse-osmosis and ultraviolet (UV) treatment, but most common and least expensive are activated carbon or specialized-media filters installed under the kitchen sink with a special drinking-water faucet. Tap water is forced through filters that remove particles as well as a wide range of contaminants, depending on the media used. The filter cartridges are replaced as needed, typically after several months of use.

Potential Issues

Although undersink water filters rely on water pressure to operate, and thus no energy waste is generated when filters are replaced, and wastewater may be generated with systems that involve backwashing of the filter. Consider lab testing of the water to determine whether installation of a filter is justified. .

Related Strategies

WE41

References and Resources

"Consumer Guide to Water Filters"
www.nrdc.org/water/drinking/gfilters.asp

176. Install water filter on showerhead

Bathroom

Although some experts recommend whole-house water filters, it often makes more sense to limit filtration to the kitchen sink to filter drinking water (See 175) and showerheads to filter the water homeowners use for showering. Screw-on showerhead water filters can remove chlorine from water-treatment chemicals and various compounds that may form when chlorine reacts with organic material in water, such as trihalomethanes, chloroform, and trichloroethylene. Showerhead filters typically rely on charged copper- and zinc-based granules which remove chlorine by changing the free chlorine atoms into charged chlorine ions that are then precipitated (this is the principle of a KDF filter), or activated carbon filtration, or a combination of the two. The result is shower water from which most of the chlorine-based contaminants have been removed.

Potential Issues

Most showerhead filters are screw-mounted and install on the shower step, above the showerhead. They can add several inches to the showerhead, necessitating mounting the showerhead higher in the shower stall. Showerhead filters have to be replaced regularly (typically every three to six months) to remain effective.

Related Strategies

EA43

References and Resources

Santa Barbara Green Remodeler Checklist, www.greendifference.org/downloads/bgsb-remodel-list.pdf

Lighting and Electrical

177. Use prudent avoidance with electromagnetic fields

Bedroom

There remains a great deal of uncertainty about health risks from electromagnetic fields (EMF), but evidence suggests that prudent avoidance strategies can minimize homeowner exposure to these fields. This is particularly important in bedrooms, where people spend so much time. Use a gauss meter to test for magnetic fields and carry out measures to minimize exposure to those fields. Common sources of high EMF include improper wiring of three-way switches (in violation of electrical code), which creates a current loop; old knob-and-tube wiring (which should be replaced for safety reasons as well); and accidental grounding of metal-sheathed (BX) electrical cable to grounded water pipes. Keep service panels away from heavily used interior spaces—especially bedrooms—and minimize high-current wiring runs along the most-used spaces.

It is also a good idea to keep electronic devices that generate significant magnetic fields (including some bedside clocks) at least several feet from beds.

Potential Issues

Scientists are not in agreement about the level of risks from EMF fields.

Related Strategies

IDP6, MR121

References and Resources

"Exposure to Radio Frequency Electro-Magnetic Fields," www.epa.gov/EPA-IMPACT/2003/September/Day-08/i22624.htm

"Electromagnetic Pollution," www.buildingbiology.net/elpo.html

The Collaborative on Health and the Environment, www.healthandenvironment.org

178. Provide controllable interior shading

Living and Working

Most rooms that are actively used during the daytime, such as home offices, should have controllable blinds or shades on windows to allow users both to block glare and to control heat gain. Although useful in most rooms, controllable shading is most important on east- and west-facing windows. Venetian blinds, which allow sunlight to be directed upward while controlling direct glare, are an excellent choice for sun control, and accordion-type blinds that fit into a track and create a layer of trapped air when lowered are effective in controlling heat loss.

Potential Issues

Inward-opening casement (tilt-turn) windows generally cannot be fitted with interior blinds or shades. Ensure that interior window treatments do not block HVAC registers, that the positive air flows created by registers below windows are not negated or compromised, and that excess heat is not trapped behind close-fitting, inside-mount window shades.

Related Strategies

EA48, EA62, EA83

References and Resources

"Window Orientation and Shading," www.fsec.ucf.edu/en/consumer/buildings/homes/windows/

Floor and Flooring Finishes

179. Avoid carpeting in high moisture areas

Kitchen, Bathroom

Carpeting and soft porous floor coverings give comfort under foot and reduce acoustical problems. But in the best of situations, carpet is difficult and to clean or dry out if it gets wet. Additionally, carpet is often installed over a carpet cushion that can break down and generate more dust: with older carpet cushion materials or materials made from recycled polyurethane, brominated flame retardants may be released into the space as the materials break down over time. In below-grade areas or in rooms where water spills are inevitable, carpet should not be used. Even carpet products that are made exclusively of synthetic materials can harbor dust, dust mites, and materials that are tracked into the house from outdoors.

Potential Issues

Some areas with high moisture potential are rooms where carpeting adds the benefits of warmth, cushioning, and sound control.

Related Strategies

IDP4, IDP20, MR156, IEQ196

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

"House Dust Mites–OSU Extension Fact Sheet," www.ohioline.osu.edu/hyg-fact/2000/2157.html

180. Choose hard-surface flooring

Kitchen, Bathroom, Basement

Hard surface flooring includes finished concrete, tile, terrazzo, and resilient floor tiles (wood flooring strategies 133, 135, and 137). Concrete can provide a high-quality

finished floor in slab-on-grade applications. Using the concrete slab as the finished floor reduces material use. New grinding and polishing equipment and sodium silicate densifying agents concrete sealant, and colorants can make the floor attractive and. Fly ash (or other pozzolanic material) content—a byproduct from the production of electricity from coal-burning power plants—can be added to the concrete mix to reduce the amount of portland cement, which is very energy-intensive to produce.

Tile and terrazzo flooring are durable, easy to maintain, and healthy flooring choices. Care should be taken to use low-toxic glues, grouts, and grout sealers in their installation. Some manufacturers are offering tile and terrazzo products with both pre- and postconsumer recycled content.

Hard surface floors may be preferable to carpeting in bedrooms because they are easy to keep clean, especially under the bed. Area rugs can provide cushioning under-foot and are removable for cleaning or drying if they get wet.

Potential Issues

Concrete has high embodied energy, but using a concrete slab as a finished floor usually saves materials because it obviates the need for a separate finished floor.

Related Strategies

IDP5, MR114, IEQ191

References and Resources

LEED for Homes program, www.usgbc.org/ShowFile.aspx?DocumentID=2267 (Materials & Resources)

"Concrete Floor Finishes," www.toolbase.org

"Floor Score: What and Why," www.rfci.com/int_FloorScore.htm

181. Install appropriate finish flooring in basements

Basement

The appropriate finish flooring for a basement depends in large part on the moisture profile of everything underneath it. If both liquid water and vapor have been decoupled from the basement floor system (with a comprehensive drainage system, capillary break, or vapor retarder or barrier—See "Upgrade Basement Floor", then a wide range of finish flooring can be used. But if the basement floor system will dry to the interior, then a vapor-permeable finish flooring must be used, and there are fewer choices; examples include finished concrete, concrete painted with an appropriate acrylic-latex paint, and terracotta tile pavers. Wall-to-wall carpeting is not recommended (even though it is highly vapor permeable), particularly if rigid insulation has not been installed as a part of the basement floor system (which would maintain a warmer floor surface where water would be unlikely to condense). Do not use a finished flooring material unless you know its vapor permeability.

Potential Issues

Sound can be a significant concern in finished basements. If carpeting is part of the abatement strategy, use throw rugs rather than permanently secured wall-to-wall carpeting; the former can be easily removed for periodic cleaning and drying should they get wet. It is very important to couple this with control of interior relative humidity.

Related Strategies

IDP25, IEQ179

References and Resources

Basement Solutions of New England, www.basementsolutionsne.com/delta_flooring.html

DRIcore Subfloor System, www.dricore.com/en/eIndex.aspx

"Upgrading Below Grade," www.pathnet.org/sp.asp?id=1800

182. Use area rugs instead of wall-to-wall carpeting

Bedroom

Wall-to-wall carpeting, large carpets, and their cushioning, are very difficult to clean or remove for drying should they get wet. Because they harbor dirt, organic detritus, and moisture, they can become a significant source for mold and mildew. Hard-surface floors can be enhanced with small area rugs that can be removed for cleaning or drying. Avoid biocide-treated (moth-repellent) wool or cotton carpets.

Potential Issues

This criterion may narrow the range of choices on furniture and fittings and add to cost.

Related Strategies

IDP5, IEQ180

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

Wall and Ceiling Finishes

183. Use nonpaper-faced gypsum board in moist areas

Bathroom, Basement

A variety of interior wallboard products can satisfy building code requirements regarding smoke and combustibility yet are also more moisture and mold resistant than conventional paper-faced drywall. These

products are either monolithic (with cellulose fibers dispersed through the board) or faced with fiberglass rather than paper. Since most of these sheathings are still porous, they should be installed with a minimum 3/16-inch free space between the board margins and concrete. Moisture-resistant (MR) "greenboard" with wax emulsifiers, but still with paper facings, is not recommended

Potential Issues

All of the nonpaper faced alternative gypsum boards are more expensive than conventional paper-faced products.

Related Strategies

IDP1, IDP24, MR126

References and Resources

"Read This before You Design, Build or Renovate," www.buildingscienceconsulting.com/resources/foundations/

184. Limit use of wallcoverings in high moisture areas

Kitchen, Bathroom

To prevent mold and mildew, avoid the use of impermeable, surface-applied wallcoverings, impermeable in most applications. Wallcoverings can trap moisture in the wall surface or within the wall cavity. Permeable wall treatments, such as paints and clay surface treatments, or uncoated wallcoverings are recommended for these applications. The need to clean a wall may pose a conflict in this regard; for maximum cleanability, an impermeable wallcovering might be desirable. The use of an impermeable layer on the interior of any building assembly means that this assembly must be capable of drying to the exterior. (see 25 "Assess vapor profiles of new assemblies").

Potential Issues

Design wall systems to minimize the transfer of moisture into the wall cavity while also providing breathability to allow wall cavities to dry.

Related Strategies

IDP25

References and Resources

"Understanding Vapor Barriers," www.buildingscience.com/doctypes/digest

185. Use low- or zero-VOC interior paints and finishes

Kitchen, Bathroom, Bedroom

Paints, coatings, and clear finishes can contain a wide range of hazardous chemicals, such as volatile organic compounds (VOCs), which are detrimental to human health. Safer products are readily available through major coating manufacturers. Although most include components that are derived from petroleum or natural gas, many are now waterborne (meaning that water, instead of solvent, is the carrier). These waterbased, acrylic products are strong and durable. Low- or zero-VOC products can be found in most tint bases to allow creation of nearly any color desired. Additionally, a few manufacturers are producing paints and coatings formulated for people sensitive to the chemical compounds found in low- and zero-VOC paints and coatings. Plant chemistry paints and coatings are formulated using (almost exclusively) plant oils and minerals. Natural clay and lime plasters provide another healthy alternative. Careful selection of safer paints and coatings is especially important in bedrooms, where people spend many hours.

Recycled paint is also available for use as primer. These paints are produced from unused paint collected at solid waste facilities. A number of brands are marketed widely.

Potential Issues

Low- and zero-VOC paints may still contain chemical compounds that could have adverse health effects for some individuals. Some alternative coatings are more expensive than solvent-based choices.

Related Strategies

IDP5, MR130

References and Resources

REGREEN Product Selection Resources, www.regreenprogram.org

186. Limit use of VOC-emitting wallcoverings

Bedroom

Plastic-coated paper and vinyl wallcoverings are popular because they are very durable and easy to clean, but PVC (vinyl) wallcoverings contain phthalate plasticizers. Phthalates are endocrine disruptors (compounds that mimic natural hormones) that many experts consider health hazards. The PVC itself may be hazardous when its entire life cycle is considered. Finally, plastic wallcoverings block moisture, which can result in mold. Avoid these products, especially in bedrooms.

Potential Issues

Paper and natural-fiber wallcoverings are susceptible to moisture damage and mold if they stay wet, and they cannot be washed as easily as plasticized wallcoverings, so great care may be required in protecting these surfaces from soiling.

Related Strategies

IDP5, MR156

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

187. Use low- or zero-VOC construction adhesives, caulking, and sealants

Kitchen, Basement

As with paints and coating products, there are many high-quality caulks and sealants for interior and exterior applications with very low VOC levels. Many major manufacturers are making these safer, durable products readily available.

Potential Issues

Along with any health-related features like VOC levels, it is important to ensure that the selected product performs well for the particular application.

Related Strategies

IDP5, EA54

References and Resources

U.S. Green Building Council, www.usgbc.org/ShowFile.aspx?DocumentID=2267 (Materials & Resources)

REGREEN Product Selection Resources, www.regreenprogram.org

Furniture and Fittings

188. Choose furniture and fittings that will not absorb moisture

Basement

Carpet, furniture made from standard particleboard and MDF, fully upholstered furniture, fabrics, and other porous products may absorb moisture, making them inappropriate choices for basement living spaces and other areas that may experience high humidity. Hard-surface flooring with smaller area rugs, solid wood furniture, loose cushion seating pieces, and solid-slat window shades would all be safer choices in these areas.

Potential Issues

This criterion may narrow the range of choices for furniture and fittings.

Related Strategies

IEQ191

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman – Associates III

189. Choose furniture finished with least-toxic products

Bedroom, Basement

Other than plastic and plastic-laminated furniture products, most furniture is made from wood and is nearly always coated with some type of finish to protect its surfaces from wear and tear. The majority of these finishes are solvent-based synthetic stains and lacquers that can pose dangers to workers during the manufacturing process and be sources of VOC off gassing in homes until they completely cure (which can take months or years). Safer synthetic finishes are conversion varnishes and water-based urethane finishes. These products may still be unsafe in the factory but can be a safer finish for the end user.

Finishes made from natural ingredients, such as tung or linseed oil, are still solvent-based and contain volatile chemicals that chemically sensitive individuals may be sensitive to. From an ecological standpoint, these plant-based, more natural finishes are generally better than conventional products.

Potential Issues

From a health standpoint alone, the safest way to guarantee the "tolerability" of a finish is to order a finished sample and have the homeowner self-test the product.

Related Strategies

MR152

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

"Product Report: Wood Finishes," www.thegreenguide.com/reports/productprint.mhtml?id=24

190. Avoid fully upholstered furniture where moisture may be problem

Bedroom, Living and Working, Basement

Upholstered furniture is made from porous and absorbent materials; once it absorbs and collects dirt and moisture, it does not readily release those agents. In areas where elevated levels of moisture are likely, one should limit the use of fully upholstered furniture. From a health standpoint, dust and dust mites will find a supportive environment in upholstered furniture, and thorough vacuuming and cleaning of upholstered furniture very difficult. Also, most fabrics are given potentially hazardous surface treatments to enhance their appearance, durability, and stain resistance.

A better choice is to use furniture made with finished wood framing and unattached cushions that can be removed, cleaned, and/or dried.

Potential Issues

This criterion may narrow the range of choices for furniture and fittings.

Related Strategies

IEQ191

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

191. Minimize use of plush and porous materials

Bedroom, Office, Bedroom, Living and Working, Basement

Carpets, fabrics, and products with plush fibers and foam may absorb moisture, collect dirt, and act as sinks for VOCs and other airborne pollutants. Design and plan the use of these porous materials to allow for good cleaning and drying. In homes with extensive use of plush materials, extra care should be taken to manage moisture levels and avoid products that will emit significant pollutants.

Potential Issues

This criterion may narrow the range of choices for furniture and fittings.

Related Strategies

IEQ190

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

192. Select furniture that is easy to clean

Bedroom, Living and Working

When choosing furniture and accessory items, consider how easy they will be to maintain and keep clean. Heavily detailed pieces, wicker and rattan, and upholstered pieces are generally not easy to keep clean. Smooth, hard-surfaced furniture is the easiest to maintain. In addition, some materials need ongoing applications of less-green cleaning products to keep them looking their best and ensure long lifetimes. Choose furniture and accessories that can be cleaned easily using environmentally responsible cleaning products and practices, and provide recommendations to homeowners for sources of such cleaning compounds. Slipcovers over upholstered furniture can be removed and laundered, while protecting and prolonging the life of the primary upholstery. Avoid permanent-press and stain-resisting fabric treatments that may contain hazardous chemicals, such as formaldehyde and fluoropolymers (for example, Teflon).

Potential Issues

This criterion may narrow the range of choices for furniture and fittings and add to cost.

Related Strategies

IEQ196

References and Resources

Destination Green, www.destinationgreen.com

193. Select window treatments with health considerations in mind

Bedroom

Shades and draperies have many benefits. They can insulate to reduce heat loss (especially blinds that seal tightly into tracks at the edges), block unwanted solar heat gain and harmful UV rays, provide privacy, and enhance a room's appearance. But all porous materials and fabrics act as dust collectors and can be difficult and time-consuming to take down and clean. Draperies may include linings that are given potentially hazardous surface treatments. Almost all fabrics themselves contain dye residues and are coated with surface treatments to enhance their resistance to fire and staining, improve appearance, modify the "hand" (how they hang), and boost durability. When possible, avoid complex fabric or foam window treatments made or treated with flame retardants. Instead, select smooth, nonporous surfaces such as shutters or untreated, shades.

