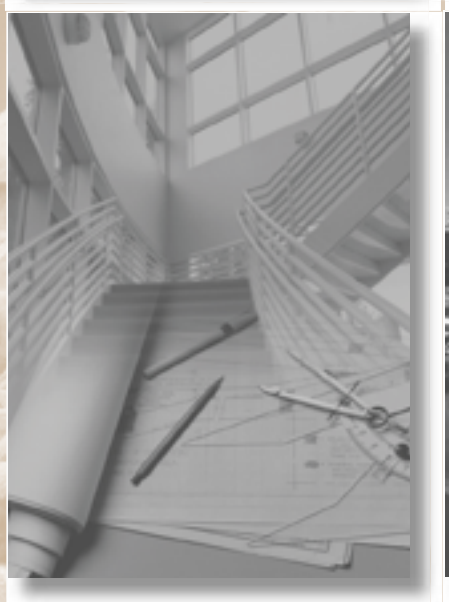
Building and Buying Green in Indian Country

A PRACTICAL GUIDE FOR CALIFORNIA TRIBES



INTEGRATED WASTE MANAGEMENT BOARD

PREPARED FOR
The California Integrated Waste Management Board
BY
The Center for Indian Community Development,
The Center for Environmental Economic Development
and Boisson & Associates
MAY, 2004

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CONTENTS

DISCLAIMER

This Guide provides ideas for consideration, not recommendations. Readers should discuss and carefully evaluate sustainable building strategies with project architects, contractors, suppliers or other building professionals. The authors take no responsibility for the performance of any particular technology or product mentioned in this Guide.

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The Guide was developed and co-authored by the Center for Indian Community Development (CICD), the Center for Environmental and Economic Development (CEED), and Boisson and Associates. CEED staff included Ed Boisson, Ruthanne Cecil, J.D., and Daniel M. Ihara, Ph.D. CEED project interns involved were Solana Foo, Molly Jacobs, Matthew Marshall, and Charles Lessman. Technical reviews were conducted by Dr. Ihara and Michael Manetas, professor emeritus, environmental engineering, Humboldt State University. The graphic design and layout was produced by Annie Reid.

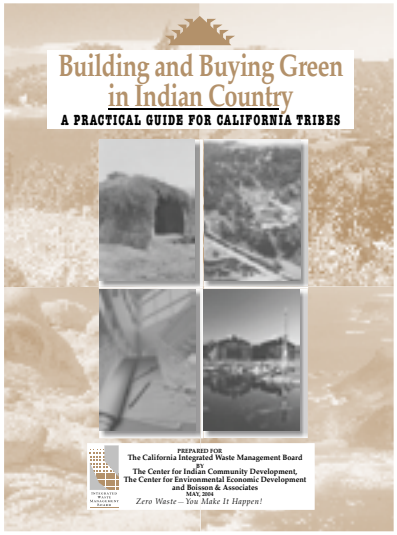
The CIWMB, CICD, and CEED project researchers and authors are grateful for the time, advice, and suggestions of the many tribal staff throughout California Indian Country who took the time to review and critique this document as it was developed.

We hope this Guide will lead to a more sustainably built environment, a lighter human impact, and a lighter tread upon the earth.

ABOUT THE COVER

Background Illustrations: These represent different bioregions found throughout California. California Indians traditional lands and ancestral territories encompass a variety of environments, spanning diverse geographic areas—desert, mountains, coastal regions, valleys—as well as urban and rural communities.

Top left photo: *Cahuilla House in the Desert*, The North American Indian; vol. 15; Edward Curtis; McCormick Library of Special Collections, Northwestern University Library, Evanston, IL. Historically, California Indian architecture utilized the materials and natural environment of each community. Redwood plank houses, cedar bark houses, and grass houses were among the many types of traditional constructions found in California Indian Country.



Bottom left photo: The Sacramento Municipal Utility District's Customer Service Building at 6301 S Street features extensive use of daylighting, an under floor air distribution system, and radiant heating to create an optimal indoor environment for occupants and visions. Significant steps were taken to preserve an existing grove of redwoods on site and incorporate renewable energy systems, such as photovoltaic panels, making this an excellent example of sustainable building in the Sacramento area.

Top right photo: Camp Arroyo Environmental Education Center and Summer Youth Camp was designed and built and is maintained and operated sustainably. This facility is located in the hills near the city of Livermore, California, in southern Alameda County. The $10 million dollar project includes many different types of structures including a dining hall/multi-purpose room, living quarters, bathhouses, and swimming pool. Phase two will nearly double the existing capacity from the current 144 to 225 guests.

The principles of sustainability are omnipresent in the project. Sustainable features have been maximized to include energy and water conservation, indoor air quality, recycled-content and environmentally preferable products and materials use, native landscaping and organics management, waste reduction and recycling practices, and on-site power generation. This facility is truly the "picture" of sustainability and a prime example of what can be accomplished by integrating the principles presented in this guide.

Bottom Right: Potawot Health Village, Arcata California. Design is a key factor for achieving the vision of the Potawot Health Village, a healing center that addresses the contemporary needs of local tribal communities. Potawot Health Village was envisioned, designed, and is operated by the United Indian Health Services. It is a sustainably built building that reflects the traditional North Coast architecture.

A Note to the Reader

Building and Buying Green in Indian Country: A Practical Guide for California Tribes was developed to provide basic information about sustainable building practices, considerations, and planning for building projects in Indian Country. It is intended to:

1. Give Tribal project decision makers and planners an overview of sustainable and "green" building practices and options.
2. Serve as a tool to support those decision makers and planners in evaluating and choosing sustainable options as they develop projects with architects, contractors, suppliers, or other building professionals.

In order to develop a tool that could really be effective in projects in Indian Country, all of the Tribes in California were surveyed and were able to review the document as it was developed. The survey results showed that 54 Tribes reported building projects valued at more than $250,000 are underway or planned, including residential buildings. Of these, 46 were commercial buildings, 43 were tribal buildings, and 34 were residential and prefabricated buildings.[1] Nationwide, more than 200 Tribes are reaping revenue of more than $10 billion and are reinvesting huge sums in their communities.[2]

The Guide was envisioned and funded by the California Integrated Waste Management Board, which encourages the use of sustainable building practices and materials because they lessen environmental impacts. Sustainable building practices can be appealing, healthy, high quality, and affordable. The Board believes that incorporating sustainable practices and elements in building projects in Indian Country will not only be compatible with, but will enhance the abilities of Tribes to achieve their vision for the future of their communities.

[1] Center for Indian Community Development. Survey in July, 2003.

[2] Montana Associated Technology Roundtables (MATR) News, March 30, 2003.

Who should use the Guide?

Anyone involved with construction in Indian Country could use this Guide regardless of their level of knowledge of sustainable building practices. Ideally, during the beginning stages of any building project, project planners will refer to this Guide in order to "green" the project (that is, use sustainable practices, methods, or materials). The Guide can help Tribal project decision-makers and planners decide whether or not to make a commitment to sustainable building in new projects, or assist in finding and working with architects, contractors, and other building professionals.

What's in the Guide?

The Guide is comprehensive and provides a range of ideas to consider for any type of building project, in any type of climate. It consists of 10 stand-alone modules. Modules One through Three provide an overview of sustainable development and offer suggestions to California Tribes on how to effectively promote and fund sustainable building projects. Modules Four through Ten provide overviews of primary elements of green building and design strategies to consider. Each strategy module includes a list of resources and tools such as fact sheets, policy models, and product specifications. The Guide is not overly technical, but sources of detailed and more technical information to be referenced are provided throughout.

Introduction To Sustainable Building In Indian Country

MODULE 1

Traditionally, all tribes lived within the rhythms and cycles of the natural world, ingeniously discovering how to prosper using what nature provided. As contemporary Tribes work to achieve healthy and prosperous communities, they are presented with the challenge of reconciling their current needs with more traditional practices, particularly those that show respect for nature. The sustainable or green construction practices presented in the guide—including the need to balance many competing considerations—provide an excellent opportunity and framework for meeting this challenge.

An Example of Vision, Tradition, Planning and Sustainability in Contemporary Building: Potawot Health Village

Design is a key factor for achieving the vision of the Potawot Health Village in Arcata, California, a healing center that addresses the contemporary needs of local Tribal communities. The United Indian Health Services (UIHS) facility looks much like a traditional north coast village, the nucleus of local Indian identity. Connection to important cultural features is maintained inside with the central focus of a spring in the Wellness Garden and displays of traditional and contemporary original artwork. It is also a modern health care facility. By making a statement about the importance of traditional ways, Potawot imparts a sense of wellness and creates a place and pathway for healthy local American Indian communities. Traditional elements are present in the structure itself and in the use of water and natural settings as a central focus.

The form and orientation of traditional American Indian structures indigenous to the north coast area is the basis for the design. Potawot appears to be constructed with redwood planks, but the walls are pre-cast concrete, molded and stained to simulate old redwood. The buildings are rectangular and the two or three-pitched roofs are typical of local indigenous architecture. These roofs are reminiscent of adjustable smoke holes and wind guards used in traditional buildings. The entryway interior is made of old redwood recycled from a demolished sawmill. The design of the facility is circular connecting hallways and a central outdoor Wellness Garden. In this garden is a spring and all the doors are orientated towards this focal point. The building itself is designed to be a natural part of the wetland, prairie, and forest lands that are being restored around it. The outdoor Wellness Garden, its spring, and all the wetlands around the building speak to the local people, who are a water-oriented people. Historically, the ocean, rivers, bays, marshes, and wetlands formed the most abundant resources in the region.

The UIHS Design Committee worked with Mulvanny/G2 Architecture in Seattle, Washington, a firm that specializes in health care facilities. Mulvanny/G2 Architecture started the design process by gaining a better understanding of what was important to local Indian people. In addition to a setting with enough space for increased client capacity, UIHS wanted a place where people would have a sense of community that draws them together. By placing culture first and then integrating the clinical requirements, the design of Potawot makes a visual and emotional connection between two worlds.

In addition to the holistic design approach, this showcase development incorporates many aspects of green design and construction as well as themes that honor traditions of local tribes. The facility is carefully sited to enhance the natural environment for Potawot's purpose as a healing center, both in terms of its central focal point garden and the surrounding restored native landscape. The building design flows, and it makes maximum use of natural light and ventilation with energy-efficient windows. The construction incorporated green materials such as recycled native redwood and cost-efficient pre-cast concrete.

SUSTAINABLE BUILDING IS PRACTICAL

Green Buildings

The buildings in which we live, work, and play protect us from Nature's extremes: cold, heat, wind, rain, and snow. But these structures affect and shape our environment too. Constructing and operating buildings requires enormous amounts of energy, water, and materials and creates large amounts of waste. Where and how they are built affects the ecosystems around us in countless ways. And the buildings themselves create new indoor environments that present new environmental problems and challenges.

As the environmental impact of buildings becomes more apparent, a new field called Green Building is arising to reduce that impact at the source. Green or sustainable building is the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition. The many elements of green building include:

Energy: Designing and operating buildings to use energy efficiently and to use renewable sources of energy, including solar, wind, and biomass.

Water: Designing and operating buildings to use water efficiently.

Materials: Using building materials that have a reduced effect on the environment throughout their life cycle compared to competing brands (for example, recycled content, low toxicity, energy efficiency, biodegradability, and/or durability).

Waste: Reducing the waste from construction, remodeling, and demolition.

Indoor Environment: Designing and operating buildings that are healthy for their occupants.

(U.S. EPA)
www.epa.gov/opptintr/greenbuilding/.

What is sustainable or green building?

Conventional building practices often overlook the interrelationships between a building, its components, its surroundings, and its occupants. "Typical" buildings consume more of our resources than necessary, negatively impact the environment, and generate a large amount of waste. Often, these buildings are costly to operate in terms of energy and water consumption. And they can result in poor indoor air quality, which can lead to health problems.

Sustainable or "green" building practices offer an opportunity to create environmentally sound and resource-efficient building by using an integrated approach to design. Green buildings promote resource conservation, including energy efficiency, renewable energy, and water conservation features. Green buildings consider environmental impacts and waste minimization, create a healthy and comfortable environment, reduce operation and maintenance costs, and address issues such as historical preservation, access to public transportation, and other community infrastructure systems. The entire life cycle of the building and its components is considered, as well as the economic and environmental impact and performance.

Sustainable building designs, options, and strategies are ultimately about resource efficiency and can be incorporated in every building project within Tribal jurisdiction. The scope of this sustainable incorporation is determined by each project's budget and use. Tribal residential, institutional, and commercial building projects can incorporate sustainable building options, strategies, and designs throughout. Or, sustainable building options can influence only one or two components of a project. A building such as a casino might be limited in its use of day lighting and may not be able to use windows as a natural ventilation system. But sustainable furnishings, flooring, and paint products can still be used.

PHOTO COURTESY OF UNITED INDIAN HEALTH SERVICES

Sustainable building emphasizes high quality and high performance.

Sustainable building materials and practices meet or exceed all of the health, safety, and engineering requirements of conventional approaches. But unlike conventional building, sustainable building emphasizes high performance strategies that reduce environmental impacts while also enhancing the beauty and function of a space. For example, ample natural light, insulation, and views of natural landscapes can make buildings more comfortable to be in. In the case of work and educational spaces, these features have been shown to boost worker productivity by up to 16 percent[1] and student performance by up to 20 percent.[2]

Sustainable design involves a systematic effort to create a useful space that takes maximum advantage of the local climatic and geographic benefits while also efficiently compensating for its less beneficial aspects. For example, orienting a building to the south and east to gain the most heat and light from the sun is a good idea in the mountains or on the coast. But for buildings in desert areas or central California, a different orientation and some form of shade (a porch roof or overhanging entry way) would be optimum. Designers can enhance any building project by incorporating even a few of the elements presented in this guide.

Sustainable building is important for the natural environment.

Sustainable building (or green building) integrates concerns over the environment, health, and comfort into the design, construction, and operation of buildings.

Buildings account for about 36 percent of the nation's total energy use, 65 percent of electricity consumption, 30 percent of total raw material use, 12 percent of potable water consumption, 35 percent of carbon dioxide emissions, and 49 percent of sulfur dioxide emissions.[3] In California, more than 4 million tons of construction and demolition waste are disposed annually, about 12 percent of the total waste stream.[4] Some building products include harmful chemicals like formaldehyde or other volatile organic compounds. In contrast, sustainable buildings may use more than 40 percent less energy[5] and 30 percent less water. Green building practices can eliminate the use of potentially harmful chemicals. These practices may reduce construction waste by up to 90 percent and can reduce the need for logging or mining resources by using reused or recycled materials.

Sustainable building does not have to add to project costs, and may save money.

Sustainable building costs and benefits vary and must be evaluated for each situation based on the needs, climate, budget, and priorities. Some sustainable building options can reduce the up-front costs for a particular building project. Some sustainable building options may increase up-front costs, but they will save money after operating and other costs are considered. The project's use, location, and budget will determine the appropriate options. A money-saving sustainable building option appropriate in one situation, may be too costly and inappropriate in another. However, even if a project budget cannot tolerate an entirely sustainable building plan, some aspect of sustainable and "green" building strategies can usually be incorporated. Module Three provides a more detailed discussion

It is early December, and an Indian arts and crafts festival is underway in a large entry area, full of shoppers and crafts people. The room is open, spacious, and inviting. The walls are recycled old-growth redwood, warm, dark, and beautiful. There is a corridor to each side of the large room, with more artists' tables set up. The corridors' interior sides are glass walls facing a large circular courtyard, with a natural stream, large rocks, a bridge, young trees and old snags, and native plants. The wide corridor is lit by daylight, naturally and comfortably, with additional lighting for the clinic areas. The corridor is a circle, leading back to the large gathering room and along corridors housing the various medical, dental, pharmacy, vision, counseling and public health clinics in separate buildings, each radiating inward to form a central corridor. The many comfortable seats and tables near the glass walls provide a place to wait for an appointment and a welcoming place to sit and visit other community members. The clinic walls are lined with beautiful art by local native artists. The overall "look" is natural, beautiful, and comfortable. This community facility is Potawot Health Village, a place of healing and an inspiring place to be.

of the costs of various sustainable building approaches; additional cost information is provided in the remaining modules.

Sustainable building practices can showcase Tribal traditions and the local environment. Sustainable building encourages the use of local resources such as local natural rock aggregate, locally grown and harvested wood, and especially natural plants as landscaping. The beauty of a well-designed sustainable building, with ample day lighting, invites the showcasing of tribal art and views of the local environment.

Sustainable building principles can work for any Tribal building projects in any climate. The varied climates within California Indian Country are not a problem in sustainable building. Sustainable building designs, options, and strategies are applicable in any environment because they take climate into account and work efficiently within any given climate.

Tribes can play a leadership role in promoting sustainable building throughout the State. Sustainable building designs, plans, and strategies are based on lessening environmental and energy impacts while producing quality, attractive, useful, comfortable projects. These are goals that may be highly compatible with Tribal values. In light of the opportunities Tribes have as governments, developers, and consumers, California Tribes have an opportunity to demonstrate how sustainable building policies can succeed in simultaneously achieving environmental and community development goals. Tribes can promote this philosophy by adopting Tribal sustainable building planning, design and construction frameworks, and codes or policies.

Information is available An impressive array of resources is available to help Tribes learn about, develop, and create sustainable building projects. For example, the California Integrated Waste Management Board's Web site (www.ciwmb.ca.gov/GreenBuilding/) is one of the best resources on sustainable building practices and has an impressive number of links to other organizations. This Guide is one avenue to find and use the information. Module Two, "Tribal Planning, Policy, and Implementation" will help you get started.

RESOURCES

Recommended starting points for detailed and technical information on sustainable building:

California Integrated Waste Management Board
www.ciwmb.ca.gov/GreenBuilding/
1001 I St., P.O. Box 4025
Sacramento, CA 95812-4025
(916) 341-6000

U.S. Environmental Protection Agency—Region 9 (San Francisco)
75 Hawthorne Street (WST-7)
San Francisco, CA 94105-3901
www.epa.gov/region09/
Contact: Kelly Doordan
Doordan.kelly@epa.gov
(415) 972-3383

U.S. Green Building Council
www.usgbc.org/
U.S. Green Building Council Leadership in Energy & Environmental Design (LEED) Program
www.usgbc.org/LEED/leed_main.asp
1015 18th St. NW, Suite 805
Washington, D.C. 20036
(202) 82-USGBC
Fax (202) 828-5110

Overviews of Sustainable Building

"Doing Well by Doing Good: The Benefits of Green Development," Rocky Mountain Institute, www.rmi.org/sitepages/pid221.php

"The Benefits of Green Building," Chapter Six, "New Home Construction: Green Building Guidelines," www.co.contra-costa.ca.us/depart/cd/recycle/gbg/GrnBldg-NewConstruction-Chap6.pdf.

U.S. Green Building Council, *Why Build Green?* www.usgbc.org/AboutUs/whybuildgreen.asp.

NOTES

[1] "Doing Well by Doing Good: The Benefits of Green Development," Rocky Mountain Institute, www.rmi.org/sitepages/pid221.php.

[2] Collaborative for High Performance Schools, Best Practices Manual, Volume I.

[3] U.S. Green Building Council, www.usgbc.org/AboutUs/whybuildgreen.asp.

[4] Statistics are from the U.S. Green Building Council and the California Integrated Waste Management Board.

[5] Pacific Gas & Electric Company, Energy by Design CD.

Tribal Planning, Policy and Implementation

MODULE 2

Sovereignty And Responsibility

"Tribes are sovereign nations: sovereignty carries with it a responsibility to take care of one's actions with integrity regarding life, family, community, fellow human beings, and the planet as a whole. Sovereignty plays an ultimate goal as Tribes develop their communities. Development of energy resources presents many difficult questions, such as impacts on Tribal communities, the environment, spiritual, and cultural. Exercising sovereignty in a responsible manner requires Tribes to consider their own operations, including environmental regulations, permitting processes, economic development strategies, and Tribal enterprises as well."

—Roger Fragua, CERT Deputy Director, *"Past and Present Tribal Actions Towards Energy Self-Sufficiency,"* Indian Energy Solutions 2002, Denver, CO, October 2–3, 2002, page 12.

SOVEREIGNTY CREATES OPPORTUNITY

Tribes possess unique opportunities to successfully achieve sustainable development.

As distinct, independent political communities retaining power derived from the original recognition of Tribes as sovereign nations, the status of Tribes is unique. Although the United States Congress has the authority to limit or even abolish tribal powers, absent Congressional action, a tribe retains its inherent right of self-government over its members and over its territories. These lands are called "Indian Country" as that term is defined in federal law.

California currently has 107 federally recognized tribes and nearly half a million acres of Indian Country. This includes reservation areas ranging from a few acres to larger areas, such as the 12-mile square Hoopa Valley Reservation in northern California. As Tribes prosper and are empowered to invest in economic development opportunities both within and outside of their territories, many unique opportunities present themselves.

The sovereign status of California Indian nations presents exciting decision-making opportunities for tribal members, councils, planners, and staff when it comes to developing or adopting building codes and construction guidelines. Within Indian Country, Tribes constitute the governing body or regulatory authority, and like the federal or State government, may legislate to encourage sustainable development. Tribes are often the owner of much of the land area within a reservation. As both the governing authority and property owner, Tribes may be in a position to implement a comprehensive, long-range vision for a sustainable community. Outside of Indian Country, to the extent sustainable building principles are incorporated into tribal goals, tribes may find sustainable building principles and programs useful tools in achieving building development objectives.

Sustainable building can be promoted in any building project within Tribal jurisdiction through the regular process of development and adoption of Tribal government codes and policies. However, at this time, not every California Tribe has building codes or policies. Some Tribes informally abide by or have formally adopted the county, State, or federal government codes. A very few Tribes have formally developed and adopted their own building codes. Tribes that wish to promote and foster the philosophy of considering the impact of a project on the environment, climate, and geography could lead the way by adopting guidelines for building projects within their jurisdiction that require sustainable or green practices.

Multiple roles available to Tribes to achieve sustainable development.

By creating new plans and laws, tribes can greatly influence the transition to more sustainable building in unique ways, compared to non-Indian jurisdictions. However, in addition to acting as regulatory authority, they may simultaneously act as regulatory authority, owner-operator, developer-builder, or client-community. Of course, options on non-tribal lands may be more limited in the regulatory arena. A wide range of opportunities exists in each of these roles, especially on tribal lands. Some of those opportunities and options are listed below, but creative leadership may envision many more.

As the sovereign authority and lead regulator, Tribes may:

- Adopt a communitywide approach covering residential, commercial, and institutional buildings, and both indoor and outdoor built environments.
- Incorporate green building methods into general plans, building codes, remodeling permits, contractor specifications, or contract and bid language.
- Fully revise procurement policies to reflect green building criteria.
- Require green building principles to be incorporated in Tribal planning documents.
- Provide green building educational materials and/or revise and amend current building plans and acquisition goals.
- Subsidize renewable energy systems on tribal lands.
- Encourage tribal staff to seek special sources of green building funds (see Module 3).

As owner-operator of the built environment and land base, the tribe may:

- Initiate the design and building process.
- Define needs and establish building criteria.
- Create a design vision reflecting the community as a whole.
- Exercise leadership to determine the best building approaches.

As developer and builder, the tribe may:

- Determine the scope of work, timelines, and contractual objectives.
- Select contractors and architects that reflect green building objectives consistent with the Tribe's philosophies and vision.
- Take actions, such as making purchasing decisions, that reflect new green building policy directions.
- Revise work plans for current building projects that reflect new green building policies.

As client and community, the tribe may:

- Express community needs and desires.
- Participate in the planning and design process.
- Provide feedback on building use and comfort, and suggest new approaches.

HOW TRIBES CAN IMPLEMENT SUSTAINBLE BUILDING PRACTICES

This module provides some practical suggestions on how to start implementing sustainable building practices.

Sustainable Building Strategies for Indian Tribes

- ✓ *At a minimum, begin by using a few select green elements.*
- ✓ *Find and work with qualified sustainable building professionals.*
- ✓ *Evaluate options for your building project and establish achievable goals.*
- ✓ *Develop a whole building sustainable design vision.*
- ✓ *Seek green building certification to showcase your efforts.*
- ✓ *Institutionalize sustainable building by:*
  - *Adopting sustainable building policies.*
  - *Incorporating sustainable building principles in standard contract documents.*
  - *Establishing a long-term sustainable building plan.*

Top 20 Cost-Effective Ways to Green an Affordable Housing Project

1. Design water-efficient landscapes.
2. Install water-efficient toilets and fixtures.
3. Use concrete composed of 15 percent or more fly ash.
4. Use paint with low or no volatile organic compounds (VOC).
5. Seal all exposed particleboard to eliminate off-gassing of formaldehyde.
6. Install carbon monoxide detectors.
7. Vent the range hood to the outside.
8. Maximize natural day lighting.
9. Provide overhangs or screens on south-facing windows.
10. Incorporate natural cooling and ventilation.
11. Select light-colored roofing.
12. Use recycled fiberglass or cellulose insulation in walls and ceilings.
13. Install high R-Value insulation.
14. Install fluorescent lights with electronic ballasts.
15. Install compact fluorescent light bulbs.
16. Install lighting controls (for example, occupant sensors or timers).
17. Install Energy Star refrigerators and other appliances.
18. Use engineered wood for headers, joints, and sheathing.
19. Install ceiling fans.
20. Select double-paned, spectrally selective windows.

Source: Adapted from Global Green USA.
www.globalgreen.org/programs/20ways.html

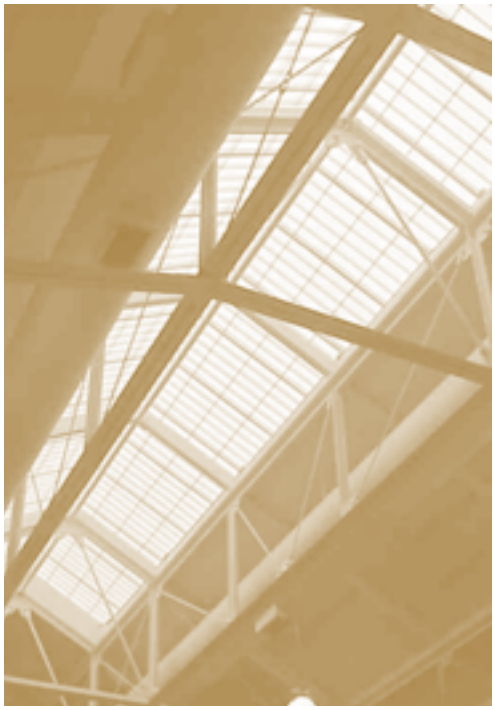
At a minimum, begin by using a few select green elements.

The most effective approach to sustainable building is to adopt a whole-building sustainable design vision from the very beginning (as described below). However, in practice this may not always be possible. Regardless of circumstances, consider, at a minimum, incorporating a few select elements. This list provides 20 examples of cost-effective ways to "green" an affordable housing project. A similar but more specific list could be assembled for any type of building project, large or small.

Find and work with qualified sustainable building professionals.

Sustainable building is a proven approach that works, as this guide illustrates. One of the most effective ways to implement sustainable practices is to hire professionals who are already highly motivated, experienced, and knowledgeable about sustainable and green building. (See examples at the end of this module.) The number of building professionals knowledgeable and experienced in green building is growing, especially in California. Regardless of the expertise of selected professionals, the Tribe should strive to hire and work with the project architects, contractors, and suppliers from the beginning of any given project to evaluate and select the best sustainable building approaches for the particular situation.

Some building professionals may be skeptical or lack motivation to find affordable, innovative solutions. Requiring that the project building professionals adhere to sustainable building principles is reasonable, although this may require increased activity on the Tribe's part. Adherence to green building principles can be part of any Tribal bid and contract documents for architects, contractors, and/or suppliers.



This guide and its resource suggestions can help project planners, architects, or contractors learn more about specific sustainable building strategies. Directories of green building professionals available online include the U.S. Green Building Council's list of professionals accredited through their *Leadership in Energy and Environmental Design* (LEED) program and their "Sustainable Source Directory of Sustainable Building Professionals." (See Web site listings at the end of this module.)

Evaluate options for your building project and establish achievable goals.

Since every building project is unique and has its own financial, geographic, and function parameters to work with, there are many varied ways to incorporate sustainable aspects into building projects. First and foremost, green building involves use of an integrated approach to design that does its best, under the particular circumstances, to create environmentally sound and resource-efficient buildings. Given this, the best place to start is to work with the building team to evaluate the options and establish clear, achievable goals. Every project's goals will vary, but any set of project goals should consider and reflect the project priorities, building type, location, and budget. There really is no one approach.

Using a three-bedroom home as an example, the chart on the following page illustrates three scenarios (among many possible approaches) for incorporating green building strategies.

- Option one includes many sustainable development approaches and adds slightly more than $1,500 to the $150,000 conventional home price. But, including reduced energy costs, this investment yields a $46 per year net savings to the occupants.
- Option two combines these approaches with select indoor air quality measures, adding $523 in up-front costs for a total of slightly more than $2,000 in added sustainable building costs. Including energy savings, the combined option one and option two investments pay for themselves over time.
- Option three adds a range of "high end" sustainable building measures, perhaps enough to qualify the building for certification under a yet-to-be released LEED certification process for homes. This premier approach adds considerably to the home's cost by more than $10,000, with a net annual cost increase of $856. While this is but one example, it illustrates the many tradeoffs and options available to sustainable building designers. The most important skills may be creativity, innovation, and patience in evaluating different options against your particular needs and budget.

An Example of Sustainable Home Building Costs

SCENARIO	TOTAL ADDITIONAL UP-FRONT COST	NET ANNUAL COST OR BENEFIT INCLUDING REDUCED OPERATING EXPENSES
OPTION 1 – Some Basic Sustainable Building Measures Enhanced ceiling insulation ($230); Additional spray cellulose insulation ($150); Redesign windows to face south ($0); High-efficiency water heater ($275); Auto setback thermostat ($75); Low-E windows ($185); Ceiling fans ($300); Recycled content decking ($163); Recycled content carpet ($0); Xeriscaping ($0); Recycled content siding ($0); Engineered lumber ($200).	$1,578	$46 Per Year Savings
OPTION 2 – Add Indoor Air Quality Measures Low-toxic adhesives ($23); Sealing particleboard cabinets and counter top ($250); VOC-free paint ($100); Water-based finishes on floors and wood ($150).	$523	$0 (All costs are covered by savings)
OPTION 3 – Add High Performance Measures High efficiency furnace ($1,000); Passive solar features ($1,350); Above-code insulation ($1,000); High-efficiency appliances ($500); Compact fluorescent lighting ($200); Cement-based roofing ($250); Recycled-content ceramic tile ($375); Formaldehyde-free sub-floors ($600); Formaldehyde-free cabinets and counters ($600); Heat recovery ventilation ($1,000)	$10,725	$856
Assumptions: Based on a 1,540 square-foot, two-story home with three bedrooms, two baths and an attached two-car garage. **Note:** The actual economics of any particular sustainable building measure are highly site specific, especially the potential payback period associated with energy cost savings.		
Source: "Building Green in a Black and White World, Chapter 3." David Ritchey Johnston. Available online at www.housingzone.com/topics/nahb/green/nhb00ca029.asp.		

Adopt an Integrated, Whole Building Sustainable Design Vision.

At its root, design is a process of balancing many competing factors and, from an infinite range of options, creating a particular path that meets the building users' needs and budget. To achieve its full promise, sustainable building should ideally be rooted in an integrated, whole-building design approach from the very beginning of project planning. Integrated means that the project team works closely together, including developers, building users, architects, contractors, and engineers. Whole building means that each component of the building is considered as part of a system. This approach allows the team to consider the many tradeoffs involved in the green design process.

The design vision should seek to create a space perfectly designed for its users, incorporating unique, creative elements that enhance the overall experience of living, working, or otherwise using the building. For example, a Tribe might choose to emphasize traditional building themes or incorporate native plants into an inner courtyard to showcase its traditions. Design objectives may include:

- Strictly adhering to a predetermined budget (that may or may not account for future savings in operations costs).
- Maximizing positive environmental impacts while minimizing negative impacts.
- Minimizing resource use (and associated environmental impacts).
- Integrating the building into the local ecosystem and community.
- Taking full advantage of positive climatic factors (for example, cool evening air) while minimizing negative climatic factors (for example, hot afternoon sun).
- Minimizing health and safety concerns while contributing to occupants' wellness.

Sustainable design principles apply equally to the outdoor landscape. The Collaborative for High Performance Schools (CHPS) suggests four principles to consider with landscape design:

- Resource conservation—do not degrade the landscape.
- Diversity—promote a range of habitats with species and genetic diversity.
- Connectivity—maintain networks of interconnecting habitats.
- Environmental responsibility—protect, restore, and manage resources to maintain a healthy ecosystem in perpetuity.

Seek green building certification to showcase your efforts.

Exemplary buildings incorporating many sustainable building elements may qualify for certification. Two opportunities are the LEED Program, operated by the U.S. Green Building Council, and the Collaborative for High Performance Schools Program, sponsored by several California State agencies and utilities. (See Web sites at the end of this module.) The LEED program is fast becoming the standard for green building efforts. Although its certification program currently only applies to commercial projects, a new set of standards for residential projects is expected soon.

The CHPS program applies specifically to schools and is probably the best program to use for school projects. The main benefits of certification include: public recognition as a leader in green building; increased positive attention to your building over time; possible qualification for special funding sources; and a systematic framework for evaluating sustainable building options. Building project managers seeking certification should begin very early in the design process, since satisfying all requirements will become difficult as construction progresses. The LEED and CHPS programs are both very flexible, but certification does involve some degree of paperwork and adherence to an established system. The project budget should allow for a qualified person to coordinate the process of working with the entire project team and the certifying organization.

Institutionalize sustainable building.

In addition to using sustainable building design principles in current building projects, Tribes can institutionalize sustainable building in all projects over the long term. These steps can include adopting sustainable building policies for energy and water efficiency standards, use of recycled-content products, pricing to encourage conservation, recycling space requirements, use of nontoxic materials, and others.

Many Tribes have adopted the State Universal Building Code and/or building codes from neighboring cities and counties. Tribes can play a leadership role in encouraging changes in these codes as well by taking deliberate, measured steps to improve upon them. Tribes can also promote sustainable building practices by including sustainable building principles into standard contract documents, including bid sheets, specifications, requests for proposals, and agreements for services with architects, contractors, and product suppliers. Finally, by establishing a long-term sustainable building plan including regular monitoring and updates, the Tribe can extend the benefits of a particular building project to the plans for the Tribe's growth and progress.

Some non-Tribal policy models that could be adapted to Indian Country include:

- *Greening Federal Facilities*, a comprehensive guide for planners, designers, and builders, with practical advice on saving energy, water, and money.
- *Building Better Buildings: A Blueprint for Sustainable State Facilities*, a comprehensive policy approach adopted by the state of California.
- City and county policies; for example, those adopted by Santa Monica (note especially their "Checklist for Affordable Housing"), San Jose (note their excellent educational materials), Seattle, Wash., Portland, Ore., and Austin, Tex.
- State of California policies such as the California Uniform Building Code; Title 24 Energy Efficiency Standards; Tier 1 and Tier 2 Energy Efficiency and Sustainable Building Measure Checklists; and Code 01350 specifications for indoor air quality.
- Model local ordinances prepared by California on construction and demolition debris recycling, general plans, and contracting specifications.