Potential Issues

The available options for insulating window treatments are less than they were in the 1980s; few such products are on the market.

Related Strategies

EA62

References and Resources

Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

"How Do I Select Safe Natural Fiber Products for My Home?," www.greenhomeguide.com/index.php/knowhow/

194. Select mattress and bedding with attention to health issues

Bedroom

The polyurethane foam used in mattresses used to contain brominated flame retardant chemicals (especially pentaBDE) to meet the federal flame-resistance standards, but today, most manufacturers achieve fire safety with fire barrier layers, rather than with BFRs. This is one reason to avoid salvaged mattresses and to look for mattresses manufactured after 2005, the year pentaBDE was phased out. Mattresses can also trap body moisture, which in combination with body heat and dead skin cells may provide an ideal environment for dust mites and mold.

If produced in an environmentally responsible chemical-free, organic fabrics, fills, and latex foam can provide natural resistance to dust mites, fire, moisture, and mold without harmful materials and chemicals. Chemical-free and/or organic wool padding is particularly suitable in mattresses for people with mold and dust mite allergies.

Bedding, which includes linens and pillows, can be manufactured from both natural and synthetic sources. Whenever possible, natural and—even better—organically grown plant-based products are good for our health and the environment. Organic cotton sheets and cotton, wool, or kapok pillows are readily available. Bamboo and Modal cellulose fiber sheets are increasingly popular, especially given their plant fiber source, but the overseas manufacturing processes for these products are poorly understood and may pose significant health and environmental risks. Fiber made from bamboo or hemp may provide natural antimicrobial and antifungal benefits. Hemp is especially durable and long-lasting when uncompromised by bleaching and other processes in the manufacturing process.

Potential Issues
This criterion may narrow the range of choices for furniture and fittings and add to cost.

Related Strategies
EA104, MR152

References and Resources
International Sleep Products Association, www.sleepproducts.org

195. Choose interior accessories with care

Bedroom, Living and Working
It is difficult to find accessories—artwork, pictures, frames, silk flowers, and on and on—that are not made in countries whose health and environmental standards may be lax. It is often best to minimize all accessories, both to avoid purchasing overseas goods with questionable health and environmental profiles and to minimize cleaning and dusting. Buying older—rather than new—decorations is often a good option.

Potential Issues
With antiques and older decorations, test for lead paint and avoid products with mold and mildew.

Related Strategies
MR141, MR142, IEQ159

References and Resources
Sustainable Residential Interiors, Foster/Stelmack/Hindman, Associates III

Use

196. Use environmentally preferable cleaning materials and strategies

Kitchen, Bathroom
Many standard cleaning products contain and emit harmful chemicals and volatile organic compounds (VOCs). This can be especially dangerous because of their proximity to occupants and the frequency with which these products are used. Many nontoxic cleaning products are inexpensive and quite basic. Their use can improve indoor air quality.

Potential Issues
This criterion may narrow the range of choices for furniture and fittings and add to cost.

Related Strategies
EA104, EA105, MR156

References and Resources
"Household Cleaners," www.seventhgeneration.com/our_products/household.php

Family and Consumer Sciences, www.ces.ncsu.edu/depts/fcs/index.html

197. Store all toxic chemicals away from living space
Harmful chemicals can escape from lawn-and-garden products, lawnmower gas cans, partially used cans of paint, and so forth. Firesafe and carefully sealed storage units located in well-ventilated garages or storage sheds should be used to store such materials. Encourage homeowners not to keep older chemicals in their homes or garages; such materials can often be disposed of during hazardous-waste collection days at municipal solid waste facilities.

Potential Issues
Some waterborne materials, such as latex paints, must be stored in locations where they won't freeze.

Related Strategies
EA103, EA104

References and Resources
www.thegreenguide.com/green_home/

198. Be attentive to chemicals that might be stored in close proximity to a finished basement room

Basement
Potentially toxic chemicals, such as paints, solvents, and cleaning compounds, are often stored in the basement. When we create living spaces in basements, keep these chemicals and their emissions away from the living space and ductwork that will feed air to the basement room.

Potential Issues
Hazardous chemicals should not be stored in living areas or basement spaces connected to living spaces, but if they must be stored in basements, at least isolate them from spaces that are to be remodeled.

Related Strategies
EA103, EA104

References and Resources
National Geographic, www.thegreenguide.com/green_home/

Strategy Image Appendix

IDP2 Home Performance Test during an Audit

Photo: Matt Golden

IDP2 Home Performance Test during an Audit

Photo: Matt Golden

IDP2 Home Performance Test during an Audit

Photo: Matt Golden

IDP23 Borate Insect Treatment of Framing

Photo: Carl Seville

IDP25 Drip-Through Deck Grating on Gutterless Eaves

Photo: Peter Yost

SS39 Clean Wood Waste for Site Erosion Control

Photo: Carl Seville

EA45 Interior Rigid Insulation (Taped Seams for Air Sealing) on Walls

Photo: Peter Yost

EA45 Interior Rigid Insulation and Air Seal (Taped Seams) on Ceiling

Photo: Peter Yost

EA45 Exterior Wall Air Sealed and Insulated with Spray Foam; Reclad (Note Exterior Jamb Extensions Furring)

Photo: Peter Yost

EA45 Exterior Wall Spray-Foam Insulation

Photo: Peter Yost

EA47 Furred-Out and Spray-Foamed Basement Walls (Vapor-Permeable Polyurethane)

Photo: Peter Yost

EA49 Spray-Foam Insulation at Roof Line for Conditioned Attic

Photo: Carl Seville

EA51 Blower Door Test Setup

Photo: Matt Golden

EA53 Tough-to-Insulate Cathedral Ceiling

Photo: Peter Yost

EA53 After-the-Fact Infrared Image of Cathedral Valley

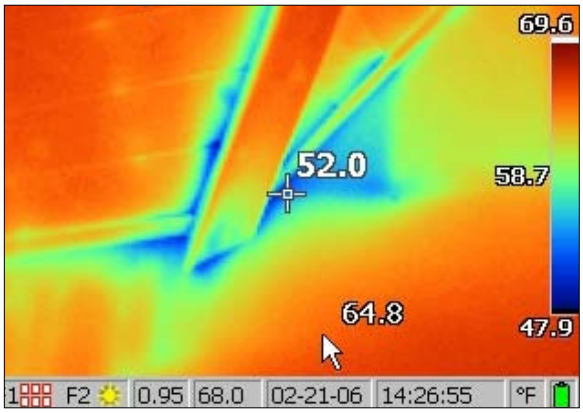


Photo: Peter Yost

EA54 Thermal Bypass: Duct Chase

Photo: Peter Yost

EA54 Spray Foam to Insulate and Air Seal

Photo: Carl Seville

EA55 Spray-Foam Insulation at Rim Joists

Photo: Carl Seville

EA56 Airtight, Low-e Triple-Track Storm Window

Photo: Peter Yost

EA58 Interior Trim Removed to Insulate and Air Seal Sash Pockets after Sash Replacement

Photo: Peter Yost

EA68 Duct Blaster Test Setup

Photo: Matt Golden

EA71 Duct Protection during Renovation

Photo: Carl Seville

EA77 PEX Plumbing for Efficient Distribution of Hot Water

Photo: Carl Seville

EA78 On-Demand Recirculation Pump for Hot Water

Photo: Carl Seville

EA79 One Approach to Efficient Hot Water: Gas Tankless Heater

Photo: Carl Seville

EA83 Solar Tube for Daylighting

Photo: Carl Seville

EA92 High-Efficiency H-Axis Clothes Washer

Photo: Peter Yost

MR107 Clean Wood Waste from Remodel

Photo: Carl Seville

MR107 On-site Recycling of Clean Wood Waste

Photo: Carl Seville

MR108 Salvaged Roofing Tiles Ready for Reinstallation

Photo: Carl Seville

MR113 Site-Processed Materials (Brick, Fill) for Patio Block Base

Photo: Carl Seville

MR116 Advanced Framing on Interior Partitions

Photo: Carl Seville

MR121 Base Board Wiring Raceway with SIP Walls

Photo: Peter Yost

MR122 PEX Piping Manifold

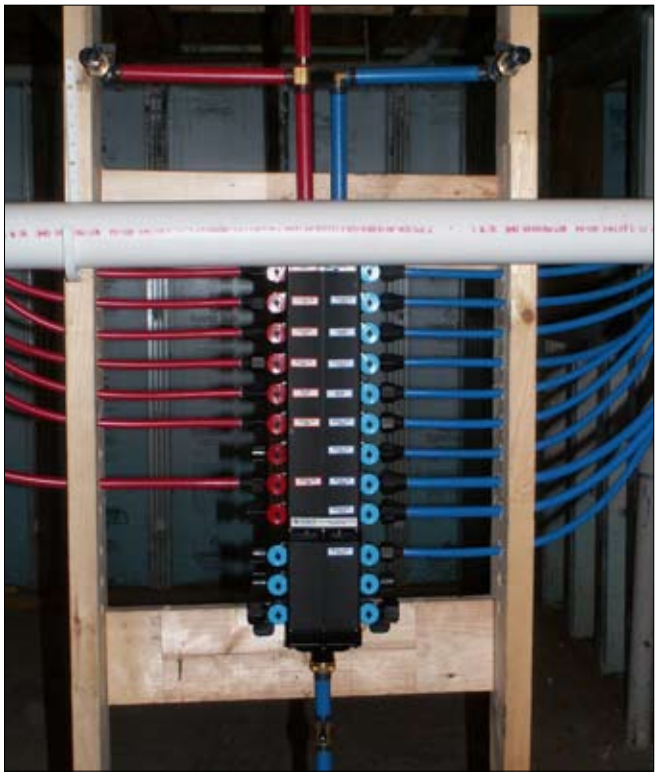


Photo: Carl Seville

MR124 Single-Throw Clothes Washer Shut-Off

Photo: Peter Yost

MR125 Alternative to Drain and Pan: Electronic Leak Detection for Clothes Washer

Photo: Carl Seville

MR133 Reused Birch Flooring

Photo: Mark Piepkorn

MR140 Secondhand Bath Countertop Purchased from Salvage Center

Photo: Mark Piepkorn

MR140 Retail Architectural Salvage Center

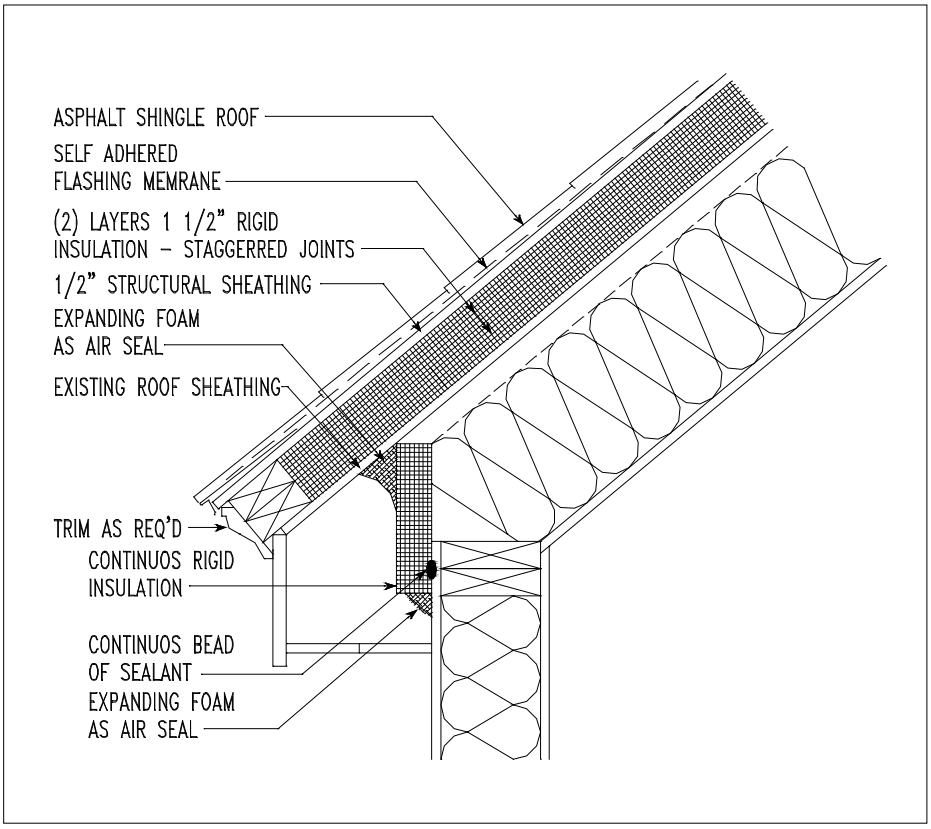
Photo: Kelly Bentham

IEQ163 Airtight Sump with Radon Exhaust System

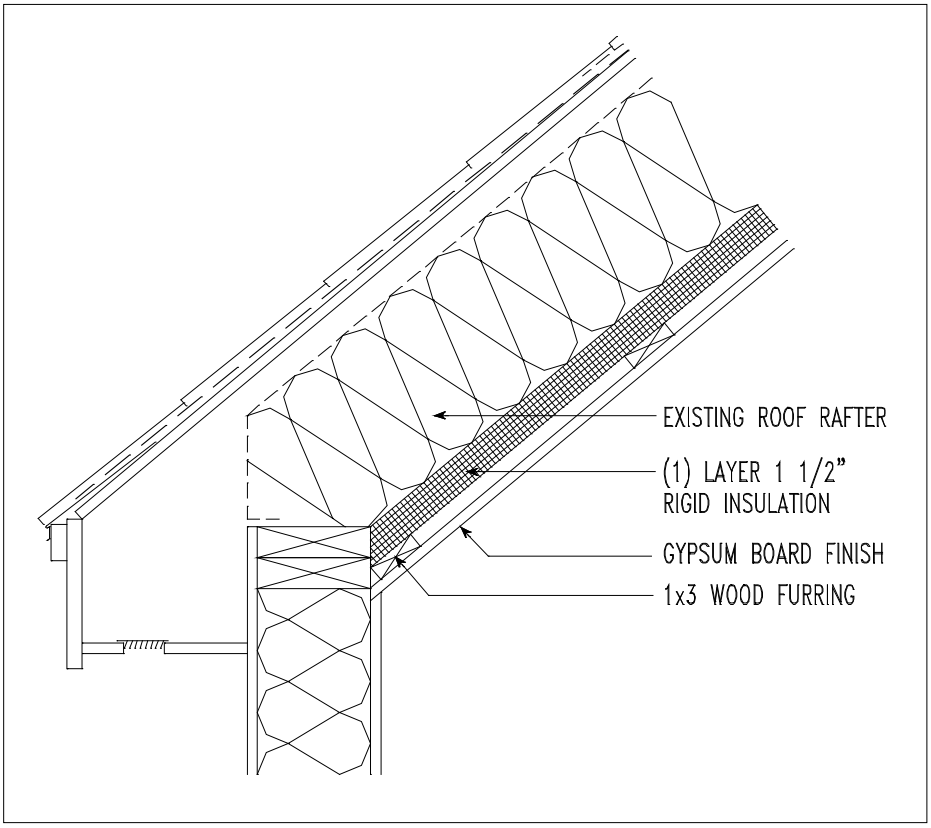
IEQ168 Sealed Combustion, Condensing Efficiency Gas Furnace

Photo: Peter Yost

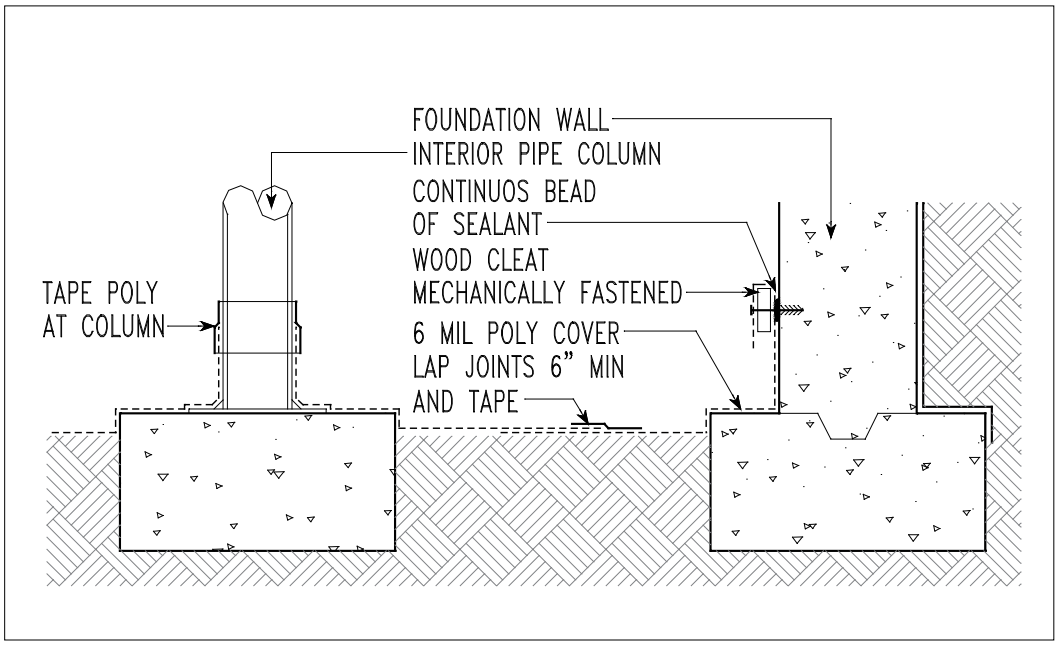
IDP3 Roof Retrofit Insulation: Exterior Roof Retrofit