Additional models and suggestions are available from Indian-focused organizations such as the Council of Energy Resource Tribes (CERT), the Native American Renewable Energy Education Project (NAREEP), and from non-Tribal organizations such as the California Integrated Waste Management Board (CIWMB) and the U.S. Green Building Council.

RESOURCES

General Reference Sources on Sustainable Building

California Integrated Waste Management Board
ww.ciwmb.ca.gov/GreenBuilding/
1001 I St., P.O. Box 4025
Sacramento, CA 95812-4025
(916) 341-6000

CIWMB, "Designing with Vision: A Technical Manual for Material Choices in Building Construction" (A comprehensive resource including product descriptions, sample bid documents and ordinances.)
www.ciwmb.ca.gov/ConDemo/Pubs.htm

Collaborative for High Performance Schools—Best Practices Manual
www.chps.net/

Environmental Building News
www.buildinggreen.com/index.cfm
122 Binge St., Suite 30
Battleboro, VT 05301
(802) 257-7300
Fax (802) 257-7304

United States Department of Energy
www.sustainable.doe.gov/buildings/gbintro.shtml

U.S. Green Building Council, Leadership in Energy and Environmental Design (LEED) Program
www.usgbc.org/LEED/LEED_main.asp
1015 18th St. N.W., Suite 805
Washington, D.C. 20036
(202) 828-7422
Fax (202) 828-5110

Whole Building Design Guide
www.wbdg.org/design/do-print.php?cn=2.2

Sample Specifications

CIWMB—Section 01350, Green Building Materials Performance Standards
www.ciwmb.ca.gov/greenbuilding/Specs/Section01350/default.htm#Latest

CIWMB—Specifications Page
www.ciwmb.ca.gov/GreenBuilding/Specs/

CIWMB—Guidelines, Rating Systems, and Specifications
www.ciwmb.ca.gov/GreenBuilding/Design/Guidelines.htm

California Energy Commission—Reference Specifications for Energy and Resource Efficient Building
www.eley.com/specs/index.htm

Collaborative for High Performance Schools—Green building specifications
www.chps.net/manual/documents/Sec_01350.doc

Construction Specifications Institute
www.csinet.org/
99 Canal Center Plaza, Suite 300
Alexandria, VA 22314
1-800-689-2900
Fax (703) 684-8436
E-mail csi@csinet.org

Eley Associates
Green Building Specifications
www.eley.com/
142 Minna St.
San Francisco, CA 94105
(415) 957-1977
Fax (415) 957-1381

Oikos—A commercial source of sustainable building information.
www.oikos.com/index.lasso

Sustainable Sources—Product Specifications and Sources
www.greenbuilder.com/general/BuildingSources.html

Environmental Resources for Indian Tribes

U.S. EPA—Tribal Environmental and Natural Resource Assistance Handbook
www.epa.gov/indian/tribhand.htm

U.S EPA—American Indian Environmental Office
www.epa.gov/indian/new.htm

Institute for Tribal Environmental Professionals
www4.nau.edu/itep/intro.html

National Tribal Environmental Council
www.ntec.org/
2501 Rio Grande Blvd., N.W., Suite A
Albuquerque, NM 87104

Tribal Environmental Resource Center
www4.nau.edu/itep/ntec_employment.html

Directories of Sustainable Building Professionals

The American Indian Council of Architects and Engineers
2310 S.W. 89th Street, Suite F
Oklahoma City, OK 73159
www.aicae.org/

Building Industry Professionals for Environmental Responsibility
www.biperusa.biz/

LEED Directory of Green Building Accredited Professionals
www.usgbc.org/LEED/Accredited_Pros/accredited_pros_search.asp

Sustainable Sources Directory, Directory of Sustainable Building Professionals
http://directory.greenbuilder.com/search.gbpro

Funding Sustainable Building Projects

MODULE 3

As the Tribe and its contractors gain experience, many cost-effective sustainable building strategies could be easily identified and built into conventional building project budgets. No matter what size a project budget is, sustainable building strategies and options can be part of most designs, do not have to add up-front costs, and can reduce costs through deferred savings over the long run.

To assist in going beyond the lowest budget options, some special funding and financing options are available, including a few tailored specifically to Tribes. But the best way to maximize sustainable building on a limited budget is to systematically consider alternative strategies during a whole building design process. Including the Tribe's architect and general contractor in planning meetings from the earliest moment possible is ideal. This module describes six funding strategies:

Sustainable Building Funding Strategies

- Identify sustainable building options that fit within the existing project budget (no matter how small it is).
- Use traditional grant sources like HUD.
- Use project life-cycle financing mechanisms.
- Use the "Savings by Design Program."
- Use government or foundation grants to fund certain sustainable building strategies.
- Assist Tribal members and businesses to secure financing for sustainable building efforts.
- Using funding options available to Tribal governments, such as bond financing.

Identify sustainable building options that fit within the existing project budget.

The four categories of sustainable building options as described in the chart on page 14 will probably stand out as options within any project budget. The key is to work with the project building team from the very beginning of a project to develop a thoughtful, informed design. The keys to sustainable building on a tight budget are:

1) Identify as many strategies as possible in Categories One and Two.
2) Seek project life-cycle financing to cover Category Three strategies that will pay for themselves over time.
3) Investigate grants and other special funding sources to cover at least some Category Four strategies.

ENERGY STAR FRONT LOADING WASHER

The Four Cost Categories of Sustainable Building Approaches

CATEGORY	EXAMPLES
CATEGORY 1. Sustainable Building Options that may **reduce up-front costs** for the building being planned and save on construction costs.	• Use standardized dimensions for framing to avoid job site waste. • Preserve existing native vegetation rather than install new landscaping. • Rehabilitate existing structures. • Finish concrete floor slabs with non-carpet coverings. • Design an open layout to reduce material and add light. • Use salvaged materials. • Consider patios rather than wood decks. • Address sustainable siting issues.
CATEGORY 2. Sustainable Building Options that may **add little or no up-front costs for the building being planned;** in addition, either lower operating costs or other benefits can make these options cost-effective.	• Orient the building on an east-west axis. • Emphasize task lighting over general lighting. • Landscape with native drought-resistant plants. • Landscape to provide shade. • Design to facilitate recycling and reuse. • Implement a construction recycling plan. • Use a rainwater catchment system for outdoor uses. • Use high-efficiency irrigation systems. • Use recycled-content building products. • Use low-emitting building products. • Manage stormwater through natural infiltration.
CATEGORY 3. Sustainable Building Options that **add to up-front costs for the building being planned, but may pay for themselves over time.** (These options save money when operating costs are considered along with up-front costs.)	• Develop an energy management plan. • Consider on-demand water heaters. • Install water-efficient plumbing fixtures. • Use a gray water recovery system. • Use natural day lighting. • Use high performance lighting, thermal insulation, and appliances. • Install small-scale energy production systems like solar or wind.
CATEGORY 4. Sustainable Building Options that **add to up-front costs for the building being planned and may not pay for themselves over time.** (Note these options may be cost-effective when all benefits are considered, including social and environmental benefits difficult to measure in dollars.)	• Purchase open space as part of the project. • Use certified wood and rapidly renewable resources. • Building commissioning. • Automated energy efficiency controls. • The highest efficiency appliances.
* **Important Note:** The examples are illustrative only. Each strategy's category could change depending on the overall building design and other project-specific factors.	

Use traditional funding sources like HUD. The U.S. Department of Housing and Urban Development (HUD) is a major funder of Tribal building projects, especially residential projects through the Native American Housing Assistance and Self Determination Act (NAHASDA). This act consolidated many HUD grant programs specifically geared to Tribes and made it more difficult for Tribes to access some conventional HUD programs. Funding from this program is provided to Tribes on a non-competitive basis. In 2002, allotments to California Tribes for detached dwellings (one four-family dwelling) including all development costs, ranged from about $147,000 to $253,000. HUD also administers the Indian Community Development Block Grant Program (ICDBG), a competitive program that provides funding for housing as well as economic development projects.

Through a memorandum of understanding with the U.S. Environmental Protection Agency (U.S. EPA) and the U.S. Department of Energy (DOE), HUD grant package language now promotes energy efficiency. According to the 2003 solicitation for the ICDBG program, "Applicants constructing, rehabilitating or maintaining housing or community facilities are encouraged to promote energy efficiency in design and operations. They are urged especially to purchase and use Energy Star labeled products."[1] Exactly how much weight is given to this factor in the proposal scoring is unclear. While HUD provides no strong monetary incentives for sustainable building, Tribes are certainly free to work within their allotted maximum budget to implement select strategies.

Use the Savings by Design program. The "Savings-by-Design" program may be able to assist Tribes in including Category Three strategies that require additional up-front costs but that will pay for themselves over time. It is a statewide program for commercial, industrial, and agricultural projects encouraging energy-efficient building design and construction. The program, administered by California's four investor-owned utilities under the auspices of the California Public Utilities Commission, rewards building projects that exceed California's minimum required energy efficiency standards by offering the following to building owners and their design teams:

- Design assistance, analysis, and resources to aid building owners and design teams with energy-efficient facility design.
- Owner incentives of up to $150,000 per project to compensate building owners for investing in energy-efficient design.
- Design team incentives of up to $50,000 per project to reward designers who meet ambitious energy-efficiency goals.
- Projects must be located within the service territories of the Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison or Southern California Gas Company. (See Resources).

NEZ PERCE HELP INNOVATE GREEN MANUFACTURED BUILDINGS

Manufactured buildings (also called *prefabricated, modular,* or *relocatable* buildings) are a low-cost option for homes and some other applications like schools and offices. Nearly one out of every three new homes nationwide is manufactured, making it the fastest growing housing market.[2] And, discussions with California Tribes indicate this percentage may be somewhat higher on Tribal land.

Manufactured buildings have some inherent advantages. In addition to reducing costs compared to custom designed and built projects, those sold in California must automatically satisfy Title 24 energy efficiency requirements. There is no need to manage construction waste (which presumably has already been efficiently managed at the manufacturer's facility). And the design process is greatly simplified since so many elements have already been determined. But manufactured buildings also have their problems. They contain a large amount of embodied energy (that is, the energy needed to manufacture the aluminum and steel used), they historically have had little or no insulation or water conserving plumbing fixtures, and they eliminate some sustainable building options.

But many sustainable building strategies still apply to manufactured building projects. For example, all strategies involving outdoors systems (for example, water-efficient landscaping), indoor air quality (for example, carpet types and ventilation) and siting issues (for example, orienting the building on an east-west axis). Another emerging option is to look for green manufactured buildings. Through a partnership with the Bonneville Power Administration, Washington State University, and several product vendors, the Nez Perce Zero Energy Manufactured Home Project has demonstrated an approach to producing a green manufactured home.[3] The home, which serves as Tribal housing for operations staff at the Nez Perce Hatchery at Cherry Lane, includes such sustainable building elements as high performance insulation, a 6 kw photovoltaic system connected to the grid with net metering, a solar hot water heating system, energy star windows, energy star heating and cooling equipment, a heat pump, and other passive solar design features. (More Information is available at www.bpa.gov/Energy/N/energy_tips/zemh/index.shtml.)

In a separate project, Champion Enterprises (Silverton, Ore.) produced a manufactured home made entirely from energy-efficient foam core panels.[4]

Use project life-cycle financing mechanisms. Another option for funding Category Three options (those that add up-front cost but also pay for themselves over time) is to use life-cycle financing mechanisms. Life-cycle financing considers the total anticipated costs over the lifetime of the building, or the financing payback period. (Life-cycle costs are explained in the box below.) Life-cycle financing programs can help increase the amount of up-front financing available to cover costs that will reduce the net operating expenses. One example is HUD's Energy Efficient Mortgage Insurance Program, which can finance energy efficiency measures at up to $8,000 per new home. The program can also fund rehabilitation projects. Another example is Fannie Mae's Housing and Environment Initiative that offers increased financing to individual homebuyers installing energy efficiency measures. Another type of life-cycle financing is the location-efficient mortgage, which recognizes that home occupants in urban locations have lower transportation costs and therefore may qualify for higher financing amounts (that can be applied to sustainable building strategies). One example is Fannie Mae's Location Efficient Mortgage Program.

The Importance of "Life-Cycle Costing" and the "Payback Period"

Tribes often need to work within a fixed budget in their building projects. For example, residential projects funded with HUD grants will have a very tight fixed budget per unit. However, when the tribe does have an option increasing the up-front costs to cover certain sustainable building approaches, it can result in substantial savings down the road.

"Life-cycle costs" refer to all costs related to a building (or other product) over a specified period of time. Life-cycle costs include not only the up-front costs, but also the following:

- Operating costs, such as building energy costs for electricity or heating, or water costs.
- Maintenance and repair costs, such as the cost to repair appliances and other building systems when they break. Some devices can be simple and inexpensive to repair; others may require specialized, high-cost service or parts.
- Replacement costs vary directly with the expected life of a product, such as a washing machine. The longer a product lasts, the lower the overall replacement costs.
- Disposal costs, such as the cost to gather and send waste to a landfill.
- Externalized environmental and social costs, though hard to quantify, include the impacts associated with producing and using products (for example, loss of scarce natural resources, loss of habitat, and air and water pollution).

For example, increasing a 10,000 square-foot commercial building's insulation rating from R-19 to R-38 may increase up-front costs by about 35 cents per square foot, or $3,500. However, a contractor can easily calculate the estimated annual energy cost savings of the added insulation for the particular location and building type. The annual savings could be in the neighborhood of $250 per year, or $5,000 over a 20-year planning period. In this example, there would likely be no significant differences in maintenance, repair, or disposal costs for the two different types of insulation. By using less energy, the building would reduce the amount of energy resources required for its operation, and the associated air pollution involved in producing electricity for heating.

Any option that adds up-front costs while decreasing lifecycle costs will have a payback period, the time required for the annual savings to equal the original up-front cost. In the above example, the additional cost of the R-38 insulation was $3,500. At an annual energy savings of $257, the insulation would pay for itself in about 14 years. In other words it would have a payback period of about 14 years.

Use government grants to fund certain sustainable building strategies. State and federal agencies offer a variety of ever-changing grant programs that may be used to fund elements of Tribal sustainable building projects. Fortunately, the agencies offer Web pages with up-to-date information. (See list at the end of this Module.) Examples include the U.S. Department of Energy Indian Resource Development Program, the California Integrated Waste Management Board Sustainable Building Grant Program, the California Department of Parks and Recreation Habitat Restoration Program, the California Water Resources Control Board Water Recycling Funding Program, and the U.S. EPA Tribal Clean Air Act Cooperative Agreements Program.

THE INDIAN ENERGY RESOURCE DEVELOPMENT PROGRAM

Several renewable energy projects have received financial assistance from the Department of Energy pursuant to the Indian Energy Resource Development Program authorized by Title XXVI of the Energy Policy Act of 1992. Since 1994 more than 56 projects have been funded at a level of more than $31 million. In 2002, the program funded $2.5 million in projects. These include a photo-voltaic water pumping system on the Ute Mountain Reservation in Colorado, utility-scale wind turbines on the Blackfeet Reservation in Montana, and hydroelectric projects sponsored by the Agdaagux Tribe and Native Village of Chignik Lagoon in Alaska. In addition, this DOE program aided some feasibility studies and resource assessments, including biomass cogeneration sponsored by the White Mountain Apache Tribe in Arizona and the Keweenaw Bay Indian Community in Michigan.

Source: DOE and "Renewable Energy in Indian Country," David Suagee.

http://solstice.crest.org/repp_pubs/articles/issuebr10/issuebr10.html

Assist Tribal Members and Businesses to Secure Financing for Sustainable Building Efforts

In addition to the mortgage assistance programs described above, a number of loans, incentives, rebates, and tax credits are available to any California citizen. Tribes may choose to offer education and information about these programs to Tribal members and their businesses to increase individual access to them. The Resources section at the end of this module lists many of these programs. Following is a short list of some programs that may be particularly useful (other rebates may also be available from local governments and utilities near Tribes).

- PG&E's Self-Generation Incentive Program—for utility customers who install renewable and clean on-site distributed generation (such as photovoltaics, wind turbines and some engines and turbines running on renewable fuel).
- The California Energy Commission (CEC) Small Wind Rebate Program—offers partial cash rebates for qualified purchases of small wind systems.
- CEC Rebates on Renewable Energy Systems—offers rebates of up to 50 percent on photovoltaics, solar thermal electric systems, fuel cells, and small wind turbines.
- CEC Solar and Wind Energy System Credit—offers a 15 percent State income tax credit on purchase and installation costs of photovoltaic and wind generating systems.
- SAFE-BIDCO Low Interest Energy Efficiency Loans. The State Assistance Fund for Enterprise, Business and Industrial Development Corporation. Small businesses, some landlords, and nonprofit organizations may receive low-interest loans for projects that conserve energy or manage load—programs such as weatherization, cogeneration, alternate energy systems, and lighting changes.
- The Cool Savings with Cool Roofs Program—offers cash rebates to local governments, businesses, schools, and other entities that "replace or resurface their old 'hot' roofs with new, light-colored, energy-conserving cool roofs."

Use funding options available to Tribal governments

The status of Tribes is unique. An Indian tribe is a distinct, independent political community, retaining power derived from its original status as a sovereign nation. There are 107 federally recognized tribes in California governing nearly half a million areas of Indian County. As sovereign nations, within Indian Country, tribes constitute the governing body or regulatory authority. Like the federal or State government, Tribes may legislate to encourage sustainable development and may have funding opportunities that are available to governments. For example, the Indian Tribal Governmental Tax Status Act of 1982, 96 Stat. 2607, accorded the tribes many of the federal tax advantages enjoyed by states, including that of issuing tax-exempt bonds to finance government projects.

Municipal Bonding – A New Approach for Indian Tribes

In one of the first examples of an Indian Tribe using a financing mechanism common to cities and counties, the Cabazon Band of Mission Indians has arranged to receive $145 million in tax-exempt bond financing issued by the California Statewide Community Development Authority. The funds will be used to build a 12-story hotel and convention center, part of a larger tribal plan including a second hotel, a golf course and a time-share development.

Source: "Indian Tribe Issues Municipal Style Bonds to Finance Growth," *Eureka Times Standard*, July 11, 2003.

RESOURCES

Sustainable Building Cost Information

Pacific Gas and Electric Company: 1-800-933-9555

Southern California Gas Company
Ph. 1-800-427-2000
Centralized Correspondence
P.O. Box 3150
San Dimas, CA 91773

Southern California Edison
e-mail: espsvsc@sce.com
Ph. 1-888-371-3777
Fax. (714) 895-0347
ESP Services SCE
SSID- Administration Building
7300 Fenwick Lane
Westminster, CA 92683

San Diego Gas and Electric
8326 Century Park Ct.
San Diego, CA 92123
Ph. (619) 696-2000
Fax: (858) 654-1515
Toll Free: 1-800-411-7343

CIWMB Cost Issues Web Site
www.ciwmb.ca.gov/GreenBuilding/Design/CostIssues.htm

CA State Architect—Funding Sustainable Building Site
www.sustainableschools.dgs.ca.gov/SustainableSchools/financing/wastemgmt.html

Top 20 Cost-Effective Ways to Green an Affordable Housing Project
www.globalgreen.org/programs/20ways.html

"Building Green on a Budget," *Environmental Building News*, Vol. 8, No. 5, May 1999.
www.buildinggreen.com/features/lc/low_cost.cfm

United States Environmental Protection Agency Funding Web Sites

U.S. EPA American Indian Environmental Office—Tribal Grants
www.epa.gov/indian/tgrant.htm

U.S. EPA Environmental Justice Collaborative Problem Solving Grant Program Fact Sheet, 2003
www.epa.gov/indian/pdfs/EJ-CPSGrant-Fact-Sheet.pdf

U.S. EPA Region 9 Drinking Water Vulnerability Assessment Grants
www.epa.gov/region09/water/drinking/grants.html

U.S. EPA Tribal Assistance Programs
www.epa.gov/owm/mab/indian/programs.htm

U.S. EPA Region 9 List of Grants Available
http://yosemite.epa.gov/R9/FSFC.nsf/fundingsources?ReadForm

U.S. EPA Drinking Water Tribal Set-Aside Grants
www.epa.gov/region09/funding/dwtsa.html

U.S. EPA Clear Lake Region Pesticide Environmental Risk Project
www.epa.gov/pesticides/grants/r9_clearlakerfp.htm

U.S. EPA Region 9, Native American Water/Waste Water System Operation and Management Training and Technical Assistance Cooperative Agreement Project
www.epa.gov/region09/funding/water_wastewater_tribal.html

Indoor Air Quality Tools for Schools Program and Asthma Management Training
www.epa.gov/region09/funding/air_iaq.html

National Pollutant Discharge Elimination System (NPDES) Water Quality Cooperative Agreements for Tribes
www.epa.gov/region09/funding/water_quality_tribes.html

Source Reduction Assistance Program
www.epa.gov/region09/funding/p2.html

Integrated Pest Management and Sustainable Agricultural Projects
www.epa.gov/pesticides/grants/r9_agfqpa.html

Drinking Water Tribal Training Intensive Co-Sponsorship Solicitation
www.epa.gov/region09/funding/water_drinking_tribal.html

U.S.-Mexico Tribal Border Infrastructure Program
www.epa.gov/region09/funding/water_border_tribes.html

Water Quality Cooperative Agreements
www.epa.gov/region09/funding/water_quality.html

Tribal Clean Air Act Cooperative Agreements
www.epa.gov/region09/funding/air_tribal.html

Resource Conservation Funding
www.epa.gov/region09/funding/rcra.html

Indoor Air Quality for Schools Program
www.epa.gov/region09/funding/indoorair.html

U.S. EPA Grant Resources for Tribal MSW Management
www.epa.gov/epaoswer/non-hw/tribal/pdftxt/tribfund.pdf

Other State and Federal Agency Funding Web Sites

California Integrated Waste Management Board—Sustainable Building Grants and Contracts
www.ciwmb.ca.gov/GreenBuilding/Grants/

California Energy Commission—Emerging Renewables Rebate Program
www.consumerenergycenter.org/erprebate/index.html

Solar Energy and Energy Distribution Grants Program
www.consumerenergycenter.org/solaranddg/index.html

Solar and Wind State Tax Credit
www.consumerenergycenter.org/renewable/tax_credit.html

Summary of California Solar Energy Property Tax Incentives
www.sdenergy.org/pvweb/property_tax_sec73.htm

California Renewable, Energy Efficiency and Demand Reduction Financing Programs
www.energy.ca.gov/peakload/AB29x-SB5x_program_summary.html

California State Architect—Sustainable Building Financial Incentives Links
www.dsa.dgs.ca.gov/sustainability/incentives.htm

California State Water Resources Control Board—Financial Assistance
www.swrcb.ca.gov/funding/index.html

California Public Utilities, Savings By Design Program
www.savingsbydesign.com/

California Department of Housing and Community Development
www.hcd.ca.gov/

U.S. Department of Energy, "Financing Energy Efficiency in Buildings."
www.rebuild.org/attachments/solutioncenter/financeEE.pdf

Department of Housing and Urban Development—Native American Housing Assistance and Self Determination Act (NAHASDA) Home Page
www-domino.hud.gov/ihp/newhome.nsf

Indian Community Development Block Grant Program
www.hud.gov/offices/pih/ih/grants/icdbg.cfm

LA Regional Water Quality Control Board, Compilation of State and Federal Grant Funding Sources for Water Related Projects
www.swrcb.ca.gov/rwqcb4/html/programs/regional_program/wmi/summary_info_on_funding.doc

List of DOE Funded Indian Energy Projects: 1994–1999
www.eia.doe.gov/cneaf/solar.renewables/ilands/appa.html

Pacific Gas & Electric Company, Self-Generation Incentive Program
www.pge.com/selfgen

Life-Cycle Financing Programs

HUD Energy Efficient Financing Insurance Program
www.hud.gov/buying/insured.cfm

Fannie Mae's Housing and Environment Initiative
www.fanniemae.com/housingcommdev/solutions/environment.jhtml?p=Affordable+Housing+%26+Community+Development&s=Affordable+Housing+Solutions&t=Environmentally+Efficient+Housing

Low Interest Energy Efficiency Loans Information, SAFE-BIDCO
www.safe-bidco.com/

Energy Star Energy Efficiency Mortgages
www.epa.gov/epahome/hi-energystar.htm

Energy Efficient Mortgages Web Site
www.pueblo.gsa.gov/cic_text/housing/energy_mort/energy-mortgage.htm

Fannie Mae's Location Efficient Mortgage Program
www.locationefficiency.com/

Natural Resources Defense Council, Guide to Location Efficient Mortgages
www.nrdc.org/cities/smartGrowth/qlem.asp

Manufactured Buildings

Collaborative for High Performance Schools—Best Practices Manual, Volume II, Guideline OS6: Relocatable Classrooms
www.chps.net/manual/index.htm - vol2

California Manufactured Housing Institute
www.cmhi.org

Modular and Manufactured Modern Housing
http://modernhousing.net/

Modularcenter.com
http://modularcenter.com/

Greening Affordable Housing

Greening Portland's Affordable Housing—Design and Construction Guidelines to Improve Environmental Performance, Tenant Health and Long-Term Durability in Affordable Housing
www.sustainableportland.org/AHGuidelines.pdf

"Los Angeles Greening Affordable Housing Charrette: Recommendations and Strategies for Resource-Efficient Design, Construction and Maintenance," Global Green USA, 1997.

Global Green USA Greening Affordable Housing Resources
www.globalgreen.org/programs/building.html

Santa Monica's Green Affordable Housing Checklist
greenbuildings.santa-monica.org/whatsnew/green-building-checklist/GreenBuildingChecklist.pdf

BOOKS

Rhonda S. Mills and Ciara Jaladoni, *Power to Your Pocket: California Consumers Guide to Energy Incentive Programs*, Center for Energy Efficiency and Renewable Technologies, 2002. Available at www.cleanpower.org

Daianna Rincones, *The Green Building Resource Guide*, U.S. EPA, Region 5, 2000. Also available in .pdf (portable document format) at www.epa.gov/greenbuilding/region5.htm

Jan McAdams, *The Energywise Construction Funding Directory*, 2001. Available at www.fundinggreenbuildings.com

California Energy Commission, *Renewable Energy Program Guidebooks*, 2003. The set of guidebooks includes "Emerging Renewables Program," "Existing Renewable Facilities Program," "Consumer Education Program," and "Overall Program Guidebook."

California Solar Center, *California Renewable, Energy Efficiency and Demand Reduction Financing Programs*, available in .pdf at www.flexyourpower.ca.gov

Alliance to Save Energy, *Funds for Energy Efficiency Projects*, 2002. Available in .pdf at www.ase.org/consumer/finance.htm

Environmental Law Institute, *Smart Links: Turning Conservation Dollars into Smart Growth Opportunities*, www.elistore.org

U.S. EPA, *Financing Brownfields Redevelopment Projects: A Guide for Developers*, 1999. Available in .pdf at www.smartgrowth.org/pdf/brownfield.pdf

NOTES

[1] Department of Housing and Urban Development, "Notice of Funding Availability for the Community Development Block Grant Program for Indian Tribes and Alaska Native Villages, Fiscal Year 2003," *Federal Register*, July 16, 2003, p. 42195.

[2] Fannie Mae.

[3] Bonneville Power Administration. www.bpa.gov/Energy/N/energy_tips/zemh/index.shtml

[4] Green Building News, June 2000. www.oikos.com/news/2000/06.html

Sustainable Siting and Design

MODULE 4

Building projects can have a huge influence on their local environment, both positively and negatively. Issues such as where a building is sited or how the whole building project (including roads, parking, landscaping, etc.) is integrated with its surrounding environment and community are critical. Using local climate, sun, wind, and shade to maximum advantage are key siting elements. While not all of these issues are relevant to every project, considering each can help the Tribe develop buildings that fit seamlessly and naturally within their natural environment and community.

Each project's particulars will determine if addressing these siting issues will add costs. For example, some sustainable building options may reduce cost (for example, by moving the project to a lower value, previously developed "brownfield" in an urban or suburban location) or may increase cost (for example, by involving expenditures to safeguard land as open space). The most important thing is to consider these alternatives and to explore opportunities for win-win design changes that further sustainable building goals and reduce cost.

SITE SELECTION

Frequently, a building site has already been established and site selection is not an option. However, here are several issues to consider when the site has not yet been determined or the location and orientation within the site have not yet been determined.

Use appropriate building sites.

Ideally, unless they are specifically part of a newly planned expansion designed according to sustainable development principles, new building projects should avoid the need for new roads, parking areas, or buildings on prime farmland or wildlife habitat; land whose elevation is within or near the 100-year flood plain; land within 100 feet of any water, including wetlands; or land that was previously open space or public park land. Tribes developing properties within or near California municipalities may choose to voluntarily adhere to the established land use policies for that community, or to meet the spirit of the policies in creative ways. As a general rule, promoting sensitive infill consistent with local plans and infrastructure is environmentally preferable to creating a new development requiring new infrastructure or services.

Sustainable Siting and Design Issues

SITE SELECTION

- *Use appropriate building sites.*
- *Preserve open space.*
- *Reduce sprawl.*
- *Develop brownfields.*
- *Safeguard endangered species.*
- *Restore damaged environments.*
- *Design to optimize sun, wind, and light.*

SITE INTEGRATION

- *Enhance naturally occurring biodiversity.*
- *Minimizing site disturbance.*
- *Manage stormwater.*
- *Optimize transportation options.*
- *Reduce heat islands.*
- *Reduce light pollution.*

Preserve open space. Consider incorporating the preservation of open spaces—undeveloped land and resource areas—into your building project while avoiding impacting previously undeveloped open spaces. For example, projects may establish a conservation easement or donate adjacent lands to a local land trust or open space district. If open spaces must be developed, consider donating an equivalent amount of land elsewhere to open space status.

Reduce sprawl. Consider channeling the new building to previously developed areas with existing infrastructure wherever possible, while protecting green fields (natural or park areas) and preserving habitat. This is most relevant to developments in established suburban or urban environments, where the danger of sprawl is most apparent. But even in rural areas, consolidating residential development through "clustering," for example, can produce vibrant communities with stores and services located within walking distance. At the same time, this practice reduces transportation needs and the potential for future sprawl patterns.

Develop brownfields. Where possible, consider rehabilitating abandoned buildings and sites. As defined in federal law, (42 U.S.C. 9601) a brownfield site is real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Such sites must be thoroughly evaluated by a qualified environmental firm, with a rehabilitation plan established, but should be considered. Developing brownfields allows the cleanup and recycling of existing infrastructure while preventing degradation of undeveloped land.

Safeguard endangered species. Avoid entirely any land or wetlands specifically designated as habitat for an endangered or threatened species. Conducting a detailed inventory of plant and animal species is critical. Once identified, the presence of endangered species may necessitate changes to the project that are hard to predict ahead of time. Once complete, information about threatened and endangered species living in harmony with a new building project can serve to tighten the connection between building users and the natural environment.

Restore damaged environments. Some building projects may provide the opportunity to restore damaged lands to a natural state, such as conversion of gravel parking lots to fields, meadows or wetlands, or replanting trees or native grasses.

Design to optimize sun, wind, and light. The beneficial impacts of designing a building around its local climate and topography to achieve desirable sun, wind, and light patterns can be quite impressive. For example, orienting a patio to provide a beautiful view, placing it outside of typical wind patterns, or orienting glazing to provide views of a sunset can make a huge difference in the qualitative feel and comfort of a building. These elements also impact energy use by affecting ventilation, lighting and heat flow, of course, and so should be considered along with these factors. The design should also consider the impact of the new building on the surrounding environment and on neighbors.

SITE INTEGRATION

Regardless of whether a site has already been identified, the following steps can aid in integrating the building project into the local environment and community.

Enhance naturally occurring biodiversity. Consider first maintaining and enhancing naturally occurring biodiversity on the site. Design the site to reconnect fragmented landscapes and establish contiguous networks with other natural systems both within the site and adjacent to it. For example, a corridor of trees might be incorporated into a project to connect two adjacent forest areas. Avoid major alterations to sensitive topography, especially removing or relocating natural vegetation and wildlife habitat. Establish car-free areas exclusively for foot traffic, with information about local species, to promote appreciation of the natural environment.

Minimize site disturbance. During construction the contractor team will need to take steps to minimize impacts to the natural environment. Issues of concern include degradation of water quality through pollution or siltation, damaging soils through digging or mixing foreign materials, and spills of hazardous substances. These can be minimized by adopting a thorough site management plan including, for example, clear directions for all parking and operations by construction workers.

Manage stormwater. Stormwater runoff is a serious concern both during and after construction. The problem arises because naturally porous vegetation is replaced with impervious surfaces like roofs, roads, and parking lots. This causes far higher flows into local streams with high amounts of silt and potential pollutants from construction vehicles or building operations. For previously developed sites, consider restoring paved portions to natural or adapted vegetation, and ensure that the post development imperviousness is less than the pre-development imperviousness, as measured by a 24-hour peak discharge rate. For all building projects, consider mitigating stormwater runoff problems by maximizing the use of porous surfaces or by capturing runoff. Examples of porous materials include rooftop vegetation, paver blocks or large aggregate concrete instead of pavement or asphalt, and crushed stone or brick for pedestrian paths. Examples of capture systems include channeling runoff to natural or constructed wetlands or using a rain water catchment system enabling use of the water for irrigation over time. (See Module 7, Water Efficiency and Landscaping.)

Optimize transportation options. Ideally, a building will include steps to maximize convenience and minimize transportation energy and time required by building users. Strategies include siting new buildings near public transportation or negotiating new access to existing public transportation services. Building projects can promote alternative transportation by including bicycle access, covered bike racks, and showers with lockers. Parking lots can include spaces with electricity or natural gas recharging capacity for alternative fueled vehicles. In commercial buildings, the best parking spots can be reserved for carpools.

Reduce heat islands. Heat islands are portions of building developments that tend to be much hotter than the surrounding undeveloped areas, and they can have a detrimental impact on the microclimate, on wildlife habitat, and on human comfort. Heat islands can be mitigated by providing shade from trees or roofs with highly reflective surfaces. Also, consider replacing or lining constructed surfaces (that is, rooftops, sidewalks, or roads) with vegetation to the extent possible to reduce heat absorption. Another option is Energy Star rated roofing materials. (See Module 8, Energy Efficiency.) Some California communities have a 51 percent shade canopy requirement for parking lots that the Tribe may consider adopting.

Reduce light pollution. Ideally, new buildings will be constructed to reduce or eliminate light trespass and improve night sky access, thereby reducing the development impact on nocturnal environments. This can be accomplished by reducing the intensity of external night lights (thereby reducing energy use as well), by limiting the height of buildings, and by covering or partially shading bright lights.