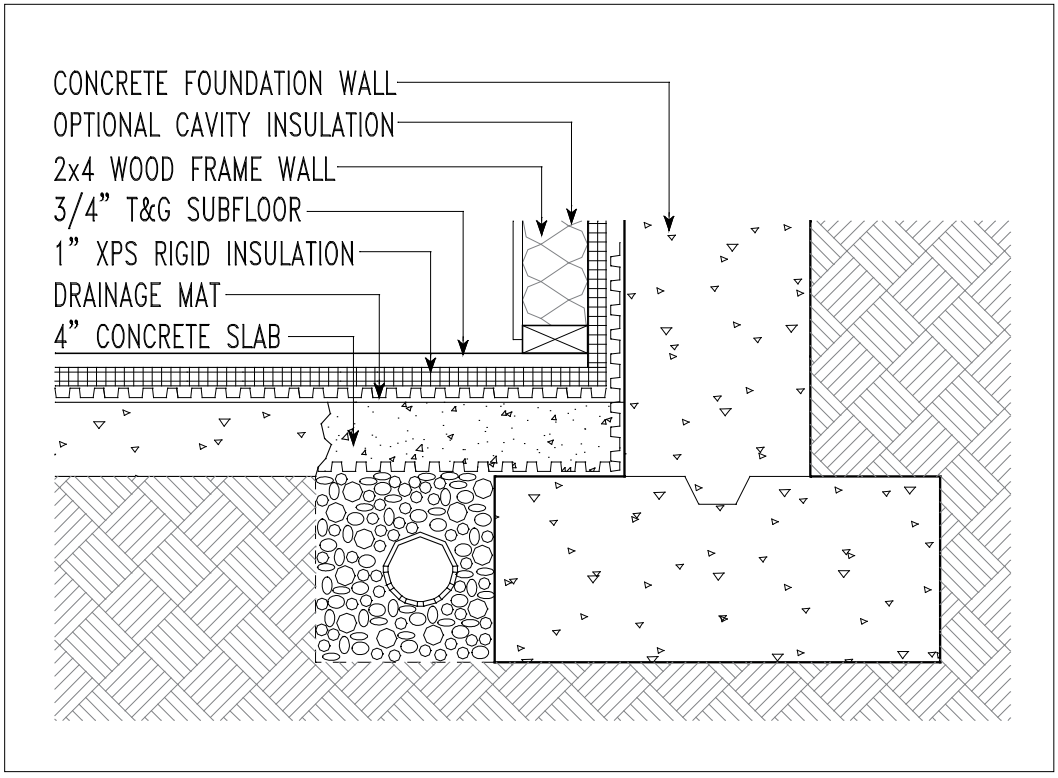
DP3 Roof Retrofit Insulation: Interior Roof Retrofit



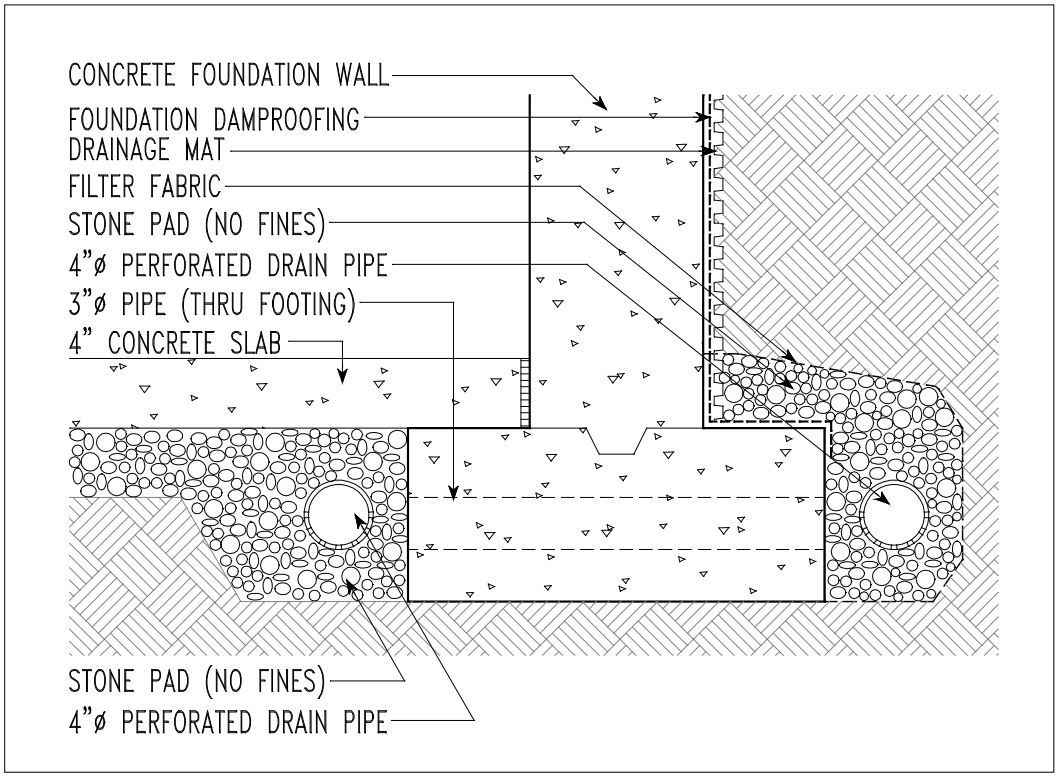
IDP20 Foundation Water Management: Crawl Space Foundation with Piers



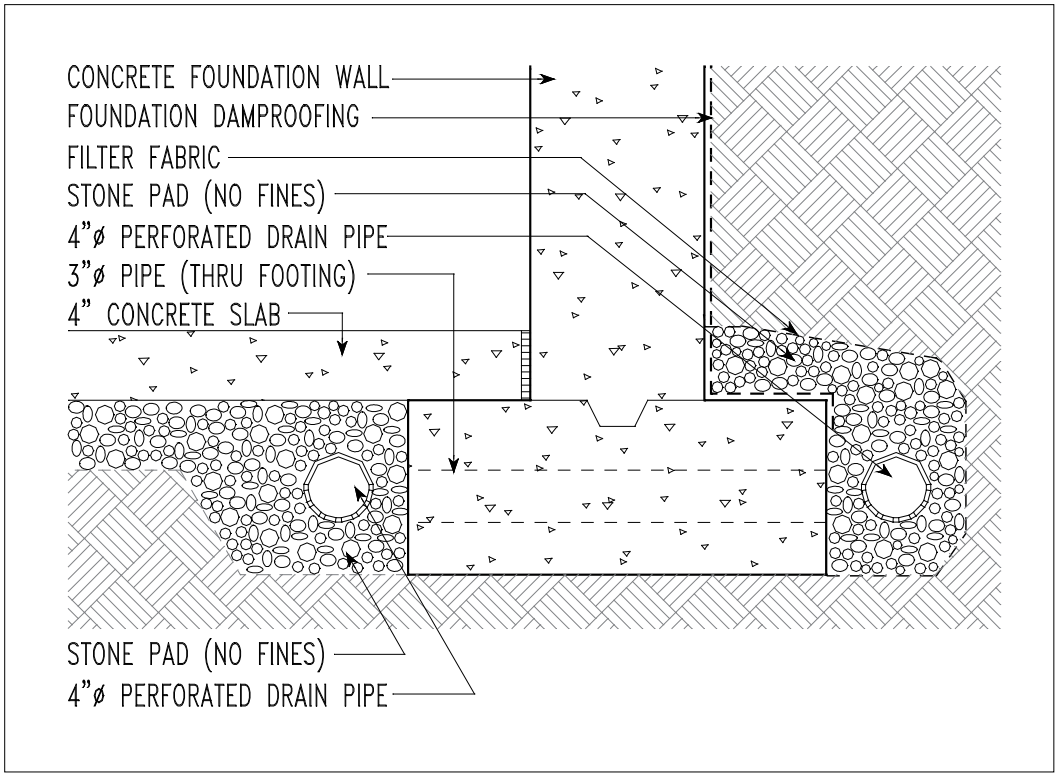
IDP20 Foundation Water Management: Inside Perimeter Drainage Retrofit



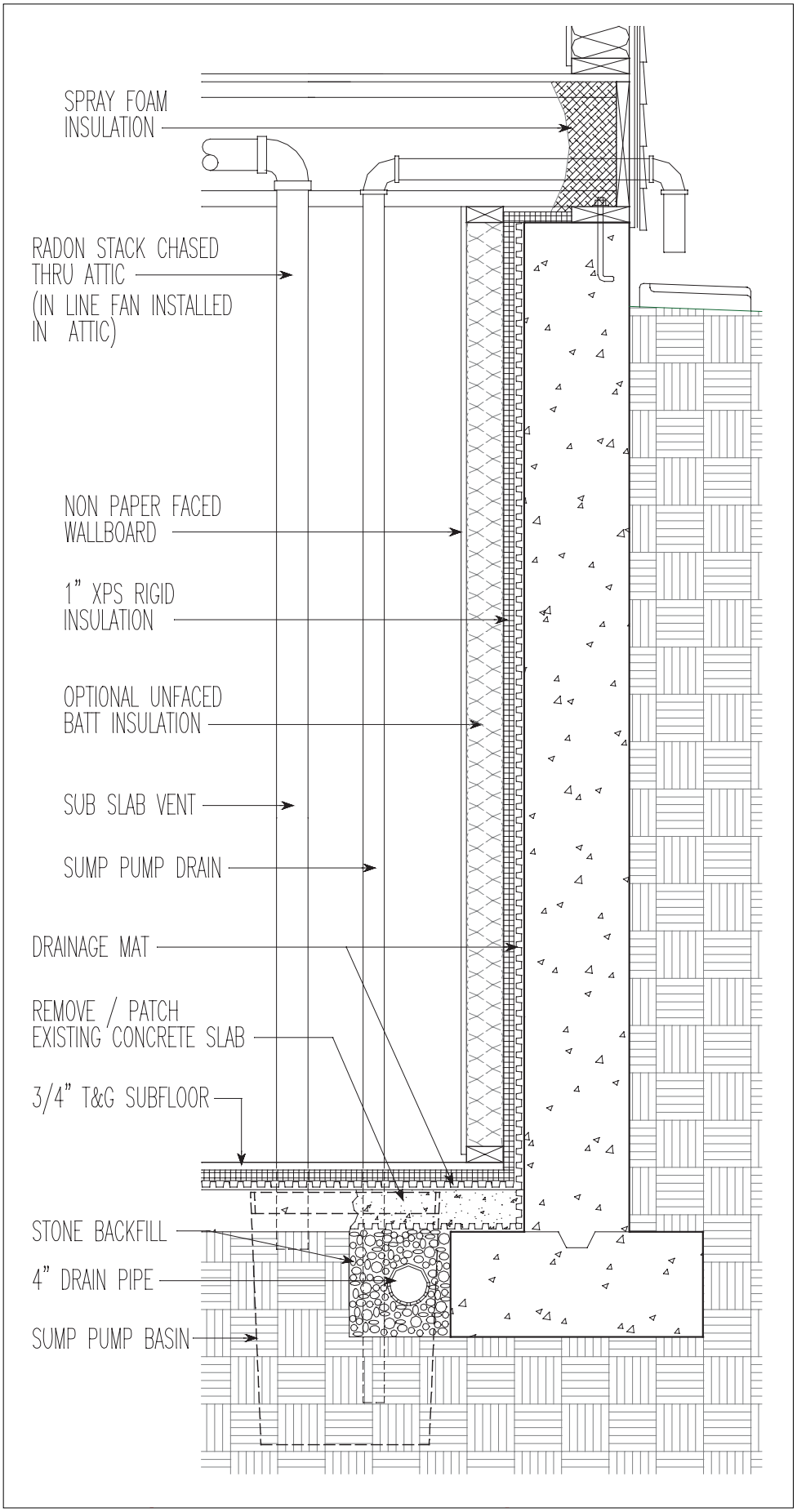
DP20 Foundation Water Management: Inside-Outside Perimeter Drain with Drainage Mat



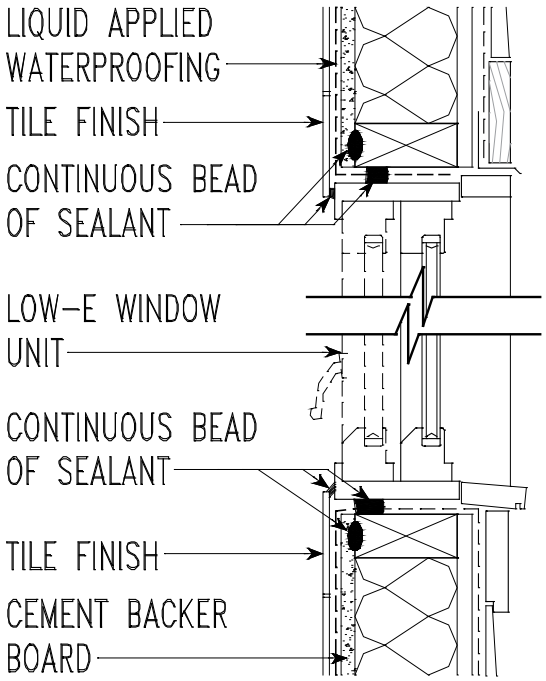
IDP20 Foundation Water Management: Inside-Outside Perimeter Drainage



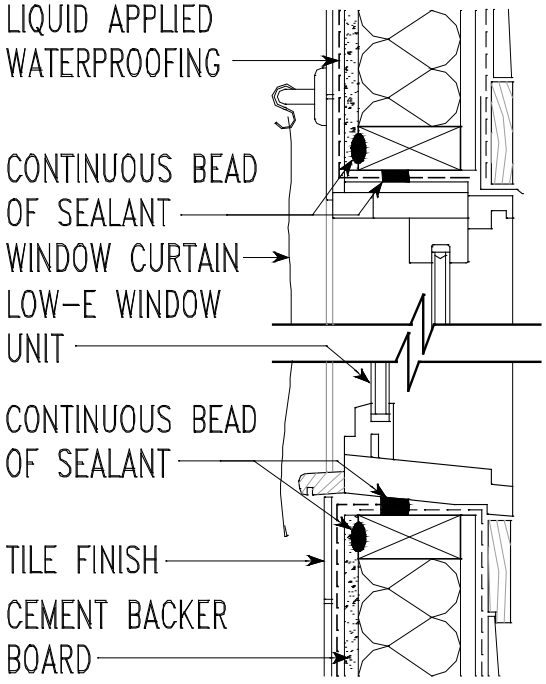
IIDP21, IDP22, and EA47 **Basement Moisture and Energy Management**



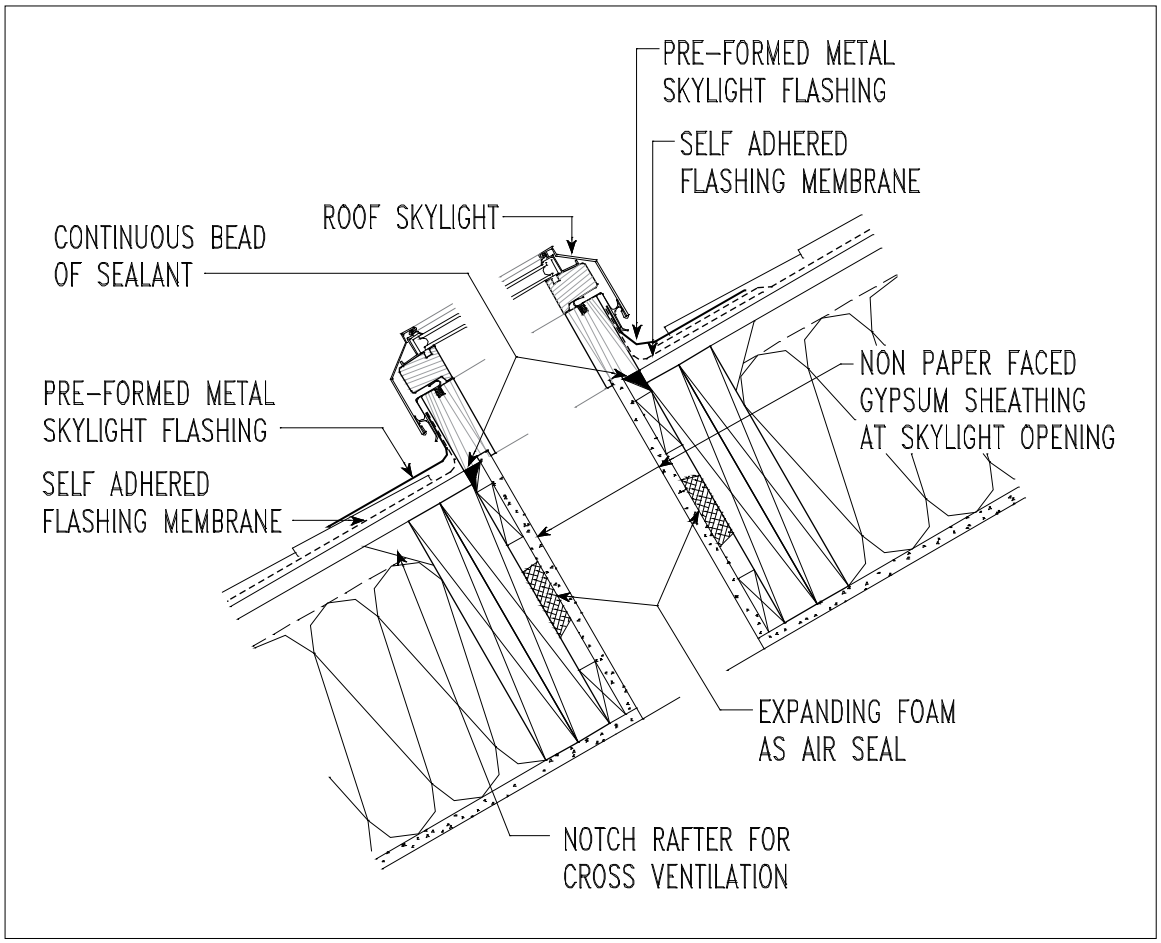
IDP26 "Wet Room" Window: High-Sill Shower Window