RESOURCES

General Reference Sources on Sustainable Building

The American Indian Council of Architects and Engineers
www.aicae.org/
Contact: Stuart Fricke
White Shield, Inc.
2515 West Falls Ave.
Kennewick, WA 99336
(509) 734-0789
sfricke@whiteshield.com

California Division of the State Architect
1102 G Street, Suite 5100
Sacramento, CA 95814
www.sustainableschools.dgs.ca.gov/SustainableSchools/financing/wastemgmt.html
Contact: Panama Bartholomy
panama.bartholomy@dgs.ca.gov
(916) 445-4229

U.S. Green Building Council
1015 18th Street, NW, Suite 805
Washington, D.C. 20036
www.usgbc.org/
(202) 828-7422
info@usgbc.org

External Lighting

"Recommended Practice Manual: Lighting for Exterior Environments." Engineering Society of North America, #RP-ss-99.

Land Use Planning

California Land Use Planning Information Network (Includes examples of local land use ordinances.)
http://ceres.ca.gov/planning/

Stormwater Management

California Integrated Waste Management Board. Recycled Aggregate Fact Sheet.
www.ciwmb.ca.gov/publications/condemo/43195052.doc

California Water Resources Control Board, Stormwater Program.
www.swrcb.ca.gov/stormwtr/index.htm

Example of guidelines for porous pavement from Washington State, "MBP T3.40, Porous Pavement".
www.ecy.wa.gov/biblio/9915.html

International Erosion Control Association. www.ieca.org/

Southern California Rock Products Association. www.scrpa.com/

Storm Water and Urban Runoff Seminars—A Guide for Builders and Developers, National Home Builders Association. www.nahb.com/

U.S. Environmental Protection Agency, "Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, Summary Guidance."
www.epa.gov/owm/sw/construction

Transportation

Bicycle Federation of America, "Policies for Planning and Designing Guidelines to Support Bicycle Use." www.bikefed.org/

"How Alternative Forms of Development Can Reduce Traffic Congestion," *Sustainable Cities: Concepts and Strategies for Eco-City Development*, Bob Walter, ed. et al., Eco-Home Media, Los Angeles.

E. Cox , "Long Term Bike Parking." www.jps.net/cbc/longbikepark.html

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Suzi Moore McGregor and Nora Burba Trulsson, *Living Homes: Sustainable Architecture and Design,* Chronicle Books, San Francisco, May 2001.

Sandra Mendler, *The HOK Guidebook to Sustainable Design,* John Wiley & Sons; 1st edition, January 15,2000. www.oikos.com/

G.Z. Brown and Mark DeKay, *Sun, Wind, and Light,* John Wiley & Sons; 2nd edition, October 24, 2001. www.oikos.com/

Whole Building Design Guide, National Institute of Building Science, 2004, www.wbdg.org/design

Joseph F. Kennedy, Michael Smith, Catherine Wanek, *The Art of Natural Building: Design, Construction, Resources,* eds, New Society Publishers, February 2002.

Fred A. Stitt, *Ecological Design Handbook: Sustainable Strategies for Architecture, Landscape Architecture, Interior Design and Planning,* McGraw-Hill, New York, 1999.

Robert D. Brown and Terry J. Gillespie, *Microclimate Landscape Design: Creating Thermal Comfort and Energy Efficiency,* John Wiley and Sons, New York, 1995.

The Green Building Advisor: Defining the Future of Environmentally Responsible Design, software available at www.crest.org/

Dianna Lopez Barnett with William D. Browning, *A Primer on Sustainable Building,* Rocky Mountain Institute, Green Development Services, 1995.

Sustainable Building Technical Manual:Green Building Design, Construction and Operations, U.S. Green Building Council, 1996.

Green Building Home

State Task Force

Basics

Project Design

Guidelines and Specs

Programs & Partnerships

Schools

Case Studies

RCP Database

Links

Events

Green Building Basics

Buildings account for one-sixth of the world's fresh water withdrawals, one-quarter of its wood harvest, and two-fifths of its material and energy flows (Roodman and Lenssen, 1995). Building "green" is an opportunity to use our resources efficiently while creating healthier buildings that improve human health, build a better environment, and provide cost savings.

What Makes a Building Green?

A green building, also known as a sustainable building, is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health; improving employee productivity; using energy, water, and other resources more efficiently; and reducing the overall impact to the environment.

What Are the Economic Benefits of Green Buildings?

A green building may cost more up front, but saves through lower operating costs over the life of the building. The green building approach applies a project life cycle cost analysis for determining the appropriate up-front expenditure. This analytical method calculates costs over the useful life of the asset.

These and other cost-savings can only be fully realized when they are incorporated at the project's conceptual design phase with the assistance of an integrated team of professionals. The integrated systems approach ensures that the building is designed as one system rather than a collection of stand-alone systems.

Some benefits, such as improving occupant health, comfort, productivity, reducing pollution and landfill waste are not easily quantified. Consequently, they are not adequately considered in cost analysis. For this reason, consider setting aside a small portion of the building budget to cover differential costs associated with less tangible green building benefits or to cover the cost of researching and analyzing green building options.

Even with a tight budget, many green building measures can be incorporated with minimal or zero increased up-front costs and they can yield enormous savings (Environmental Building News, 1999).

What Are the Elements of Green Buildings?

Below is a sampling of green building practices.

Siting

- Start by selecting a site well suited to take advantage of mass transit.
- Protect and retain existing landscaping and natural features. Select plants that have low water and pesticide needs, and generate minimum plant trimmings. Use compost and mulches. This will save water and time.
- Recycled content paving materials, furnishings, and mulches help close the recycling loop.

Energy Efficiency

Most buildings can reach energy efficiency levels far beyond California Title 24 standards, yet most only strive to meet the standard. It is reasonable to strive for 40 percent less energy than Title 24 standards. The following strategies contribute to this goal.

- Passive design strategies can dramatically affect building energy performance. These measures include building shape and orientation, passive solar design, and the use of natural lighting.
- Develop strategies to provide natural lighting. Studies have shown that it has a positive impact on productivity and well being.
- Install high-efficiency lighting systems with advanced lighting controls. Include motion sensors tied to dimmable lighting controls. Task lighting reduces general overhead light levels.
- Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell. Maximize light colors for roofing and wall finish materials; install high R-value wall and ceiling insulation; and use minimal glass on east and west exposures.
- Minimize the electric loads from lighting, equipment, and appliances.
- Consider alternative energy sources such as photovoltaics and fuel cells that are now available in new products and applications. Renewable energy sources provide a great symbol of emerging technologies for the future.
- Computer modeling is an extremely useful tool in optimizing design of electrical and mechanical systems and the building shell.

Materials Efficiency

- Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclability, durability, longevity, and local production. Such products promote resource conservation and efficiency. Using recycled-content products also helps develop markets for recycled materials that are being diverted from California's landfills, as mandated by the Integrated Waste Management Act.
- Use dimensional planning and other material efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example,

design rooms on 4-foot multiples to conform to standard-sized wallboard and plywood sheets.
- Reuse and recycle construction and demolition materials. For example, using inert demolition materials as a base course for a parking lot keeps materials out of landfills and costs less.
- Require plans for managing materials through deconstruction, demolition, and construction.
- Design with adequate space to facilitate recycling collection and to incorporate a solid waste management program that prevents waste generation.

Water Efficiency

- Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other nonpotable water for site irrigation.
- Minimize wastewater by using ultra low-flush toilets, low-flow shower heads, and other water conserving fixtures.
- Use recirculating systems for centralized hot water distribution.
- Install point-of-use hot water heating systems for more distant locations.
- Use a water budget approach that schedules irrigation using the California Irrigation Management Information System data for landscaping.
- Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in nonturf areas.
- Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.

Occupant Health and Safety

Recent studies reveal that buildings with good overall environmental quality can reduce the rate of respiratory disease, allergy, asthma, sick building symptoms, and enhance worker performance. The potential financial benefits of improving indoor environments exceed costs by a factor of 8 and 14 (Fisk and Rosenfeld, 1998).

Choose construction materials and interior finish products with zero or low emissions to improve indoor air quality. Many building materials and cleaning/maintenance products emit toxic gases, such as volatile organic compounds (VOC) and formaldehyde. These gases can have a detrimental impact on occupants' health and productivity.

Provide adequate ventilation and a high-efficiency, in-duct filtration system. Heating and cooling systems that ensure adequate ventilation and proper filtration can have a dramatic and positive impact on indoor air quality.

Prevent indoor microbial contamination through selection of materials resistant to microbial growth, provide effective drainage from the roof and surrounding landscape, install adequate ventilation in bathrooms, allow proper drainage of air-conditioning coils, and design other building systems to control humidity.

Building Operation and Maintenance

Green building measures cannot achieve their goals unless they work as intended. Building commissioning includes testing and adjusting the mechanical, electrical, and plumbing systems to ensure that all equipment meets design criteria. It also includes instructing the staff on the operation and maintenance of equipment.

Over time, building performance can be assured through measurement, adjustment, and upgrading. Proper maintenance ensures that a building continues to perform as designed and commissioned.

City of San Diego's Ridgehaven Green Building

At a glance, the Ridgehaven Building appears identical to its neighbor. In 1996, however, the 73,000 sq ft. Ridgehaven Building was completely renovated with many cost-effective sustainable performance methodologies and technologies. As a result, the Ridgehaven Building now uses 65 percent less total energy than its nearly identical neighbor, yielding a saving of more than $70,000 in annual utility costs. This equates to $1per sq ft. in annual savings. Even more important, the building occupants love its light and "healthy" atmosphere, boosting their productivity (Gottfried, 1999).

Steps to Ensure Success

- Establish a vision that embraces sustainable principles and an integrated design approach.
- Develop a clear statement of the project's vision, goals, design criteria, and priorities.
- Develop a project budget that covers green building measures. Allocate contingencies for additional research and analysis of specific options. Seek sponsorship or grant opportunities.
- Seek advice of a design professional with green building experience.
- Select a design and construction team that is committed to the project vision. Modify the RFQ/RFP selection process to ensure the contractors have appropriate qualifications to identify, select, and implement an integrated system of green building measures.
- Develop a project schedule that allows for systems testing and commissioning.
- Develop contract plans and specifications to ensure that the building design is at a suitable level of building performance.
- Create effective incentives and oversight.

For More Information

- California Integrated Waste Management Board Green Building Web site: www.ciwmb.ca.gov/GreenBuilding/. Includes the manual *Designing With Vision: A Technical Manual For Material Choices In Sustainable Construction* (Pub. #431-99-009). Hard copies are available from the publications clearinghouse at 1-800-CA-WASTE.
- *Sustainable Building Technical Manual*, http://www.sustainable.doe.gov/freshstart/articles/ptipub.htm
- *A Guide to Irrigation Water Needs of Landscape Plants in California*:

www.dpla.water.ca.gov/urban/conservation/landscape/wucols/

- Department of Health Services, Indoor Air Quality Web site: http://www.cal-iaq.org/
- U.S. Department of Energy Web site: http://www.sustainable.doe.gov/buildings/gbintro.shtmll
- Environmental Building News: www.buildinggreen.com/
- U.S. Green Building Council Web site: http://www.usgbc.org/

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1. D.M Roodman and N. Lenssen, *A Building Revolution: How Ecology and Health Concerns are Transforming Construction*, Worldwatch Paper 124, Worldwatch Institute, Washington, DC, March 1995, p. 5. (Back)
2. Environmental Building News, *Building Green on a Budget*, Vol 8, No. 5, May 1999, www.ebuild.com/Archives/Features/ Low_Cost/Low_Cost.html#General (Back)
3. William Fisk and Arthur Rosenfeld, *Potential Nationwide Improvements in Productivity and Health From Better Indoor Environments*, Lawrence Berkeley National Laboratory, May 1998. (Back)
4. Gottfried Technology, excerpt from Web site, www.buildingfutures.com/p3.htm, Feb. 9, 1999. (Back)

Last updated: January 08, 2004

Green Building http://www.ciwmb.ca.gov/GreenBuilding/
Kathy Frevert: kfrevert@ciwmb.ca.gov (916) 341-6476

Sustainable Building

Training Programs

- State Training
- Local Government

State Training Program

The California Integrated Waste Management Board currently provides sustainable design training workshops to State personnel. Workshop attendees receive the tools necessary to integrate sustainability into State construction projects. This dynamic 8-hour training covers topics found in the California Sustainable Design Training participant's manual. The manual provides in depth information on each of the topics listed below as well as references for further investigation as appropriate to an individuals needs.

California Sustainable Design Training 2001

This manual is being developed as part of a ten-point plan to implement the Governor's sustainable building goal as outlined in Executive Order D-16-00 and the report Building Better Buildings: A Blueprint for Sustainable State Facilities (Blueprint). Task 7 of the Blueprint calls for developing sustainable building technical assistance and outreach tools, including a training program for state departments, as well as local government and private sector partners. This manual was developed by DGS, the Sustainable building task force, and CIWMB as one component of the sustainable building training program for state departments. This document will be undergoing constant revision as other deliverables outlined in the Blueprint are completed and technological and process breakthroughs advance the rapidly emerging

field of sustainable design.

Download a copy of the entire manual: Participant's Manual (PDF, 10.7 MB) or http://www.ciwmb.ca.gov/GreenBuilding/

Download sections of the manual from the following parts:

- Sustainable Design Introduction (Word, 136 KB)
  - Resource List (Word, 95 KB)
- Sustainable Design Process (Word, 1.7 MB)
  - Resource List (Word, 84 KB)
- Site Selection (Word, 1.6 MB)
  - Resource List (Word, 92 KB)
- Energy (Word, 2.3 MB)
  - Energy Technologies (Word, 121 KB)
  - Resource List (Word, 121 KB)
- Indoor Environmental Quality (Word, 102 KB)
  - Resource List (Word, 95 KB)
- Indoor Air Quality (Word, 130 KB)
  - Resource List (Word, 93 KB)
- Construction Waste Management (Word, 603 KB)
  - Resource List (Word, 86 KB)
- Sustainable Materials Selection (Word, 107 KB)
  - Resource List (Word, 87 KB)
- Specifications (Word, 93 KB)
  - Resource List (Word, 84 KB)
  - Insulation Specification (Word, 78 KB)
  - Carpentry Specification (Word, 80 KB)
- Operations and Maintenance (Word, 124 KB)
  - Resource List (Word, 82 KB)

Local Government Training Program

The CIWMB is currently developing a sustainable design training program for local governments. The first local government training workshops are coming up soon. Please check the events page for upcoming workshops. A local government review group has been assembled to review the materials under development.

If you would like to participate in the local government

review group or if you would like more information on training programs, please contact Clark Williams at (916) 341-6488.

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Last updated: November 14, 2003

Green Building http://www.ciwmb.ca.gov/GreenBuilding/
Kathy Frevert: kfrevert@ciwmb.ca.gov (916) 341-6476

LEED Version 2.1 Registered Project Checklist

Project Name
City, State

Yes	?	No			
			Sustainable Sites		**14** Points
Y			Prereq 1	**Erosion & Sedimentation Control**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Development Density**	1
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
			Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	1
			Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
			Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
			Credit 6.1	**Stormwater Management**, Rate and Quantity	1
			Credit 6.2	**Stormwater Management**, Treatment	1
			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
			Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
			Credit 8	**Light Pollution Reduction**	1
Yes	?	No			
			Water Efficiency		**5** Points
			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
			Credit 2	**Innovative Wastewater Technologies**	1
			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
			Credit 3.2	**Water Use Reduction**, 30% Reduction	1
Yes	?	No			
			Energy & Atmosphere		**17** Points
Y			Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
			Credit 1	**Optimize Energy Performance**	1 to 10
			Credit 2.1	**Renewable Energy**, 5%	1
			Credit 2.2	**Renewable Energy**, 10%	1
			Credit 2.3	**Renewable Energy**, 20%	1
			Credit 3	**Additional Commissioning**	1
			Credit 4	**Ozone Depletion**	1
			Credit 5	**Measurement & Verification**	1
			Credit 6	**Green Power**	1
Yes	?	No			
			Materials & Resources		**13** Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
			Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
			Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
			Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
			Credit 2.1	**Construction Waste Management**, Divert 50%	1
			Credit 2.2	**Construction Waste Management**, Divert 75%	1
			Credit 3.1	**Resource Reuse**, Specify 5%	1
			Credit 3.2	**Resource Reuse**, Specify 10%	1
			Credit 4.1	**Recycled Content**, Specify 5% (post-consumer + _ post-industrial)	1
			Credit 4.2	**Recycled Content**, Specify 10% (post-consumer + _ post-industrial)	1
			Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1

U.S. Green Building Council **LEED Checklist** LEED™ Green Building Rating System 2.1

			Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
			Credit 6	**Rapidly Renewable Materials**	1
			Credit 7	**Certified Wood**	1
Yes	?	No			
			Indoor Environmental Quality		**15** Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
			Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
			Credit 2	**Ventilation Effectiveness**	1
			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
			Credit 4.2	**Low-Emitting Materials**, Paints	1
			Credit 4.3	**Low-Emitting Materials**, Carpet	1
			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber	1
			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
			Credit 6.1	**Controllability of Systems**, Perimeter	1
			Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
			Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
			Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1
Yes	?	No			
			Innovation & Design Process		**5** Points
			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
			Credit 1.2	**Innovation in Design**: Provide Specific Title	1
			Credit 1.3	**Innovation in Design**: Provide Specific Title	1
			Credit 1.4	**Innovation in Design**: Provide Specific Title	1
			Credit 2	**LEED™ Accredited Professional**	1
Yes	?	No			
			Project Totals (pre-certification estimates)		**69** Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

U.S. Green Building Council **LEED Checklist** LEED™ Green Building Rating System 2.1

For current staff contacts, please see the CIWMB Web site at www.ciwmb.ca.gov/GreenBuilding/Overview.doc.

California Integrated Waste Management Board (CIWMB) Overview of Sustainable Building Activities

Implementing the Governor's Sustainable Building Executive Order
Governor Davis issued Executive Order D-16-00 establishing the State's sustainable building goal:

> ***To site, design, deconstruct, construct, renovate, operate, and maintain State buildings that are models of energy, water, and materials efficiency; while providing healthy, productive, and comfortable indoor environments and long-term benefits to Californians.***

The Sustainable Building Task Force, comprised of representatives from various State departments with specific fiscal, construction, and environmental policy expertise, developed *Building Better Buildings: A Blueprint for Sustainable State Facilities.* This document recommends a course of action to achieve the Governor's goal. When implemented, this strategy will result in institutionalized changes to improve building performance throughout the state. The CIWMB plays a key role in supporting the Sustainable Building Task Force by providing resources and facilitating activities. **Contact:** Kathy Frevert, kfrevert@ciwmb.ca.gov, 916-341-6476.

Programs at the CIWMB

Leadership in Energy and Environmental Design™ (LEED) Green Building Rating System
The U.S. Green Building Council (USGBC), the creator of LEED™ was in the process of developing LEED Commercial Interior (CI), LEED Residential (R), and LEED Operations & Maintenance (O&M). Recently, the USGBC decided to merge these three individual rating systems into one, which will be known as LEED 2.1.

The CIWMB has been active in the development of LEED-R and LEED-CI, and will continue to assist in the development of LEED 2.1. Additionally, the Sustainable Building Technical Group has developed a LEED supplement for California state facilities. **Contact on LEED 3.0:** Gregory Dick, gdick@ciwmb.ca.gov, 916-341-6497. **Contact on LEED supplement:** Kathy Frevert, kfrevert@ciwmb.ca.gov, 916-341-6476.

High Performance Schools
Since 2000, staff from the CIWMB Sustainable Building program have participated in a group of government agencies, utilities, and nonprofit organizations recognized as the Collaborative for High Performance Schools (CHPS). In January 2001, CHPS completed a High Performance Schools Best Practices Manual to assist California school administrators, architects, and engineers in planning, designing, and building schools that are energy efficient, resource efficient, healthy, comfortable, well lit, and contain the amenities needed for a quality education. The collaborative recently finalized a set of design criteria for schools to self-certify that they have achieved "high performance schools" status. To download a copy of the manual or for more information on the collaborative, visit the web site: www.chps.net. **Contact:** Dana Papke, dpapke@ciwmb.ca.gov, 916-341-6496.

State Agency Buy Recycled Campaign (SABRC)
CIWMB Buy Recycled program staff implement the mandated recycled content product procurement laws of the Public Contract Code. State law requires all state agencies to buy recycled products in place of non-recycled products, to require their product suppliers to certify the recycled-content of all products offered or sold to the State, and to track and report purchases, annually. Staff also assists local government agencies and the private sector in establishing and improving "Buy Recycled" policies to successfully implement procedures that will assist with policy implementation, and to track and report their successes. Concurrently, CIWMB staff is working with the Board and the Department of General Services to develop a multifaceted approach to increase acceptance and awareness of recycled-content products throughout all levels of state and local government. **Contact:** Kathy Marsh, kmarsh@ciwmb.ca.gov, 916-341-6482.

Educate Landscaping Professionals
Staff is pursuing an outreach program and building partnerships with landscape architects and maintenance professionals, whether they maintain residential, commercial, or public properties, to promote resource-efficient landscape design and maintenance practices respectively. Landscape professionals are paying more attention to landscape design and management practices that reduce waste generation, reuse trimmings on-site, and recycle organic products (mulch and compost) back into urban landscapes.

Information on suppliers of urban compost and mulch and grasscycling techniques is currently available on the CIWMB's Organics Outlook web page www.ciwmb.ca.gov/organics. In addition, information on companies that supply recycled-content landscape products is also available through the CIWMB's recycled-content product database, in the landscape and garden category. A series of fact sheets and technical publications on resource-efficient landscape design and management guidelines are available at www.ciwmb.ca.gov/Organics/landscaping. Staff is also working with landscape industry associations regarding the development of outreach programs, educational curriculum and professional certifications regarding resource-efficient landscape design and maintenance practices. **Contact:** Ken Decio, kdecio@ciwmb.ca.gov, 916-341-6586.

Services Provided by the Board

Recycled-Content Product Database
CIWMB's recycled-content product database is one of the largest of its kind on the Internet, listing more than 2200 companies and 7000 products, including construction and landscaping products. Visit the RCP directory at www.ciwmb.ca.gov/rcp/.
Contact: Linda Hennessy at rcp@ciwmb.ca.gov, 916-341-6606.

Green Building Website
The CIWMB website contains information about our Sustainable Building and Construction and Demolition Debris Recycling Programs. Information on sustainable building basics, materials, specifications, programs, and case studies can be reviewed at the following web site: http://www.ciwmb.ca.gov/Greenbuilding/.
Contact: Dana Papke at dpapke@ciwmb.ca.gov, 916-341-6496.

Construction & Demolition Recycling Program Databases
A searchable database of construction and demolition waste processors and receivers, C&D Debris Recyclers Database, can be accessed at this address: www.ciwmb.ca.gov/ConDemo/Recyclers/
Another database of and the Recycled-Content Building Products can be accessed at this address: http://www.ciwmb.ca.gov/ConDemo/Recyclers/.
Contact: Sabra Ambrose, sambrose@ciwmb.ca.gov, 916-341-6489.

Sustainable Building Training Program
The CIWMB is currently developing a sustainable building design and construction curricula in order to conduct regional training seminars to state and local governments. The curricula will include training modules to provide attendees with a basic understanding of sustainable design and construction including:

- Cost vs. benefits of sustainable building
- Designing projects for energy and water efficiency
- Designing/building for waste prevention and recycling
- Using recycled content and sustainable/renewable building materials
- Designing, building, and operating buildings for high standards of indoor air quality
- Resource conscious deconstruction and demolition practices
- Construction-site materials management
- Sustainable operation and maintenance
- Case studies of green building performance, building materials and building codes to help justify the adoption of new design and construction guidelines.

The first training seminars will be conducted in fall of 2001. **Contact:** Clark Williams, clarkw@ciwmb.ca.gov, 916-341-6488.

Building Material Emissions Study
Have you heard claims that recycled products may contribute to poor indoor air quality? A Final Report of the Building Material Emissions Study is now available to give you the scientific evidence to dispels those myths and prove that there are low-emitting recycled content products that contribute to healthy indoor environments. While most recycled content products performed about the same as standard products, some may need further refinement and testing before they can be promoted for wide-use indoors, and others are lower emitting. A copy of the final report that the Board approved during their June 17-18, 2003 Board Meeting is available at the following website: http://www.ciwmb.ca.gov/GreenBuilding/Specs/Section01350/METStudy.htm
Contact: Dana Papke, dpapke@ciwmb.ca.gov, 916-341-6496.

Life Cycle Costing Study
The Integrated Waste Management Board has joined with the State and Consumer Services Agency, the State Energy Resources Conservation and Development Commission, Air Resources Board, California Department of Transportation, Division of the State Architect, and the Department of Water Resources to develop a methodology for analyzing the cost effectiveness of sustainable building strategies and features.

This study will be a key step in implementing Executive Order D-16-00 that requires the State to integrate sustainable building practices into its capital outlay design,

construction, and operations processes. Unfortunately, like many other governmental and private builders, the State's current capital outlay process primarily focuses on the building's "first cost" without much regard to long-term operations and maintenance costs. Often, these long-term operations and maintenance costs have significant impacts on the State's budget. This study is anticipated to provide data supporting the contention that the use of life-cycle costing will achieve lower total costs throughout the life of the building. **Contact:** John Blue, jblue@ciwmb.ca.gov, 916-341-6484.

Construction and Demolition (C&D) Diversion Efforts
As approved in late 2002, Senate Bill 1374 requires the Board to develop voluntary Model Ordinances for local governments and three reports for diverting Construction and Demolition (C&D) materials. These reports will provide recommendations to local governments and contractors on how to create markets and adopt methods for recovering C&D materials. Both, the Model Ordinances and reports will be completed by March 2004. **Contact:** Francisco Gutterres, fgutterr@ciwmb.ca.gov, 916-341-6493.

Sustainable Aggregate Mining Specifications
C&D program staff is participating in efforts to promote hot-in-place (HIP), cold-in-place (CIP), and cold foamed (CF) asphaltic concrete recycling. Staff is writing specifications that will be adopted by CalTrans district engineers. These specifications will incorporate the maximum amount of recycled aggregate as possible depending on the mix design of the original asphalt structure. During the next fiscal year, other recycled materials such as tires and asphalt roofing shingles may be used in the same type of specification. Currently the task force for HIP asphaltic concrete recycling is looking for a location to do a maintenance pilot project. **Contact:** Sabra Ambrose, sambrose@ciwmb.ca.gov, 916-341-6499.

Funding Sources

Sustainable Building Grant and Contract Program
The Sustainable Building Grant and Contract Program was designed to leverage and empower existing sustainable building efforts. It advances sustainable building practices in California by providing grants and contracts to local government and state agencies to promote sustainable building through program implementation, workshops, educational outreach, and construction. Current funding availability and grant information is available on the CIWMB web site: www.ciwmb.ca.gov/greenbuilding/grants/. **Contact:** Kristen McDonald, kmcdonal@ciwmb.ca.gov, 916-341-6485.

Waste Reduction

MODULE 5

"Waste reduction" is one of the two approaches used to conserve materials in sustainable buildings. (The other approach, the purchase of reused and recycled products, is discussed in Module 6). Waste reduction can focus on the construction site and can be part of an overall maintenance and operations plan developed along with the construction plan at the beginning of the project. A well-planned approach to Waste reduction will curb construction waste and can facilitate materials reuse and recycling in the building after it is completed. In general, construction and demolition recycling often saves on first costs in areas with established recycling markets.

As with most sustainable building strategies, the net cost of materials conservation strategies will vary depending on the particular circumstances. Rehabilitating buildings, reusing components of existing buildings, or using salvaged building products may result in substantial cost savings, where it is a feasible option.

However, all of the strategies discussed in this module help conserve material resources during the construction of a building and during its future maintenance. But just as importantly, they also have significant environmental benefits involving the reduced use of energy, reductions in air and water pollution during resource extraction and manufacturing, and the safeguarding of scarce natural resources.

WASTE REDUCTION STRATEGIES

- ✓ Prepare and implement a construction waste reduction plan.
- ✓ Rehabilitate existing buildings.
- ✓ Demolition/deconstruction waste management.
- ✓ Design to facilitate recycling and reuse.
- ✓ Specify products that can be repaired or renovated instead of replaced.
- ✓ Specify environmentally preferable products and practices.

Prepare and implement a construction waste reduction plan.

Construction and demolition waste accounts for nearly 12 percent of all waste disposed in California.[1] Most materials generated on construction sites are recyclable or reusable, and State technical assistance and recycling service companies are available to make sure it is recycled. Types of construction waste include concrete, asphalt paving, asphalt roofing, lumber, gypsum board, rock, soil, paint, carpet ends, and fines. Several California cities and counties have adopted ordinances requiring construction site recycling programs.

Some elements of a construction waste reduction plan include:

- Requiring on-site recycling in bid and contract documents for all contractors and subcontractors.
- Holding a pre-construction waste management meeting with all contractors and subcontractors to ensure they understand and agree to abide by all recycling procedures.
- Waste management in all regular meetings during construction.
- Developing clear instructions for all personnel involved at the job site, for example, covering proper handling procedures for each material and contamination concerns.
- A preference for reduced packaging or returnable packaging in supply agreements.
- Minimizing waste generation through efficient framing practices, such as using modular dimensions.
- Assigning designated areas with clear signs for recycling materials.
- Conducting materials separation and processing off-site, reserving the construction site for conventional materials management practices as much as possible.
- Requiring contractors to self-haul materials to reduce the number of trucks visiting the site.

Recycling levels for construction projects in the range of 60 to 70 percent can be achieved, but availability of local markets is critical to achieving this level of recycling. One Portland project achieved a 76 percent recycling level, comprised of recyclable or reusable wood (61 percent), cardboard (11 percent) and gypsum wallboard (4 percent). Excellent technical assistance is available to assist in developing an on-site waste reduction plan and incorporating recycling requirements into bid and contract language. (See the resources at the end of this module.) Disposal costs vary by region and by the particular practices employed. In a 1995 survey, contractors reported paying between $250 and $1,000 per home for waste removal and disposal, not including revenue from recyclables.[2] Reducing material use by using strategies like standard dimensions in framing and modular components can reduce costs on a typical home by nearly $1,000 while reducing the amount of materials used and wasted.

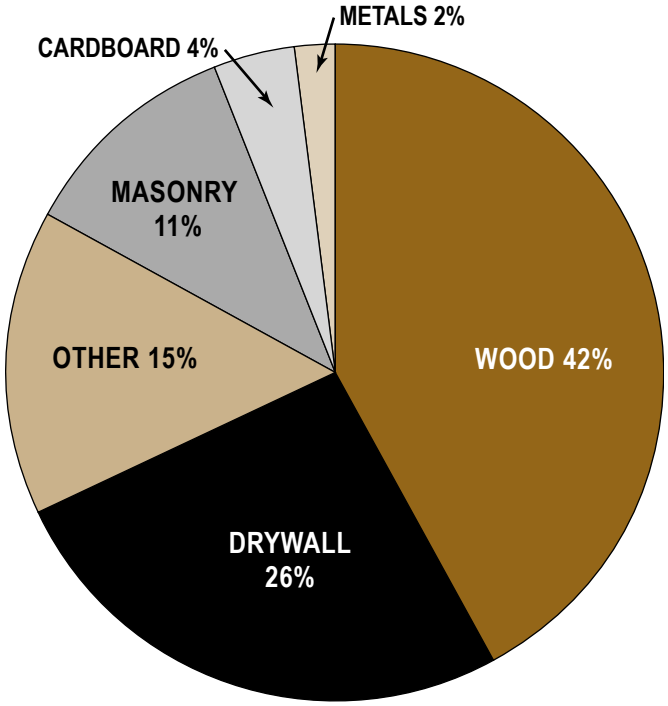
RECYCLABLE CONSTRUCTION MATERIALS

Land Clearing Debris
Clean, Dimensional Wood
Plywood and Particle Board
Concrete
Asphalt Concrete
Concrete Masonry Units
Bricks
Gypsum Wallboard
Rigid Foam Insulation
Asphalt Shingles
Paint
Window Glass
Carpet and Pads
Plastic Film
Polystyrene
High Density Polyethylene
Cardboard, Paper and Packaging

Source: U.S. Green Building Council, LEED Reference Package Version 2.0.

Rehabilitate existing buildings. One environmentally desirable form of green building involves the reuse of existing buildings. This may involve merely reusing the shell or components of the shell, or additional components like plumbing, interior walls, etc. This can have several mutually reinforcing benefits, including eliminating the need for demolition and landfilling of on-site materials, eliminating the need to produce lumber and the many other products used on site, eliminating transportation costs, etc. It also reduces construction waste considerably. Also, rehabilitating existing buildings may contribute to the rebirth of neighborhoods and saving artifacts of community interest into the future. Finally, infrastructure like electricity, water, and sewage are all likely to be in place already. On the other hand, energy efficiency and other improvements will likely be necessary, and environmental review is essential to determine whether hazardous or toxic materials are present. Check compliance with safety and fire codes as well as adaptability to the new building's design. In one example, the Southern California Gas Company reused an existing building in a 44,000 square-foot project and saved an estimated $3.2 million, including savings on masonry (87 percent savings), site work (57 percent savings), concrete (49 percent savings) and carpentry (70 percent savings).[3]

CONSTRUCTION WASTE BY WEIGHT



NAHB, Residential Construction Waste Management: A Builder's Field Guide.

Construction and Demolition/ Deconstruction Waste Management.

There are a number of ways to reduce demolition waste including reuse and recycling. But prior to demolition of a building, deconstruction of the building should take place. This is the removal of the more valuable materials such as doors, windows, cabinets, millwork, paneling, dimensional lumber, plumbing fixtures, electrical fixtures and wiring, HVAC equipment, and architectural fixtures. These materials can be reused in the same project or because of their high resale value can be sold for use or other projects.

Materials that have a lower resale value often are reused on-site. Clean lumber can be chipped into mulch and later used for landscaping; water damaged wood can be composted and used as a soil amendment. Additionally clean concrete and masonry as well as bricks can be reused on the project, although it may not be cost-effective to deconstruct these materials. However, they may be crushed on-site and used as aggregate fill for the new project.

After all of the reusable items are removed, the remaining building is demolished and the easily recyclable materials are separated. These materials include steel and other metals, tile, asphalt, concrete, masonry, and bricks. In most areas there are well-developed markets for these products, especially steel and metal. The remaining materials are usually crushed for use in road construction. There are many companies that process this material with significant amounts used by CalTrans and local municipalities.

Wood and bricks are two recyclable construction materials

Design to facilitate recycling and reuse.