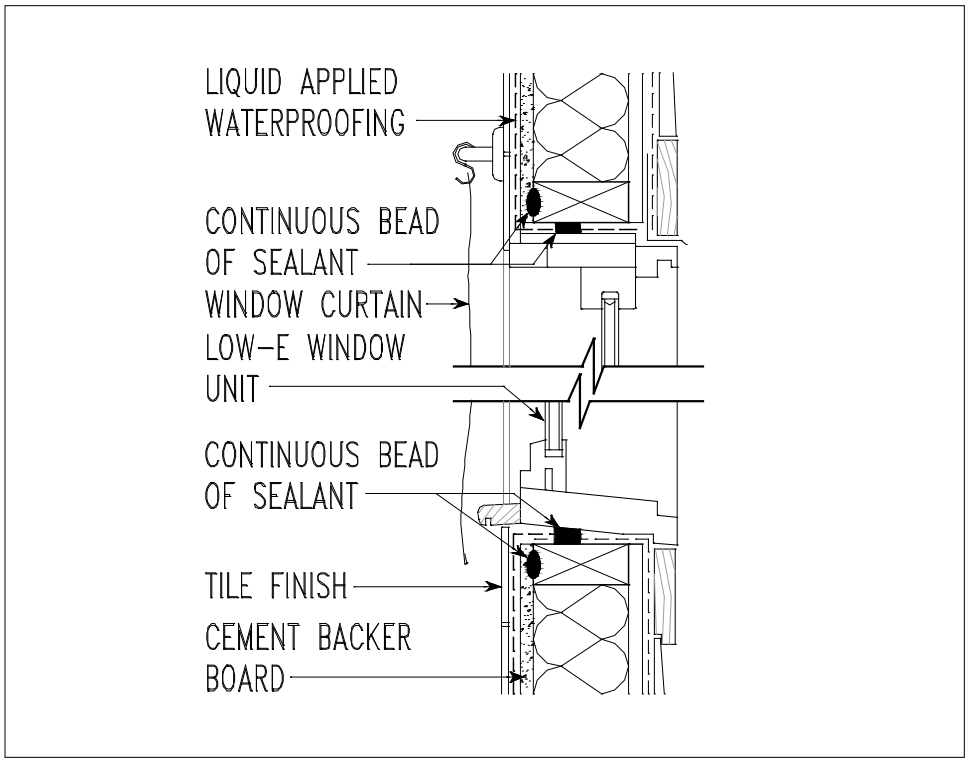
IDP27 "Wet Room" Window: Low-Sill Shower Window



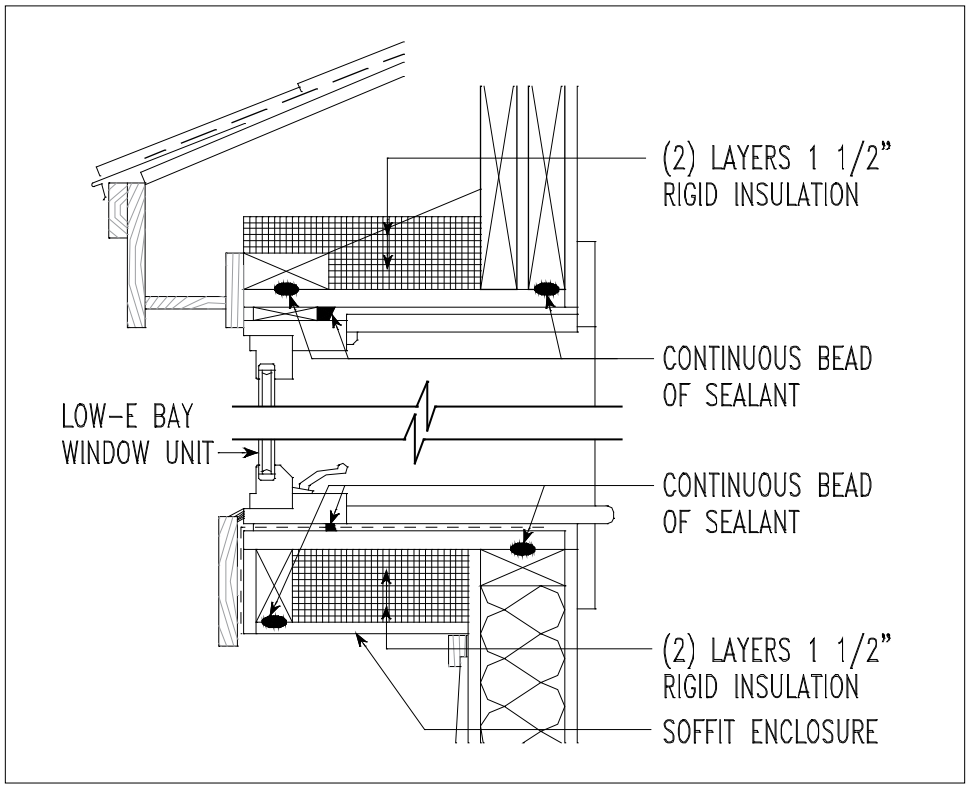
IDP27 Air Sealing at Skylight Head and Sill



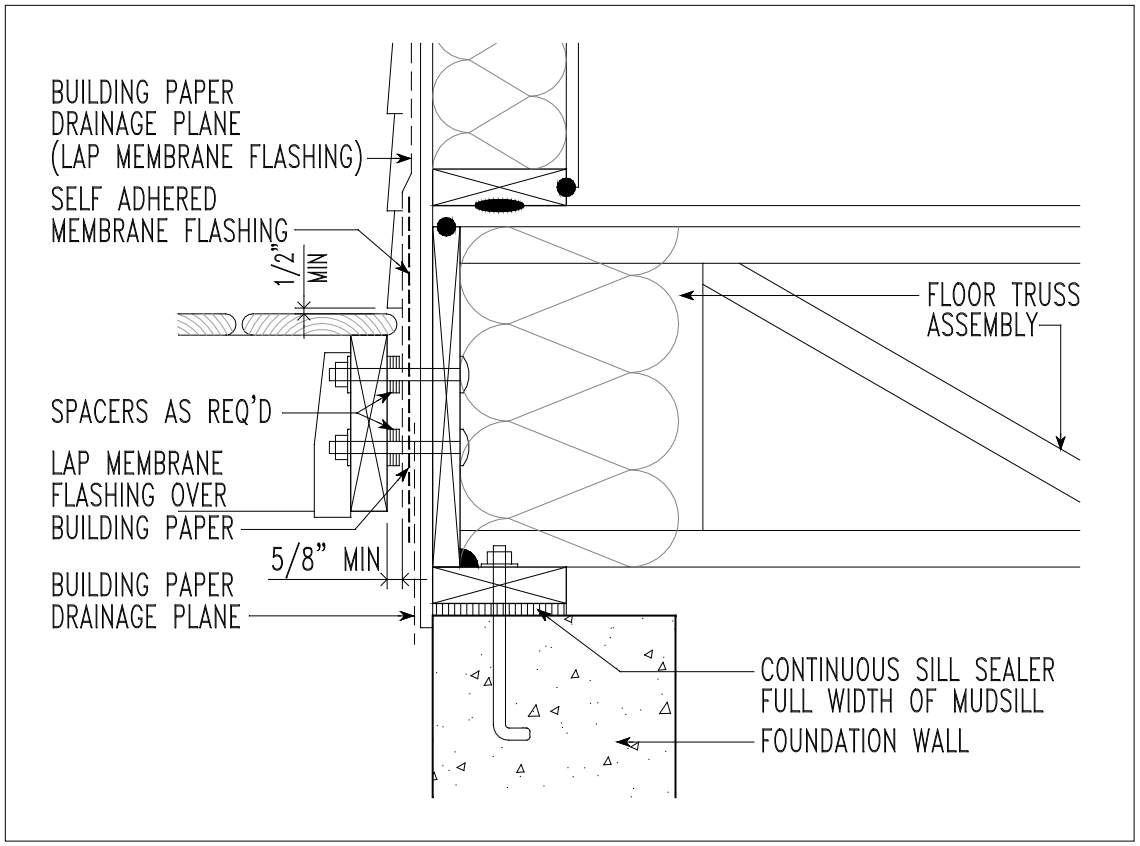
IDP27 Air Sealing at Skylight Jamb



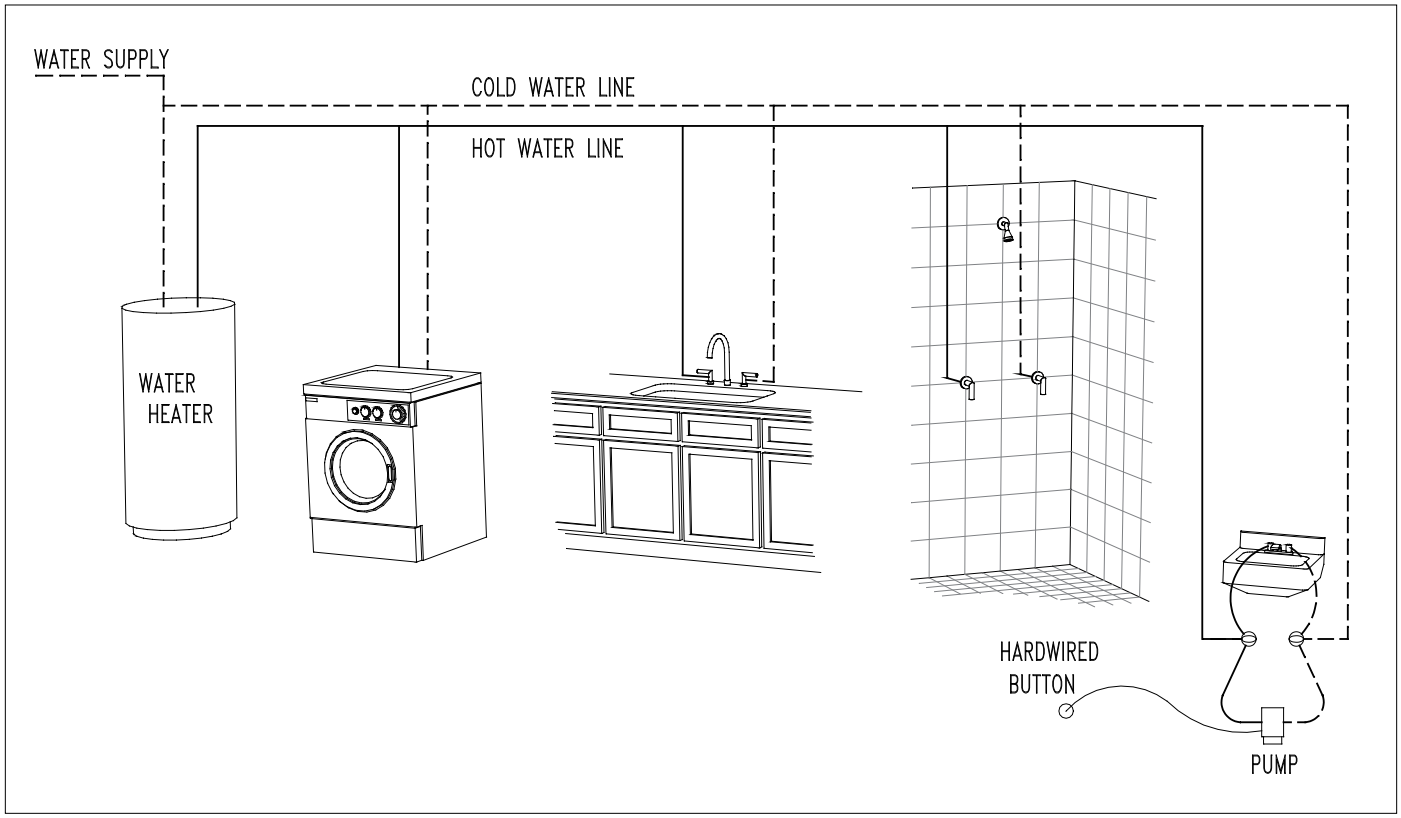
IDP27 Air Sealing at Bay Window



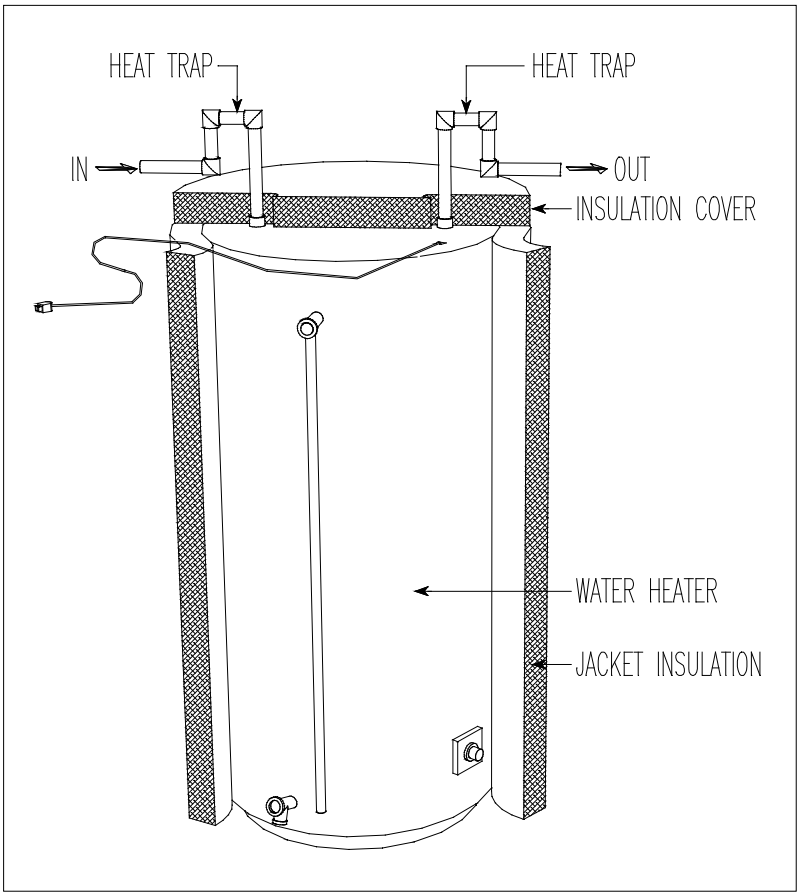
IDP28 Deck Attachment at Band Joist



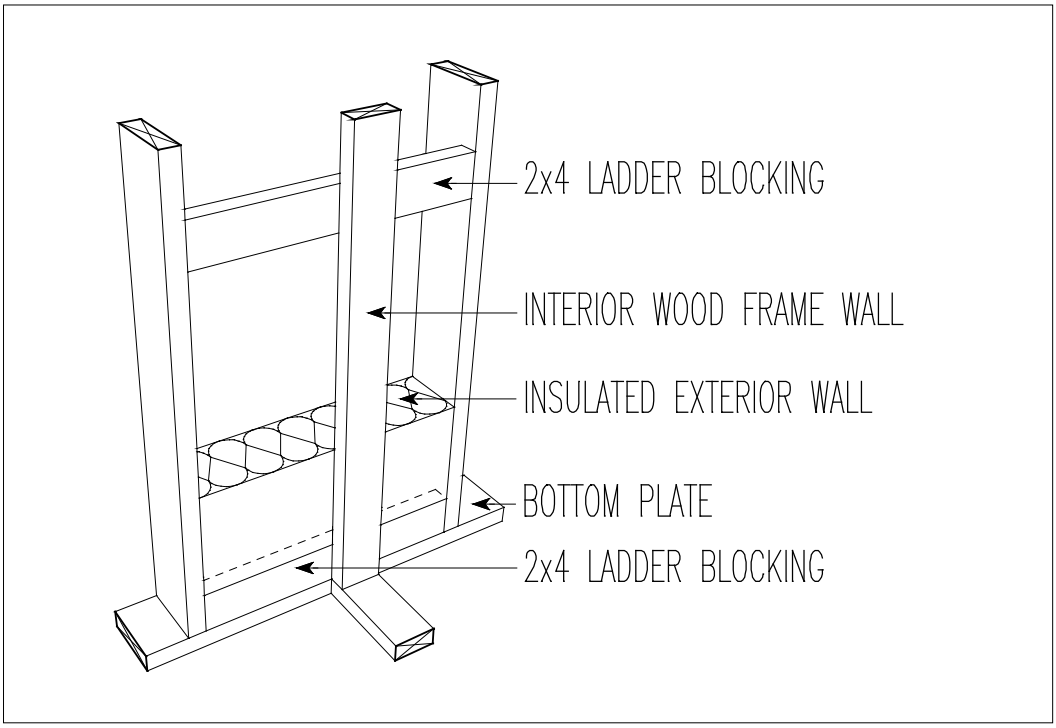
EA78 Typical On-Demand Recirculation System for Retrofit



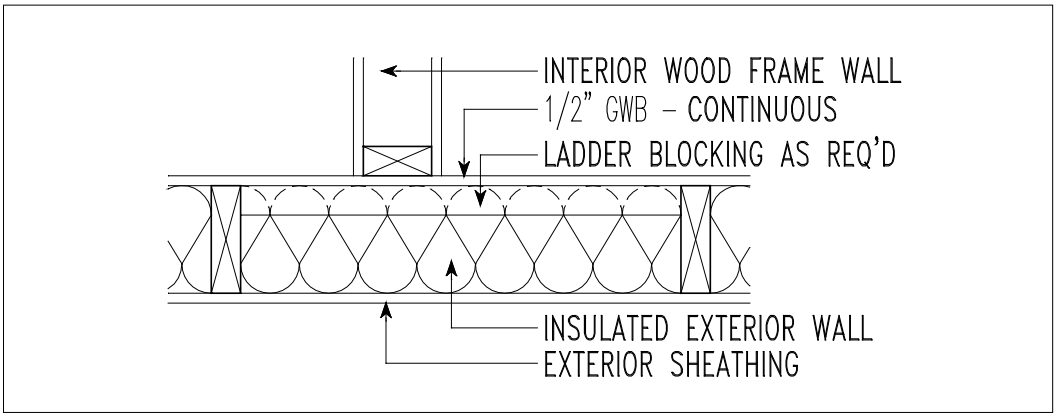
EA80 Improving Efficiency of Existing Water Heater



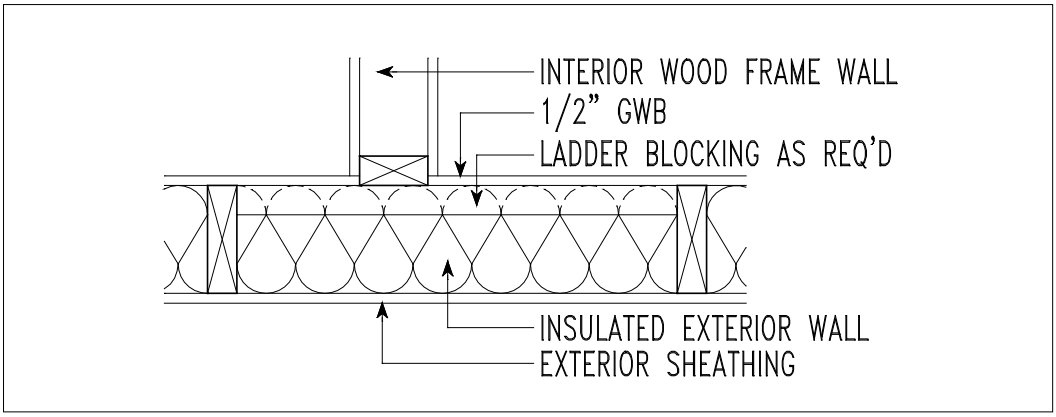
MR116 Advanced Framing: Ladder Blocking



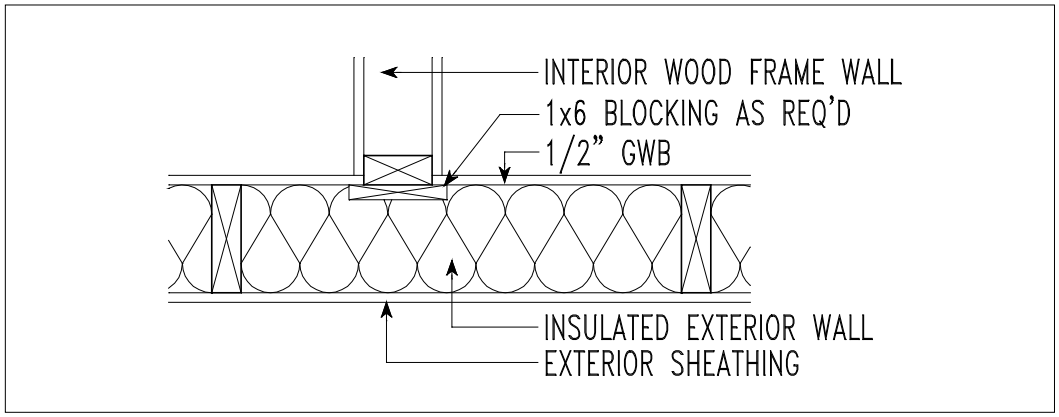
MR116 Advanced Framing: Intersecting Wall, Ladder with Continuous Gypsum Wallboard



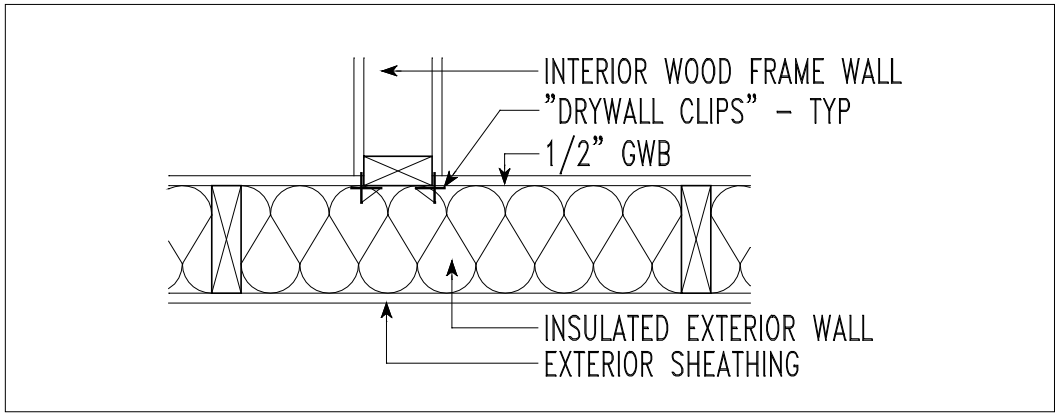
MR116 Advanced Framing: Ladder Blocking



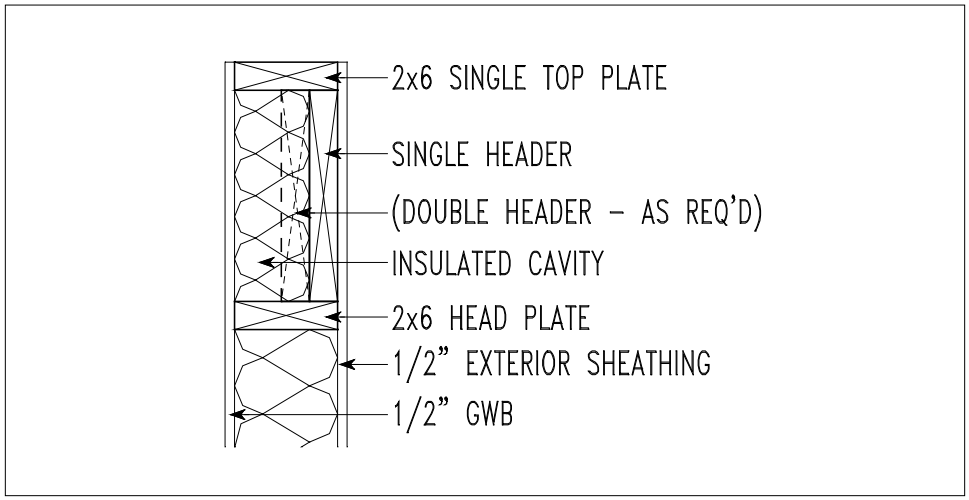
MR116 Advanced Framing: Intersecting Wall, 1x6



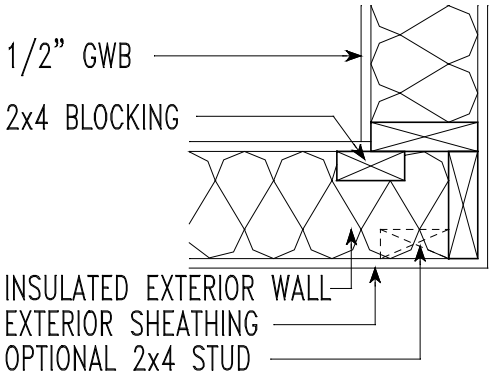
MR116 Advanced Framing: Intersecting Wall, Drywall Clips



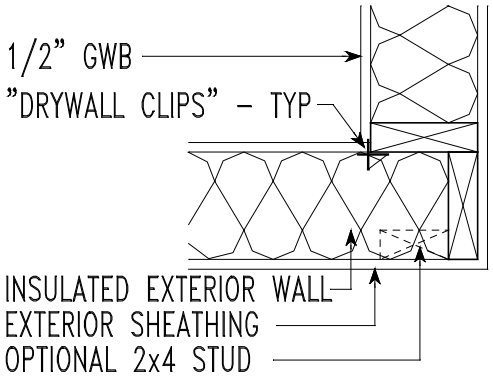
MR116 Advanced Framing: Corner, Recessed Insulated Header



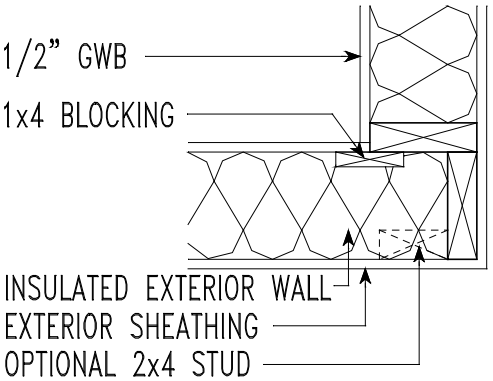
MR116 Advanced Framing: Corner, 2x4



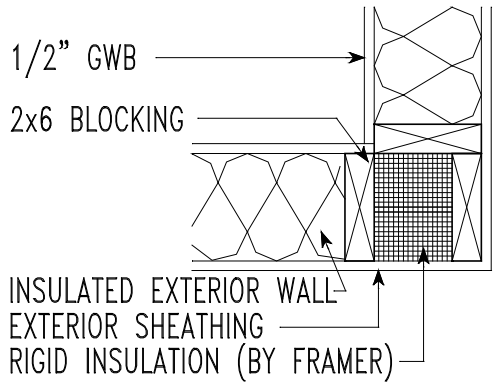
MR116 Advanced Framing: Corner, Drywall Clips



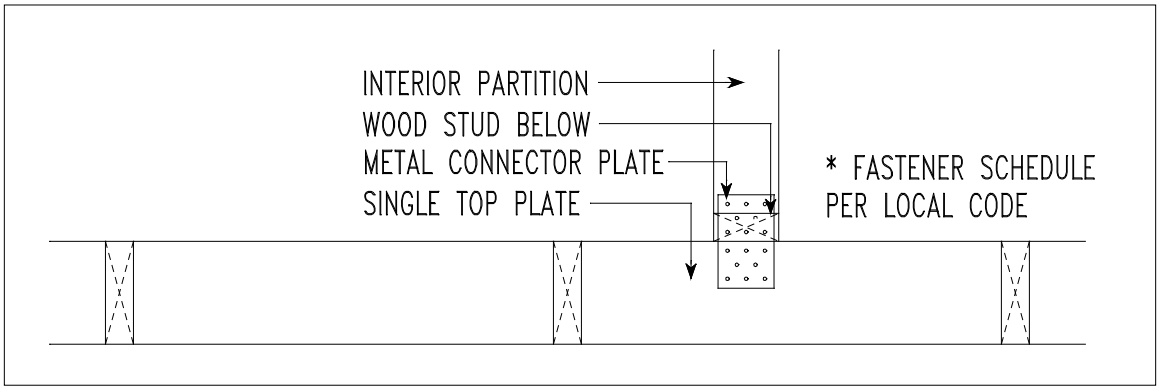
MR116 Advanced Framing: Corner, 1x4



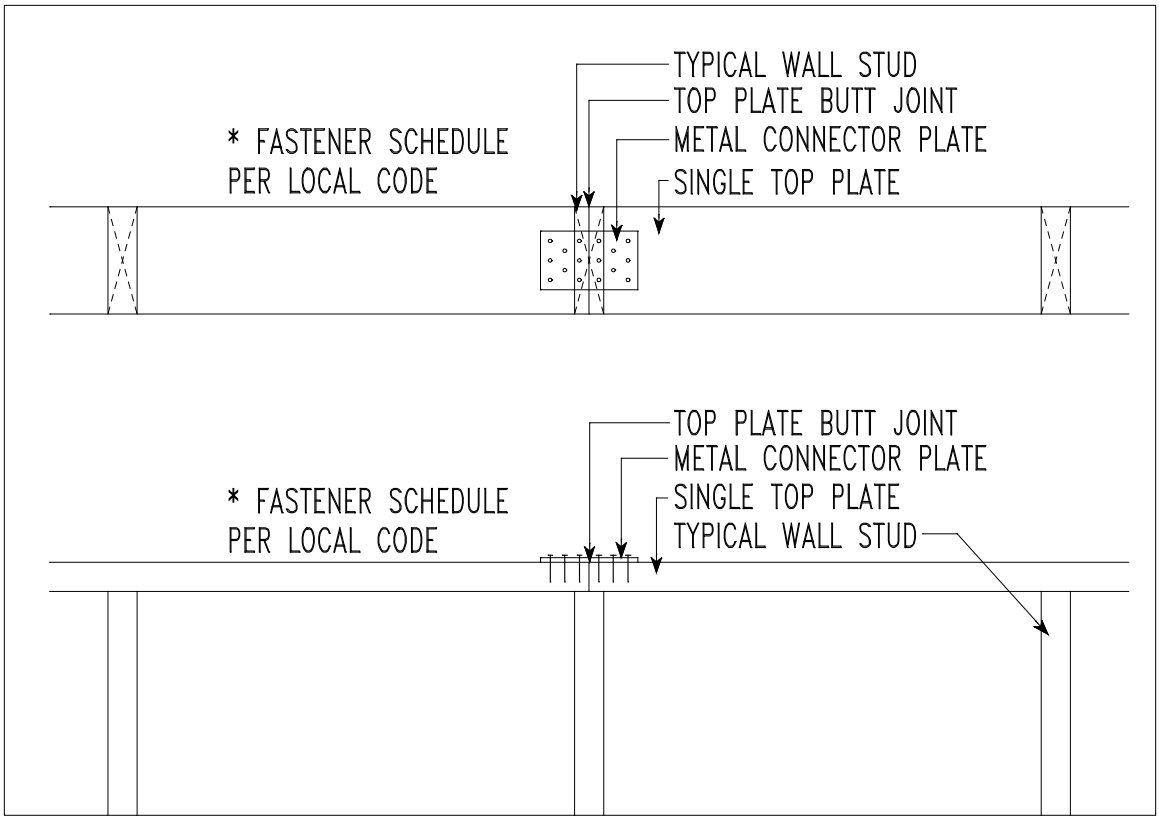
MR116 Advanced Framing: Corner, Rigid Insulation



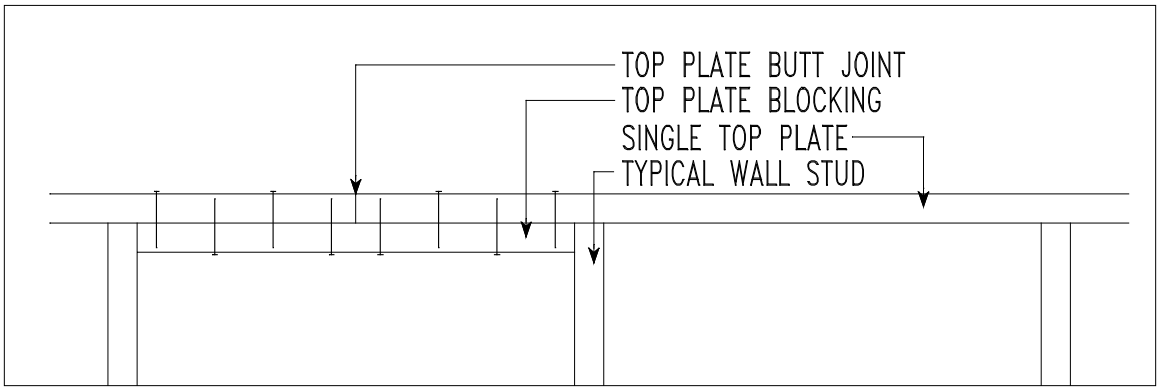
MR116 Advanced Framing: Corner, Plate at Intersecting Wall