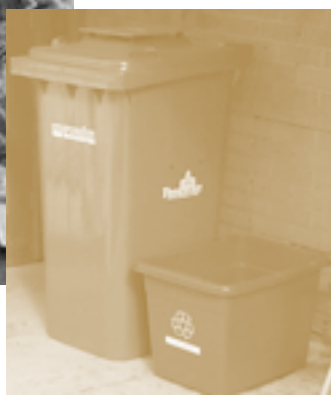
Buildings can be designed from the beginning to facilitate recycling and waste reduction practices by the occupants. The specific needs will vary depending on the type of building, but in general there is a need for a dedicated space for storing and/or processing recyclables that is convenient. In a single-family home this might mean a space in a garage or utility room. In a multi-family complex it would mean a covered area large enough for one or more dumpsters. In a commercial building it could mean designating multiple locations to place recycling bins in offices or storage areas near a loading dock with waste paper balers or other equipment, depending on the type of operation. A 1991 State law required all California cities and counties to adopt ordinances requiring space allocating new construction for recycling. To date, dozens of municipalities have complied with this law. In those that have not adopted an ordinance, a model ordinance prepared by the California Integrated Waste Management Board is in effect by default. This ordinance can also serve as a model for Tribes. (See link in the resources section.) Landscaping too can be designed from the beginning to reduce waste, for example, by using native plants that require little maintenance. (Landscaping is covered in Module 7, Water Efficiency and Landscaping).

Specify products that can be repaired, renovated, or partially replaced.

Over the lifetime of the building, adopting a strategy of repairing and renovating, rather than replacing products or building components when they become obsolete, can reduce waste. This involves researching product durability, reparability, and replacement issues. It also means considering the entire lifecycle costs of products and building components from the outset. For example, commercial carpet tiles can be specified that can be replaced one at a time. This allows building managers to "repair" a carpet when needed in high traffic areas, significantly reducing the cost of replacing carpet in the entire space and reducing associated carpet waste. But such benefits are contingent upon the building construction team specifying commercial carpet tiles from the outset. By considering the potential to extend product life through repair or renovation, similar benefits may be realized by specifying appliances and building components that can be repaired or renovated when they fail or become obsolete, rather than being replaced outright.

Specify environmentally preferable operations and maintenance products and practices.

Building operations and maintenance products and practices can be specified that will reduce waste and the disposal of toxic chemicals while benefiting the overall indoor environmental quality of a building. For example, cleaning products can be evaluated based on such factors as the percentage of volatile organic compounds, toxicity, flammability, presence of ozone depleters, biodegradability, or their potential for bioaccumulation for occupants and workers. Additionally, products with recycled content or reduced packaging, such as recycled-content restroom towels and tissues, can reduce overall waste and help build markets for recycled materials.



RESOURCES

California Integrated Waste Management Board

Construction and Demolition Debris Recycling Program
www.ciwmb.ca.gov/ConDemo/

Database of C&D Recyclers
www.ciwmb.ca.gov/ConDemo/Recyclers/

C&D Recycling Plans and Policies
www.ciwmb.ca.gov/Publications/default.asp?pubid=926

C&D Specifications
www.ciwmb.ca.gov/ConDemo/Specs/

Recycling Space Allocation Guide
www.ciwmb.ca.gov/Publications/default.asp?pubid=832

Local Government Sample C&D Ordinances
www.ciwmb.ca.gov/ConDemo/SampleDocs/

Other Resources

Advance Wall Framing
www.eere.energy.gov/buildings/documents/pdfs/26449.pdf

Strategies for Waste Reduction of C & D Debris from Buildings
www.ilsr.org/recycling/buildingdebris.pdf

U.S. EPA—Waste Management in Indian Country
www.epa.gov/epaoswer/non-hw/tribal/index.htm

U.S. EPA—Construction and Demolition Waste Recycling Web Page
www.epa.gov/epaoswer/non-hw/debris/

Tribal Environmental Resource Center—Solid Waste Management Links
www4.nau.edu/itep/s_waste.html

Construction Materials Recycling Association
www.cdrecycling.org/wholeframe.htm

Residential Construction Waste Management: A Builder's Field Guide
National Association of Home Builders
www.nahbrc.com/

BOOKS

Residential Construction Waste Management: A Builder's Field Guide: How to Save money and Landfill Space.
www.nahbrc.com/

Building Savings: Strategies for Waste Reduction of Construction and Demolition Debris from Buildings, 2000.
www.epa.gov/osw

J. Ferguson, et al., *Managing and Minimizing Construction Waste: A Practical Guide, Institute of Civil Engineers,* 1995.

NOTES

[1] California Integrated Waste Management Board, *1999 Statewide Waste Characterization Study.*

[2] "Residential Construction Waste Management: A Builder's Field Guide." National Association of Home Builders.

[3] As cited by the U.S. Green Building Council, Reference Package.

Urban Wood Waste

Introduction

Urban wood waste is the portion of the wood waste stream that can include sawn lumber, pruned branches, stumps, and whole trees from street and park maintenance. The primary constituents of urban wood waste are used lumber, trim, shipping pallets, trees, branches, and other wood debris from construction and demolition clearing and grubbing activities.

The disposal of wastes generated from construction and demolition (C&D) activities represents a significant portion of operating expenses in addition to consuming valuable landfill space. C&D waste represents a significant part of the solid waste steam, with current estimates at 28 percent of total tonnage. Its reduction will help meet the State mandated diversion goal of 50 percent by 2000.

Wood waste is, by far, the largest portion of the waste stream generated from construction and demolition activities. As such, this fact sheet is geared toward contractors and local governments considering alternatives to disposal. These alternative uses represent significant potential savings in disposal costs.

Quantities

The quantity of urban wood waste documented in California varies depending on the study and the source. Based on information compiled from local waste generation studies, the California Integrated Waste Management Board (CIWMB) estimates that approximately 3.8 million tons of wood waste (this does not include yard waste) are generated throughout the state and enter the municipal waste stream in California every year. Of the 3.8 million tons generated, approximately 3.35 million tons are disposed of in permitted disposal facilities and the remaining 450,000 tons are diverted from landfilling.

A considerable amount of wood waste is also consumed by the biomass industry for boiler fuel to produce electricity, and steam in some cases. Based on figures supplied by the biomass industry, it currently consumes approximately 1.3 million tons of urban wood waste. This is above and beyond the 3.8 million tons quantified in the previous paragraph. The biomass industry's fuel consumption is decreasing due to closures and curtailment of operations of private and public plants contracted to sell power to utilities in the state.

Markets

Markets for wood waste include use as feedstocks for engineered woods, landscape mulch, soil conditioner, animal bedding, compost additive, sewage sludge bulking medium, and boiler fuel. All these end uses have similar processing requirements in that the wood waste must be separated from other wastes, cleaned by removing contaminants and fasteners, and processed through grinding or chipping. The final use of the wood waste often determines how clean and consistent the feedstock must be.

Reuse

The most desirable option for wood waste management is reuse of structural members and architectural elements such as casings, banisters, and moldings. Large timbers from older or unique structures can be salvaged and reused as structural elements in new buildings. However, lumber to be reused as structural elements must first be recertified by a lumber inspector.

One option that may be potentially cost effective is the employment of firms that offer certified lumber inspectors that can grade lumber for use on site. If you are considering hiring this type of service, verify that it is approved by American Lumber Standards (ALS). ALS is the licensing body for lumber graders. Refer to the CIWMB fact sheet Lumber Waste for a listing of inspection and grading services.

Engineered Wood Products

The next most desirable option for wood waste is as a feedstock for engineered woods. Engineered wood is the term given to material derived from smaller pieces of wood that are bound together with glues, resins, and other chemicals to make a wood-like product. These include particle boards, laminated woods, and plywoods.

Biomass Fuel, Mulch, and Compost
Because of the limited options available to reuse wood waste as building materials or feedstocks for engineered woods, the largest markets for urban wood waste are as a feedstock for biomass fuel, mulch, and compost. The processing requirements for all three products are similar and recyclers of wood waste for this type of end use are more plentiful throughout the state.

Recovery

The end uses of wood recovered from demolition activities are sometimes limited because the wood is commingled with other materials and contaminants or is in such poor condition that the cost of processing and cleaning limits the economic viability of processing and reusing the material.

Construction Sites
Wood waste generated at residential and commercial wood frame construction sites offers a greater potential for reuse due to the ease of separating the wood during the various stages of construction. Cut-offs and scraps generated during the framing and trimming stages constitute a relatively clean and homogeneous waste steam that can make an excellent feedstock for engineered wood production. This is a highly desirable form of wood waste that processors are eager to obtain.

To minimize disposal costs and potentially generate income, contractors should contact local wood waste processors and inquire about setting up drop boxes on site for wood waste scraps. Contractors should also consider collecting pallets and crates that building materials and equipment are shipped in. There are usually several businesses listed in the phone directories, under "pallets" or "skids," that collect and remanufacture pallets.

Demolition Activities
Demolition operations usually generate a far less desirable form of wood waste due to the nonuniform nature of the wood waste compounded by the commingling of the wood with other materials. The wood can still be reused, but generally has a lower value and is destined for uses such as boiler fuel or mulch feedstock. Wood waste processors may still be interested in this material for processing. Since demolition activities generate far more waste per square foot than construction activities, disposal costs represent a much greater portion of operating expenses. It is therefore worth the time to contact local processors to determine if a savings in disposal costs can be realized.

Processing

The CIWMB maintains a list of businesses that receive and process construction and demolition materials. This list contains the names of more than 100 wood waste processors in addition to other businesses that are interested in whole pallets or reusable building materials.

The wood waste processors vary in what they require for a feedstock. Some request only clean wood that is untreated or unpainted while others will take a mixture of waste woods. Disposal fees vary with each facility and some facilities may pick up loads and supply drop-off boxes. It is therefore important to contact the wood waste processors in the area to determine the most cost effective option for each situation.

Publications

The following documents are among those published by the CIWMB:

Construction and Demolition Recyclers—Processors & Receivers (Pub. #431-96-017)

Job Site Source Separation (Pub. #443-95-066)

Nonyard Wood Waste (Pub. #500-94-045)

Nonyard Wood Waste Report: Annual Update for 1995 (Pub. #443-95-026)

Lumber Waste (Pub. #443-96-028)

CalMAX: California Materials Exchange (quarterly catalog)

Waste Exchanges (Pub. #443-96-025)

Construction and Demolition Recycling Program (Pub. # 431-97-030)

Wood Waste: How to Keep Wood Waste Out of Landfills (Pub. #500-94-017)

Publication #443-95-057 Revised October 1998

Demolition or Deconstruction?

By Marisa Hegyesi and Brian Yeoman

With the investment of a little extra time and money, many of the components of an old building can be salvaged and reused rather than disposed of in a landfill.

You are faced with demolishing an old building to make room for a new, state-of-the-art building. Do you just demolish the old, or do you invest a little extra time and money to deconstruct it? Do you try to do your fair share to recycle and reuse, and in turn take a small step toward protecting the environment? Or do you just dump the demolition debris in a landfill because the tipping fees are cheap?

The University of Texas Health Science Center (UTHSCH) was recently faced with these questions when it began planning the design of its new School of Nursing and Student Community Center with Berkebile Nelson Immenschuh McDowell Architects (BNIM). As part of the university's commitment to sustainability, the design team is pursuing certification under the US Green Building Council's LEED? Green Building Rating Program? for the new building. But before the new building could be constructed, the old Graduate School of Biomedical Sciences (GSBS), a 37,368 square foot building built in 1974, had to be removed from the site.

Demolition is the accepted practice - especially in Texas, where landfill costs are very low and the land is cheap. The average rate for a local landfill is $9.95 per cubic yard. But UTHSCH, a proponent of The Natural Step program, wanted to do more than just design a new sustainable building - it also wanted to ensure that removing the old building wouldn't create a negative impact on the environment. It began working with BNIM to investigate how the old building could be "deconstructed," generating the least amount of waste possible and maximizing the salvage of material being removed from the project.

At first the university's goal was to have no materials landfilled, but the team quickly found this goal to be impossible. BNIM created drawings, wrote specifications and developed guidelines, and a more realistic goal was set to recycle/reuse at least 70% of the total building.

A joint venture between Jacobs Engineering and Vaughn Construction as construction managers, and D. H. Griffin of Texas, Inc., as the deconstruction contractor, played a major role in supporting the -UTHSCH's new deconstruction policy.

Saving the Earth One Piece at a Time

The team looked carefully at every aspect of the GSBS building to determine how to best remove it from the site. The metal hardware from the doors was removed and separated for recycling. The wood doors were taken and chipped into a landscape cover.

The UTHSCH inventoried the building's furniture and equipment so that it could be taken to surplus or reused. A.G.V., Inc., auctioneers and liquidators specializing in refurbishing and selling used office furniture, removed and sold the majority of the remaining furniture. Laboratory Construction Specialists (LCS), Inc., was able to salvage a great deal of the laboratory casework and laboratory bench tops; the remaining casework items were salvaged by the UTHSCH and private individuals, with much of the laboratory casework set aside for use in other UTHSCH's buildings. Iso-Tex Diagnostics, Inc. was able to salvage and reuse several large pieces of laboratory equipment, including two large glass refrigeration units, a Subzero refrigerator and an autoclave.

Much of the landscaping that surrounded the old GSBS building, including small deciduous trees, palm trees, shrubs, plants, light poles and benches, were removed and relocated throughout the campus. Large trees that could not be transplanted were cut down and taken to the UTHSCH's Urban Ecology Research Park to be chipped into mulch by a solar-powered chipper.

Almost all of the 1,012 square yards of carpet were removed and given to DuPont for recycling. The remaining carpet was reinstalled in Iso-Tex Diagnostics, Inc.'s Friendswood, TX, facility.

The age and energy inefficiency of the fluorescent lights removed from the building did not make them good candidates for reuse, but the ballasts, bulbs, metal housings and plastic lenses were recycled.

Through Armstrong's Ceiling Reclamation Program, 14.28 tons of ceiling tiles were recycled. The tiles were taken to the local Armstrong plant where they were added to the raw mix and reemulsified to create new ceiling tiles. This program not only diverts waste material from the landfill but also reduces the amount of fresh raw material depleted from the earth.

In an effort to reuse building materials, the face brick (approximately 50,000 bricks) was removed from the building prior to deconstruction. The brick was then stockpiled so it could be cleaned and palletized for use at a later date. The UTHSCH even went so far as to remove the canopy connecting the North and South wings of the building so that it can be reassembled and reused at a later date in a new location.

Continuing the Quest for Sustainability

In the end, the UTHSCH, with the assistance of BNIM, Jacobs, Vaughn, D. H. Griffin and others, not only met their goal of recycling/reusing 70%, they surpassed it. Table 1 shows a breakdown of the tonnage of material salvaged, recycled and landfilled.

This project proved that deconstruction is a viable option for any organization that is trying to become more sustainable in its operations. Based on the success of this project, the university plans to use the same environmental and sustainable building practices to deconstruct any other buildings that may need to be removed in the future.

Editor's note: For more information about The Natural Step program, see the article in this issue.

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A Series of Factsheets on New Construction Issues

Construction Waste Minimization Methods

Summary

Waste prevention is even more beneficial than recycling. Activities that prevent waste production, such as reusing building materials, not only cut garbage and recycling collection costs but also reduces materials' expenses. Small changes to building practices and extra attention to detail can add up to significant savings to the builder, the homebuyer and the environment.

Construction Waste Facts

Most construction waste currently goes into landfills, increasing the burden on landfill loading and operation. Nationally, construction waste contributes a large portion to the waste stream destined for our nation's landfills. It is estimated that 2.5 to 4 tons — about 3 to 5 pounds per square foot — of waste is created during the construction of a typical home. Very little reuse or recycling is currently practiced. Construction waste consists mainly of lumber and manufactured wood products, 35 percent; drywall, 15 percent; masonry materials, 12 percent; and cardboard 10 percent. The remainder is a mix of roofing materials, metals, plaster, plastics, foam, insulation, textiles, glass and packaging.

With the implementation of an effective construction waste minimization effort, a high percentage of all waste materials listed above can be diverted from the landfill and recycled into new products.

How To Develop A Construction Waste Minimization Program

To develop a successful Construction Waste Minimization Program, a builder should evaluate each of the following steps and determine the best and most cost-effective approach.

Step 1) Design To Prevent Waste

Paying attention to waste potential in the building's design stage can lead to less waste on the site. Some issues to consider in the design phase of a building are:

Optimize building dimensions to correspond to standard lumber dimensions.
Modify framing details to optimize lumber use and reduce waste and costs when ordering.
Develop framing layouts to avoid waste and costs when ordering lumber.
Order drywall in optimal dimensions to minimize cut-off waste. Drywall is available in different lengths, and designed dimensions should correspond to standard sizes.
Minimize the number of blueprints and reproductions necessary during the design and construction.
When remodeling, evaluate if salvaging used lumber is possible.

Step 2) Plan For Waste Prevention

Estimate the types and quantities of waste the project will generate and determine a schedule of when the wastes will be developed.
Work with all suppliers to reduce waste on a project by asking them to buy back

unused product.
u Ask suppliers to deliver supplies using sturdy, returnable pallets and containers. Then have the suppliers pick up the empty containers when delivering new building materials.
Ascertain if storage and handling practices prevent loss from weather and other means and make revisions as needed.

Step 3) Prevent Waste On-Site

Store lumber on level blocking and under cover to minimize warping, twisting and waste.
Set aside, in a marked and designated area, lumber and plywood/oriented strand board (OSB) cut-offs that can be used as fire blocking, spacers in header construction and in other ways.
Set aside, in a marked and designated container, clean sawdust for use in compost piles or around planting areas. Avoid sawdust that might contain painted or treated wood. This should be bagged separately and sent to appropriate facilities.
Set aside, in a marked and designated area, large drywall scraps for use as filler pieces in small hidden areas.
Reuse joint compound buckets for tool or material storage by clients or crews.
During construction, collect, stack and cover brick and other masonry materials to prevent soiling or loss.
Clean concrete chunks, old brick, broken blocks and other masonry rubble can be used as backfill along foundation walls.
During remodeling, separate metal radiators, grates, piping, aluminum siding and old appliances.
Install leftover insulation in interior wall cavities or on top of installed attic insulation if it can not be used on another job.
Branches and trees from site clearing can be stored separately and chipped for use on the site as landscaping mulch.

Step 4) Purchase To Prevent Waste

Avoid excessively packaged materials and supplies. Packaging should be adequate to prevent damage and waste.
Minimize waste of vinyl siding, flooring and countertop materials by ordering only the quantity needed in building specific lengths.
Evaluate estimating procedures to make sure that excess material is not delivered to the site.

Step 5) Document Waste Prevention Savings/Costs

Keep accurate project records of the costs and savings associated with Waste Prevention. Provide the information to the building owner and, if possible, estimate the cost savings and the corresponding environmental impacts.
Develop a list of suppliers and recycling contacts for easy reference and use in future projects.

Nebraska Green Building Program

Builders participating in the Nebraska Green Building Program are encouraged to reduce construction waste during all phases of the construction of their homes. Construction Waste Minimization options provide builders with "Green Building" credit in each of the following phases of construction:

Site Development

A construction waste reduction, recycle and reuse plan is written and followed by the builder that includes recycle bins for wood, drywall, cardboard, metal. A waste specification document is prepared and followed. Burying construction waste is prohibited.

Foundations

Aluminum foundation forms are used during construction. The use of wood forms, which are often landfilled after one use, is prohibited.

Building Envelope Construction

Buildings constructed under the program are provided "credit" when the following materials are installed:
Minimum 30-year roofing material including concrete, slate, clay, composition, metal or fiberglass
Finger-jointed wood windows
Large dimension, solid lumber — 2' x 10' or greater — is avoided
Engineered wood "I" joists are used for flooring
Trusses or "I" joists are used for roofs
Finger-jointed top and bottom plate material is used
Finger-jointed studs or engineered stud material is used
Structural insulated panels used for walls or roofs
Engineered lumber products for beams, joists or headers is used
Optimum value engineering framing (24" O.C. studs, 3 or less stud corners, etc.)
Engineered alternatives to wood framing

Interior Finishing

Buildings constructed under the program are provided "credit" when the following materials are installed:
Finger-jointed trim

Resources

Seattle/King County Contractors' Guide to Preventing Waste and Recycling - 2001
Connecticut Department of Environmental Protection
http://dep.state.ct.us/wst/recycle/construwaste.htm

Sustainable Building Sourcebook — Construction Waste
http://www.greenbuilder.com/sourcebook/ConstructionWaste.html

U.S. Department of Energy — Green Building Guidelines

Produced by the
Nebraska Energy Office
1111 "O" Street, Suite 223
P.O. Box 95085, Lincoln, NE 68509
Phone 402-471-2867, Fax 402-471-3064

Construction Waste Minimization Methods is one in a series of factsheets on issues related to energy and resource efficient construction of new homes and buildings.

Other factsheets and additional information can also be found at:
www.nol.org/home/NEO/home_const/design_build.htm

This fact sheet was partially financed through the Nebraska Department of Environmental Quality Litter Reduction and Recycling Program.

Green Building Materials

MODULE 6

Using green building materials is one of two fundamental material conservation strategies for buildings. (The other, waste reduction, is covered in Module 5.) Green building materials are those with the least environmental impacts throughout their life cycle, whether measured in terms of energy used, scarce natural resources used, or air and water emissions. Because of the huge amount of energy, air, and water pollution involved in producing "virgin" building materials (that is, logging trees and processing them into lumber), reusing or recycling materials has substantial environmental benefits well beyond the weight of the material actually reused or recycled on-site. Green building products, like other building supplies, are required to meet the highest safety and performance requirements. (Low-toxicity and low-emission building products are discussed in Module 10, Indoor Air Quality.) All of the strategies discussed in this module have the effect of conserving material resources. The most significant benefits involve the reduced use of energy, reductions in air and water pollution during resource extraction and manufacturing, and the safeguarding of scarce natural resources.

Green Building Material Strategies

- ✓ Prepare a green building product selection plan.
- ✓ Use salvaged building products.
- ✓ Use recycled-content building products.
- ✓ Use locally available materials.
- ✓ Use rapidly renewable or naturally occurring resources.
- ✓ Use certified wood.
- ✓ Use structural insulated panels.

Prepare a green building product selection plan.

Using green building materials may require additional research, evaluation, and sourcing as compared to conventional products, unless your architect and contractor team is already well experienced. Excellent resources are available to assist with each of these tasks, and you should discuss priorities with your contractor team at the earliest moment. While it is impractical to thoroughly evaluate every product alternative, it is reasonable to ask your contractor team to include green building products in the products considered at every stage.

EVALUATING AND COMPARING SUSTAINABLE BUILDING PRODUCTS

A number of resources are available to assist with evaluating and comparing sustainable building products. An excellent starting point is the California Integrated Waste Management Board (CIWMB) Web sites: www.ciwmb.ca.gov/GreenBuilding/ and www.ciwmb.ca.gov/RCP/. These sites include excellent resources on green building products. The CIWMB staff worked with other State agencies and green building experts to develop these specifications for a range of green materials and products. The specifications cover energy, materials, water efficiency, and indoor air quality (IAQ) (see Module 10), including product selection guidelines, emission testing protocols to distinguish low-emitting materials, nontoxic performance standards for cleaning products, and landscaping considerations, among others. The CIWMB site also includes links to case studies, research reports on green building materials and products, and a link to the *Building for Environmental and Economic Sustainability* (BEES). BEES software package can facilitate evaluating the environmental and cost impacts of alternative building products. It was developed by the National Institute of Standards and Technology and the U.S. Environmental Protection Agency based on consensus standards and is practical, flexible, and transparent. Version 3.0 of the Windows-based decision support software includes actual environmental and economic performance data for nearly 200 building products.

Use salvaged building products.

High-quality salvaged building products are now more widely available than ever. Salvaged products like doors, framing, windows, or plumbing can save costs and sometimes allows the use of high-end or antique products that can greatly add to a building's ambiance. Reclaimed lumber in particular is widely available. Some reclaimed lumber like old-growth redwood may be vastly superior to newly harvested lumber, especially for some specialized uses. By reusing products directly, salvaged products tend to have the highest environmental benefits. They simultaneously keep old products out of the waste stream, and they eliminate the need to manufacture new products.

A growing number of salvage businesses make products available, as does the California Integrated Waste Management Board's CalMax program. Deconstruction firms are beginning to compete effectively in some instances with demolition firms. In deconstruction, a building is carefully dismantled with an eye towards the eventual reuse of as many salvaged products as possible. The U.S. EPA describes a project in Philadelphia (EPA Green Lease) where 260 interior doors were reused instead of purchasing 260 new doors. The cost of the new replacement doors, according to Means' Commercial Cost Data, would have been $228 per door. Consequently, using the existing doors saved $59,280. In addition, the U.S. EPA example assumes an average cost of $100 per ton for container rental, trucking, and tipping fees combined. The recycled doors weighed 7 tons. Use of the recycled doors saved an additional $700 in avoided disposal costs, making a total of nearly $60,000 in savings.[1]

Use recycled-content building products.

Vast ranges of high quality building materials with recycled content are available on the market, as well as information on specifications and suppliers. (See the resources section at the end of this module.) Recycled-content products (RCP) must meet or exceed all the performance and health and safety requirements of other building products. RCPs benefit the environment by keeping reusable materials out of the waste stream, and they reduce the need to harvest and manufacture new "virgin" materials. The California Integrated Waste Management Board's Web site has a database of recycled-content building products and numerous examples of their use.

Examples of products include lumber and carpet made from recycled plastics, cellulose insulation made from recycled newsprint, aggregates made from recycled asphalt or glass, masonry blocks made with recycled glass, and many, many more. Many recycled-content products are available at a lower cost or a comparable cost to non-recycled content products. For example, recycled plastic lumber made from 100 percent post-consumer recycled plastic is available (milk jugs with non-wood fiber added). This is suitable for 2 x 4 decking. Many other dimensions and products are available, such as 2 x 4 structural strength; 3/8" plywood sheet at prices comparable to the wood counterparts. Some of these come with 50-year warrantees guaranteeing against rotting, splitting, cracking, splintering, and insects. These products are advertised as being maintenance-free and come with a claim of no staining or rotting.

Use locally available or naturally occurring building products. Products produced in the local region save on transportation impacts and costs, and they also contribute to the local economy. Some construction products like brick, concrete, or aggregate are heavy and have low value. These products are often produced for regional markets, and purchasing these products from local suppliers rather than from distant sources can save substantially on shipment costs while greatly reducing their life cycle energy use. Depending on the region, materials such as straw bales, earth, or cob may be available. These are appropriate for some residential buildings in certain climates with adequate re-bar or other fortification to meet any applicable earthquake safety specifications. Compost is a highly effective landscaping product that is often produced and sold regionally. Compared to petroleum-based fertilizers, using compost can save substantial amounts of energy while eliminating toxicity concerns associated with production and use. Each region produces a range of construction products unique to that region. For example, locally produced lumber is plentiful in California's North Coast region, while a variety of unique rock and aggregate products may be available in more arid areas of Southern California.

Use rapidly renewable resources. Most raw materials are technically renewable, since even old growth trees and oil are eventually replenished on Earth. But some products are made from materials that are rapidly renewable and are very attractive environmentally because they are quickly replenished. Because these resources are replenished at a rate faster than they are consumed, using them does not reduce their availability to future generations. Rapidly renewable resources include agriculture-based materials like straw converted into pressed board products. Plastics can be made from agriculturally grown products, although they have not become commercialized on a wide scale yet. Cotton batt insulation can be used in certain applications. Boards can be made from sunflower seed and wheat grass. Wool carpet is another example.

COMMERCIAL CARPET TILES

Commercial carpet tiles are a convenient way to simultaneously reduce waste and operations and maintenance costs over the life of a building. Tiles can be specified instead of standard 12-foot wide carpet rolls. Use of carpet tiles allows replacement of worn carpet in high-use areas as needed without replacing the entire carpet. The highly competitive commercial carpet market is changing quickly. An increasing number of such innovative products are available, including carpet products made with recycled content, low percentages of volatile organic compounds, and other environmental benefits. Carpet companies are also expanding their recycling services, with several companies offering to recycle old carpets when new carpet is purchased. Some, such as Interface, even offer a carpet-leasing program whereby the seller maintains ownership—and repair and maintenance responsibilities—for the life of the carpet. The carpet industry has formed an organization called the Carpet America Recovery Effort to help coordinate and promote recycling and other environmental characteristics of carpet products. More information is available at www.carpetrecovery.org/.

JANITORIAL AND MAINTENANCE PRODUCTS CAN BE GREEN, TOO

Building operations and maintenance products and practices can be specified that will reduce waste and the disposal of toxic chemicals or provide other environmental benefits. For example, janitorial practices can be specified that do not use toxic or hazardous cleansers or solvents. Recycled-content restroom towels and tissues reduce overall waste and help build markets for recycled materials. A range of "environmentally preferable products" related to building operations is available. The U.S. EPA's Cleaning Products Pilot Project has developed tools to assist in identifying and evaluating environmentally preferable cleaning products, considering such factors as reduced air pollutants, percent volatile organic compounds, food chain exposure, the presence of dyes, use of recycled-content or reduced packaging, skin irritating components, toxic components, and concentration to reduce packaging. More information is available at: www.epa.gov/opptintr/epp/cleaners/select/.

Use certified wood. Over the past decade a number of systems for certifying that forests are managed according to principles of sustainability have emerged. For example, at least two tribal lumber producers, the Hoopa Tribal Forestry Department (operated by the Hoopa Valley Tribal Council) and Menominee Tribal Enterprises in Wisconsin sell lumber that has been certified as "smart wood," a program operated by the Rainforest Alliance. The Smart Wood program evaluates and recognizes forests managed according to sustainability principles. The Hoopa lumber is also certified by the Forest Stewardship Council (FSC), an international nonprofit organization founded in 1993 that has developed a widely recognized certification process for wood products. Products are awarded the FSC certification if they demonstrate they are derived from a forest sustainably. A large number of organizations accredited by FSC perform the certifications, and the FSC label on certified wood products easily identifies these products. Criteria for certification include ensuring the long-term health and productivity of forests for timber production, wildlife habitat protection, clean air and water supplies, climate stabilization, spiritual renewal, and social benefits. Information on a range of forestry certification programs is available at: www.forestdirectory.com/certification.aspx.

Use structural insulated panels. Structural insulated panels (SIPs) are high-performance building panels that can be used in floors, walls, and roofs, in both residential and commercial buildings. The panels are often made of expanded polystyrene (EPS) or polyisocyanurate rigid foam insulation sandwiched between two structure skins. SIPs are very strong, energy-efficient, and often cost-effective. SIPs can reduce construction waste considerably and can be a very cost-efficient way of increasing the overall energy insulation of the building.

RESOURCES

General Green Building Material Resources

California Integrated Waste Management Board Green Building Materials Web Site
www.ciwmb.ca.gov/GreenBuilding/Materials/default.htm

Overview of Recycled Content Levels and Product Availability
www.ciwmb.ca.gov/GreenBuilding/Materials/Matrix.htm

Alameda County Waste Management Authority, Green Building Materials Resource Guide
www.stopwaste.org/Resource_Guide.pdf

Certified Wood and Paper Association
www.cwpa.info/.

Forest Stewardship Council
www.fscoax.org/

Scientific Certification Systems
www.scs1.com/

Structural Insulated Panel Association
www.sips.org/

Structural Insulated Panel Fact Sheet (City of Austin)
www.ci.austin.tx.us/greenbuilder/fs_basicsips.htm

Green Building Material Information, Specifications and Suppliers

CIWMB Green Building Material Publications
Includes "Designing with Vision: A Technical Manual for Material Choices in Building Construction," a comprehensive resource including product descriptions, sample bid documents, and ordinances.
www.ciwmb.ca.gov/ConDemo/Pubs.htm

CIWMB Cal Max Materials Exchange
www.ciwmb.ca.gov/CalMAX/

CIWMB Database of Recycled Content Product Suppliers.
www.ciwmb.ca.gov/rcp

CIWMB Database of Recycled Content Building Product Suppliers.
www.ciwmb.ca.gov/ConDemo/Products/

CIWMB List of suppliers of recycled paint
www.ciwmb.ca.gov/ConDemo/FactSheets/Paint.htm

City of Tucson Straw Bale Building Code Example www.sustainable.doe.gov/codes/azstraw.shtml

Construction Specifications Institute
www.csinet.org/

Evaluation Software for Building Products (BEES)
www.bfrl.nist.gov/oae/software/bees.html

Forest Certification Resource Center—Includes a searchable database of FSC products.
www.certifiedwood.org/

Green Spec Searchable Database
www.buildinggreen.com/bg/gsmenu/index.jsp

Oikos Green Product Directory
www.oikos.com/products/index.lasso

U.S. EPA Comprehensive Environmentally Preferable Purchasing Guides
www.epa.gov/cpg/factshts.htm

BOOKS

CIWMB: Designing with Vision: A Technical Manual for Material Choices in Sustainable Construction, California Integrated Waste Management Board, Pub # 431-99-009, 1999.

The Alternative Building Sourcebook: Traditional, Natural and Sustainable Building Products and Services, Steve Chappell, ed., Brownfield, Maine, Fox Maple Press, Inc., 1998.

David Aniak, et al., *Handbook of Sustainable Building: An Environmental Preference Method for Selection of Materials for Use in Construction and Refurbishment,* James & James, 1996.

Environmental Building News Product Catalog (annual).

Tom Woolley and Sam Kimmins, *Green Building Handbook: A Guide to Building Products and Their Impact on the Environment,* London, E&FN Spon, 2000.

Ianto Evans, Michael Smith and Linda Smiley, *The Hand-Sculpted House: A Practical and Philosophical Guide to Building a Cob Cottage,* Real Goods, 2002.

Paul Graham McHenry, *Adobe and Rammed Earth Buildings: Design and Construction,* University of Arizona Press, 1998.

Matts Myhrman and S.O. MacDonald, *Build it with Bales: A Step-by-Step Guide to Straw Bale Construction,* Out on Bale, 1999.

CalMAX—California Materials Exchange: The Classified Reuse Ads for California Business (Catalog)
www.calmax.org/

Green Spec Binder and Directory, at www.buildinggreen.com/

NOTES

[1] The Door example is described on U.S. EPA's web site at www.epa.gov/opptintr/epp/ppg/case/region3.htm

Steps to Implement a Successful Buy Recycled Program

Implementing a Successful Buy Recycled Program

A successful buy recycled program within any agency contains many elements. The results can vary considerably depending on the size of the agency, how it is organized, and whether purchasing is centralized. Access to online purchasing and tracking systems and the commitment to meeting the buy recycled mandates (Public Contract Code sections 12200–12320) also play a part.

Adopt a Policy

Adopting an agencywide policy is often enough to break through many barriers and provide the opportunity for recycled-content products (RCP) to prove themselves. A buy recycled policy will increase awareness of the mandates and requirements related to RCP procurement. It will also allow staff to address agencywide commitment and resource allocation needs. Adoption of a policy involves upper-level management and raises awareness about RCPs at all levels.

Develop a Buy Recycled Team

A buy recycled team formed to meet RCP procurement requirements should include a high-level procurement official and cross-divisional staff. Those who place the orders should be involved—along with the procurement officers reviewing the purchase orders—to make sure all reportable purchases are noted. Staff in the contracts and legal offices should review all contract and bid documents to ensure that buy recycled language is included. Upper-level management should lead the team to provide policy direction.