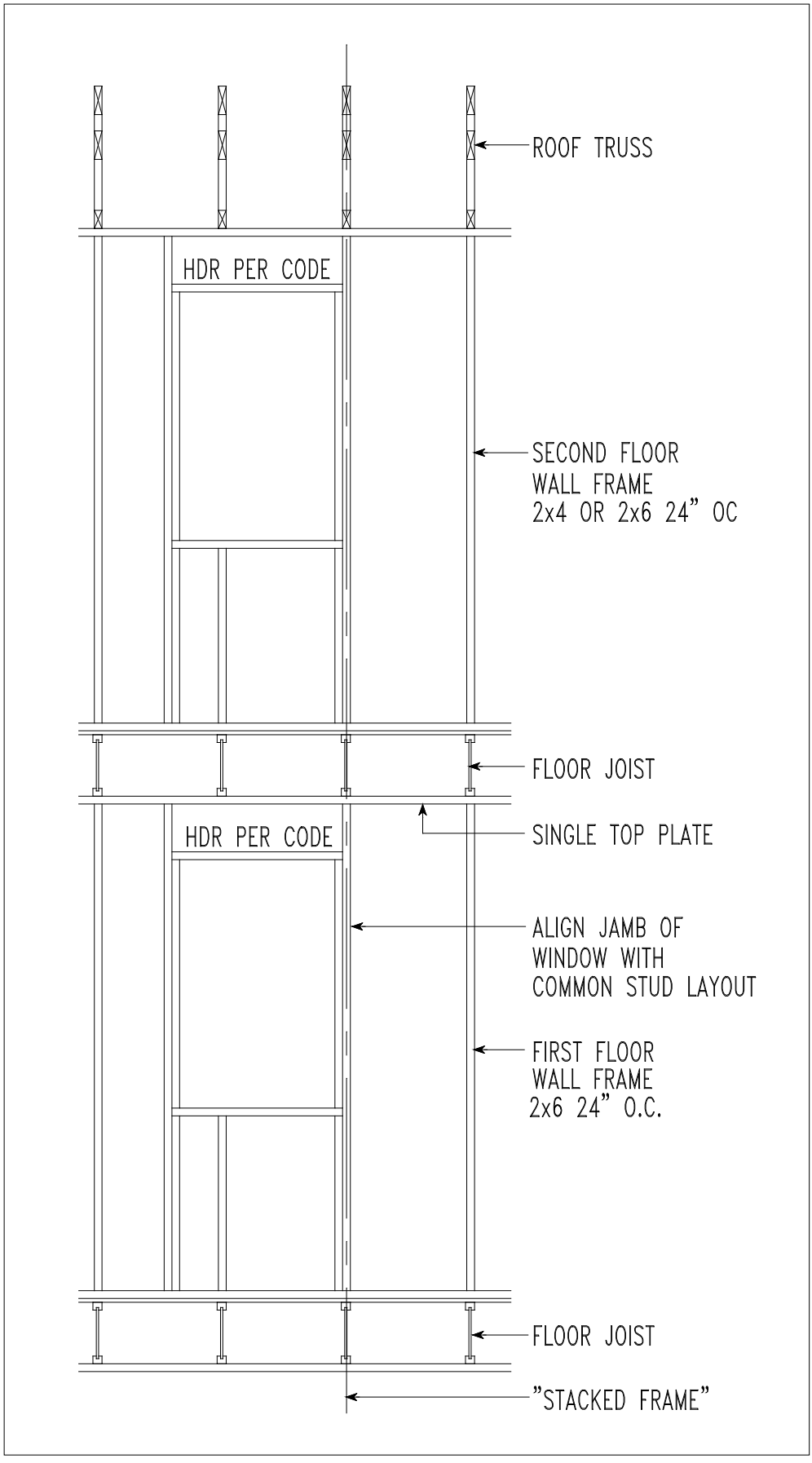
MR116 Advanced Framing: Corner, Plate at Single Top Plate



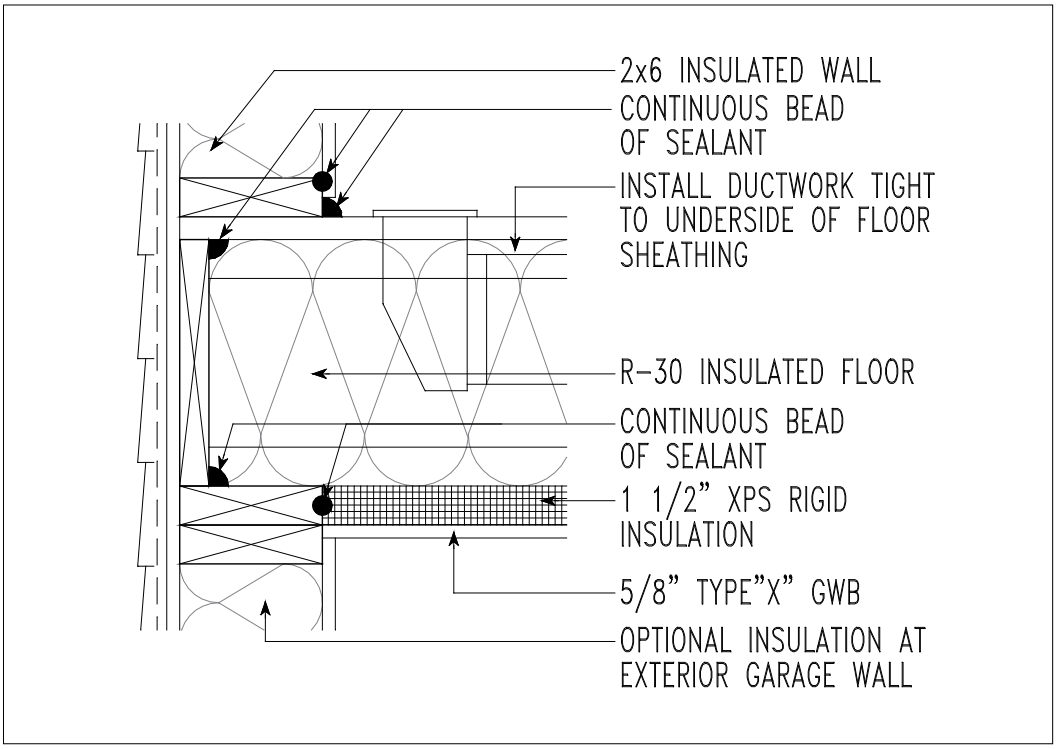
MR116 Advanced Framing: Corner, Blocking at Single Top Plate



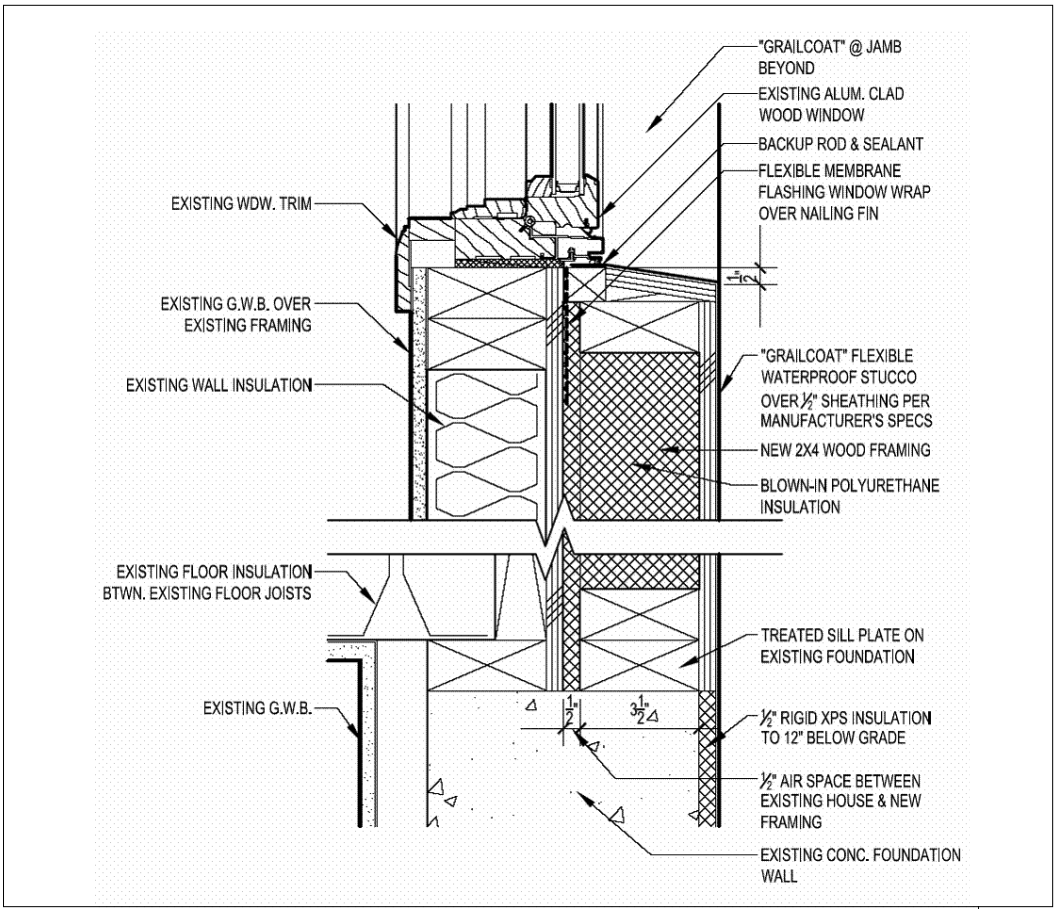
MR116 Advanced Framing: Stacked Frame Elevation



IEQ165 Air Sealing in Garage Ceiling



Wall Section Detail: Deep Energy Retrofit



REGREEN Guidelines Glossary

Active closed-loop solar water heater: Solar water heater in which an electric pump circulates a freeze-protected heat-transfer fluid through the collector and heat exchanger within a storage tank.

Active drainback solar water heater: Solar water heater in which water or another heat-transfer fluid is pumped through the collector and drains back to a tank in the house when the pump turns off.

Advanced framing: House-framing techniques in which lumber use is optimized, saving material and improving the energy performance of the building envelope.

Air barrier: Building assembly components that work as a system to restrict air flow through the building envelope an air barrier may or may not act as a vapor barrier. The air barrier can be on the exterior, the interior of the assembly, or both.

Air handler: Fan that a furnace, whole-house (central) air-conditioner, or heat pump uses to distribute heated or cooled air throughout the house.

Air-source heat pump: Heat pump that relies on outside air as the heat source and heat sink; not as effective in cold climates as ground-source heat pumps.

Airtight drywall: Use of drywall with carefully sealed edges and joints that serves as an interior air barrier in building assemblies.

Albedo: Percentage of light reflected off a surface; a material with high albedo is very reflective.

Ammonium sulfate: Flame retardant commonly used in cellulose insulation. Borates are also used.

Annual fuel utilization efficiency (AFUE): Energy efficiency of a heating system that accounts for start-up, cool-down, and other operating losses that occur during operation; AFUE is always lower than combustion efficiency.

Asbestos: Mineral fiber once commonly used in building materials, including insulation, fireproof siding, and resilient flooring; a known human carcinogen (causing lung cancer), asbestos is no longer used in the United States.

Autoclaved aerated concrete (AAC): Masonry building material made of portland cement, sand, and water in an autoclaving process (heating under pressure), which the setting results in the production of air pockets in the material, making it less dense and better insulating. AAC has been used throughout much of the world for more than 70 years.

Backdrafting: Indoor air quality problem in which potentially dangerous combustion gases escape into the house instead of going up the chimney.

Balanced ventilation: Mechanical ventilation system in which fans exhaust stale indoor air and bring in fresh outdoor air in equal amounts; often includes heat recovery or heat and moisture recovery (see also *heat-recovery ventilator* and *energy-recovery ventilator*).

Batch solar water heater: Solar water heater in which potable water is heated where it is stored. Also called an integral collector storage (ICS) solar water heater.

Binder: Glue used in manufacturing wood products, such as medium-density fiberboard (MDF), particleboard, and engineered lumber. Most binders are made with formaldehyde. See *urea-formaldehyde binder* and *methyl diisocyanate (MDI) binder*.

Bio-based material: Material made from living matter, such as agricultural crops. Bio-based materials are usually biodegradable.

Biophilia: Theory developed by biologist Edward O. Wilson suggesting that humans have an innate affinity for nature.

Blower door test: Test used to determine a home's airtightness. A powerful fan is mounted in an exterior door opening and used to pressurize or depressurize the house. By measuring the force needed to maintain a certain pressure difference, a measure of the home's airtightness can be determined. Operating the blower also exaggerates air leakage and permits a weatherization contractor to find and seal those leakage areas.

Blowing agent: Compound used in producing foam insulation. Mixed as a liquid with the foam ingredients under pressure, the blowing agent evaporates, creating gas bubbles that provide the insulation. Until recently, most blowing agents (HCFCs and CFCs) depleted Earth's protective ozone later; except for extruded polystyrene, the industry has now switched to ozone-safe blowing agents.

Boiler: System used to heat water for hydronic heating. Most boilers are gas-fired or oil-fired, although some are electric or wood-fired; a boiler can also heat water for domestic uses through a tankless coil or an indirect water heater.

Borate: Chemical containing the element boron that provides fire resistance to materials such as cellulose insulation and decay resistance to wood products.

Brominated flame retardant (BFR): Chemicals added to various plastics and foam materials to provide fire resistance. There is growing concern these are harmful to humans.

Btu: British thermal unit, the amount of heat required to raise one pound of water (about a pint) one degree Fahrenheit in temperature, about the heat content of one wooden kitchen match. One Btu is equivalent to 0.293 watt-hours or 1,055 joules.

Building envelope: Exterior components of a house that provide protection from colder (and warmer) outdoor temperatures and precipitation. The envelope ncludes the house foundation, framed exterior walls, roof or ceiling, and insulation and air-sealing materials.

Capillary forces: Forces that lift water or pull it through porous materials, such as concrete.

Carbon-neutral house: House that, on an annual basis, does not result in a net release of carbon dioxide (a greenhouse gas that contributes to global warming) into the atmosphere.

Cavity-fill insulation: Insulation installed in the space created by wall, ceiling, roof, or floor framing, most commonly fiberglass-batt, spray-applied or dense-pack cellulose, or spray polyurethane.

Chromated copper arsenate (CCA): Type of wood preservative that has now been largely eliminated from residential wood products because of concerns about leaching and toxicity. Huge quantities of CCA-treated wood remain in use, especially in residential decks.

Cistern: Vessel for storing water, such as that collected with a rainwater-harvesting system.

Cladding: Materials used to enclose a house, providing protection against weather.

Combustion efficiency: Efficiency at which a fuel is burned in a combustion appliance when operating at its rated output; the combustion efficiency is always higher than the annual fuel utilization efficiency (AFUE).

Commissioning: Process of testing a home after a construction or renovation project to ensure that all of the home's systems are operating correctly and at maximum efficiency.

Compact fluorescent lamp (CFL): Fluorescent light bulb in which the tube is folded or twisted into a spiral to concentrate the light output. CFLs are typically three to four times as efficient as incandescent light bulbs and last eight to ten times as long.

Composite lumber: Lumber, typically decking, made from plastic (often high-density polyethylene) and wood fiber or other agricultural byproducts. Composite lumber often contains recycled content.

Composting system: Outdoor bins for converting vegetable scraps, garden trimmings, and other plant matter into a rich, high-organic-content soil amendment. An alternative for indoor use is a worm bin.

Concrete masonry unit (CMU): Block made of concrete used for wall construction. The hollow cores can be filled with concrete to reinforce walls.

Conduction: Movement of heat through a material as kinetic energy is transferred from molecule to molecule. The handle of an iron skillet on the stove gets hot due to heat conduction. R-value is a measure of resistance to conductive heat flow.

Convection: Movement of heat from one place to another by physically transferring heated fluid molecules, usually air or water. Natural convection is the natural movement of that heat; forced convection relies on fans or pumps.

Cripple studs: Studs in a wall system that support headers above (and below) windows or doors; indiscriminately placed, these additional studs can result in extra heat loss because they do not insulate as well as the insulation in the wall cavity.

Cross-linked polyethylene (PEX): Specialized type of polyethylene plastic that is strengthened by cross-linking (chemical bonds formed in addition to the usual bonds in the polymerization process). PEX is used primarily as tubing for hot and cold water distribution and radiant-floor heating.

Current loop: In electrical wiring, a situation in which separation of hot and neutral leads results in higher-than-normal electromagnetic fields (EMFs).

Curtain truss: Nonstructural truss that extends from a structural wall system solely for the purpose of holding cavity-fill insulation known also as a Larson truss. Often used on timber-frame houses and in superinsulation retrofits, curtain trusses may be as much as 12 inches deep, providing an insulating value greater than R-40. Since they aren't structural, curtain trusses are often constructed from 2x2s with plywood reinforcement flanges to minimize wood use.

Daylighting: Use of sunlight for daytime lighting needs.

Degree day: Measure of heating or cooling requirements based on the average outdoor temperature. To calculate the number of heating degree days of a given day, find the average of the maximum and minimum outdoor temperatures and subtract that from 65°F. The annual number of heating degree days is a measure of the severity of the climate and is used to determine expected fuel use for heating. Cooling degree days, which measure air-conditioning requirements, are calculated by subtracting the average outdoor temperature from an indoor base temperature, usually 75°F.

Demand water heater: Water heater that heats water only as needed; there is no storage tank and thus no standby heat loss. Also called a tankless water heater.

Double wall: Construction system in which two layers of studs are used to provide a thicker-than-normal wall system to accommodate extra insulation. The two walls are often separated by several inches to reduce thermal bridging through the studs and to provide additional space for insulation.

Dual-flush toilet: Toilet that provides two flush levels: a full-volume flush for use with solid wastes and a reduced-volume flush (often half the volume) when only liquid waste and paper need to be flushed.

Duct blaster: Calibrated air-flow measurement system developed to test the airtightness of forced-air duct systems. All outlets for the duct system except for the one being tested are sealed off and the system is either pressurized or depressurized; the work needed by the fan to maintain a given pressure difference provides a measure of duct leakage.

Electric-resistance heat: Heat provided by electricity in which high-resistance wires convert electric current directly into heat. See also heat pump.

Electromagnetic field (EMF): Field given off by electric current flow. Some health experts are concerned that the magnetic field component of EMFs may be harmful or even cause cancer. Magnetic fields are stronger near current in which there is separation between the positive and neutral leads.

Embodied energy: Energy that goes into making a product, including energy for transporting both the raw materials and the finished product.

Endocrine disruptor: Chemical that mimics natural hormones, such as estrogen, and may interfere with reproductive development or alter. Endocrine disruptors include such commonly used chemicals as phthalate plasticizers (used in PVC plastic), and bisphenol-A (used in epoxies and polycarbonate plastic).

Energy efficiency rating (EER): Operating efficiency of a room air-conditioner, measured in Btus of cooling output, divided by the power consumption in watt-hours; the higher the number, the greater the efficiency.

Energy factor: Efficiency measure for rating the energy performance of dishwashers, clothes washers, water heaters, and certain other appliances; the higher the number, the greater the efficiency. A "modified energy factor" accounts for certain adjustments according to accepted test procedures.

Energy Star: Labeling system sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy for labeling the most energy-efficient products on the market. The ratings apply to a wide range of products, from computers and office equipment to refrigerators and air-conditioners.

Energy-efficient mortgage (EEM): Special type of mortgage in which the lending institution raises the allowable mortgage amount for a given earnings level, since energy-saving features in the house will reduce the monthly operating costs, thus leaving more money available to pay the mortgage.

EnergyGuide: Label from the Federal Trade Commission that lists the expected energy consumption of an appliance, heating system, or cooling system and compares consumption with other products in that category, The energy performance is based on specified operating conditions and average energy costs; actual performance may vary.

Energy-recovery ventilator (ERV): Type of heat-recovery ventilator (HRV) that captures water vapor as well as heat from the outgoing airstream in a balanced ventilation system. In winter months, this can reduce the drying that occurs when outdoor air is brought indoors and warmed.

Engineered lumber: Lumber made by gluing together veneers or strands of wood to create very strong framing members. Stronger and less prone to warping than standard framing lumber, it can be made from smaller-diameter trees, saving old-growth forests.

Evaporative cooler: Energy-efficient cooling system in which a fine mist of water is evaporated, lowering the air temperature. Evaporative coolers are most appropriate in dry climates, becauses they add humidity to a house. Also known as a swamp cooler.

Exhaust-only ventilation: Mechanical ventilation system in which one or more fans are used to exhaust air from a house, with make-up air supplied passively. See also *balanced ventilation*.

Expanded polystyrene (EPS): Type of rigid foam insulation. Unlike extruded polystyrene (XPS), EPS does not contain ozone-depleting HCFCs.

Extruded polystyrene (XPS): Type of rigid foam insulation that is widely used below grade, such as underneath concrete floor slabs, In North America XPS is currently made with ozone-depleting HCFC-142b.

Fan-coil: Electric or hydronic heating or cooling element installed in a duct. In a highly energy-efficient home, fan coils in ventilation ducting can be used for heating or cooling the living space.

Fiber-cement siding: Siding material made from wood fiber and portland cement that is highly durable, moisture resistant, and fire proof. Developed in New Zealand, the material is becoming common as a siding material in North America.

First cost: Initial cost of buying or building something, as distinguished from the operating cost.

Flashing: Material, usually sheet metal, rubber, or plastic, installed to keep rain from entering a building. When properly installed in a wall or roof assembly, flashing sheds rain to the exterior.

Fluorescent lighting: Type of energy-efficient lighting introduced in the 1930s in which electric discharge within a sealed glass tube energizes mercury vapor, producing ultraviolet (UV) light, which is absorbed by a *phosphor coating*, which in turn fluoresces, generating visible light. See also compact *fluorescent lamp*.

Forced-air heating: Heat distribution system in which heat is delivered by forcing warm air through a network of ducts. A furnace or heat pump typically generates the warm air.

Forest Stewardship Council (FSC): Nonprofit organization that promotes forestry practices that are sustainable from environmental, economics and social standpoints. FSC certification on a wood product is an indicator that the wood came from a well-managed forest.

Formaldehyde: Chemical found in many building products; most binders used for manufactured wood products are formaldehyde compounds. Reclassified by the United Nations International Agency for Research on Cancer (IARC) in 2004 as a known human carcinogen. See also *phenol-formaldehyde binder* and *urea-formaldehyde binder*.

Friable: Ability of a solid material to break down or disintegrate. A friable insulation material may lose its effectiveness; some friable materials release hazardous dust into a house.

Fuel cell: Electrochemical device similar to a battery in which electricity is generated by chemically reacting hydrogen with oxygen, producing electricity, water vapor, and heat..

Furnace: System used to heat air for a forced-air heating system. Furnaces can be gas-fired, oil-fired, wood-fired, or electric.

Glazing: Transparent or translucent layer of window or door that transmits light.High-performance glazings may include multiple layers of glass or plastic, low-emissivity (low-e) coatings, and low-conductivity gas fill.

Global warming potential: Measure of how a given mass of greenhouse gas is estimated to contribute to global warming compared with carbon dioxide, which is given a value of 1.0 on this relative scale.

Gravity-flush toilet: Toilet whose flush is powered solely by the force of falling water. See also *pressure-assist toile*t.

Graywater: Wastewater from a building that does not include flush-water from toilets or (as most commonly defined) water from kitchen sinks or dishwashers. In some places, graywater can be collected and used for subsurface irrigation.

Green building: Design and construction of buildings that minimize impacts on the environment while helping keep occupants healthy.

Green electricity: Electricity generated from renewable energy sources, such as photovoltaics (solar power), wind power, biomass, and small-scale hydropower. (Large, conventional hydropower sources usually are not included in definitions of green electricity.)

Grid-connected power system: Electricity generation system, usually relying on photovoltaics or wind power, that is hooked up to the utility company's electric grid through a net-metering arrangement so that electricity can be obtained when the locally generated power is not sufficient. See also *stand-alone power system*.

Ground-source heat pump: Heat pump that relies on the relatively constant temperatures underground as the heat source and heat sink. The energy performance of ground-source heat pumps is usually better than that of air-source heat pumps.

Gut rehab: Building renovation in which the walls are gutted (reduced to the wall framing and sometimes sheathing), then insulated, sheathed, and finished.

Heat exchanger: Device that allows for transfer of heat from one material to another. An air-to-air heat exchanger, or heat-recovery ventilator, transfers heat from an outgoing airstream to an incoming airstream. A copper-pipe heat exchanger in a solar water heater tank transfers heat from the heat-transfer fluid circulating through a solar collector into the potable water in the storage tank.

Heat pump: Heating and cooling system in which specialized refrigerant fluid in a sealed system is alternately evaporated and condensed by altering its pressure; this phase change allows heat to be transferred into or out of the house. See *air-source heat pump* and *ground-source heat pum*p.

Heat distribution: System for delivering heat throughout a house. See *forced-air heating* and *hydronic heating*.

Heat-recovery ventilator (HRV): Balanced ventilation system in which most of the heat from outgoing exhaust air is transferred to incoming fresh air via an air-to-air heat exchanger. See also *energy-recovery ventilator*.

High-efficiency toilet (HET): Toilet that provides at least 20% water savings over the federal standard of 1.6 gallons per flush and still meets the most rigorous standards for flush performance.

Home performance audit: An energy audit that also includes inspections and testing assessing moisture flow, combustion safety, thermal comfort, indoor air quality, and durability.

Home run plumbing system: Water distribution piping system in which individual plumbing lines extend from a central manifold to each plumbing fixture or water-using appliance. The piping is typically cross-linked polyethylene (PEX). Because diameter of the tubing can be matched to the flow of the fixture or appliance, hot water can be delivered more quickly.

Horizontal-axis clothes washer: Washing machine (typically front-loading) in which the laundry drum is configured horizontally. This design allows significant water savings, because the laundry is dipped into and out of the wash water as the drum rotates. See also *vertical-axis clothes washer*.

Hydrochlorofluorocarbon (HCFC): Compound commonly used as a refrigerant in compression-cycle mechanical equipment (refrigerators, air-conditioners, and heat pumps) or as a blowing agent in producing foam insulation. HCFCs are damaging to Earth's protective ozone layer.

Hydronic heating: Heat distribution system in which hot water produced by a boiler is circulated through pipes and baseboard radiators or tubing in a radiant floor. Also called baseboard hot-water heating.

Impervious surface: Surface that does not permit stormwater runoff to infiltrate the ground. See also *porous paving*.

Incandescent light: Light produced when electric current heats a tiny coiled filament to glowing. Such light bulbs convert about 90% of the electricity into heat and only 10% into light. See also *fluorescent lighting*.

Indirect water heater: Water heater that draws heat from a boiler used for space heating. The boiler heats water in a separate, insulated tank via a water-to-water heat exchanger. See also *tankless coil*.

Indoor air quality (IAQ): Healthfulness of an interior environment. IAQ is affected by such factors as moisture and mold, emissions of volatile organic compounds from paints and finishes, formaldehyde emissions from cabinets, and ventilation effectiveness.

Insulated concrete form (ICF): Hollow insulated forms, usually made from expanded polystyrene (EPS), used for building walls (foundation and above ground), that are stacked and stabilized and then filled with concrete, which provides the wall structure.

Integral collector storage (ICS) solar water heater: Solar water heater in which potable water is heated where it is stored.

Integrated design: Building design in which different components of design, such as the building envelope, window placement and glazings, and mechanical systems, are considered together. High-performance buildings and renovations can be created cost-effectively using integrated design, since higher costs in one place can often be paid for through savings elsewhere. For example, by improving the performance of the building envelope, the heating and cooling systems can be downsized or even eliminated.

Inverter: Device for converting direct-current (DC) electricity into the alternating-current (AC) form required for most home uses. An inverter is necessary if home-generated electricity is to be fed into the electricity grid through a net-metering arrangements.

Kilowatt-hour (kWh): Measure of electricity consumption; a 100-watt light bulb burning for ten hours consumes 1 kWh.

Leaching: Process by which chemicals can escape from certain materials in the environment;. For example, arsenic can leach out of older pressure-treated wood.

Lead: Toxic heavy metal often found in paints made or applied before 1978. When renovating, follow proper lead-abatement procedures to avoid lead poisoning.

LEED for Homes: Rating system for green homes developed by the U.S. Green Building Council. The acronym stands for Leadership in Energy and Environmental Design.

Life cycle: Entire life of a product or material, from raw material acquisition through disposal.

Life-cycle assessment (LCA): Examination of theenvironmental and health impacts of a product or material over its life cycle. LCA provides a mechanism for comparing different products and materials for green building.

Life-cycle cost (LCC): Economic cost of a product or building over its expected life, including both first cost (purchase cost) and operating cost.

Light-emitting diodes (LEDs): Small lights that use semiconducting (solid-state) materials to turn electricity into light. Different semiconductors create different colors of light. White LEDs appropriate for residential use are continuously improving in quality, efficacy, and cost-effectiveness. LEDs are very long-lasting; unlike fluorescent lamps, they do not contain mercury.

Light organic solvent preservatives (LOSPs): Organic pesticides, biocides, and fungicides suspended in a hydrocarbon (solvent-based) carrier. "Organic" in this case refers to the fact that the chemicals are carbon-based.

Light pollution: Nighttime lighting that escapes into the night sky. Light pollution can interfere with the day-night patterns of ecosystems, disrupt the flights of migrating birds, interfere with sea turtle nesting in coastal areas, and hinder astronomical observation.

Low-conductivity gas fill: Transparent gas installed between two or more panes of glass in a sealed, insulated window that resists the conduction of heat more effectively than air. The fill boosts a window's R-value and reduces its U-factor.

Low-emissivity (Low-e) coating: Very thin metallic coating on glass or plastic window glazing that reduces heat loss through the window. The coating emits less radiant energy (heat radiation), which makes it, in effect, reflective to that heat. The coating boosts a window's R-value and reduces its U-factor.

Make-up air: Outside air supplied to replace household air that was used in a combustion appliance or exhausted through a ventilation system.

Manifold: Component that distributes the waterin a home-run plumbing system. It has one inlet and many outlets, each of which feeds one fixture or appliance.

Mechanical ventilation: Ventilation system using one or more fans to exhaust stale indoor air from a home as a way to ensure adequate indoor air quality. See exhaust-only ventilation and balanced ventilation.

Medium-density fiberboard (MDF): Panel product used in cabinets and furniture, generally made from wood fiber glued together with binder. Similar to particleboard, MDF has finer texture, offering more precise finishing. Most MDF is made with formaldehyde-emitting urea-formaldehyde binders.

Methyl diisocyanate (MDI) binder: Nonformaldehyde binder used in some medium-density fiberboard and particleboard products, including straw-based particleboard.

Net metering: Arrangement through which a homeowner who produces electricity using photovoltaics or wind power can sell excess electricity back to the utility company, running the electricity meter backward. The utility effectively buys the power at the retail price, but the amount of electricity the utility company will "buy" in a given month is limited to the amount that the homeowner buys; any excess electricity is purchased at a much lower, wholesale price. See *grid-connected power system*.

Net-zero energy: Producing as much energy on an annual basis as one consumes on site, usually with renewable energy sources, such as photovoltaics or small-scale wind turbines. Calculating net-zero energy can be difficult, particularly in grid-tied renewable energy systems, because of transmission losses in power lines and other considerations.

Offgassing: Release of volatile chemicals from a material or product. See also *volatile organic compounds*.

On-center: As used in house construction, the distance from the center of one framing member to the center of another. In wood-frame construction, studs are typically 16 or 24 inches on-center.

On-demand hot water circulation: System that quickly delivers hot water to a bathroom or kitchen when needed, without wasting the water that has been sitting in the hot-water pipes, which circulates back to the water heater.

On-site wastewater system: Treatment and disposal of wastewater (sewage) from a house that is not connected to a municipal sewer system; most on-site systems include a septic tank and leach field.

Operating cost: Cost of operating a device or building; including energy, maintenance, and repairs.

Operating energy: Energy required to operatea device or building.

Oriented-strand board (OSB): Wood sheathing or subfloor panel made from strands of wood glued together in layers oriented for strength. Most OSB is made using phenol-formaldehyde or methyl diisocyanate (MDI) binder.

Ozone depletion potential: Amount of damage to the ozone layer a given chemical can cause compared trichlorofluoromethane (CFC-11), which is given a value of 1.0 on this relative scale.

Particleboard: Panel product used in cabinets and furniture, generally made from wood fiber glued together with binder. Similar to medium-density fiberboard (MDF), a coarser texture. Most particleboard is made with formaldehyde-emitting urea-formaldehyde binder, although some wood particleboard and all straw particleboard use a nonformaldehyde methyl diisocyanate (MDI) or low-emitting phenol-formaldehyde binder.

Passive solar heating: Building design in which solar energy provides a significant portion of the heating without fans or pumps; the building itself serves as the solar collector and heat storage system.

Payback period: Length of time it takes for an investment to pay for itself. For example, water and energy savings from replacing an old showerhead with a new, water-saving model can often pay back the investment in a few months; the payback period for a photovoltaic power system will be much longer.

Peak watt: Highest possible unit of rated power output, (for example, from a photovoltaic (PV) module in full sunlight), as distinct from its output at any given moment, which may be lower.

Pellet stove: Woodstove designed to burn pellets made from compressed sawdust or wood shavings which are fed into the firebox at a metered rate by a screw auger. An electric fan provides combustion air.

Phenol-formaldehyde binder: Formaldehyde-based binder used for wood products, especially those made for exterior applications. It generally has lower formaldehyde emissions than urea-formaldehyde binder.