Upper Management Support

To ensure the success of a buy recycled program, an agency will need to have sufficient staff to do the job. Usually, an upper-level manager has the best success in overseeing the agency's buy recycled activities and goals. A manager has the authority to mobilize resources and commitment from throughout the agency and to coordinate the buy recycled team.

Must Have a "Can Do" Commitment

A "can do" commitment from all buy recycled team members can be contagious throughout the agency. Staff members are more likely to help their agency succeed in its commitment if they know their management believes in the benefits and advantages of a buy recycled program.

Develop an Automated Tracking System

An agencywide system must be in place for an agency to accurately identify, track, and document all reportable purchases. Both RCPs and non-RCPs must be included in order to submit a complete and accurate State Agency Buy Recycled Campaign (SABRC) annual report.

An automated tracking system would require one or all of the following:

- Revising internal forms to capture specific information from purchase orders.
- Modifying CalSTARS object codes.
- Creating a database or spreadsheet application using software like Microsoft Excel or Access.
- Developing a custom-designed computer application to capture all purchases.
- Electronic reporting of purchases directly from product suppliers.

All RCP tracking must minimally be capturing product ID#(s); total recycled content (TRC); postconsumer content (PC); which SABRC category applies; total purchase dollars; and RCP dollars.

Share Information

Educating staff on RCPs is critical to a successful program. Many RCPs have improved over the years, but a poor experience 10 years ago may still cause apprehension among staff members. They need to hear about advancements in RCPs, and agencies need to share information with each other. Management needs the ability to network among the buy recycled team members. Buyers need to communicate with suppliers, and the buy recycled team members should inform product manufacturers of their RCP preferences and needs.

Provide Adequate Resources

As with any program, success depends on assignment of adequate resources to attain the stated goals and objectives of the program. In order to implement a successful buy recycled program, the following resources are typically necessary:

Upper-management commitment and involvement to lead the buy recycled team.

Knowledgeable and interested lead staff.

Internal training and communication of RCP procurement preferences.

Computer resources with Internet access.

Any automated procurement tracking system.

Allocation for staff training and travel.

Annually Evaluate Your Program

Analyze past purchases with respect to product performance, price, delivery, and user satisfaction. This information is useful in developing an RCP procurement history.

Each member of the team—management, buyers, users, and those tracking the purchases—must analyze their own past purchases to determine how they can increase RCP purchases in the future. A periodic review will prevent future mistakes and will establish purchasing practices that include RCPs.

Buy recycled team members should consult suppliers for their insight on increasing RCP procurement. They should also convey their agency's commitment to obtaining RCPs to the product suppliers.

Use CIWMB as a Resource

The CIWMB Buy Recycled Section staff is available to provide you with any assistance you may need for your buy recycled program. The Buy Recycled Web site (www.ciwmb.ca.gov/BuyRecycled/) provides a wide variety of buy recycled resources and information, including but not limited to:

The SABRC Training Manual. Includes definitions of terms, forms, and procedures for State agencies.

Training/Workshops. Regularly scheduled events (specialized training available upon request).

Online RCP database. Includes thousands of products and suppliers and links to their Web sites free of charge.

Sample policies and contract language. Examples of documents that you can download and modify for your own use.

Contact CIWMB's Buy Recycled Section staff at (916) 341-6481.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut energy costs, Flex Your Power and visit www.consumerenergycenter.org/flex/index.html.

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Green Building Home

State Task Force

Basics

Project Design

Guidelines and Specs

Programs & Partnerships

Schools

Case Studies

RCP Database

Links

Events

Green Building Materials

Introduction

The concept of sustainable building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of green building materials and products represents one important strategy in the design of a building.

Green building materials offer specific benefits to the building owner and building occupants:

- Reduced maintenance/replacement costs over the life of the building.
- Energy conservation.
- Improved occupant health and productivity.
- Lower costs associated with changing space configurations.
- Greater design flexibility.

Building and construction activities

worldwide consume 3 billion tons of raw materials each year or 40 percent of total global use. (Roodman and Lenssen, 1995) Using green building materials and products promotes conservation of dwindling nonrenewable resources internationally. In addition, integrating green building materials into building projects can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these building industry source materials.

What is a green building product or material?

Green building materials are composed of renewable, rather than nonrenewable resources. Green materials are environmentally responsible because impacts are considered over the life of the product. (Spiegel and Meadows, 1999) Depending upon project-specific goals, an assessment of green materials may involve an evaluation of one or more of the criteria listed below.

Green building material/product selection criteria

This information was based on Lynn Froeschle's article, "Environmental Assessment and Specification of Green Building Materials," in the October 1999 issue of *The Construction Specifier*. Selection criteria similar to what is presented below was also used for the East End Project as identified in the Review of Construction Projects Using Sustainable Materials.

Overall material/product selection criteria:

- Resource efficiency
- Indoor air quality
- Energy efficiency
- Water conservation
- Affordability

Resource Efficiency can be accomplished by utilizing materials that meet the following criteria:

- **Recycled Content**: Products with identifiable recycled content, including postindustrial content with a preference for postconsumer content.
- **Natural, plentiful or renewable**: Materials harvested from sustainably managed sources and preferably have an independent certification (e.g., certified wood) and are certified by an independent third party.
- **Resource efficient manufacturing process**: Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing greenhouse gases.
- **Locally available**: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site.
- **Salvaged, refurbished, or remanufactured**: Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.
- **Reusable or recyclable**: Select materials that can be easily dismantled and reused or recycled at

the end of their useful life.

- **Recycled or recyclable product packaging**: Products enclosed in recycled content or recyclable packaging.
- **Durable**: Materials that are longer lasting or are comparable to conventional products with long life expectancies.

Indoor Air Quality (IAQ) is enhanced by utilizing materials that meet the following criteria:

- **Low or non-toxic**: Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.
- **Minimal chemical emissions**: Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions.
- **Low-VOC assembly**: Materials installed with minimal VOC-producing compounds, or no-VOC mechanical attachment methods and minimal hazards.
- **Moisture resistant**: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- **Healthfully maintained**: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.
- **Systems or equipment:** Products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.

Energy Efficiency can be maximized by

utilizing materials and systems that meet the following criteria:

- Materials, components, and systems that help reduce energy consumption in buildings and facilities. (See Green Building Basics for more information.)

Water Conservation can be obtained by utilizing materials and systems that meet the following criteria:

- Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas. (See Green Building Basics for more information.)

Affordability can be considered when building product life-cycle costs are comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget. (See Environmental and Economic Assessment Tools for links to resources.)

Three basic steps of product selection

Product selection can begin after the establishment of project-specific environmental goals. The environmental assessment process for building products involves three basic steps. (Froeschle, 1999)

- Research
- Evaluation
- Selection

1. Research. This step involves gathering all technical information to be evaluated, including manufacturers' information such as Material Safety Data Sheets (MSDS), Indoor Air Quality (IAQ) test data, product

warranties, source material characteristics, recycled content data, environmental statements, and durability information. In addition, this step may involve researching other environmental issues, building codes, government regulations, building industry articles, model green building product specifications, and other sources of product data. Research helps identify the full range of the project's building material options.

2. Evaluation. This step involves confirmation of the technical information, as well as filling in information gaps. For example, the evaluator may request product certifications from manufacturers to help sort out possible exaggerated environmental product claims. Evaluation and assessment is relatively simple when comparing similar types of building materials using the environmental criteria. For example, a recycled content assessment between various manufacturers of medium density fiberboard is a relatively straightforward "apples to apples" comparison. However, the evaluation process is more complex when comparing different products with the same function. Then it may become necessary to process both descriptive and quantitative forms of data.

A life cycle assessment (LCA) is an evaluation of the relative "greenness" of building materials and products. LCA addresses the impacts of a product through all of its life stages. Although rather simple in principle, this approach has been difficult and expensive in actual practice (although that appears to be changing).

One tool that uses the LCA methodology is BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) software. It

allows users to balance the environmental and economic performance of building products. The software was developed by the National Institute of Standards and Technology's Building and Fire Research Laboratory and can be downloaded free on their Web site.

3. Selection. This step often involves the use of an evaluation matrix for scoring the project-specific environmental criteria. The total score of each product evaluation will indicate the product with the highest environmental attributes. Individual criteria included in the rating system can be weighted to accommodate project-specific goals and objectives.

References

1. Lynn M. Froeschle, "Environmental Assessment and Specification of Green Building Materials," *The Construction Specifier*, October 1999, p. 53. (Back)
2. D.M. Roodman and N. Lenssen, *A Building Revolution: How Ecology and Health Concerns are Transforming Construction,* Worldwatch Paper 124, Worldwatch Institute, Washington, D.C., March 1995, p. 5. (Back)
3. Ross Spiegel and Dru Meadows, *Green Building Materials: A Guide to Product Selection and Specification*, John Wiley & Sons, Inc., New York, 1999. (Back)

Last updated: November 14, 2003

Green Building
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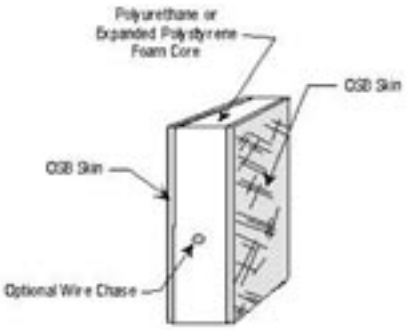
Basic SIPs

(Structural Insulated Panels)

A Factsheet from Austin Energy's Green Building Program

Structural Insulated Panels (SIPs) can be substituted for wood framed walls, floors, and roof/ceilings when building an energy-conscious home.



Structural Insulated Panels (SIPs) are relatively new to the building marketplace and are growing in acceptance with builders, developers, and homeowners. SIPs currently represent less than 1 percent of all residential/light construction (8,000 homes per year), with 5 percent anticipated growth according to the Structural Insulated Panel Association (SIPA) the product's trade association. As a direct substitute for wood framing and infill insulation, SIPs offer considerable energy and resource conserving advantages. A SIP is a panel with a core of insulation (either the white expanded polystyrene or the yellow-orange polyurethane) sandwiched between various skins of metal, drywall, or oriented strand board (OSB). As blank slabs or pre-engineered with door and window openings cut out, SIPs arrive at the site, are unloaded, uprighted, fastened, and the framing stage is complete. Speedy installation is not the only advantage to SIP construction, though. They also promote excellent energy efficiency due to their continuous foam cores, and because they can come in lengths up to 28 feet, fewer joints means fewer points of air entry, further reducing energy bills. SIPs typically come in 8-foot heights and can be stacked up to three stories high without additional bracing requirements. Cathedral ceilings and exposed beam details can be simplified by using SIP construction as one roof panel can form structure, insulation, sheathing, and sheet rock attachment. SIPs can be clad with most conventional sidings, and they work within standard wood framing dimensions which makes it easy on your contractor. In addition, buildings using SIPs are stronger than stick-built structures. They can withstand winds in excess of 160 mph, ground movement, freeze and thaw movement, and seismic class 4 standards.

When choosing a SIP, look for:

- **Non ozone-depleting foam cores**--All expanded polystyrene foams are now produced without CFCs/HCFCs, polyurethane foams may or may not use CFCs/HCFs.
- **Low formaldehyde content skins**--Formaldehyde is a necessary ingredient in engineered wood products, but new adhesives retain formaldehyde rather than letting it leach off into indoor air.
- **Engineered testing of the panels for any building application**--Different manufacturers have different tests which certify different structural aspects of their products. You want a panel which will do all that you need it to and has the engineered testing to prove it to you and local building officials.
- **Excellent product support**--Is the manufacturer willing to come out to your site and help train you or your contractor?
- **Make sure SIPs match your project's priorities**--If your project's priorities are quick dry-in time, tight energy-efficient construction, wood frame modularity, and cost (SIPs are competitive to stick framing if installed with unskilled labor in Austin), SIPs are a good product choice.

When planning a SIP building, be sure to include exhaust fans for the removal of bathroom, laundry, and kitchen odors and humidity. The tight construction afforded by SIPs can create indoor humidity above recommended levels, which can be remedied with fans to remove unwanted indoor air pollutants at their source.

Phone: 512/505-3700 www.ci.austin.tx.us/greenbuilder 1129O1LKN

Resources

Trade Associations:

APA-The Engineered Wood Association
P.O. Box 11700
Tacoma, WA 98411
(253) 565-6600 (ask for publications desk)
www.apawood.org

Structural Insulated Panel Association (SIPA)
P.O. Box 1699
Gig Harbor, WA 98335
Phone: (253) 858-7472
Fax: (253) 858-0272
www.sips.org
E-mail: staff@sips.org

Publications:

Foam Core Panels and Building Systems
Cutter Information Corp.
37 Broadway
Arlington, MA 02174-5539
outside North America
Phone: 1 (800) 964-5118
Fax: 1 (800) 888-1816
E-mail: Carolyn Licata at clicata@cutter.com
http://cutter.com/energy/reports/index.html

principles, practice, and product directory available

Other trade publications have published articles on SIPs in the last year, including Architecture Magazine, Journal of Light Construction, and Environmental Building News

Regional Manufacturers/Distributors/Installers:

Chapman Building Systems
5275 Highway 27 East
Kerrville, TX 78028
(830) 792-5050
www.sips-chapman.com
full-service panel fabricator, also build modular homes

Futurebilt Structural Insulated Panels
A-104 Plaza del Sol
Wimberly, TX 78676
(800) 487-5722
full-service panel fabricator

Korwall Industries, Inc
326 N. Bowen Rd.
Arlington, TX 76012
(817) 277-6741
full-service panel fabricator

Structall Building Systems
3417 Steen, Ste. A
San Antonio, TX 78219
(800) 880-4198
full-service panel manufacturer , also build modular homes, only one type of specialty panel made here in Texas, the rest made in Florida

The Panel Factory
326 N. Bowen Rd.
Arlington, TX 76012
(817) 277-6742
www.panelfactory.com
smaller scale panel fabricator (additions)

Innovative Building Panels
PO Box 3187
Lubbock, TX 79452
(806) 744-4868
full-service panel fabricator

Creative Panel Solutions
4122-B Billy Mitchell Dr.
Addison, TX 75001
(972) 980-4747
www.creativepanel.com
full-service panel fabricator

This list does not constitute an endorsement or recommendation by the City of Austin, Austin Energy or the Green Building Program. Please check references thoroughly before employing the services of any contractor.

Recycled-Content Products Deserve Another Look

Recycled-content products (RCP) have been around for a long time. In fact, many waste hauling companies began decades ago as scrap merchants turning discards into industrial feedstock. With the expansion of consumer-based recycling in the early 1970s following the first Earth Day celebration, the quantity and variety of available secondary materials inspired a quest for new products to be made from recovered resources.

Unfortunately, some of these products were frivolous or not well designed and gave RCPs a bad name. The RCPs of today are an entirely new breed of high-tech, high-value, earth-friendly products.

Purchasing RCPs presents a tremendous opportunity. First and foremost, RCPs provide your company, office, or home with a quality product capable of meeting any performance specifications. Secondly, with the wide array of RCPs currently available, you can save money when buying recycled..

Additionally, RCPs are good for the environment, reducing the demand for virgin resources and preserving landfill space. Buying RCPs from local manufacturers and suppliers also enhances economic development at the local level.

The California Integrated Waste Management Board (CIWMB) is dedicated to informing the public—both businesses and consumers—of the opportunities to purchase and use today's RCPs. You may be surprised by what you learn.

Increase Comfort Level

Experiment

Given a chance, RCPs will prove their value. You have an opportunity to save money, improve the environment, and perhaps help comply with a buy recycled mandate or policy.

Those wishing to buy RCPs may find the following categories a good place to start: janitorial paper products, recycled latex paint, compost, re-tread tires, re-refined oil, notebooks, and ruled writing pads. These RCPs are readily available, cost-competitive, and every bit as good as nonrecycled products. Choose a product from a manufacturer or a vendor you already trust. Experiment with the most common RCPs and increase your comfort level.

Experience

Take it one step at a time if RCPs are new to you. Stay with what you know best and as your positive experiences grow, try a new product and/or a new vendor. Brainstorm with other interested people. Get help from the CIWMB's Buy Recycled staff. Before long, you will be making bigger and better RCP purchases from the wide variety of available products. Soon you will find yourself gaining the experience necessary to provide assistance to others.

Network

Share your experiences with others. Some people may have more experience buying RCPs within a specific product category or may know of a reliable vendor. Learn from those around you and try to avoid the few bad apples. Before long, you will experience the value of buying RCPs for all of your needs.

Dispelling the Myths

Price

Many RCPs are less expensive than comparable nonrecycled products. Like any product, the price of RCPs is dependent upon quality, quantity ordered, whether the product is a specialty item or a more common product, etc. Many large corporations are currently manufacturing and selling RCPs. Compare prices and shop around. Today, many companies supply RCPs at very competitive prices.

Quality

Many RCPs are at least as good as nonrecycled products. Today's modern high technology companies and new entrepreneurial companies spend millions of dollars to research materials and test products. RCPs have inherent qualities that result in improved performance characteristics. For

example, the fibers of recycled newsprint curl more easily through the printing presses, and recycled printing and writing papers have increased printability and readability. Re-refined oil meets the same specifications as virgin oil. Plastic lumber lasts longer and requires less maintenance than comparable wood or concrete products.

Availability

Many RCPs are now as easy to find and obtain as other products. With the decrease in price and increase in quality, demand for RCPs is rising rapidly. Your current contractors and vendors can easily obtain RCPs if they are requested to do so. No new business relationships are necessary, although it may be beneficial to investigate additional suppliers. RCPs are now available through supermarkets, discount, retail, and club/membership stores.

A variety of RCP guides are available from State, federal, and local government offices, industry associations, and environmental groups. The CIWMB Buy Recycled staff can help you locate these guides. Check out the CIWMB Web site at www.ciwmb.ca.gov/BuyRecycled/ and find a collection of links to useful resources.

RCP Sources

RCP Database

Request RCPs every time you buy a product. A list of 8,000 RCPs from more than 2,000 RCP suppliers can be found by viewing CIWMB's RCP Database on-line at: www.ciwmb.ca.gov/RCP/.

Identify

You may already be buying RCPs without even knowing it. Ask your suppliers to identify the recycled content of the products you are currently buying. Talk to the manufacturers to identify the recycled content of their products.

The CIWMB can provide you with a certification form to be completed by the manufacturer or vendor, to verify the recycled content of their products. Identifying RCPs is a critical first step to procuring them.

Vendors

You do not need new vendors or product suppliers. With the rise in demand for RCPs, supply has followed. Ask your current vendors to substitute RCPs for non-RCPs whenever possible. Tell them you prefer RCPs and that you would like to see more of them.

Maintain Records

Track

Once RCPs are identified, record and track your purchases. Keeping records may help you identify the best RCP purchases to make your dollars stretch. It may also be necessary to maintain RCP purchasing records in order to comply with buy recycled mandates or other policy directives. Other people will be interested in RCP procurement data to help them establish their own buy recycled policies and programs.

Evaluate

Evaluate your RCP purchases regularly. Keeping accurate records will enable you to make adjustments for the following year to take full advantage of the RCP procurement opportunities and make your budget last longer. If RCP procurement data is required for any report or summary, you will be better prepared to recommend increased RCP procurement activities.

For More Information

For more information, visit our Web site at: www.ciwmb.ca.gov/BuyRecycled/.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut energy costs, Flex Your Power and visit www.consumerenergycenter.org/flex/index.html.

Publication #422-96-003 Revised March 2003

Benefits of Buying Recycled

Introduction

Purchasing recycled-content products (RCP) has many benefits. Below is a brief listing and explanation of just some of the advantages buying recycled offers.

Saves Money

Many RCPs, such as janitorial paper products, corrugated packaging, padded mailers, latex paint, compost, mulch, writing tablets, remanufactured toner cartridges, and many others, cost less than or the same as their non-recycled counterparts.

Some RCPs, particularly durable plastic and rubber products like plastic lumber and rubberized asphalt, have an initial cost that may be higher than comparable non-RCPs. However, when looking at the cost of the products over their entire lives, these RCPs often turn out to be less expensive. When cost comparisons include repair, maintenance, labor, replacement, and other costs, the total cost of durable RCPs will probably become less than similar non-RCPs.

Job Creation

Studies indicate that every 15,000 tons of solid waste recycled into a new product creates nine jobs, and every 15,000 tons of yard trimmings composted rather than discarded creates seven jobs. When compared to two jobs created for every 15,000 tons of solid waste incinerated and one job for the same amount of yard trimmings landfilled, the economic benefits of recycling become clear.

Conserve Natural Resources

Recycling products rather than discarding them after they have exceeded their useful lives reduces our reliance on natural resources. The products we place in the recycling bins become the raw secondary materials from which new products are manufactured. By purchasing RCPs, we increase manufacturers' demand for secondary materials, which leads to more recycling. Purchasing RCPs also decreases the need for virgin natural resources, which means cutting down fewer trees, mining fewer minerals, and pumping less oil from the ground.

Conserve Energy

Manufacturing RCPs from secondary materials is almost always less energy-intensive than manufacturing non-RCPs from virgin resources. The energy needed to collect, clean, and process secondary materials is often less than extracting virgin resources. Also, the energy needed during the manufacturing of an RCP is normally less than what's needed to manufacture non-RCP products. Purchasing RCPs will decrease the need for energy, which subsequently reduces the need for coal, oil, and other non-renewable energy resources.

Reduce Waste and Pollution

Manufacturing products from secondary materials rather than virgin materials is not pollution free, but it is typically a much cleaner process. Because fewer steps are usually required to make RCPs than to make non-RCPs, this creates less waste.

RCP manufacturing facilities try to locate in major metropolitan areas where the secondary materials are generated and collected. This usually requires less transportation, which in turn causes less pollution. RCP manufacturers are usually more concerned about unnecessary or excessive packaging, which is another significant source of waste. Purchasing RCPs helps to reduce the amount of waste created during manufacturing and transportation, and it reduces the amount of air and water pollution generated by manufacturing.

Conserve Landfill Space

More than 35 million people live in California. More people result in more solid waste. More solid waste, combined with less landfill capacity, increases the need to find alternatives to landfilling or incinerating solid waste. Diverting materials to be recycled—rather than landfilled—preserves the landfill capacity currently permitted in California.

Attain RCP Procurement Goals

Each State agency and many local governments are required by law to buy RCPs in sufficient quantities to attain their specified procurement goals. Purchasing RCPs exhibits your support of these State laws and documents your efforts to attain compliance with them.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, Flex Your Power and visit www.consumerenergycenter.org/flex/index.html.

Publication #433-02-005 Revised March 2003

Manufacturer Identification of Recycled Content

Introduction

This fact sheet is provided by the California Integrated Waste Management Board (CIWMB) to assist manufacturers and suppliers to certify the recycled content of their products. The certification process assures potential buyers that the recycled-content products (RCP) are in conformance with federal or State law, local ordinances, and consumer demand.

Why is identifying recycled content important?

Federal, State, and local governments all have laws requiring them to purchase RCPs. In addition, many private corporations—large and small—have RCP procurement policies, and the general public is looking for these products as well. But there are no universal, consistent definitions of recycled-content terminology. Therefore, proper labeling of RCPs is very important.

Since many people are looking for RCPs, your products will benefit from an RCP designation. And since everyone has different ideas about RCPs, the exact content of the product should be identified so buyers can see for themselves if your product meets their needs.

In addition, the Public Contract Code requires all product suppliers to certify the recycled content of all products offered or sold to California State agencies. This is just one part of the RCP procurement requirements for State agencies.

What are the recycled-content certification laws?

Public Contract Code (PCC) sections 10233, 10308.5, and 10354 require all vendors and contractors to certify in writing, under penalty of perjury, to the State agency awarding a contract, the minimum, if not the exact, percentage of postconsumer and secondary material in the materials, goods, or supplies offered or used.

Furthermore, PCC section 12205(a) requires all State agencies to require all contractors to certify in writing, under penalty of perjury, the minimum, if not the exact, percentage of postconsumer and secondary material in the materials, goods, or supplies provided or used.

What are the RCP procurement requirements for State agencies?

The CIWMB oversees the State Agency Buy Recycled Campaign (SABRC). The SABRC mandate (Public Contract Code sections 12200-12320) requires State agencies and the Legislature to purchase RCPs instead of non-RCPs. State agencies are mandated to ensure that at least 50 percent of the dollars spent on products within 11 product categories and 25 percent of the dollars in a 12th category are spent on RCPs (see chart on page 3). State agencies must annually report to the CIWMB their total dollars spent on purchases within each of the 12 product categories, along with the total dollars spent on RCPs within each category. State law also requires product suppliers to certify the recycled content of all products offered or sold to the State (both secondary and postconsumer).

What do "virgin material, "recycled content," "postconsumer material," and "secondary material" mean for SABRC purposes?

The "Buy Recycled" mandates governing the SABRC provide specific definitions for these terms. The term "recycled content" refers to either postconsumer or secondary material; it does not discriminate between the two, therefore, must be further described by actual postconsumer and/or secondary material content.

- Virgin material content is that portion of the product made from non-recycled material, or the material that is neither secondary nor postconsumer.
- Postconsumer material is defined as "a finished material which would have been disposed of as a solid waste, having completed its life-cycle as a consumer item, and does not include manufacturing wastes." This is material such as discarded newspaper that was recycled and then made into recycled-content newsprint or some other recycled product.
- Secondary material is defined as "fragments of finished products or finished products of a manufacturing process, which has converted a resource into a commodity of real economic value, but does not include excess virgin resources of the manufacturing process." This is material such as newsprint that is trimmed from a roll in the paper plant and made into recycled-content newsprint. The material (product) did not get to the consumer before being recycled.

The supplier must identify the minimum percentage of postconsumer material and must also certify the amount of secondary material.

Secondary material **DOES NOT** include postconsumer material. For example, if a printing and writing paper contained 20 percent postconsumer material, you would indicate 20 percent postconsumer content. If the product contained 40 percent secondary material and 20 percent postconsumer material, you would indicate 40 percent secondary content and 20 percent postconsumer content.

To meet the 50/10 content requirement (50 percent total recycled content, 10 percent postconsumer content), a product would need to contain at least 10 percent postconsumer material and 40 percent secondary material (and 50 percent virgin material). However, a product containing 50 percent postconsumer and 50 percent virgin material would also meet the requirement.

The amount of virgin, postconsumer, and secondary material must equal 100 percent.

How do I certify "multiple material" products?

For products made from multiple materials, choose the material that comprises the majority of the product either by weight, volume, or material cost.

For instance, if a chair is made from steel, aluminum, and plastic, and most of the material—either by weight, volume, or cost—is plastic, report it as a plastic product. If most of the product is steel, report the chair as a steel product. If that plastic or steel is recycled-content material, then the purchase is reportable as a recycled-content purchase.

Note: Please do not describe the recycled content of individual components. Once you determine what category the product will be reported in, consider that to be 100 percent of the product.

How do I identify the recycled content of my products?

Identify the total postconsumer content and the secondary material content of your product(s):

- On product labeling.
- In your catalog descriptions.
- On your Web site.
- In product advertising.
- On the recycled-content certification form.

Or, all of the above.

What would the certification look like?

Regardless of how the recycled content is provided, you must identify total recycled content, postconsumer content, and secondary material content. Sample language may look like the following:

- 100 percent recycled with 30 percent postconsumer paper fiber.
- Made from 75 percent recycled plastic, 30 percent postconsumer.
- Lumber made from 100 percent postconsumer recycled plastic.
- 100 percent postconsumer tire-derived product.

Be concise! Do not use ambiguous descriptions like these:

- 100 percent recycled plastic.
- 48 percent recycled material.
- 30 percent recycled content.
- 25 percent postconsumer waste.

Ambiguous content percentages will be treated as secondary content that does not meet State procurement mandates. In addition, the material content must be described as belonging to one of the 12 recycled product categories such as "plastic, paper, steel, paint, glass . . . "

Remember: When postconsumer or secondary material isn't labeled, your customers will assume the product contains only virgin materials.

Product Categories	Content Requirement (%)	Procurement Mandates (%)
Printing and writing papers (PWP)	30% Postconsumer (PC)	25%
Paper products (PP)	50% Total recycled content (TRC) 10% PC	50%
Plastic products (PL)	50% TRC 10% PC	50%
Compost/co-compost (CO)	50% TRC 10% PC	50%
Glass products (GL)	50% TRC 10% PC	50%
Lubricating oils (LO)	70% Re-refined base oil	50%
Paint (PT)	50% PC	50%
Solvents (SO)	70% PC	50%
Anti-freeze (AF)	70% PC	50%
Tire-derived products (TD)	50% PC	50%
Steel products (ST)	25% TRC 10% PC	50%
Tires (TI)	50% TRC 10% PC	50%

What are the minimum content and procurement requirements for the 12 product categories? (See table at lower left.)

Product Category Descriptions

Printing and Writing Paper: Copy and xerographic papers, high-grade paper such as watermarked and cotton fiber papers, high-speed copier paper, offset paper, forms bond, computer paper, non-carbon paper, manila file folders, white wove envelopes, non-coated printing and writing papers, book paper, newsprint, ruled tablets, posters, index cards, and calendars.

Paper Products: Paper janitorial supplies, hand towels, facial tissue, toilet paper, seat covers, corrugated boxes, various types of paperboard (boxes, cartons, wrapping, packaging), hanging files, file boxes, building insulation, and containers.

Plastic Products: Toner cartridges, diskettes, carpet, office products, plastic lumber, buckets, waste baskets, containers, benches, tables, fencing, clothing, mats, packaging, signs, posts, binders, sheeting, buckets, building products, garden hoses, and trays.

Compost and Co-Compost Products: Compost product is derived from organic materials (landscape and tree trimmings; clean wood by-products) diverted from landfills. Compost products are typically used in landscaping and agricultural applications such as soil amendment; erosion or weed control; and turf grass top dressing.

Co-compost products are derived from the blending of compost feedstock with additional organic materials such as food scraps, manures, bio-solids, or other organic by-product. Since compost and co-compost feedstock is virtually comprised of 100 percent recovered materials, both final products should far exceed both the 50 percent recycled and 10 percent postconsumer minimum-content requirements.

Glass Products: Windows, test tubes, beakers, laboratory/hospital supplies, fiberglass (insulation), reflective beads, tiles, construction blocks, desktop accessories, flat glass sheets, loose-grain abrasives, deburring media, liquid filter media, and containers.

Lubricating Oils: Motor, engine, transmission fluid, power steering, crank case, diesel, transformer dielectric fluid, chain saw, cutting, gear, hydraulic, industrial fluids; and base stock used for tractors, vehicles, fleet cars, trucks, and buses.

Paint: Latex paint, graffiti abatement, interior and exterior, maintenance.

Solvents: Printer cleaner, copier cleaner, auto/engine degreaser, parts cleaner, and paint thinner.

Anti-freeze: Engine coolant added to radiator water in cars, trucks, and many other types of engines.

Tires: Truck, passenger, trailer, aircraft, and bus retread.

Tire-Derived Products. Flooring mats, wheelchair ramps, playground covers, parking bumpers, bullet traps, hoses, bumpers, truck bed liners, pads, walkways, tree ties, road surfacing, wheel chocks, rollers, traffic control products, mud flaps, and posts.

Steel Products: Automobiles, trucks, buses, staplers, appliances, motors, paper clips, motorcycles, steel furniture, desks, pedestals, scissors, jacks, rebar, pipe, plumbing fixtures, chairs, ladders, file cabinets, shelving, containers, lockers, sheet metal, guard rails, and girders.

CIWMB Contacts

For more information about the CIWMB Buy Recycled Program, visit our Web site at: www.ciwmb.ca.gov/BuyRecycled/.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, Flex Your Power and visit www.consumerenergycenter.org/flex/index.html.

Publication #433-01-018 Revised March 2003

Building AMERICA
U.S. Department of Energy

Case Study

Modular and Manufactured Houses Offer Homeowners the Building America and ENERGY STAR® Advantage

Genesis Homes — Auburn Hills, Michigan

Building America is sponsored by the U.S. Department of Energy. The program aims to:

- Reduce energy use by 50% and reduce construction time and waste
- Improve indoor air quality and comfort
- Encourage a systems-engineering approach for design and construction of new homes
- Develop system cost/performance tradeoffs that improve housing quality and performance without increasing cost
- Conduct cost-shared research to accelerate development and adoption of innovative building systems.

Genesis Homes, headquartered in Michigan with 11 factories throughout the nation, has committed to quality designs, construction practices, and building materials in its modular and manufactured homes. Part of this commitment has been to work with the Building America Industrialized Housing Partnership (BAIHP) to build energy-efficient homes that qualify for ENERGY STAR labeling.

Buyers Recognize ENERGY STAR® Homes

ENERGY STAR for homes is a marketing program operated cooperatively by the U.S. Department of Energy and the Environmental Protection Agency to help consumers choose energy-efficient houses and other products, such as appliances and lights. The well-known ENERGY STAR logo benefits Genesis Homes and other builders by providing a way for them to prove that their products meet quality standards. When builders, such as Genesis, display the ENERGY STAR label, they are assuring consumers that they will be purchasing homes with energy efficiency, comfort, and reduced operating costs. Homes with the ENERGY STAR label offer more home, for less money, than standard homes.

Genesis Homes and Building America

The key to ENERGY STAR is quality construction and materials. Genesis and Building America have worked together to achieve these performance levels. BAIHP sent researchers to Genesis factories to evaluate ENERGY STAR potential and suggest ways of improving performance, specifically targeting improved duct systems. BAIHP performed design analysis for the prototype show home, built in North Carolina, to qualify the home for the ENERGY STAR program. This home is the same model as the home presented in the 2002 International Builders' Show in Atlanta, Georgia.

Genesis Homes/PIX10801

Building America helped Genesis Homes qualify this home for ENERGY STAR.

ENERGY STAR homes incorporate reliable and established technologies and building practices that require 30% less energy for heating, cooling, and water heating than homes built to the Model Energy Code. These technologies and practices save the owners of ENERGY STAR homes money on their utility bills, while also providing a home that's more comfortable, more durable, good for the environment, and cheaper to own. Buyers can pocket the monthly cost savings, or put them to work in the form of purchasing more home or additional options.

Genesis is taking the extraordinary step of training its own staff to build and rate all of its homes to ENERGY STAR levels. Genesis has made a quality commitment to its homes, distributors, consumers, and the environment.

Visit Genesis Homes at www.genesishomes.com

OFFICE OF BUILDING TECHNOLOGY, STATE AND COMMUNITY PROGRAMS
ENERGY EFFICIENCY AND RENEWABLE ENERGY • U.S. DEPARTMENT OF ENERGY

BUILDINGS FOR THE 21ST CENTURY

Buildings that are more energy-efficient, comfortable, and affordable ... that's the goal of DOE's Office of Building Technology, State and Community Programs (BTS). To accelerate the development and wide application of energy efficiency measures, BTS:

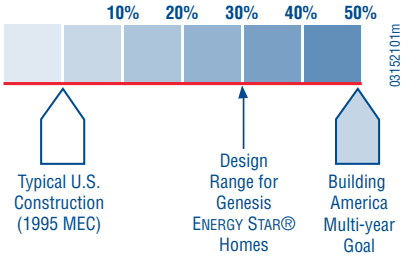
- Conducts R&D on technologies and concepts for energy efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy- and money-saving opportunities to builders and buyers of homes and commercial buildings
- Works with state and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use
- Provides support and grants to states and communities for deployment of energy-efficient technologies and practices.

The Approach

Building America's systems-engineering approach unites segments of the building industry that have traditionally worked independently of one another. It forms teams of architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, and contractor trades. More than 230 different companies make up the five teams of Building America:

- Building Science Consortium (BSC)
- Consortium for Advanced Residential Buildings (CARB)
- Hickory Consortium
- Industrialized Housing Partnership
- Integrated Building and Construction Solutions (IBACOS) Consortium

Building America Performance Goal
(Heating and Cooling Energy Savings)



The Building America teams design houses from the ground up, considering the interaction between the site, building envelope, mechanical systems, and other factors. With this approach, the teams can incorporate energy-saving strategies at little or no extra cost.

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Buildings for the 21st Century

Water Efficiency and Sustainable Landscaping

MODULE 7

Water may be the most vital of all resources for people, plants, and animals. Water supply and quality concerns vary considerably among California Tribes, from the arid desert regions to the moist North Coast region. For many, the state's annual summer drought and highly variable winter rains, combined with fierce competition from agriculture and sprawling cities, mean water concerns may figure prominently in many Tribal building projects. Statewide, urban water use is expected to grow by nearly 40 percent through 2020, compounding pressures on water flows to sustain natural ecosystems.[1] The good news is that some water conservation strategies are both economic and highly effective. If integrated with sustainable landscaping and permaculture, they can also be beautiful and useful. Sustainable water strategies involve every aspect of water use, from stewardship of local sources to reducing use indoors and out and managing wastewater. (Stormwater management is covered in Module 4, Sustainable Siting and Design.)

Sustainable Water and Landscaping Strategies

General Water Conservation Strategies
- ✓ **Prepare a water use management plan.**

Indoor Water Conservation
- ✓ **Use low-flow plumbing fixtures.**
- ✓ **Use high-performance appliances.**

Outdoor Water Conservation
- ✓ **Use a rainwater collection system.**
- ✓ **Use sustainable landscaping techniques.**
- ✓ **Use high-efficiency irrigation systems.**

Innovative Waste Water Management
- ✓ **Use gray water recovery systems.**
- ✓ **Use waterless urinals.**
- ✓ **Use biological treatment or other "off grid" systems.**

Prepare a water use management plan.

Just as for energy, a water use management plan involves projecting and evaluating steps to reduce water use and costs. The plan may also address local concerns related to groundwater quality and recharging aquifers. A water use management plan should include information useful to occupants, such as projections of potential cost savings, a summary of water quality testing results, and suggestions for reducing water use. Informing occupants about water conservation is critical. Perhaps more than any other sustainable building practice, the most effective strategies depend on water use practices of occupants.

INDOOR WATER CONSERVATION

The U.S. Green Building Council suggests targeting at least a 20 percent reduction in indoor water use. This goal compares to the minimum performance levels resulting from the Energy Policy Act of 1992 for water fixtures. Four effective strategies are described below.

Use low-flow plumbing fixtures.

Low-flow plumbing fixtures can significantly reduce water use. Low-flow toilets can reduce water use from as much as 7 gallons to 1.6 gallons per flush or lower. Not all models perform equally, and the Tribe should carefully evaluate experience with low-flow toilets before selecting a model. This is especially true if one of the ultra low-flow toilets is considered, some of which use much less than 1.6 gallons per flush. Federal law requires that faucets and showerheads have flow rates no greater than 2.5 gallons per minute. Flow rates as low as 1.5 gallons per minute are available. Low-flow showerheads may be the most important water conserving faucet type because they are used so frequently and because they also reduce the amount of energy used to heat water.

Again, not all products perform equally. The Tribe can seek products with the "feel" of higher flow that are guaranteed against clogging. The added cost of higher-performance, low-flow heads is minimal, generally less than $25 per house. An option for commercial buildings is infrared faucet

sensors and delayed action shut-off or automatic mechanical shut-off valves. Commercial scale low-flow faucets with rates less than 0.5 gallons per minute are also available.

Life Cycle Costing and Payback Period Low-flow Shower Heads

Even small sustainable building expenditures can have a payback period. (Payback periods are explained in Module 3.) For example, a family of four each taking a five-minute shower a day might use about 350 gallons of water every week. A low-flow shower head that reduces flow by 60 percent would save 210 gallons, or about 28 cubic feet, of water a week. At 7.5 cents a cubic foot, the reduced water use would save about $2.10 per week, so the payback period on a low flow showerhead costing $12 would be just under six weeks. This example considers only savings in water costs. Assuming hot showers, additional savings include those from reductions in electricity or natural gas use and social and environmental benefits from reductions in water and energy use.

Use high-performance appliances. Residential front-loading tumbling washing machines can use as little as one-third the water and 40 to 50 percent less energy than a conventional top-loading center-agitator machine. They also save on drying requirements because they spin at much faster speeds, removing significantly more water than conventional washing machines. Furthermore, they use as little as a quarter of the detergent normally required per load of clothing. For example, U.S. EPA Energy Star rated washers use 15–20 fewer gallons than conventional machines. Several brands of horizontal axis washers have been on the market for many years, with a solid performance track record. National efficiency standards established in 1994 require dishwashers to use about 7–10 gallons per cycle, and the most water-efficient models use as little as 3.9 gallons per cycle. Water-efficient dishwashers use proportionately less energy and have the added benefit of performing more quietly. Energy Star rated dishwashers use at least 13 percent less energy than the minimum federal requirements. Commercial scale dishwashers can be rated as low as 120 gallons per hour (for the continuous use conveyor type) or 1 gallon or less per rack (for the single-use door type).[2]

OUTDOOR WATER CONSERVATION STRATEGIES

Lawns and gardens are often the largest consumer of unheated water in both residential and commercial buildings. Water saving strategies include capturing rainwater for reuse, using sustainable landscaping techniques, and installing high-efficiency irrigation systems.

Use a rainwater collection system. Rainwater collection systems funnel rainwater from roofs and sometimes other surfaces into covered cisterns for use throughout the year. The main use is likely to be irrigation, but rainwater may also be used for washing machines, toilet flushing, and other indoor uses. The simplest system uses roof gutters with downspouts directed into barrels and a gravity pressured hose to deliver water to landscaping. This system may cost as little as $100 to $200.[3] More sophisticated systems might include filtering or other treatment, a pump, and plumbing for indoor delivery. As a rule of thumb, about 600 gallons may be collected per inch of rain per 1,000 square feet of roof area.[4]

RAINWATER COLLECTION SYSTEM

Use sustainable landscaping techniques. Sustainable landscaping involves selecting plants and maintenance strategies to minimize water use, maximize filtration of stormwater runoff, minimize use of chemical fertilizers and pesticides, and provide plants and foods that can be eaten or have other uses. The term "permaculture" is often used to broadly refer to sustainable landscaping practices that integrate these and other social, human, and environmental objectives. Native vegetation is adapted to regional climate conditions and may require little or no additional irrigation once established. Also called "xeriscaping," this is the easiest and most cost-effective way to landscape a site. Because native plants are disease- and pest-resistant, they can also reduce maintenance costs. Xeriscaping also provides a historical connection to the local environment that may assist the Tribe in highlighting the important roles of local plants within its historical traditions. The first principle in xeriscaping is to consider retaining existing plants and foliage to the extent possible, and to ensure that soil is not overly disrupted during construction (since this may impact the ability of some native plants to thrive).

BARONA BAND OF MISSION INDIANS GOLF COURSE

Using a diverse range of plants and ecosystems, such as ponds, meadows, groves, creeks, gardens, vines, perennials, etc. can provide added effect. At a minimum, turf grass areas should be reduced since they require such large quantities of water and maintenance. Other sustainable landscaping techniques include planting food gardens and fruit trees, using mulches, natural contouring, erosion control, wetlands restoration, and habitat enhancement.

Use high-efficiency irrigation systems. Conventional watering or irrigation can be very inefficient, with typical spray heads delivering only about 55 to 65 percent of the sprayed water to the ground. Drip irrigation, on the other hand, can be up to 95 percent efficient while benefiting plants more by delivering water directly to the root zone and depriving weeds of water.[5] Employing technologies such as programmable switches, timers, evapotranspiration controllers, moisture-sensing valves, and rain sensors can yield even higher water savings. However, automated irrigation systems that are not responsive to actual watering needs may sometimes result in higher water use, so training and careful design is critical. A simple timer may cost about $30, while irrigation controllers (including a programmable timer, switching valves, and rain delay system) run about $30 to $50 for the mechanical type and $100 to $150 for the digital variety.[6] The most efficient drip systems are buried, but these are best designed along with other building components at the beginning of the process rather than as a retrofit. Depending upon soil type and the number of emitters, a drip irrigation system may cost about $250 per 1,000 linear feet. One consideration with automated devices is that they must be maintained carefully to ensure they are working properly. A poorly maintained system could inadvertently increase water use.

INNOVATIVE WASTE WATER MANAGEMENT

Innovative wastewater technologies can prolong the life of conventional septic or municipal treatment systems and reduce the use of potable water in transporting wastewater. Strategies include gray water recovery, waterless urinals, and biological treatment systems.

Use gray water recovery systems. Gray water systems capture wastewater from sources other than toilets, possibly with some minimal on-site treatment. The main benefit of gray water systems is to reduce the use of potable water for uses in which non-potable water is sufficient. Treatment technologies include constructed wetlands, basins, ponds, cisterns, and mechanical recirculating sand filters. Although the State of California amended its gray water regulations in 1997 to allow systems in commercial, multi-family and single family buildings, many gray water enthusiasts point to Arizona's approach as a highly effective and flexible approach. (See next page.) Because the system's performance is closely related to what homeowners put down the drain (for example, cleaning agents, diaper washing, etc.), occupant training is critical. A small residential gray water system may cost from $1,000 to more than $5,000, with an initial cost of about $8 to $15 per gallon capacity. Gray water is most attractive economically where public sewage services or septic systems are not already in place.

ARIZONA'S GRAY WATER REGULATIONS—

A Model for Tribes?

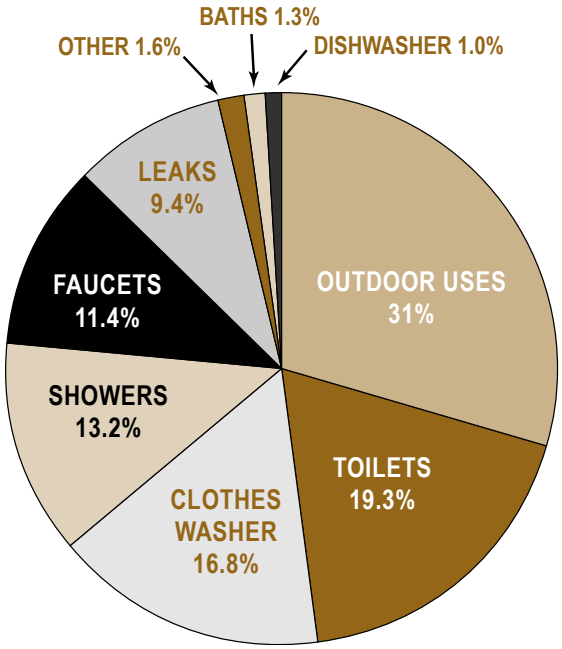
Gray water systems have historically been regulated by states in a way that inhibited their use. Until 1997, California discouraged their use in all but single-family homes, and then only for use in subsurface irrigation. According to the Gray Water Policy Center, Arizona's approach to regulating gray water systems is a model that should be emulated. The law has three separate tiers: 1) a relatively simple and flexible set of guidelines for small residential systems under 400 gallons per day; 2) somewhat more detailed and cautious regulations for residential or commercial systems from 400 to 3,000 gallons per day; and 3) a more rigorous approach for commercial scale systems of more than 3,000 gallons per day. The Arizona regulations and a comparison with other approaches are online at:

www.oasisdesign.net/greywater/law/.

Use waterless urinals. Waterless urinals have been on the market for over a decade and are used in many California schools and commercial buildings. They look just like conventional urinal systems except they use no water. The devices have three main parts—a polypropylene trap insert, a sealant liquid that floats above urine, eliminating odors, and a reinforced fiberglass urinal body. They require only a few ounces of sealant liquid every 1,500 uses and replacement of traps about four times per year. They have a typical payback period of one to four years, depending on use levels and local water pricing. They can result in a cost savings of up to $330 per year.[7]

Use biological waste treatment or other "off grid" systems. "Off grid" waste treatment systems reduce or eliminate the need for relying on municipal or conventional septic sewage treatment. Biological waste treatment systems reduce the volume of black water (waste water from sewage) entering the municipal or septic system. There are a wide variety of technologies available including peat moss drain fields that function like septic systems, constructed wetlands, aerobic treatment systems, solar aquatic water systems, and composting toilets. Some systems may allow for the management of 100 percent of its sewage on-site.

Typical Household Water Use
(Gallons per Person — Total: 105)



Source: Water Wiser—1998 American Water Works. Taken from National Association of Home Builders (NAHB) *A Guide to Developing Green Builder Program.*

RESOURCES

General Water Conservation Resources

California Department of Water Resources
www.owue.water.ca.gov/

Collaborative for High Performance Schools—Best Practices Manual
www.chps.net/

U.S. Green Building Council, Leadership in Energy and Environmental Design (LEED) Program
www.usgbc.org/LEED/LEED_main.asp

WaterWiser, a program of the American Water Works Association operated in cooperation with the U.S. Bureau of Reclamation. (202) 628-8303
www.awwa.org/waterwiser/

National Small Flows Clearinghouse (Good source of information on water quality issues).
www.nesc.wvu.edu/snfc

Resources for Indian Tribes

Native American Water Association
www.nawainc.org/

Tribal Environmental Resource Center—Water Resources Links
www4.nau.edu/itep/water.html

Tribal Environmental Resource Center—Tribal Wastewater Training Center
www4.nau.edu/itep/twwtc.html

U.S. EPA—Guide to Water Quality on Indian Tribes www.epa.gov/ogwdw/protect/tribe.html
U.S. EPA—Fact Sheet on Drinking Water Quality on Indian Tribes
www.epa.gov/ogwdw/protect/pdfs/swp_indian_fact.pdf

U.S. EPA—Clean Water Tribal Resource Directory for Wastewater Treatment Assistance,
www.epa.gov/owm/mab/indian/cwtrd.htm

U.S. EPA—Protecting Public Health and Water Resources in Indian Country: A Strategy for EPA and Tribal Partnerships
www.epa.gov/indian/pdfs/owstrat.pdf

U.S. EPA—Water Quality Standards and Criteria
epa.gov/waterscience/tribes/

Landscaping Resources

California Integrated Waste Management Board—Managing a Waste-Efficient Landscape
http://www.ciwmb.ca.gov/organics/Landscaping/KeepGreen/Manage.htm

California Native Plants Society
www.cnps.org/index.htm

California Landscape Contractors Association (CLCA) (916) 448-2522
www.clca.org/index.html

"A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California"
www.owue.water.ca.gov/docs/wucols00.pdf

Landscape auditors certified by the Irrigation Association (703) 536-7080
www.irrigation.org/

Model Water Efficient Landscape Ordinance
www.owue.water.ca.gov/docs/Revised_Graywater_Standards.pdf

Gray Water and Recycled/Reclaimed Water Resources

California Department of Health Services, "Guidelines for Preparing an Engineering Report for the Production, Distribution and Use of Recycled Water"
www.dhs.ca.gov/ps/ddwem/publications/waterrecycling/ERGUIDE2001.PDF

Gray Water Policy Center, Model Gray Water Policies and Ordinances
www.oasisdesign.net/greywater/law/

U.S. EPA Region 9 fact sheet, "Water Recycling and Reuse: The Environmental Benefits"
www.epa.gov/region09/water/recycling/index.html

California Revised Gray Water Guidelines
www.owue.water.ca.gov/docs/graywater_guide_book.pdf

Recycled Water Web Page
www.owue.water.ca.gov/recycle/index.cfm

BOOKS

Craig Campbell and Michael Ogden, *Constructed Wetlands in the Sustainable Landscape*, 1999.
www.oikos.com/

Water Efficient Products Directory. www.waterwiser.org/products/default.cfm

Theodore Osmundson, *Roof Gardens: History, Design and Construction*, 1999.
www.oikos.com/

Robert D. Brown and Terry J. Gillespie, *Microclimate Landscape Design: Creating Thermal Comfort and Energy Efficiency*, New York, John Wiley and Sons, 1995.

J. Wm. Thompson and Kim Sorvig, *Sustainable Landscape Construction: A Guide to Green Building Outdoors*, Island Press, Washington, D.C., 2000.

Connie Ellefson, Tom Stephens, and Doug Welsh, *Xeriscape Gardening: Water Conservation for the American Landscape*, 1992.

The Green Partnership Guide: A Practical Guide to Greening Your Hotel, Fairmont Hotels and Resorts, 2001.

NOTES

[1] California Department of Water Resources.

[2] Stanford University, Environmental Stewardship Committee.

[3] National Association of Home Builders, "A Guide to Developing Green Builder Programs."

[4] U.S. Green Building Council, LEED Training Workshop Handbook, June 2003.

[5] California Collaborative for High Performance Schools, Volume II, Design.

[6] National Association of Home Builders, "A Guide to Developing Green Builder Programs."

[7] California Collaborative for High Performance Schools, Volume II, Design.

[8] California Department of Water Resources.

Green Rooftop Technology

A green roof is an innovative technology that can reduce storm-water runoff, improve energy performance and extend the roof life of a commercial building. Green roofs, also called eco-roofs, have been popular in Europe for more than 25 years. They are gaining increasing recognition in the United States as an economical and environmental improvement to conventional roofing.

Technology Description

A green roof is a living roof that supports soil and plant growth. A series of carefully engineered layers are applied to the roof deck and used in place of the conventional roof. These layers are watertight, lightweight and long-lasting. From the bottom up, the layers typically include: a waterproof membrane to protect the roof deck, a root barrier to prevent roots from penetrating the waterproof membrane, optional insulation, a drainage layer to direct excess water from the roof, a filter fabric to keep fine soil from clogging the layers below, an engineered soil substrate or growing medium, and carefully chosen vegetation.

There are two broad types of green roofs: eco-roofs and roof gardens.

- Eco-roofs, otherwise known as "extensive" green roofs, have the widest application because they commonly weigh no more than a gravel-bed roof surface. The soil depth on an extensive green roof ranges from one to five inches, and the load usually varies from 10 to 50 pounds per square foot. Vegetation frequently consists of small, low-growing, spreading plants that thrive in shallow soil and are capable of retaining water in their roots and leaves. Alpine-like plants are selected for their ability to withstand harsh roof-top conditions, including high winds, intense heat and no irrigation (after the plants are established). Depending on the location and application, vegetation options may include plants such as native grasses, sedum, phlox and creeping thyme. Extensive green roofs can be accessed for maintenance, which is minimal and generally occurs only about once per year.

- Roof gardens, otherwise known as "intensive" green roofs, are designed for public use and often serve as parks or terraces where building occupants can enjoy being outside. The soil depth on an intensive green roof can be six to 12 inches or more. This allows roof gardens to support a wide variety of larger plants such as shrubs and trees. The building must be designed and engineered to accommodate extra loads ranging from 80 to 150 pounds per square foot. Unlike extensive green roofs, roof gardens usually require irrigation and intensive maintenance.

Design Considerations

Green roofs can be incorporated into a range of new and existing buildings as long as load requirements are met. They are suited for roofs that have slopes ranging up to 20 degrees. Steeper slopes may require an additional platform to hold the engineered layers in place. Installing a green roof on a flat roof requires an additional drainage layer to help ensure that water is removed and plant roots protected from too much moisture.

Mike O'Brien

This lightweight roof is used as an outdoor terrace by occupants of the Family Services of the Rostock building in Germany.

It is important to implement reliable green rooftop technology systems to minimize concerns about water leakage. Recent technological advances have opened the door to a variety of products that offer high-quality, reliable waterproofing and lightweight, efficiently engineered layers. Common waterproof membranes are made of rubber membranes (EPDM), modified bitumen, hypolan (CSPE) or thermoplastic polyolefins (TPO).

The most successful green roofs are those in which sufficient attention has been paid to selecting plants that will thrive in the local climate and conditions. Because green roofs are subject to wind erosion, it is beneficial to plant densely. Overseeding with native grasses often is recommended to retain the soil both initially and during conditions when the alpine plants are not at their optimum. Even with an extensive green roof, it is important to provide sufficient water while the plants are becoming established.

Estimated Benefits

A green roof offers many benefits for the building owner, the environment and the community.

One of the most significant advantages is that a green roof can last up to three times longer than a standard roof, thereby reducing maintenance and replacement costs. This occurs because the plants and soil protect the roof from the on-going harsh effects of ultraviolet radiation, precipitation and temperature extremes that cause expansion and contraction. A grass rooftop, for example, typically does not exceed 77° F. Contrast that with a conventional flat roof, which can reach 140° F in the summer. The ability of a green roof to buffer temperature extremes also has the potential to improve a building's energy

performance. Some studies show that dropping the temperature on the roof by 3º F to 7º F can result in a 10 percent reduction in air conditioning requirements, translating into significant cooling cost savings. On the community level, green roofs may mitigate "urban heat islands," which are created when a large percentage of the natural environment is replaced with pavement and buildings. Green roofs help counteract urban heat islands because the plants evaporate moisture through their foliage, providing a cooling effect through a process known as evapotranspiration.

Another key benefit of green roofs is that they are capable of retaining between 15 and 70 percent of the stormwater from the roof. This decreases the amount of runoff that the community's storm sewer system must absorb. Stormwater benefits from green roofs can be significant enough for many communities to offer incentives or reductions in stormwater impact fees for properly designed green roofs.

Estimated Costs

The additional cost for an extensive green roof ranges from $8 to $15 per square foot, including the waterproofing and other membranes, soil and plants. Roof gardens may cost double, depending on the design and plant selection. Over the life of a building, the benefits of a green roof may offset the cost by extending the life of the roof, improving energy performance, reducing stormwater fees and providing amenities for building occupants.

Financing Options

Some funding for green roofs may be available through the U.S. Environmental Protection Agency's Clean Water Act Section 319 (non-point source pollution) grant program. Depending on the location, financial incentives also may be available from local jurisdictions, water and sewer authorities, and power companies. These may include grants or rebates as well as reductions in development fees, stormwater fees or property taxes. Local jurisdictions may also offer technical assistance to larger commercial and institutional projects.

LEED* Green Building Rating System

Green roofs may earn one LEED rating point for Landscape and Exterior Design to Reduce Heat Islands if the green roof is used for at least 50 percent of the roof area. A green roof also may contribute to one point for stormwater management that meets LEED criteria.

LEED, which stands for Leadership in Energy and Environmental Design, is a program of the U.S. Green Building Council. The LEED Rating system is a recognized checklist of performance goals and measures that provides standardization and independent oversight for environmental performance in nonresidential building.

Projects Using Green Roof Technology

- Gap, Inc. headquarters (also known as 901 Cherry), San Bruno, CA, http://bacqube.bayareacouncil.org/901/and www.mcdonough.com/gap.html
- Chicago City Hall, Chicago, IL, www.roofmeadow.com/project1.html
- Hamilton Apartments West, Portland, OR, http://www.cityfarmer.org/GreenRoof.html
- Liberty Square Building, Vancouver, BC, www.greenroofs.com/north_american_cases.htm
- Lincoln-Mercury World Headquarters, Irvine, CA, (under construction), www.roofmeadow.com/project4.html
- Schiphol International Airport, Amsterdam, The Netherlands, www.greenroofs.com/world_extensive_cases.htm

Further Resources

- "Green rooftop technology saves energy, cools air," Suzanne Elston, Environmental News Network, December 2000, www.enn.com/news/enn-stories/2000/12/12302000/rooftops_40979.asp
- "Green Roofs: Stormwater Management from the Top Down," Katrin Scholz-Barth, Environmental Design & Construction Home, January/February 2001, www.edcmag.com/archives/01-01-4.htm
- "Greenbacks from Green Roofs: Forging a New Industry in Canada," Steven W. Peck and Chris Callaghan, www.peck.ca/grhcc/resources.htm
- Green Roof Infrastructure Monitor, www.peck.ca/grhcc/resources.htm
- www.greenroofs.com
- www.roofmeadow.com
- www.hydrotechusa.com

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TIPS FOR BASIC SUSTAINABLE LANDSCAPING

Sustainable landscaping is landscaping that looks at the site and purpose of the building as a whole. Sustainable landscaping considers the all aspects of a building's location- its bioregion, the geographic area, water access, weather patterns – and the building's purpose – commercial, public, private, home, large or small – when planning the landscaping design elements.

Xeriscaping is landscaping that uses drought-resistant, natural vegetation that is able to survive on local rainfall or groundwater after the vegetation has been established. It conserves water.

Planning and Design

Planning and design is the first step in any Xeriscaping effort. It is also the most important step. Without a comprehensive design plan, the full benefits of Xeriscaping will not be realized. A good Xeriscaping design considers:

Regional and microclimatic conditions

Existing vegetation and topographical conditions

What the site will be used for

Grouping plants according to their water needs.

Proper site planning

The buildings footprint and floorplans should take the site topography into account. Terracing, decks, porches, or split level designs in a building's design can reduce the cost and effects of grading while also integrating the building into the site environment.

Xeriscaping can decrease energy demands for cooling if a building's design combines appropriate placements of shade plants such as trees, tall bushes, and hedges, east-west axis building orientation, and a minimal amount of windows on the outside walls with the most sun will.

Utilize as much existing vegetation as possible

As much as possible develop building sites and powerline location plans around any existing trees or vegetation. Allow room for this existing vegetation to continue to mature.

Incorporate existing vegetation into designs for walkways, patios, decks, stairways, or any other traffic areas. For example, using existing trees near decks and patios can provide shade, while leaving natural grasses or flowers or succulents along a pathway beautifies the walk.

Orienting a building's windows or sliding glass doors towards natural, pre-existing vegetation such as shrubs, succulents, cactuses, or forests increases the overall ambience building design.

Utilizing existing vegetation can help maintain the site's natural drainage patterns.

Preserve topsoil during construction

During the construction phase collect and store as much of the topsoil as possible for use in landscaping. Topsoil is a valuable resource and is an integral part of Xeriscaping.

Controlling topsoil erosion during the construction phase goes a long way towards protecting topsoil. Erosion can be controlled with strategically placed devices such as hay bales or erosion control fencing.

Stabilize bare soil areas

Natural vegetation, terracing, locally found rocks and boulders can help stabilize bare soil areas on slopes, hillsides, and stream banks.

Apply thick layers of organic mulch to plant beds also shredded mulch can be used in slopping areas because it forms a mat and doesn't wash out as much as other types of mulch.

Cover slopes and hillsides with erosion controlled fabrics or jute netting before planting groundcovers and plants. Erosion control fabrics and nettings help hold soil in place, allowing plants to be established.

Energy conservation landscaping

When possible, plant deciduous trees on the west and southwest sides of buildings.

Deciduous trees can provide enough shade that roof and wall temperatures can be lowered by up to 20 degrees. During the winter the bare tree branches allow sunlight to hit rooftops providing solar warmth.

Shrubs and vines on arbors or trellises also provide good sources of shade.

Plant evergreen shrubs and/or trees on the north and northwest sides of a building. These plantings can insulate exterior building walls. Varieties that branch all the way to the ground are good, effective choices.

Shading the outdoor compressor of an air conditioning system can save up to 10% on summer cooling bills. Leave at least 3 feet around the compressor for air flow and service access.

Trees that are situated in such a way that they channel southeastern summer breezes are natural cooling agents.

Tall, dense plants, hedges, and trees provide windbreaks to block cold winter winds.

Several staggered rows of plantings should be located on the leeward side of the wind.

Water Conservation

Water consumption in commercial buildings can be reduced as much as 50 percent using a variety of innovative strategies that are integrated into the plumbing and mechanical systems as well as the landscaping design. With water and sewer rates increasing nationwide, such integrated water use management can deliver a favorable economic return while demonstrating responsible use of this precious resource.

Technology Description

Although federal law now requires low-flush (1.6 gallons per flush) fixtures and automatic valves for water closets and public lavatories, the opportunities for water conservation in commercial buildings are still substantial.

Options for further reducing water use and cost include:

- **More efficient fixtures.** Fixtures are now available for water closets that use only 1.2 gallons or less per flush, which is 20 percent less than what is required by the National Energy Policy Act of 1992. Other water-saving options include faucet aerators in sinks and low-flow showerheads in buildings where showers are provided (typically those that have in-house exercise facilities or on-site bicycle parking).
- **Waterless urinals.** Code approval for waterless urinals is increasing, as is their commercial availability. They use a trap liquid with a lower specific gravity than urine, allowing waste to pass through while maintaining a constant trap seal. No water is required and there is no odor. Waterless urinals are becoming common in institutional settings, such as elementary and secondary schools, as well as campus situations, including corporate headquarters. They are easy to maintain, and reduce problems associated with stuck valves and accidental or intentional flooding.
- **Gray water reuse.** Gray water from sinks, kitchens and food service locations can be used for toilet and urinal flushing, cooling tower or boiler makeup water, landscaping and on-site water storage for fire fighting. Such systems require dual piping to route the gray water as well as appropriate valves, filters and signage. Plumbing codes differ widely among jurisdictions as to the acceptability of such approaches.
- **Electric instantaneous hot water heaters.** In areas where electricity is less than $0.06 per kilowatt-hour, "on-demand" electric water heaters placed under lavatories can deliver cost-effective water and energy savings.
- **Rainwater reuse.** In wetter climates, it may be possible to pipe roof drains directly to a storage tank in the building and use that water in the same manner as gray water. Capturing 36 inches of rain per year from a 20,000-square-foot roof would yield 60,000 cubic feet of rainwater, for annual savings of nearly 450,000 gallons.
- **Water-efficient landscaping.** Landscape architects and designers can specify native plantings, which use no water after becoming established, as well as drip irrigation and other low-water-using systems.
- **Cooling Towers.** Submetering can reduce sewer charges by eliminating charges for water lost to evaporation.

Design Considerations

Water conservation is maximized and most cost-effective when it is integrated into the design of a building's plumbing, mechanical, fire-safety and landscaping systems. An effective design strategy is to create multiple uses for each gallon of water: Potable water can be used for drinking, hygiene and health; recaptured water can be used for toilet flushing, boiler and cooling tower makeup as well as landscape irrigation.

For long-term savings, it is beneficial to measure water use as part of on-going building operations and to identify near-term improvements in fixture, circulation and wastewater management design.

Estimated Costs and Benefits

In most communities, water conservation can improve a building's bottom line by reducing water use charges, sewer system charges and "system development" impact use charges.

- Water use charges commonly include fixed charges that may vary with the meter size and consumption charges that are based on monthly or seasonal water use.

- Sewer system charges often are calculated based on the amount of water used in a given time period. It is not unusual for sewer system charges to be two-to-four times higher than water use charges. Additionally, some communities assess new developments with "impact fees," based on the projected amount of storm water runoff or sanitary sewer discharge. Reducing these impact fees can help offset some of the costs of water conservation measures.
- A system development charge is a one-time fee assessed for each new water service. The charge typically varies according to the diameter of the meter. Extensive water conservation may allow the meter size to be reduced, saving thousands of dollars on the system development charge, and possibly impacting the monthly fixed charge for water use.

When evaluating the cost-effectiveness of water conservation strategies, it is important to factor each of the above charges into the economic analysis. By making reasonable assumptions about future water and sewer rates, the economics of water conservation improvements can be more accurately determined.

Financing Options

Depending on the location, state and local tax credits or water utility rebates may be available for water conservation beyond a certain baseline. Local jurisdictions may also offer technical assistance to larger commercial and institutional projects.

LEED™ Green Building Rating System

LEED, which stands for Leadership in Energy and Environmental Design, is a project of the U.S. Green Building Council. The LEED Rating system is a recognized checklist of performance goals and measures that provides standardization and independent oversight for environmental performance in commercial buildings.

Water conservation strategies in commercial buildings may earn LEED rating points as follows:

- Innovative wastewater technologies: One point for reducing sewage flow by 50 percent or for treating all wastewater onsite to tertiary standards, typically through a biological ("living machine") system.
- Non-landscaping water use (sanitary fixtures and HVAC equipment): One point for a 20-percent reduction. A second point for an additional 10-percent reduction.
- Water-efficient landscaping: One point for reducing potable water consumption for irrigation by 50 percent through high-efficiency irrigation technology or by using captured rain water or recycled site water. A second point for reducing potable water consumption for irrigation by an additional 50 percent.

Projects Using Building Water Conservation

- C.K. Choi Institute for Asian Research, University of British Columbia, Vancouver, BC, www.iar.ubc.ca/choibuilding/matsuzaki.html
- Austin-Bergstrom International Airport, Austin, TX
- King Street Center, Seattle, WA
- Southface Energy and Environmental Resource Center, Atlanta, GA, www.southface.org/home/house/seerc.html.

Further Resources

- "Cascade Your Way to H20 Conservation," Jerry Yudelson, P.E., and Steffen Brocks, P.E., *Consulting-Specifying Engineer,* March 1999, www.csemag.com.
- "King Street Center demonstrates environmentally friendly design, construction and operations features," King County, WA, Department of Natural Resources, press release, June 18, 1999, http://dnr.metrokc.gov/dnradmin/press/990618kf.htm.
- "Rainwater Harvesting," Gretchen Gigley, The Southface Energy Institute, www.southface.org/home/sfpubs/articles/rainwater.htm.
- "Breaking New Ground: A look at the C.K. Choi Building for the Institute of Asian Research," *Wastenot,* Spring 1996, www.raic.org/wastenot/issues/9604/9604-1a.html

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Energy Efficiency

MODULE 8

Energy efficiency may be the foundation of sustainable building. Buildings account for 36 percent of all energy use, with more than $220 billion spent annually for lighting, heating, cooling and appliances.[1] Buildings that are designed without considering energy efficiency are very hard on the environment. For example, building energy consumption accounts for about 47 percent of total U.S. sulfur dioxide emissions, 22 percent of nitrogen oxide emissions, and 35 percent of carbon dioxide emissions. Energy supplied to the 100 million homes in the U.S. accounts for 20 percent of national greenhouse gas emissions.[2] Reducing energy use in buildings reduces these impacts proportionately. Increased efficiency also yields increased comfort, aesthetics, and productivity.

Because of California's long history with energy conservation, architects and contractors are highly experienced. The state's utilities offer important incentives to promote energy conservation. There are many proven, cost-effective strategies to reduce energy use and cost in all types of buildings in all types of climates. These strategies also result in a home or commercial space that is vastly more comfortable to live or work in.

PASSIVE SOLAR DESIGN

Passive solar design means designing a building that is tailored to the unique climate and topography. Although each situation is unique, passive solar design makes sense in any of California's 16 climate zones.