Photovoltaics (PV): Generation of electricity directly from sunlight. A photovoltaic (PV) cell has no moving parts; electrons are energized by sunlight and result in current flow.

Phthalate plasticizer: Chemical added to polyvinyl chloride (PVC) and certain other plastics to make them more flexible; some phthalates are known or thought to be endocrine disruptors. See *endocrine disruptors*.

Pier foundation: Building foundation consisting of piers instead of continuous walls. Piers are resource-efficient because they avoid the need for continuous foundation walls.

Plasticizer: Chemical compound added to a material to make it more flexible or softer. See *phthalate plasticizer*.

Polyisocyanurate (polyiso): Type of rigid foam insulation used in above-grade walls and roofs, typically with a foil facing on both sides. This kind of insulation was made with ozone-depleting HCFC-141b blowing agent, but manufacturers have switched to ozone-safe hydrocarbons.

Polyurethane foam: Insulation material made from polyol and isocyanate and a blowing agent that causes it to expand, typically sprayed into wall cavities or sprayed on roofs. Both open-cell and higher-density closed-cell products are used.

Polyvinyl chloride (PVC): Most common plastic in building construction, widely used in such applications as drainage piping, flooring, exterior siding, window construction, and electrical wire. Also known as vinyl.

Porous paving: A paving material that allows precipitation to percolate through and infiltrate the ground rather than contributing to stormwater runoff. Pavers can be asphalt, concrete, or porous grid.

Portland cement: Building material made from limestone, gypsum, and shale or clay, which when mixed with water, binds sand and gravel into concrete. Portland cement was invented in 1824 by Joseph Aspdin, a British stone mason, who named it after a natural stone quarried on the Isle of Portland off the British coast.

Postconsumer recycled material: Material recovered from a waste product that has been in use by a consumer before being discarded. See also *postindustrial recycled material*.

Postindustrial (preconsumer) recycled material: Material recovered from the waste stream of an industrial process that has not been placed in use. See also *postconsumer recycled material*.

Potable water: Water considered safe for drinking and cooking.

Pozzolan: Any silicon or silicon-aluminum material - which when finely divided and mixed with moisture, reacts with calcium hydroxide to form a cementitious

compound. Common examples of pozzolans include fly ash, blast furnace slag, volcanic ash, silica fume, and rice hull ash.

Pressure-assist toilet: Toilet that uses air pressure, generated as the toilet tank refills, to produce a more forceful flush; some high-efficiency toilets (HETs) rely on pressure-assist technology.

Pressure-treated wood: Wood that has been chemically treated to extend its life, especially when outdoors or in ground contact. The most common pressure-treated wood until a few years ago, chromated copper arsenate (CCA), has now been phased out for most applications, because of health and environmental concerns. Other pressure-treating chemicals include ACQ, copper azole, and sodium silicate.

Prudent avoidance: Strategy using relatively easy and low-cost tactics to avoid exposure to something that may prove to be harmful, such as electromagnetic fields (EMFs).

R-value: Measure of resistance to heat flow; the higher the R-value, the lower the heat loss. R-value is the inverse of U-factor.

Radiant energy: Energy transmitted by electromagnetic waves.

Radiant-floor heating: Heat distribution system in which a floor serves as a low-temperature radiator. When used with hydronic heating, hot water is usually circulated through tubing embedded in a concrete slab; alternatively, the tubing can be installed on the underside of wood subflooring, although the benefit of thermal mass is lost.

Radiation: Movement of energy via electromagnetic waves.

Radon: Colorless, odorless, short-lived radioactive gas that can seep into homes and create lung cancer risk. Radon and its decay products emit cancer-causing alpha, beta, and gamma particles.

Rainscreen: Construction detail appropriate for all but the driest climates to prevent moisture entry and to extend the life of siding and sheathing materials, most commonly produced by installing thin strapping to hold the siding away from the sheathing by a one-quarter to three-quarters of an inch.

Raised heel truss: Preconstructed roof truss designed to allow room at the eaves (above exterior walls) for large amounts of insulation. (Standard roof trusses have sufficient depth for adequate insulation near the eaves.)

Rankine-cycle compressor: Technology used in a standard air-conditioner and refrigerator to achieve cooling, in which a refrigerant is alternately compressed and allowed to expand, cooling air in the process.

Reflective roofing: Roofing material that reflects most of the sunlight striking it to help reduce cooling loads. The Energy Star Cool Roof program certifies roofing materials that meet specified standards for reflectivity.

Refrigerant: Compound used in refrigerators, air-conditioners, and heat pumps to transfer heat from one place to another (using the *Rankine cycle*), thus cooling or heating a space. Most refrigerants today are hydrochlorofluorocarbons (HCFCs), which deplete the ozone layer.

Renewable energy: Thermal or electrical energy produced using solar, wind, hydropower, or biomass energy sources.

Room air-conditioner: Air-conditioner installed in a window or through a wall, usually used to cool a relatively small area. With a very energy-efficient, tight house, a single room air-conditioner may be able to cool the entire space. See also *whole-house (central) air-conditioner*.

Sealed combustion: Combustion system for space heating or water heating in which outside combustion air is fed directly into the combustion chamber and flue gases are exhausted directly outside.

Seasonal energy efficiency ratio (SEER): Energy performance rating of a whole-house (central) air conditioner or heat pump operating in the cooling mode, calculated as the ratio of the estimated seasonal cooling output divided by the seasonal power consumption in an average climate.

Sheathing: Material, usually plywood or oriented-strand board (OSB) but sometimes wooden boards, installed on the exterior of wall studs, rafters, or roof trusses. Siding or roofing installed on the sheathing, sometimes over strapping to create a rainscreen.

Solar collector: Device for capturing solar energy and transferring heat to water or air that circulates through it.

Solar gain: Sunlight entering a building. A passive solar direct-gain system uses solar gain.

Solar heat gain coefficient (SHGC): The fraction of solar gain admitted through a window, expressed as a number between 0 and 1.

Space planning: Process of converting the needs expressed by the client into the drawings and supporting documentation that outline the plan for

the team. For the interior designer, space planning includes the placement of all fixed and unfixed elements, from plumbed and wired appliances to furniture and the way people move around in the space. Plumbing and HVAC contractors are concerned primarily with hidden elements. With comprehensive space planning, the team works together to ensure that the design is optimized across disciplines.

Stormwater: Runoff from precipitation that is either carried off site in storm sewers or allowed to infiltrate the ground; stormwater can be reduced through the use of porous paving and other infiltration strategies.

Structural insulated panel (SIP): Building panel usually made of oriented-strand board (OSB) skins surrounding a core of expanded polystyrene (EPS) foam insulation. SIPs can be erected very quickly with a crane to create an energy-efficient, sturdy home.

Sump: Reservoir or pit in the basement of a house into which water can drain, especially during flooding. A sump pump is used to pump collected water out of this reservoir.

Sun tempering: Practice of using a modest area of south-facing windows to provide limited passive solar heating to a house.

Superinsulate: To insulate extremely well. A house with very efficient windows and tight construction results in very low heating and cooling costs.

Swale: Low area of ground used for drainage and often the infiltration of stormwater.

Tankless coil: Heat exchanger used for heating water that is integrated into a boiler. Effective in the winter months when the boiler is operating for space heating, tankless coils waste energy in warmer months, since they require the boiler to fire up every time hot water is drawn.

Therm: Unit of heat equal to 100,000 British thermal units (Btus), commonly used to measure natural gas consumption.

Thermal bridging: Heat flow that occurs across more conductive components in an otherwise well-insulated material, resulting in disproportionately significant heat loss. For example, steel studs in an insulated wall dramatically reduce the overall energy performance of the wall because of thermal bridging through the steel.

Thermal mass: Heavy, high-heat-capacity material that can absorb and store a significant amount of heat; used with a passive solar heating system to keep the house warm at night.

Thermosiphon solar water heater: Solar water heater that operates passively (through natural convection), circulating water through a solar collector and into an insulated storage tank situated above the collector. Pumps and controls are not required.

Top plate: Wood framing member that forms the top of a wall. In advanced framing, a single top plate is often used in place of the more typical double top plate.

Track-off mat: Mat at a house entrance across which people scuff their feet to remove moisture, dirt, and other particulates, keeping contaminants out and reducing cleaning requirements.

Tubular skylight: Round skylight that transmits sunlight down through a tube with internally reflective walls, even through an attic space to deliver daylighting through a ceiling light diffuser. Most tubular skylights are 12 to 16 inches in diameter and deliver daytime lighting comparable to several 100-watt incandescent light bulbs.

U-factor: Measure of the heat conducted through a given product or material calculated as the number of British thermal units (Btus) of heat that move through a square foot of the material in one hour for every one degree Fahrenheit difference in temperature across the material (Btu/ft^2°F hr). U-factor is the inverse of R-value.

United States Green Building Council (USGBC): Organization devoted to promoting and certifying green buildings. USGBC created the LEED rating systems.

Universal design: Design that makes a building accessible to as many individuals as possible, including older people and those with physical handicaps.

Unvented (or vent-free) gas heater: Gas-burning space heater that is not vented to the outdoors. Although unvented gas heaters burn very efficiently, indoor air quality experts strongly recommend against their use because combustion gases, including high levels of water vapor, are released into the house.

Urea-formaldehyde binder: Interior-grade, formaldehyde-based binder used for particleboard, medium-density fiberboard (MDF), and hardwood plywood. This type of binder generally has higher formaldehyde emissions than phenol-formaldehyde binder.

UV light treatment: Water treatment system in which water passes through a column where it is exposed to ultraviolet light to kill any pathogens.

Vapor diffusion: Movement of water vapor through a material. Water vapor can diffuse through even solid materials if the permeability is high enough.

Vapor profile: The relative individual component and total combined vapor permeability of building assemblies. The vapor profile addresses not only how the assembly protects itself from getting wet by vapor diffusion, but also how it dries the assembly gets wet.

Vapor retarder: Layer that inhibits vapor diffusion through a building envelope. Examples include polyethylene sheeting, foil facing, kraft paper facing on batt insulation, and low-permeability paints. Most building codes define a vapor retarder as 1 perm or less, with many common vapor retarders being significantly less than 1 perm. Note that many building scientists prefer a focus on the vapor profile of a building assembly rather than just the individual vapor permeability of the designated vapor retarder.

Variable air volume (VAV) air handler: System for controlling an HVAC system in which the volume of air provided to conditioned space is varied to control comfort.

Ventilation: Replacement of stale indoor air with fresh outdoor air, usually with fans but sometimes naturally through building design elements. See also *heat recovery ventilator*.

Vertical-axis clothes washer: Top-loading washing machine with a tub that rotates back and forth and spins on a vertical axis, such that the center of rotation is a line extending up from the center of the tub. See also *horizontal-axis clothes washer*.

Vinyl: Common term for polyvinyl chloride (PVC), a carbon-and-hydrogen group ($H_2C=CH–$) that attaches to another functional group, such as chlorine (vinyl chloride) or acetate (vinyl acetate).

Volatile organic compound (VOC): Organic compound that evaporates readily into the atmosphere. As defined by the U.S. Environmental Protection Agency, VOCs are organic compounds that volatize and then contribute to photochemical smog production.

Waste management plan: Plan that addresses the collection and disposal of waste generated during construction or renovation, usually including the collection and storage of recyclable materials.

Wastewater: Used water from toilets, showers, sinks, dishwashers, clothes washers, and other sources in the home, including all contaminants, which can either flow into a municipal sewer system or be treated with an onsite wastewater disposal system. See also *graywater*.

WaterSense: Program developed and administered by the U.S. Environmental Protection Agency to promote and label water-efficient plumbing fixtures.

Weatherization: Cost-effective energy efficiency measures for existing residential and multifamily housing. When weatherization includes the house as a system, it is often called whole-house weatherization.

Whole-house (central) air-conditioner: Air-conditioning system that serves an entire house; cooled air is delivered through a system of ducts. See also *room air-conditioner*.

Whole-wall R-value: Average R-value of a wall, taking into account the thermal bridging through wall studs.

Xeriscaping: Type of landscaping that requires little if any irrigation, is suited to dry and drought-prone climates, and generally relies on regionally adapted native plants.

Building Profile Worksheet

Client _____ Date _____
E-mail _____ Phone _____
Mobile _____ Fax _____
Client Address Building Address
_____ _____
_____ _____
_____ _____

Contact Notes

_____
_____

Context Details (Items with Bearing on the Specific Project):

Av. Annual Rainfall _____ Seasonal Distribution _____
HDD _____ CDH _____ HDD Distribution _____
CDH Distribution _____
Heating Design Temperature _____ Cooling Design Temperature _____
Av. Monthly Dewpoints _____
○J ○F ○M ○A ○M ○J ○J ○A ○S ○O ○N ○D
Prevailing Wind Direction _____ Prevailing Wind Speed _____
Top Wind Speed _____ Relevant Recent Weather Events _____
Building Perimeter Soil Characteristics _____
Site Soil Characteristics _____
Soil Surface Conditions _____
Prevailing Slope of Site _____
Building Perimeter Grade _____
Water Table Depth _____ Irrigation System Check _____
Neighboring Site Conditions _____
_____

Building Characteristics

Age of Building _____ Rehab or Renovation Dates _____
R/R Details _____
_____
Hazardous Materials Assessment (lead, asbestos, radon, etc) _____
_____
_____
Original Plans/Documents Available?_____ R/R Plans/Documents Available? _____
Lot Size _____ Building Footprint _____ Building Total Sq. Ft. _____
Floors Above Grade _____ # Floors Below Grade _____
Building Orientation (Front Entrance) _____
Below-Grade Assemblies _____
Above-Grade Assemblies _____
Roof Assemblies _____
Glazing (as % of Floor Area) _____ Glazing Properties _____
_____

Building Science Details

Site Run-Off Management _____

Windbreaks? _____ Shading? _____

Building Run-Off Management _____

Surface Details (Hardscape, Variegation, etc.) _____

Foundation Perimeter Drainage Details _____

_____

Footer/Foundation Wall Junction Details

- Drainage Plane _____
- Capillary Break _____

Below-Grade Wall Details

- Capillary Break _____
- Thermal Barrier _____
- Air Barrier _____
- Vapor Profile _____
- Drainage Plane _____

Below-Grade Floor Details

- Capillary Breaks _____
- Thermal Barrier _____
- Air Barrier _____
- Vapor Profile _____

Above-Grade Wall Details

- Capillary Breaks _____
- Thermal Barrier _____
- Air Barrier _____
- Vapor Profile _____
- Drainage Plane _____

Roof Assembly Details

- Thermal Barrier _____
- Air Barrier _____
- Vapor Profile _____
- Drainage Plane _____

Pest Management Details

- Insects _____
- Other _____

Drainage Plane Design Details

- Overhangs _____
- Sheltered Entryways _____
- Wall Penetrations _____
- Roof Penetrations _____
- Window Flashing _____
- Deck Attachment Details _____
- Other Flashing _____

Air Barrier Design Details

- Soffits Extending to Conditioned Space Boundary (CSB) _____
- Vertical Chases Extending to CSB _____
- CSB Penetrations _____

HVAC/Water Heating Details

- Combustion Sources _____
- Heating Details _____
- Cooling Details _____

DEH and Humidifier Details_____
Ducting Details _____
Ventilation Details _____
Spot Exhaust Details _____
Water Heating _____

Fail-Safe Plumbing Details

Leak Sensors_____ Easy-Throw or Single-Throw Shut-Offs_____
Drained Pans_____ Concealed Drainage Plane in Wet Walls_____

Maintenance and Commissioning Details

_____
_____
_____

Wildfire Management Details

_____
_____
_____

Building Performance/Conditions Metrics

Whole Building Air Tightness (Blower Door)_____
HVAC Duct Tightness (Duct Blaster) _____
Room-to-Room Pressure Measurements _____
Low-e Window Testing_____
Infrared Imaging/Thermometer Readings _____
Humidity (air moisture) Readings _____
Moisture Content (material moisture) Readings _____
HVAC Flow (air velocity) Measurements _____

Overall Comments

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Recommendations

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Followup

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Credits for Photography and Illustration

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3-D Building Solutions, LLC

The American Society of Interior Designers' Foundation and the U.S. Green Building Council have partnered on the development of best-practice guidelines and targeted educational resources for sustainable residential improvement projects. This program will increase understanding of sustainable renovation project practices and benefits among homeowners, residents, design professionals, product suppliers, and service providers to build both demand and industry capacity.

This program will complement the release of LEED for Homes but is not itself a LEED-branded rating system with certification thresholds and recognition levels. It is a guide with educational resources for setting and achieving performance-based objectives for sustainable residential improvement projects.

A technical committee comprising of both ASID and USGBC members and invited experts has developed these guidelines. The guidelines focus on the major practice areas and define performance-based objectives for sustainable residential renovation projects. The accompanying manual will outline detailed strategies for applying the guidelines and include illustrative case studies and resource references.

www.regreenprogram.org

THE AMERICAN SOCIETY OF INTERIOR DESIGNERS FOUNDATION

U.S. GREEN BUILDING COUNCIL USGBC