Optimize the site, design, and orientation. A building's site, design, and orientation make a big difference in terms of its energy use. For example, siting buildings on an east-west axis can maximize high solar gain through south-facing windows in winter, while overhangs or trees can restrict solar gain in summer when the sun is higher. An optimal solar design might include a partial Earth wall on the North side, where there is little solar gain and potentially high loss of heat or cooling.

Landscape to provide natural shade. Strategically designed landscaping such as trees and large shrubs, especially in hot desert regions, can reduce residential energy use by 25 percent, saving up to $250 per year in a typical home.[3] Deciduous trees,

Energy Efficiency Strategies

PASSIVE SOLAR DESIGN
- ✓ Optimize the site, design, and orientation.
- ✓ Landscape to provide natural shade.
- ✓ Use natural day lighting.
- ✓ Use natural heating and ventilation.

ENERGY MANAGEMENT PLAN
- ✓ Evaluate tradeoffs and minimize projected energy costs.
- ✓ Train building occupants.
- ✓ Track and optimize performance over time.
- ✓ Employ an energy management system and commissioning.

ENERGY EFFICIENT PRODUCTS
- ✓ Use high-performance thermal insulation.
- ✓ Use high-performance roofing and glazing.
- ✓ Use high-performance lighting.
- ✓ Use high-performance heating, ventilation, and air conditioning systems.
- ✓ Use high-performance appliances.

in particular, can provide shade in summer while allowing solar gain in winter. Vines can filter intense sun in an aesthetically pleasing way.

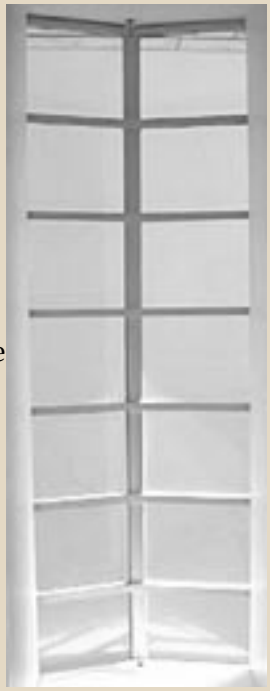
Use natural day lighting. Day lighting is a highly effective energy conservation strategy that can greatly enhance the visual impact and overall comfort of a space. Using glazing in creative ways that complement traditional windows, designers use the building itself to funnel light where it is needed, while avoiding glare and direct sunlight. Because glazing allows not only light, but also heat to flow to and from the building, designers must consider tradeoffs to ensure that the overall building design optimizes energy efficiency and comfort.

A SAMPLING OF DAY LIGHTING STRATEGIES

Side lighting funnels light through glazing around a building's perimeter. Side lighting can light up to 70 percent of the footprint of some buildings.[4]

Top lighting funnels light through glazing in a building's roof, often in high atriums. Top lighting can light an entire building footprint.

Skylights allow light to access otherwise dark spaces, but they can also result in high heat or cooling loss. Keeping skylights small can minimize this. For example, one or two square feet of light will adequately light 50 square feet of floor space.



Light tubes are more efficient than sky lights because they are smaller and direct light more precisely to where it is desired. Unlike skylights, light tubes are installed between framing, requiring no structural modifications. Light tubes retail for about $200 to $400.[5]

Use natural heating and ventilation. Natural heating and ventilation take advantage of natural cycles of heat and cold by using thermal mass, natural convective air movement, fans, and pumps to capture and channel heat or cold where and when it is needed. Especially in areas characterized by hot days and cool nights like the high desert or some inland coastal areas, thermal mass like heavy masonry or stored water can slow heat gain during the day and release it during the night. Fans and pumps can stimulate natural convection to enhance the effect. Whole house ventilation systems exchange outside air with inside air quickly, while spot ventilation uses very low energy fans targeted to a small area like a kitchen or bathroom.

ENERGY MANAGEMENT PLAN

Working with the project architect or contractor to prepare an energy management plan can ensure that tradeoffs have been carefully evaluated and an effective whole building approach has been achieved. A comprehensive plan could include the following components.

Evaluate tradeoffs and minimize projected energy costs. At the very least, the project architect or contractor should estimate the building's projected energy costs, and consider steps to reduce those costs. This is one way to comply with California Title 24 standards, and there are several excellent software packages available to model building energy performance. This is the best way to evaluate the costs and benefits of all the optional measures described in this module.

Train building occupants. Energy performance depends to a degree on the ability of occupants to correctly use building components. At a minimum, occupants should be provided with written information explaining how heating, cooling, and appliances should be used, with necessary maintenance steps to take.

Track and optimize performance over time. The most aggressive energy management plan would include monitoring equipment and a plan for evaluating and optimizing energy performance over time. Such a system may also include automated controls for lighting and heating (for example, systems that turn down the thermostat automatically during certain times of the day, or in response to changing outdoor temperatures). Ideally, total energy use should be monitored and compared to performance targets and systems adjusted accordingly.

Employ an energy management system and commissioning. For large commercial and multifamily residential buildings, an energy management system (EMS) can reduce overall energy use by automatically optimizing the operation of heating, ventilation, and air conditioning (HVAC), lighting and other systems. On average EMS saves about 10 percent of overall annual building energy consumption, and nearly one-third of all U.S. buildings larger than 100,000 square feet have one.[6] EMS systems vary widely in sophistication, and simple ones may control only one or two functions (for example, lighting). As an upper-end cost estimate, a comprehensive system including direct digital control might run $2.99 to $4.00 per square foot.[7] Building commissioning can ensure that energy systems are designed and functioning properly. Experts agree that commissioned buildings are generally more energy-efficient, more comfortable, and easier to manage.[8] Commissioning may add an additional 0.5 to 2 percent in cost.[9]

ENERGY-EFFICIENT PRODUCTS

The overall energy efficiency of a building can be increased significantly by considering the specification of certain building products, including thermal insulation, roofing and glazing, lighting systems, heating, cooling and ventilation systems, and appliances. Perhaps more than any other green building topic, and especially in California, excellent resources are available to find, evaluate, and specify these products to optimize the energy performance of a building.

Use high performance thermal insulation. Thermal insulation is the most fundamental way to reduce building energy use. The "R-Value" is a measure of total insulating ability. Typical R-Values for walls are R-11 to R-23, for attics at least R-30 and for walls at least R-13. In colder climates, a minimum of R-19 under the floor is recommended. Two common insulation products are fiberglass and cellulose insulation, both of which have the added benefit of being produced with recycled materials. (Recycled content building materials are discussed in Module 6.) Thermal insulation is greatly affected by air leakage or, conversely, the "tightness" of a building. As much as 30–40 percent of a building's energy load can be attributed to infiltration in some climates. While a tight building saves energy, it is also important to ensure adequate ventilation to prevent moisture build-up that creates the right environment for old and mildew growth.

Use high performance roofing and glazing. Energy efficient building materials like roofing and windows must be selected carefully to optimize the day lighting and natural heating and ventilation strategies discussed above. For example, cool roofing materials are reflective or painted a light color to maximize reflection of heat during the summer. Radiant barriers within walls can reduce heat loss at night. Window design is a particularly important design challenge, involving tradeoffs between day lighting and heat or cooling loss. High-efficiency windows include double pane windows (sometimes with an insulating gas like argon between the panes), tinted windows, and Low-E windows treated with an energy-efficient glaze.

Use high performance lighting systems. Optimizing lighting systems is one of the easiest and lowest-cost ways to reduce energy use. In mild climates lighting can constitute up to 25 percent of residential energy use. Lighting also directly influences the feel of a space and the productivity and comfort of its occupants. Some key strategies include: 1) Targeted lighting to provide just the right amount of light for the task; 2) Use day light first wherever possible and use artificial lights to compliment natural light; 3) High-efficiency alternatives to incandescent bulbs (for example, linear fluorescent fixtures use 1/6 the energy, compact fluorescent use ¼ the energy, halogen bulbs use 3/5 the energy and low voltage halogens use ½ the energy of incandescent bulbs[10]); and 4) Automated controls, especially in larger buildings, to turn lights down or off at appropriate times (for example, motion, temperature, or time-dependent controls). The combined energy savings of sensor and dimming can be as high as 40 to 44 percent.[11] In certain commercial buildings, a "digital addressable lighting interface" (DALI) control system can revolutionize fluorescent lighting systems, resulting in massive savings.[12]

Use high-performance heating, ventilation, and air conditioning systems.

Technologies for heating, ventilation, and air conditioning systems (HVAC) have been evolving rapidly, and many energy-efficient options are on the market. HVAC systems constitute up to one-fourth of an office building's electricity and about 38 percent of residential energy use,[13] so this is an important area to look for savings.

Following are some options to consider when designing traditional heating and cooling systems:

The *Energy Star* label identifies and rates the most cost-effective and efficient options. In the Central Valley climate zone, the most efficient Energy Star air conditioning systems can save from 7 to 20 percent of the cooling costs compared to other models.[14]

Heat Pumps are the most efficient form of electric heating in moderate climates, providing three times more heat than the equivalent amount of energy they consume in electricity. Heat pumps collect heat from the air, water, or ground outside and concentrate it for use inside. They also can do double duty as a central air conditioner and can trim residential energy use by as much as 30 to 40 percent.

Radiant Cooling Systems circulate cold water through walls, ceiling, or floor panels (instead of air as in traditional air conditioning systems). Radiant cooling, which can work in all climate zones, has up front costs similar to traditional air conditioners but can have life cycle costs of about 25 percent less.[15]

Evaporative Cooling Systems use less than one-fourth the energy of refrigerant-based cooling systems. Their use is most appropriate in mild climates such as inland Southern California.

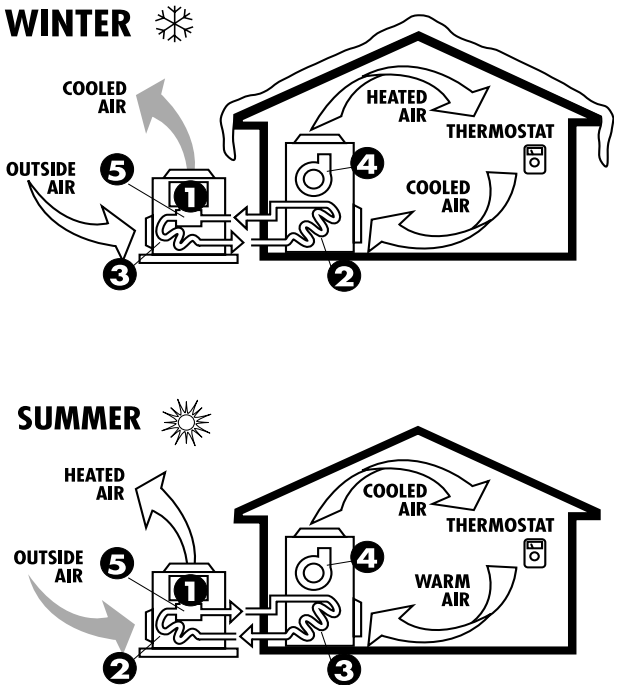
Chilled Water Cooling Systems can be a highly efficient option, especially for larger, commercial buildings.

Programmable Thermostats can save up to 10 percent on heating and cooling costs by automatically adjusting thermostat settings during parts of the day.

Fireplaces, though aesthetically appealing, are one of the most inefficient forms of heating a building. They send heat up the chimney while sucking cold air in from outside. Airtight stoves using wood pellets are more efficient and are certified by the U.S. EPA.

Use high-performance appliances.

The easiest way to find highly efficient appliances is again to look for the Energy Star rating label. Energy star refrigerators, for example, can save up to 8 percent of residential energy use compared to inefficient models. In residences, kitchens use about 20–40 percent of household energy, with refrigerators often using more energy than any other appliance. Water heaters are also energy-intensive appliances. The most efficient choice is a gas heater with a rated energy factor of 0.6 or higher, with built-in R-16 insulation. Electric water heaters should have an efficiency factor of 0.94 or above. More than 1.5 million homes and businesses in the U.S. have invested in solar water heating systems. Look for those certified by the Solar Rating and Certification Corporation (SRCC).



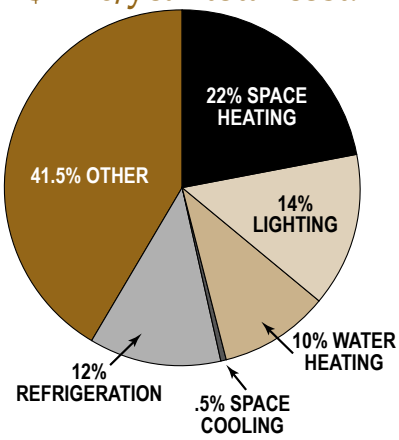
HEAT PUMP DIAGRAM

Source: SRP (Salt River Project), Tuscon, Arizona

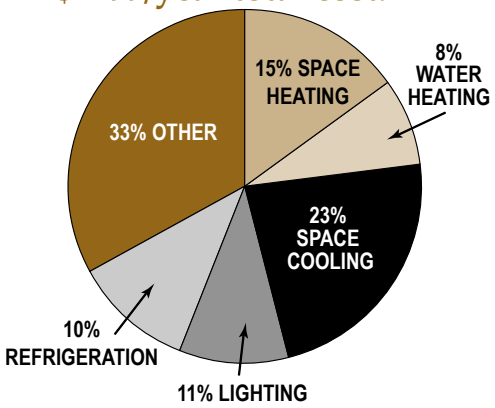
Energy Conservation Cost Savings

Every building situation is unique. But with appropriate design, each of the strategies described in this module can provide cost savings over time that covers the initial up front-costs. The amount of time required to recover those costs varies with each individual project and depends on the complexity of the project and the overall efficiency of the design. The question of which combination of strategies will produce the greatest savings at the lowest cost is the central sustainable building design task facing architects and contractors. The charts below estimate typical energy costs for residential and commercial office buildings and can be used to estimate potential savings from energy efficiency strategies. For example, reducing lighting energy use in a Coastal California home by 40 percent would cut energy costs by $68 per year. Careful site selection alone can save up to 25 percent energy use, and proper insulation can reduce overall use by up to another 30 percent.[16] Lowering winter thermostat settings from 70 to 60 degrees can save 10–15 percent of residential energy use.[17]

TYPICAL RESIDENTIAL ENERGY COSTS
– Coastal California
$1216/year total cost.



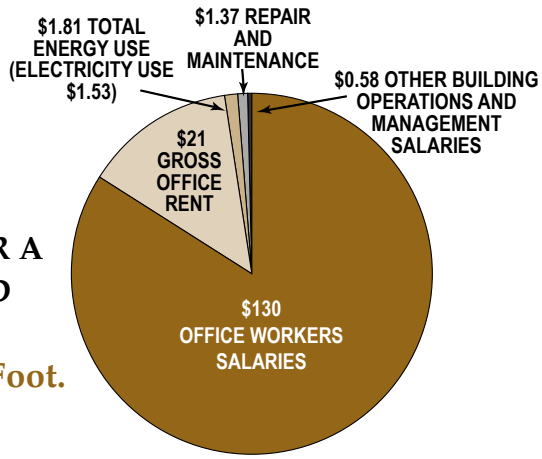
TYPICAL RESIDENTIAL ENERGY COSTS
– Central California
$1499/year total cost.



Source for both charts: PG&E's Home Savings and Comfort booklet., P. 2. www.homeenergy.org; 510-524-5405

TYPICAL COSTS FOR A MODERATELY SIZED OFFICE BUILDING
– Cost Per Square Foot.

Source: PG&E



RESOURCES

General Energy Conservation References

California Integrated Waste Management Board, Green Building Design and Construction, www.ciwmb.ca.gov/greenbuilding.

California Energy Commission
www.energy.ca.gov.

Consumer Energy Center
www.consumerenergycenter.org.

Energy Efficiency and Renewable Energy Network (EREN)
www.eren.doe.gov

Pacific Gas & Electric Company, Pacific Energy Center (A free two-CD set entitled Energy Design Resources has a wealth of resources on all energy efficiency strategies discussed in this module.)
www.pge.com/pec

U.S. Green Building Council
www.usgbc.org
Leadership in Energy & Environmental Design (LEED) Rating System
www.leedbuilding.org.

Whole Building Design Guide
www.wbdg.org.

Energy Conservation Incentive Programs

Energy Star Program
www.energystar.gov/

Savings By Design, a statewide incentive program sponsored by California's four investor-owned utilities
www.savingsbydesign.com

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John Bower, *Understanding Ventilation*, Healthy House Institute., June 1999.www.oikos.com/.

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Margaret Suozzo, Jim Benya, et al., *Guide to Energy-Efficient Commercial Equipment*, 2nd edition, American Council for an Energy-Efficient Economy, July 2000

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www.eandle.lbl.gov/bookstore.html.

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NOTES

[1] U.S. Green Building Council, Training Workshop, June 2003, p. 28.

[2] U.S. Department of Energy.

[3] PG&E Energy Design Resources, "Design Brief, Daylighting," 2002.

[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Ibid.

[8] PG&E Design Brief, "Building Commissioning," 2002.

[9] Cox, Dorgan & Dorgan, "The Value of Commissioning: Costs and Benefits." Best of the 2002 U.S. Green Building Council Conference. Business Green, Inc. 2002. As reprinted by U.S. GBC in the 2003 LEED Reference Manual.

[10] PG&E Energy Design Resources.

[11] Ibid.

[12] PG&E Learning Center Brochure.

[13] PG&E Energy Design Resources, "Design Brief: Air Conditioning and Ventilation," 2002.

[14] Ibid.

[15] PG&E Energy Design Resources. "Design Brief: Radiant Cooling." 2002.

[16] U.S. Energy Information Administration Annual Energy Outlook, 1997. As quoted in Office Building Technology, State and Community Programs, U.S. DOE

[17] Pacific Gas & Electronic, Residential energy use fact sheet, 2003.

Buildings for the 21st Century

Buildings that are more energy efficient, comfortable, and affordable...that's the goal of DOE's Office of Building Technology, State and Community Programs (BTS). To accelerate the development and wide application of energy efficiency measures, BTS:

- Conducts R&D on technologies and concepts for energy efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy/money saving opportunities to both builders and buyers of homes and commercial buildings
- Works with state and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use
- Provides support and grants to states and communities for deployment of energy-efficient technologies and practices

PASSIVE SOLAR DESIGN

Increase energy efficiency and comfort in homes by incorporating passive solar design features

DESIGN WITH THE SUN IN MIND

Sunlight can provide ample heat, light, and shade and induce summertime ventilation into the well-designed home. Passive solar design can reduce heating and cooling energy bills, increase spatial vitality, and improve comfort. Inherently flexible passive solar design principles typically accrue energy benefits with low maintenance risks over the life of the building.

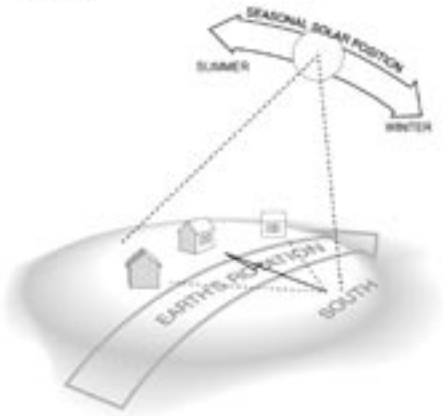
DESIGN TECHNIQUES

Passive solar design integrates a combination of building features to reduce or even eliminate the need for mechanical cooling and heating and daytime artificial lighting. Designers and builders pay particular attention to the sun to minimize heating and cooling needs. The design does not need to be complex, but it does involve knowledge of solar geometry, window technology, and local climate. Given the proper building site, virtually any type of architecture can integrate passive solar design.

Passive solar heating techniques generally fall into one of three categories: *direct gain*, *indirect gain*, and *isolated gain*. Direct gain is solar radiation that directly penetrates and is stored in the living space. Indirect gain collects, stores, and distributes solar radiation using some thermal storage material (e.g., Trombé wall). Conduction, radiation, or convection then transfers the energy indoors. Isolated gain systems (e.g., sunspace) collect solar radiation in an area that can be selectively closed off or opened to the rest of the house.

Passive solar design is not new. In fact, ancient civilizations used passive solar design. What is new are building materials, methods, and software that can improve the design and integration of passive solar principles into modern residential structures.

SOLAR POSITIONING CONSIDERATIONS
The south side of the home must be oriented to within 30 degrees of due south.



COST

It takes more thought to design with the sun; however, passive solar features such as additional glazing, added thermal mass, larger roof overhangs, or other shading features can pay for themselves. Since passive solar designs require substantially less mechanical heating and cooling capacity, savings can accrue from reduced unit size, installation, operation, and maintenance costs. Passive solar design techniques may therefore have a higher first cost but are often less expensive when the lower annual energy and maintenance costs are factored in over the life of the building.

OFFICE OF BUILDING TECHNOLOGY, STATE AND COMMUNITY PROGRAMS
ENERGY EFFICIENCY AND RENEWABLE ENERGY • U.S. DEPARTMENT OF ENERGY

DIRECT GAIN PASSIVE SOLAR DESIGN TECHNIQUES

Passive solar design strategies vary by building location and regional climate, but the basic techniques remain the same—maximize solar heat gain in winter and minimize it in summer. Specific techniques include:

- Start by using energy-efficient design strategies.
- Orient the house with the long axis running east/west.
- Select, orient, and size glass to optimize winter heat gain and minimize summer heat gain for the specific climate. Consider selecting different glazings for different sides of the house (exposures).
- Size south-facing overhangs to shade windows in summer and allow solar gain in winter.
- Add thermal mass in walls or floors for heat storage.
- Use natural ventilation to reduce or eliminate cooling needs.
- Use daylight to provide natural lighting.

These techniques are described in more detail below.

✓ **Cutting Losses.** A passive solar home should start out well sealed and well insulated. By reducing heat loss and gain, remaining energy loads can be effectively met with passive solar techniques. Approaches that contribute to minimizing heating and cooling loads include using advanced framing guidelines, properly installing insulation, using recommended insulation levels (International Code Council's International Energy Conservation Code, (703) 931-4533, www.intlcode.org or the U.S. Department of Energy's Insulation Fact Sheet, DOE/CE-0180, (800) DOE-EREC, www.ornl.gov/roofs+walls), reducing duct losses, and tightening the building envelope.

✓ **Site Orientation.** The building's southern exposure must be clear of large obstacles (e.g., tall buildings, tall trees) that block the sunlight. Although a true southern exposure is optimal to maximize solar contribution, it is neither mandatory nor always possible. Provided the building faces within 30° of due south, south-facing glazing will receive about 90 percent of the optimal winter solar heat gain.

✓ **Window Selection.** Heating with solar energy is easy: just let the sun shine in through the windows. The natural properties of glass let sunlight through but trap long-wave heat radiation, keeping the house warm (the greenhouse effect). The challenge often is to properly size the south-facing glass to balance heat gain and heat loss properties without overheating.

Increasing the glass area can increase building energy loss. New window technologies, including selective coatings, have lessened such concerns by increasing window insulation properties to help keep heat where it is needed.

In heating climates, reduce the window area on north-, east-, and west-facing walls, while still allowing for adequate daylight. Effective south-facing windows require a high Solar Heat Gain Coefficient (SHGC)—usually 0.60 or higher—to maximize heat gain, a low U-factor (0.35 or less) to reduce conductive heat transfer, and a high visible transmittance (VT) for good visible light transfer. SHGC refers to the portion of incident sunlight admitted through a window, and U-factor indicates the heat loss rate for the window assembly.

In cooling climates, particularly effective strategies include preferential use of north-facing windows along with generously shaded south-facing windows. Shading from landscaping, overhangs, shutters, and solar window screens helps lower heat gain on windows that receive full sun.

WINDOW RATINGS

Many windows include a National Fenestration Rating Council sticker that lists U-factors, SHGC, and VT.


National Fenestration Rating Council

AAA Window Company

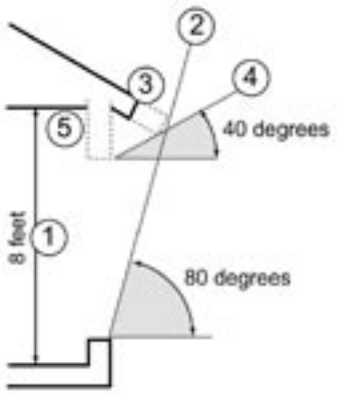
Energy Rating Factors	Ratings		Product Description
U-factor	0.40	0.38	Model 1000 Casement Low-e Argon Filled
Solar Heat Gain Coefficient	0.65	0.66	
Visible Transmittance	0.71	0.71	

Cost effective windows for cooling climates have a U-factor below 0.4 and a SHGC below 0.55 (a lower SHGC cuts cooling costs).

Wherever possible, climate-specific window property recommendations from the Efficient Windows Collaborative should be followed.

- ✓ **Suntempering.** In cold climates, a strategy termed "suntempering" orients most of the home's glazing toward the south—a glazing area of up to 7 percent of the building floor area. Additional south-facing glazing may be included if more thermal mass is built in. Such a shift in window location is a great strategy for cold climates and costs nothing beyond good planning. Many passive solar homes are merely suntempered.

SIZE SOUTH FACING OVERHANGS TO PROPERLY SHADE WINDOWS



- OVERHANG SIZING RULES:
  1. Draw the wall to be shaded to scale.
  2. Draw the summer sun angle upward from the bottom of the glazing.
  3. Draw the overhang until it intersects the summer sun angle line.
  4. Draw the line at the winter sun angle from the bottom edge of the overhang to the wall.
  5. Use a solid wall above the line where the winter sun hits. The portion of the wall below that line should be glazed.

- ✓ **Shading.** The summer sun rises higher overhead than the winter sun. Properly sized window overhangs or awnings are an effective option to optimize southerly solar heat gain and shading. They shade windows from the summer sun and, in the winter when the sun is lower in the sky, permit sunlight to pass through the window to warm the interior. Landscaping helps shade south-, east-, or west-facing windows from summer heat gain. Mature deciduous trees permit most winter sunlight (60 percent or more) to pass through while providing dappled shade throughout summer.
- ✓ **Heat Storage.** *Thermal mass*, or materials used to store heat, is an integral part of most passive solar design. Materials such as concrete, masonry, wallboard, and even water absorb heat during sunlit days and slowly release it as temperatures drop. This dampens the effects of outside air temperature changes and moderates indoor temperatures. Although even overcast skies provide solar heating, long periods of little sunshine often require a back-up heat source. Optimum mass-to-glass ratios, depending on climate, may be used to prevent overheating and minimize energy consumption (*The Sun's Joules*, http://solstice.crest.org/renewables/SJ/passive-solar/136.html). Avoid coverings such as carpet that inhibit thermal mass absorption and transfer.
- ✓ **Natural Cooling.** Apt use of outdoor air often can cool a home without need for mechanical cooling, especially when effective shading, insulation, window selection, and other means already reduce the cooling load. In many climates, opening windows at night to flush the house with cooler outdoor air and then closing windows and shades by day can greatly reduce the need for supplemental cooling. Cross-ventilation techniques capture cooling, flow-through breezes. Exhausting naturally rising warmer air through upper-level openings (stack effect; e.g., clerestory windows) or fans (e.g., whole-house fan) encourages lower-level openings to admit cooler, refreshing, replacement air.
- ✓ **Natural Lighting.** Sometimes called daylighting, natural lighting refers to reliance on sunlight for daytime interior lighting. Glazing characteristics include high-VT glazing on the east, west, and north facades combined with large, south-facing window areas. A daylit room requires, as a general rule, at least 5 percent of the room floor area in glazing. Low-emissivity (low-E) coatings can help minimize glare while offering appropriate improved climatic heat gain or loss characteristics. Sloped or horizontal glass (e.g., skylights) admit light but are often problematic because of unwanted seasonal overheating, radiant heat loss, and assorted other problems.

PASSIVE SOLAR DESIGN

For more information, contact:

Energy Efficiency and Renewable Energy Clearinghouse (EREC)
1-800-DOE-3732
www.eren.doe.gov

Or visit the BTS Web site at www.eren.doe.gov/buildings

Or visit the Sustainable Buildings Industry Council Web site at www.sbicouncil.org

Or visit the Efficient Window Collaborative Web site at www.efficientwindows.org

Written and prepared for the U.S. Department of Energy by:

NAHB Research Center
800-898-2842
www.nahbrc.org

Southface Energy Institute
404-872-3549
www.southface.org

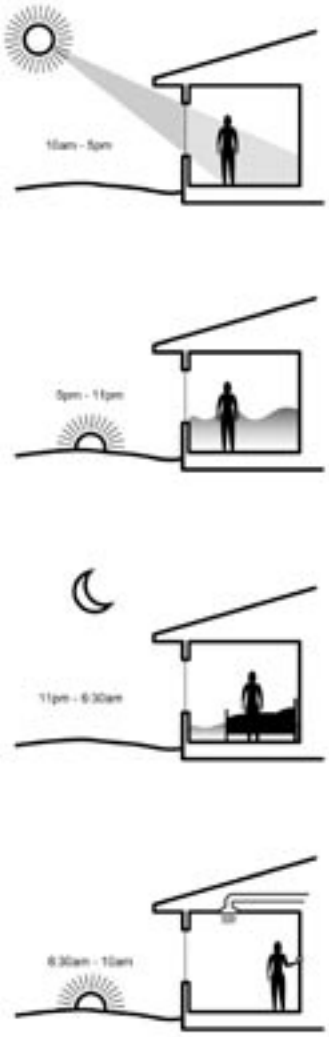
U.S. Department of Energy's Oak Ridge National Laboratory
Buildings Technology Center
423-574-5178
www.ornl.gov/ORNL/BTC

Factsheets on insulation are available from the Energy Efficiency and Renewable Energy Clearinghouse (EREC)
1-800-DOE-3732
www.eren.doe.gov

PASSIVE SOLAR DESIGN TOOLS

One of the best ways to design an energy-efficient house featuring passive solar techniques is to use a computer simulation program. Energy-10 is a PC-based design tool that helps identify the best combination of energy-efficient strategies, including daylighting, passive solar heating, and high-efficiency mechanical systems. Another tool to optimize window area and aid window selection is RESFEN. Access these and other passive solar design tools from the DOE's Office of Building Technology, State, and Community Program's website.

THERMAL MASS IN THE HEATING SEASON



10:00 am to 5:00 pm

Sunlight enters south-facing windows and strikes the thermal mass inside the home. The sunlight is converted to heat energy, which heats both the air and thermal mass materials. On most sunny days, solar heat maintains comfort during the mid-morning to late afternoon periods.

5:00 pm to 11:00 pm

As the sun sets, it stops supplying heat to the home. However, a substantial amount of heat has been stored in the thermal mass. These materials release the heat slowly into the passive solar rooms, keeping them comfortable on most winter evenings. If temperatures fall below the comfort level, supplemental heat is needed.

11:00 pm to 6:30 am

The home owner sets the thermostat back at night, so only minimal back-up heating is needed. Energy-efficient features in the home minimize heat losses to the outside.

6:30 am to 10:00 am

The cool early morning hours are the toughest for passive solar heating systems to provide comfort. The thermal mass has usually given up most of its heat, and the sun has not risen enough to begin heating the home. During this period, the home owner may have to rely on supplemental heat. Energy-efficient features in the home minimize the need for supplemental heating.

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December 2000 DOE/GO102000-0796

Green Building Services

Green Technology Brief

Daylighting

Daylighting is the controlled admission of natural light into a building through windows, skylights, atria and other components of the building envelope. Using daylight as a design strategy can increase occupant satisfaction and productivity, moderate energy usage and may enhance a building's aesthetics.

Technology Description

Daylighting usually can be included in new or existing buildings. Depending on a building's design and orientation, there are several options for bringing in light:

- Windows along a building's perimeter are the most common daylighting method.
- Skylights can be an effective retrofit option that brings in light from the top story.
- Clerestory windows work well on buildings with high ceilings, with the vertical glass bringing in low-angle light.
- Atria, glass-covered rooms, spread daylight throughout the inside. A courtyard is an atrium with no roof.
- Light shelves are reflective horizontal shelves mounted along vertical windows inside and/or outside. Light shelves double as shading devices to reduce heat and glare, and soften the natural light adjacent to the windows.

Daylit buildings may also include interior glass partitions (relights); overhangs or exterior shading devices; special reflectors, louvers or blinds; and light-colored paints and furnishings.

High-performance glazing typically is used conjunction with daylighting to help maximize visible light transmission, while reducing solar heat gain and fading of interior finishes. The building's electric lighting should be controlled by continuous dimming controls, helping to trim energy use as well as cooling requirements.

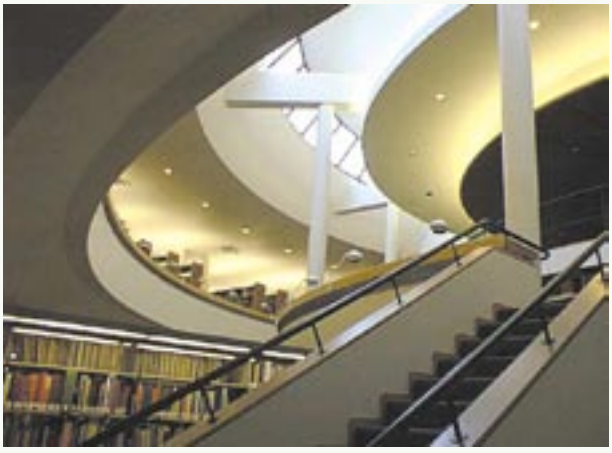
Design Considerations

The goal of a properly designed daylighting system is to admit only as much light as necessary, distribute it evenly, and avoid glare and overheating. Therefore, it's important to consult with an architect or lighting designer who is experienced in designing for daylight. Daylight analysis tools are available to help guide the design process.

The most successful and cost-effective daylighting applications are those in which daylighting has been integrated into the building's initial design. Integrated design allows the building's orientation, floor-to-floor heights, window placement and selection, lighting and mechanical systems to work together as a package that optimizes the comfort, aesthetics and long-term economics of the building.

Estimated Benefits

Daylighting offers a pleasant connection with the outdoors that is highly valued by building occupants. The presence of natural light and views elicits physiological and psychological responses that contribute to a sense of well-being and improved morale. This can translate into tangible economic benefits.



Multiple studies show that daylighting can boost the performance and productivity of building occupants by 15 to 20 percent. Consider how even a 5 percent increase in productivity can reap a significant economic return: Salary and benefits for the average employee cost about $250/sq.ft./yr. So a 5 percent productivity gain reaps savings of $12.50/sq.ft./yr. That savings approaches the average cost of rent ($15 to $30/sq.ft./yr.) and far exceeds the average cost of energy to operate a building ($1 to $3/sq.ft./yr.), as well as the average cost of building operation and maintenance ($1 to $3/sq.ft./yr.). This conservative estimate of the value of productivity gains does not even factor in the value of employee retention, boosting the economic value of daylighting even further.*

Daylighting can trim a building's lighting energy use by 10 to 30 percent when it is integrated with photosensors that dim electric lighting in daylit areas. A well-designed daylighting system can interact with a building's HVAC system in a way that can

delivers even more savings. When daylighting is integrated into building design, the reduction in lighting load often induces a reduction in the cooling load, making it possible to install a smaller mechanical system. This delivers ongoing energy cost savings and lowers the first cost and replacement cost of the mechanical system. The resulting savings* may offset the additional cost of high-performance glazing.

Estimated Costs

The cost of daylighting components ranges from $0.25 to $4/sq.ft./yr. (based on 2001 costs). However, when daylighting is properly integrated into the building design, the net cost of building design and construction can be equal or less than a conventional building. This is due to the reduced first cost and replacement cost of the smaller mechanical equipment as mentioned above in Estimated Benefits.

Financing Options

The components that contribute to daylighting in a building may be eligible for tax credits, utility rebates and accelerated depreciation depending on the system and its location.

LEED™ Green Building Rating System

Daylighting earns one LEED rating point for Indoor Environmental Quality, in addition to contributing to possible points for optimized energy performance in the LEED Energy and Atmosphere category.

LEED, which stands for Leadership in Energy and Environmental Design, is a project of the U.S. Green Building Council. The LEED Rating system is a recognized checklist of performance goals and measures that provides standardization and independent oversight for environmental performance in nonresidential building.

*Individual circumstances vary, ask Green Building Services for more information.

Projects Using Daylighting

- The Gap Headquarters, San Bruno, CA
- Norm Thompson Headquarters, Hillsboro, OR
- Wal-Mart, Lawrence, KS and numerous other Wal-Mart stores
- North Clackamas High School, Clackamas, OR
- Phillip Burton Federal Building, San Francisco, CA

Further Resources

- "Skylighting and Retail Sales: An Investigation into the Relationship between Daylighting and Human Performance," August 1999. Study performed by Heschong Mahone Group, Fair Oaks, California, for Pacific Gas and Electric Company on behalf of the California Board for Energy Efficiency, www.h-m-g.com.
- "Daylighting in Schools: An Investigation into the Relationship between Daylighting and Human Performance," August 1999. Study performed by Heschong Mahone Group, Fair Oaks, California, for Pacific Gas and Electric Company on behalf of the California Board for Energy Efficiency, www.h-m-g.com.
- Greening the Building and the Bottom Line: Increasing Productivity through Energy-Efficient Design, November 1994, Joseph J. Romm and William D. Browing. Available through the Rocky Mountain Institute at www.rmi.org.
- Illuminating Engineering Society of North America, www.iesna.org
- Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY, www.lrc.rpi.edu

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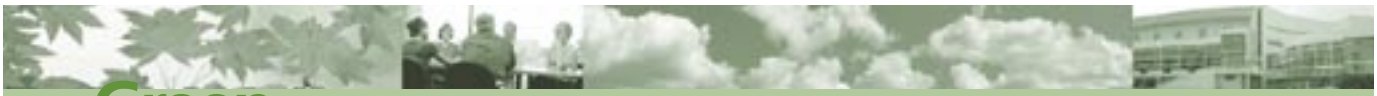

Green Building Services

Green Technology Brief

Underfloor Air Distribution Systems

An underfloor air distribution system may also be referred to as a raised-access flooring system or displacement ventilation. This innovative approach to heating, ventilating and air conditioning offers the utmost in occupant comfort and is an effective means of conserving energy. Some industry leaders believe underfloor air distribution will soon become the design standard for commercial office buildings.

Technology Description

Buildings that use underfloor air distribution have a raised-panel flooring system that is supported on vertical supports approximately 12 to 16 inches above the slab floor. The underfloor space delivers conditioned air through small, floor-mounted diffusers located in individual workspaces. High-induction swirl diffusers quickly mix the supply air as it enters the occupied zone. Air is circulated in an upward motion similar to natural convection and is exhausted through return grilles in the ceiling.

Other characteristics of an underfloor air distribution system include:

- By delivering air directly to each workspace, the HVAC system eliminates "dead zones" of air flow.
- Electrical power, telephone, data cable and other portions of the building's infrastructure are located in the underfloor space.
- Plug-in electrical boxes, power/data outlet boxes and air diffusers are flush-mounted in the floor panels and can easily be moved to accommodate reconfiguration of the workspace or floor plan.
- The surface of the floor panels can be made of a variety of materials, including carpet tiles, decorative concrete, linoleum, finished metal or wood composite.

Design Considerations

Underfloor air distribution systems can be used for whole buildings or portions of buildings. The approach requires an integrated design, making these HVAC systems appropriate for new construction and, in some cases, major renovation of older buildings with high ceilings.

With much of the HVAC system removed from the ceiling, underfloor air distribution permits a much more open ceiling design, making it easier to include indirect lighting, daylighting, light shelves and other design features in the ceiling. By reducing the size of ceiling mounted return air ducting and utilizing the underfloor cavity for the air supply, floor-to-floor heights often can be reduced by 6 to 12 inches. This can result in significant cost savings for multi-story buildings.*

Estimated Benefits

The key benefits of an underfloor air distribution system are occupant comfort, energy efficiency and space planning flexibility.

Occupants can adjust the diffusers to deliver air according to their individual temperature preferences. In addition, the upward flow of low-velocity air reduces lateral mixing compared to a conventional high-velocity HVAC system. The improved air circulation can further enhance comfort and reduce the concentration of air contaminants at the breathing level of seated occupants.

The supply air of an underfloor system is typically delivered at a higher temperature (62° F) than a conventional HVAC system (55° F). This increases energy efficiency by extending the hours that the building can be cooled with 100 percent outside air. The lower static air pressures (0.1 in. water gage vs. 3.0 in. water gage) can deliver significant cost savings as a result of downsizing supply air fans. However, care must be taken to avoid creating any obstructions to the air flow under the floor.

The raised-panel flooring permits a "plug and play" floor design and eliminates the need to hard-wire furniture systems and most walls. The components of the underfloor system are highly modular, making it much easier and less expensive to reconfigure workspaces during churn or renovation of the building. Commonly used floor panels typically weigh only 40 pounds and are easy to move or replace. The vertical supports, air diffusers, electrical boxes and data boxes can be quickly adjusted or moved by building maintenance staff.

Other benefits of underfloor air distribution systems may include increased chiller efficiency and reduced cooling load requirements.

Estimated Costs

Compared to a building with a conventional HVAC system, a building with an underfloor air distribution system can be constructed at a competitive first cost and can operate at a considerably lower life cycle cost.

The structural components of the underfloor system typically cost about $6 to $8 per square foot*. However, significant labor and capital savings result from the reduced cost of installing duct work, supply fans, electrical service and data/communication services. These savings bring the net increase in first cost down to approximately $2 per square foot (based on 1999 costs). The elimination of hard-wired furniture and partitions, if these were being considered, can reduce the unit cost of a work station by as much as $1,500, further decreasing the building's first cost and possibly delivering first-cost net savings.*

The flexibility of the system can reduce design and construction costs during churn and often eliminates the need for a specialty contractor. Churn savings can range from $3 to $5 per square foot – a substantial amount considering the U.S. churn rate now averages 33 percent annually.

Financing Options

If portions of the underfloor system qualify as a furniture system, they may be eligible for accelerated depreciation. For more information, seek the advice of a qualified tax consultant.

*Individual circumstances vary, ask Green Building Services for more information

LEED Green Building Rating System

Underfloor air distribution systems may contribute to earning one LEED™ rating point for Indoor Environmental Quality as part of an individual temperature/air flow control system. LEED, which stands for Leadership in Energy and Environmental Design, is a program of the U.S. Green Building Council. The LEED Rating system is a recognized checklist of performance goals and measures that provides standardization and independent oversight for energy and environmental performance in nonresidential building.

Projects Using Underfloor Air Distribution

- City of Portland Development Center, Portland, OR
- Alcoa Headquarters, Pittsburgh, PA
- CNF Information Technology Center, Portland, OR
- Owens Corning World Headquarters, Toledo, OH
- Stevens Hall, George Fox College, Newberg, OR
- BC Hydro Headquarters, Vancouver, British Columbia
- Wieden & Kennedy Headquarters, Portland, OR

Further Resources

- "Three Case Studies for Improved Indoor Air Quality," Environmental Design and Construction, May/June 1998, www.edcmag.com
- "The Underfloor Air Alternative," Building Design and Construction, November 1996.
- "Access Floors: A Step Up for Commercial Buildings," Environmental Building News, January 1998.
- "Innovative Underfloor System," ASHRAE Journal, March 1998.
- "Turning Air Conditioning on its Head: Underfloor Air Distribution Offers Flexibility, Comfort and Efficiency," E Source, pub. TU-95-8, August 1995.

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More than Skin Deep: Window Decisions

A Pacific Energy Center Factsheet

Pacific Gas and Electric Company.
Pacific Energy Center

Introduction

Windows are among the most critical parts of a building. They provide light and view for a pleasing visual connection to the outdoors. When they are operable, windows bring in fresh breezes. They give the building facade character, serving an expressive function inside and out. Because windows are also a significant factor in the work that the building's mechanical and electrical systems must do, it is important to design them with care and knowledge. Intelligent window design offers many energy saving benefits.

?? Good window design reduces heating and cooling equipment costs and operating costs.
?? Good window design reduces lighting costs through daylighting.
?? Well lighted spaces can increase the value of a building.

How Window Design Can Fail

Poor fenestration design can both waste energy and cause discomfort. For example, dark gray glass used for solar control is usually disadvantageous overall.

Although the glass is dark, it does only a fair job of keeping out solar heat. It also warms up in the direct sun, reaching temperatures of up to 120 deg. F and turning the window into a virtual furnace. Heat is radiated from the glass to those in the room, making them overheat on a sunny day. If a window is single pane the problem is exacerbated during cold weather.

Single-pane glass is highly conductive, so the entire exterior edge of a building fluctuates widely with changes in outdoor conditions and the HVAC system may be unable to keep up. In cold weather, the surface temperature of the glass is nearly the same as the outdoor temperature. A person sitting near the window feels chilled, no matter the indoor air temperature, since his or her body radiates heat to the cold glass. Making matters worse, a chilly downdraft results as room air touches the glass, cools, and flows down along the window pane towards that person's ankles.

Well-Integrated Window Design

Good fenestration design saves energy, increases comfort, and makes a better indoor environment. An integrated design yields appropriately sized windows with exterior shading and advanced glazing for both daylight admission and solar control. The higher

first costs of advanced glazing, exterior shading, and insulating windows, if not offset by lower mechanical system first-costs, are usually quickly recovered in reduced operating costs and higher occupant productivity due to improved comfort.

Properly sizing a window balances light, view, comfort and energy use. Floor-to-ceiling glazing is not necessary for a good view or sense of openness.

Today's advanced glazings provide good solar control and maintain visible transmittance - the best of both worlds. These glazings are spectrally selective, admitting the beneficial visible light wavelengths, while reflecting the infrared (heat) wavelengths, which otherwise would add to air conditioning load. With the addition of a light tint, also spectrally selective, the window reduces glare while still admitting plenty of useful light. An ideal glazing choice for a high performance window combines a spectrally selective tint with a spectrally selective coating, probably in an insulating unit (see below). This combination provides better solar control than the outdated dark tint describe above and looks clearer as well. Exterior shading saves even more by reducing air conditioning energy. See "Understanding Glazing Properties" factsheet.

Insulating units provide a tremendous improvement over single-pane glazings. Depending on the application, these windows can use various combinations of double- triple-pane glass, an insulating gals fill (argon or krypton), and framing materials chosen to reduce conductive heat losses around the window edges. For even better performance in all construction types, add low-emissivity coatings, which reflect long-wave radiant energy (heat), to further enhance energy performance and comfort. Comfortable occupants are generally more productive and less likely to bring in energy-consuming fans and heaters.

Finally, a well-integrated design incorporates electric lighting systems that take advantage of the additional daylight provided by a window with high visible transmittance. Such a lighting system uses bi-level switching, dimming, and/or photocell controls to turn lights off or down when daylight is available. The potential energy savings are substantial, since up to 50% of electricity use in a commercial building goes to lighting and the air conditioning required to remove the heat from lights.

Details

?? Size windows to provide adequate light without burdening the mechanical system. Windows are oversized far more often that undersized. Use a mechanical engineer to assess the thermal impact of your windows and reduce glazing areas where possible.
?? Evaluate the concept of view. An all-glass wall may not be the best way to celebrate a grand view. Consider viewing angles from various positions in the space plan. If windows are not providing light or view to the occupants, then their only influence is a negative one on the mechanical system.
?? Select a glazing that best balances all aesthetic, performance, and comfort needs.

- ?? Don't forget that sill depth and color affect incoming daylight. A deeper sill provides a diffusing surface for daylight and helps reduce glare. Light colors reflect daylight better than dark colors.
- ?? Consider incorporating an exterior shading strategy, which can be anything from self-shading via thick walls, to a simple overhang, to a complex, operable louver system. Exterior shading is the best way to keep the sun's heat out of a building.
- ?? Interior window treatments are an important part of the fenestration system. If the shades, drapes, or blinds are light colored, they have a beneficial impact on cooling, as they will reflect some solar energy back out the window. If the interior coverings are dark, there is little or no reduction in heat gain. Interior treatments are also a way for occupants to adjust window brightness to suit their own visual comfort needs. Window glare reflected in computer screens can be a serious problem. Provide personal control of the glare for each occupant rather than universally treating the entire building with very dark glass.
- ?? Consider the potential for glare due to brightness of windows or incoming direct solar beams. Bright windows create serious discomfort when the eye tries to balance bright surfaces with the relatively dim surfaces elsewhere in the room. Brightness glare is more difficult to combat than that from a lighting fixture, as the window is directly in the field of view rather than in the ceiling plane. The solution for brightness glare combines glazing treatment, shading, window coverings, and space planning. Select a glazing with a reduced visual transmittance (although not too low to preserve daylight), use exterior shading to prevent sunlight from directly striking the glass, use interior window coverings to provide occupant control, and position work stations to best shield light-sensitive activities from a direct view of the window.
- ?? Work with a lighting or electrical designer to consider daylighting the building. When windows are used properly electric lighting can be offset during daylight hours. A lighting designer understands how to integrate daylighting, lighting systems, and photocell controls to automatically adjust the lighting when daylight is present.

For More Information

Contact your PG&E representative or call 1-800-468-4743 for more information about PG&E's energy efficiency programs and other services.

On-site Power Generation

MODULE 9

Small-scale power systems may have particularly strong potential in Indian Country, where more than 14 percent of homes are without electricity. Some Indian families pay as much as 20 percent of their income for electricity. In contrast, less than 2 percent of the homes in the United States have no electricity.[1] While power generation may not be a priority consideration for most projects, changing technologies, price swings, or new incentive programs could arise at any time to make these approaches increasingly economical.

This module focuses on small-scale power generation systems that might be appropriately integrated with Tribal building projects. The economics of large-scale power ventures may be entirely different. Energy efficiency strategies are covered in Module 8.

This module focuses on renewable energy-based power systems, which have very significant environmental benefits since they displace the use of fossil fuels. For example, California generates more than 10 million megawatts of wind energy per year. This reduces emissions of sulfur dioxide by 140 tons and nitrous oxide by more than 1,700 tons. Greenhouse gas generation is reduced by more than 1.6 million tons.[2] In an era of potential energy shortages and concerns about traditional conventional generation impacts, small-scale renewable systems can contribute greatly to a more efficient means of powering Tribal economies and the California economy as a whole.

Small-scale renewables-based power systems are in a class of their own, compared to the other sustainable building strategies discussed in this guide. They require an additional capital investment that may be quite significant. These technologies require qualified expertise to build and, to varying degrees, to operate. The systems with the highest potential for single homes or buildings are photovoltaics, solar hot water, and wind.

On-Site Power Generation Strategies

✓ Maximize energy efficiency before considering on-site power generation.

✓ Evaluate the feasibility of small-scale renewables-based power generation, including:

- **Photovoltaics.**
- **Wind turbines.**
- **Micro-hydro systems.**
- **Solar thermal.**
- **Biomass.**
- **Fuel cells.**

Maximize energy efficiency before considering on-site power generation.

Except where Tribes are considering on-site power generation as a commercial venture, they should first maximize energy efficiency before making final decisions about on-site power generation. The life-cycle costs of reducing energy needs often far outweigh the life-cycle costs of generating power. For example, it is much cheaper to spend scarce funds on compact fluorescents for your building, rather than buy photovoltaic panels or wind turbine capacity to run less efficient standard light bulbs. Energy conservation, however, will not eliminate the power needs of buildings. Once the actual energy needs have been determined (and reduced as much as possible), on-site power generation can be evaluated.

Photovoltaic Systems

Solar photovoltaic (PV) cells are thin film semiconductors produced in layers from silicon and other conductive materials. When sunlight strikes the PV cell, chemical reactions release electrons, generating electric current. Each PV module contains many cells and produces a small current that can power individual homes and businesses, can connect directly to the mainstream power grid, or can be stored in battery arrays.

Photovoltaics can be installed in an array separate from any building structure or integrated into the structure directly, sometimes in ingenious ways. One option is traditional panels that can be installed on roofs. Another option is integrated panels that serve as both roofing shingle and PV panel. Yet another option is a transluscent version that can be used unassumingly with green houses, glass roofs, and skylights. A new product by Toshiba consists of titanium dioxide nanocrystals coated with a dye. This product is manufactured using silk screen printing techniques. Small systems supported by California's solar incentive programs have been averaging $7.00 per watt after rebates.[3]

To be a candidate for a PV system, the building property should have a clear, unobstructed access to the sun for most of the day and be free from shade. A south facing roof with integrated composition PV shingles may be the easiest and most efficient type of system. Nationally, the Million Solar Roofs program begun by President Bill Clinton in 1997 supported the installation of 70,000 PV systems by the end of 1999. In California, a variety of incentives help promote PVs and other renewable technologies.

Photovoltaic system costs vary, depending on the size of the system and the type of components used. A simple 2-kilowatt system that could offset about 60 percent of an average California home's electricity demand may cost $16,000 to $22,000, or $8 to $11 per installed watt, not including State incentives. Including an $8,000 State rebate ($4 per watt) and a 15 percent State tax credit, the final installed cost may be about $7,000 to $11,000. A qualified PV firm should install the system, but once installed maintenance costs are very low.

Net Metering—A Key to Renewable-Based Power Generation

Net metering allows homes and other buildings to generate renewable-based power and send it directly into the power grid. This eliminates the need for on-site storage in battery systems and greatly benefits the economics of small power systems, making the overall power grid more efficient. In the best systems, the power meter runs backwards when excess power flows into the grid. In other utility systems, power flowing into the grid is credited at the utility's "opportunity cost," the price they would pay for the power from other sources, which is far less attractive to the system owner.

PAYBACK PERIODS – PHOTOVOLTAIC PANELS

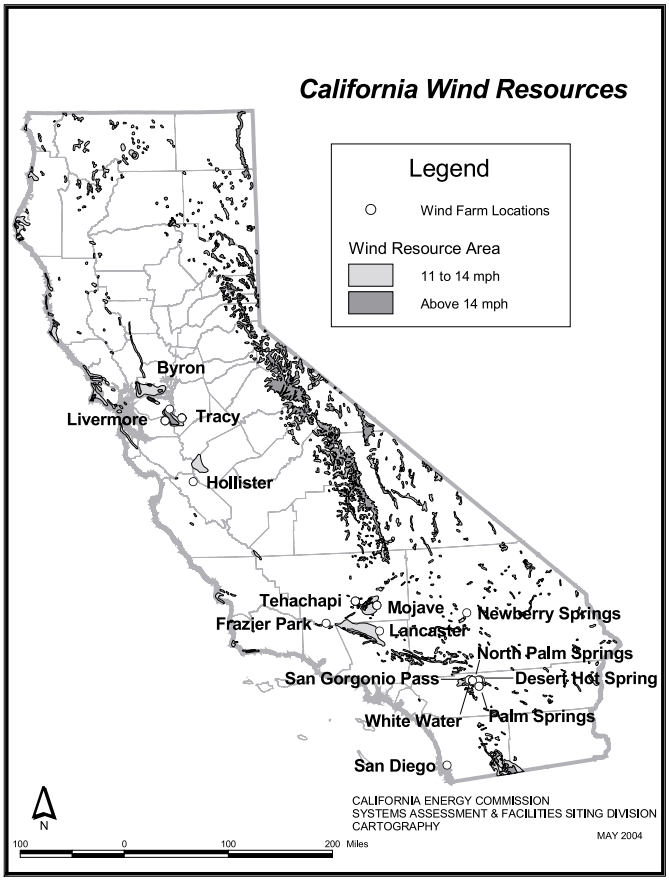
Estimating photovoltaic (PV) life-cycle costs and payback periods can be complex. Systems vary tremendously in size and cost, and the amount of electricity generated depends on the location and orientation of the system. In off-grid environments, PVs may be the most cost-effective way to provide electricity. In on-grid environments, PVs may not be directly competitive but can be grid-connected to feed "excess" power back to the grid through a "net metering" arrangement. Special financing programs like subsidies and tax credits vary as well.

Notwithstanding these challenges, the National Renewable Energy Lab (NREL) estimated typical payback periods for photovoltaics in the United States based on 1999 commercial energy prices.[4] The analysis assumes electricity production from photovoltaics varied with latitude and assumed a cost of $10,000 per kilowatt installed. Most of California was estimated to have photovoltaic payback periods of 50–80 years and the remainder of 20–50 years. Only one place in the country, a small area of North Dakota, was identified as having payback periods of less than 10 years. It is important to note that these estimates are based on 1999 electricity prices. Subsidies and tax credits may have an impact on the payback period in a given area. PV costs are becoming more competitive and the technology is constantly improving.

Higher energy prices than those used in the NREL estimates would result in shorter payback periods, as would more extensive subsidies or tax credits than those used in the NREL estimate. Another important assumption in NREL's analysis is the need for batteries, which can be eliminated through participation in a net metering program. (See box below.) A more thorough evaluation of photovoltaic systems would consider the costs of producing the photovoltaic system itself, including the energy needed to produce the photovoltaic panels. This analysis would take into account the greenhouse gas emissions avoided by producing electricity from sunlight rather thanby burning fossil fuel. Disposal costs of PV panels and batteries would also need to be considered. The direct and indirect impacts on ecosystems and natural resources would be different between a photovoltaic system and fossil fuel or other means of generating the same amount of electricity.

Wind Turbines

Small wind turbines (usually producing less than 10 kilowatts of electricity) can be used to generate electricity in homes and small businesses. A typical 10-kilowatt home system may be about 100 feet tall, with a blade diameter of about 20–25 feet and may cost $25,000–$35,000 to install. Depending on the amount of wind available, it will produce between 10,000 to 18,000 kilowatt/hours (kWh) per year. Homes sitting on a 1-acre parcel could probably accommodate such a turbine, depending on local zoning restrictions.[5] The smaller turbines today are fairly efficient, producing electricity in winds as low as 7 to 10 mph. They are also fairly quiet. Wind systems can be designed to generate power at the same voltage as homes use, so the turbine can be wired directly to the home or business electrical system like an appliance. To be a candidate for a wind system, your site must have adequate winds and be feasible from a local permitting perspective (check local ordinances, zoning, and building codes).



CALIFORNIA WIND RESOURCES MAP
www.energy.ca.gov/maps/wind_map.html

WIND TURBINES – PAYBACK PERIOD

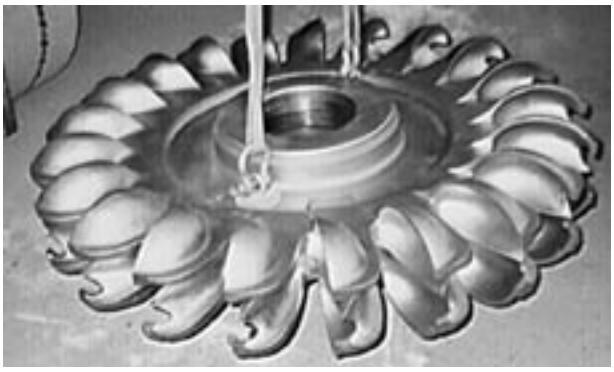
Under some circumstances, wind turbines may have a shorter payback period than PVs. For example, a small 1.5 kW wind turbine might cost $15,000 and, in a Class II wind area (one that averaged 12.5 mph at a height of 50 meters, as is the case in many California coastal and mountain locations), it could generate about 1,080 kWh per year, approximately enough to meet the electricity needs of one house. Assuming electricity costs 10 cents per kWh, the value of the electricity generated by this wind turbine would be $1,080 a year, and the payback period about 14 years. This payback period would vary for different wind class areas. As with PV systems, subsidies or tax credits would shorten the payback period. In locations that are not currently tied into the grid, wind turbines might avoid significant transmission line extension costs. For locations that are tied into the grid, net metering may be an option, which can reduce system costs and maximize the payback period. PV systems have life-cycle costs and benefits not included in the above example. In addition, ecosystem and natural resource impacts of wind turbines would be different than other means for generating the same amount of electricity.

Larger systems can have an even shorter payback period. For example, a 600 kW wind turbine might cost $585,000. Operating an average of 50 percent of the time, it could generate approximately 2.3 MWh annually, enough electricity to supply roughly 200 homes. If electricity were sold at 6 cents per kWh, this would result in $157,680 and a payback period of less than four years. If this wind turbine were financed through a loan at 8 percent interest, and assuming semi-annual payments of $78,840, then the loan would be paid off in approximately four and one-half years.[6]

Micro-Hydropower Systems

If the Tribe has access to an elevated body of water such as a stream or pond on the building site, micro-hydropower systems might be worth investigating. Hydropower systems of all types work according to the same principles. Water stored behind a dam flows through a narrow pipe called a penstock and is forced onto the blades of a turbine, connected to an electricity generator. The efficiency of such systems can be close to 90 percent. Micro-hydropower facilities often use small dams constructed of earth, concrete, and/or steel. Of the roughly 2,000 private hydro facilities in the United States, about 89 percent can be categorized as small hydro. While even small dams may create secondary benefits such as flood control, recreation opportunities, and water storage, hydropower also has negative impacts, and smaller facilities doesn't necessarily mean smaller impacts. Hydro plants along small rivers or streams may be harmful to fish and other aquatic species. The Low Impact Hydropower Institute certifies environmentally responsible "low impact" Hydropower systems. In order to be certified by the institute, a hydropower facility must meet criteria in the following eight areas:

- River flows.
- Water quality.
- Fish passage and protection.
- Watershed protection.
- Threatened and endangered species protection.
- Cultural resource protection.
- Recreation.
- Facilities recommended for removal.



A HYDROELECTRIC TURBINE

Solar Thermal Systems

Two types of solar thermal systems are available. The most familiar type is hot water heating systems used to pre-heat water on rooftops, reducing the load on conventional water heaters. More than one-half million solar hot water systems have been installed in the United States, mostly on single-family homes, the majority used to heat swimming pools. Typically, a homeowner relying on electricity to heat water could save up to $500 in the first year of operation by installing a solar water heating system. This system may pay for itself in four to seven years. The cost of solar water heating systems declined by about 30 percent between 1980 and 1990, and California's incentive progams make solar even more attractive.

The second type of solar thermal power system involves concentrating the sun's rays and increasing water temperature sufficiently to generate steam and drive an electric generator. This is the technology used at the largest centralized solar power generating facilitiy in the world, located in the Mojave Desert. The plant generates 360 megawatts, enough to power 360,000 homes. This type of solar thermal power system probably does not lend itself to small-scale facilities.

Biomass Power Systems

Biomass consists of organic residues from plants and animals that are obtained primarily from harvesting and processing of agricultural and forestry crops. Of the three ways to generate power from biomass in small facilities, the first, and probably the only biomass option appropriate to most building sites, is the fireplace. While they create an inviting aesthetic, they are relatively inefficient and contribute to local air pollution. Using highly efficient fireplaces with easily controllable dampers, glass or metal doors and heat shields, and recirculating fans can greatly improve fireplace efficiency.

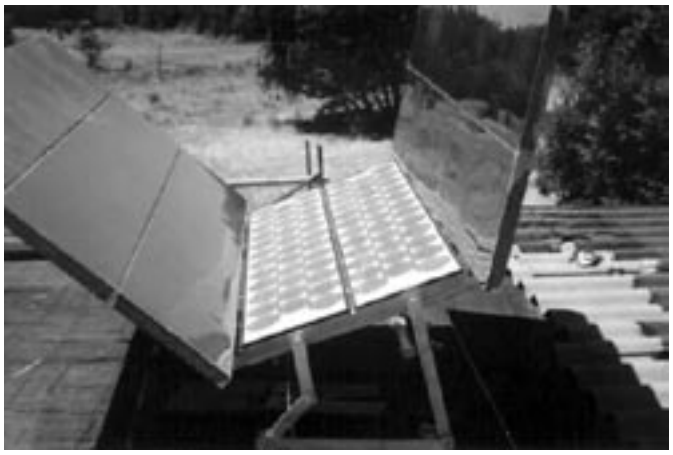
The second type of biomass power is biomass thermal electricity, used widely in California by commercial wood waste burning facilities. This method is probably not suitable to small-scale operations unless tied to agricultural or some other commercial activity producing steady streams of biomass.

The third type is burning digester gas produced from organic materials. Anaerobic digestion is a biological process that produces a gas principally composed of methane (CH_4) and carbon dioxide (CO_2) otherwise known as biogas. Energy production from biomass gas is done commercially at several landfills, and some forms have successfully experimented with small-scale biogas

operations. An example is Royal Farms No. 1 in Tulare, California, where hog manure is slurried and sent to a covered lagoon for biogas generation. The collected biogas fuels a 70-kW engine generator and a 100-kW engine generator. Many anaerobic digestion technologies are commercially available and have been demonstrated for use with agricultural wastes and for treating municipal and industrial wastewater. Due to capital costs and the complexity of the technology, biogas is best suited to a dedicated commercial facilitiy tied to a unique source of organic raw material generated through the Tribe's building project. For Tribes interested in exploring biomass options, California's Public Interest Energy Research (PIER) Program provides technical and financial assistance.

RENEWABLES TO POWER CALIFORNIA TRIBE

The Ramona Band of Cahuilla Mission Indians is the first tribe seeking to bring its entire reservation off-grid, using renewable energy as the primary power source, including a 65–80 kilowatt-hours per day central wind-photovoltaic-propane system to power the reservation's housing, offices, ecotourism, and training businesses. The electricity will be distributed through an underground mini-grid. The tribe's cultural and economic development strategy is to establish a renewable energy-powered ecotourism business on the reservation. A secondary goal is to demonstrate how renewable energy power systems can be used to eliminate the environmental impact of electric grid power lines on Indian lands, National Forests, National Parks, other protected areas, and the general rural environment. Up to 90 percent of the electrical and thermal energy needed to power tribal housing, offices, eco-tourism, and training businesses will come from wind or solar energy. Propane will be used as a back-up energy source. Revenues to support the project in the long term will come primarily from tourism and training, not energy sales. Planning, research, and fund raising for this project have been underway for three years, and the project is currently in the design phase. The Department of Energy, Department of Housing and Urban Development, U.S. Department of Agriculture Rural Development, and Bureau of Reclamation have contributed funding and technical resources to the project. The Tribe is also working closely with the U.S. Forest Service and Bureau of Land Management on land use and resource management in the area.[7]



Fuel Cells

Fuel cells are a very promising technology whose time has not quite come. Fuel cells are highly efficient systems for storing and using hydrogen energy. The technology dates back to the 1800s, but not until the end of the 20th century were fuel cells used successfully in space craft to provide electricity and water. The technology can be used to make electricity to power vehicles, homes, and businesses. Energy is required to access hydrogen sources, and if renewable energy is used, a fuel cell can be considered a renewable energy source. In California, fuel cell electricity systems using renewable resources are eligible for funding under the State's Emerging Renewables Rebate Program.

Unlike conventional technologies, fuel cells don't "burn" their fuel, they use a chemical process that relies on hydrogen. A fuel cell system that includes a "fuel reformer" can obtain hydrogen from any hydrocarbon fuel: natural gas, methanol, and even gasoline. Other possible fuels include propane, hydrogen, anaerobic digester gas from waste water treatment facilities, and landfill gas. Fuel cells are being designed for use in stationary electric power plants to provide reliable, clean, high-quality electricity for distributed power generation. Eventually, smaller fuel cells will be sold for use in homes, most of which will connect to natural gas supplies. But because these are not yet available, fuel cells remain a future possibility for Tribal building projects.

California's Incentives for Renewable Energy

In February 2003 the California Energy Commission established the California Emerging Renewables Incentive Program, consolidating several previous incentives for solar and other renewables based systems. The State is pushing to replace conventional energy sources with renewables, and more than $100 million is allocated for rebates for renewable energy systems less than 30 kilowatts in size.

As sovereign nations, Tribes may not always benefit directly from additional tax incentives, but these elements may be useful to Tribal projects involving partners subject to State tax. The California Franchise Tax Board administers a tax credit for solar and wind systems in consultation with the Energy Commission. The credit is equal to 15 percent of the purchase price—or $4.50 per installed watt, whichever is less—for systems of less than 200 kilowatts. The credit is currently set to be reduced to 7.5 percent in 2004 and to sunset in 2006, but it may be extended. A State property tax exemption is also available for solar electric and wind systems.

A Plan for Indian Energy Self-Sufficiency

The Council of Energy Resource Tribes (CERT) is comprised of 49 federally recognized American Indian Tribes and four Canadian First Nations. CERT crafted a vision that simply states every Tribe in the country should have the ability to secure sufficient energy to support their economic and social well being by the year 2010. The strategy has three components:

- Access low-cost federal hydropower produced from federal water projects in the west.
- Implement strict energy management and conservation measures to reduce energy use.
- Develop new generation with an emphasis on renewables.

More information is available at www.certredearth.com/.

Source: Council of Energy Resource Tribes, "A National Conference to Define Sustainability from a Tribal Perspective," March 21–22, 2002.

Hopi Solar Electric Enterprise—Native Sun

The Hopi Solar Electric Enterprise/Native Sun was established in 1985 by the Hopi Foundation to assist Native American families living in isolated locations who do not have access to electricity. Currently, Native Sun serves the Hopi community and the Navajo Nation, as well as local non-Indian landowners. Native Sun has installed more than 300 solar electric systems. Native Sun has a revolving loan program to assist homeowners in purchasing systems, which usually range from two to eight panels (100–600 watts). Although originally established with foundation grants, the program is moving towards economic self-sufficiency.

Contact: Debby Tewa,
The Hopi Foundation,
P.O. Box 705,
Hotevilla, AZ 86030,
(520) 734-2380.

RESOURCES

General Energy Resources

California Energy Commission (CEC)
www.energy.ca.gov

CEC Renewable Energy Programs and Rebates (Slide Show)
www.energy.ca.gov/renewables/presentations/2003-08-12_ENERGY_EXPO.PDF

CEC Emerging Renewables Program
www.energy.ca.gov/renewables/emerging_renewables.html

CEC Clean Power Estimator
www.consumerenergycenter.org/renewable/estimator/index.html

Home Power Magazine
www.homepower.com/

Public Renewables Project
www.repartners.org/natlactres.htm

Rocky Mountain Institute
www.rmi.org/

Renewable Energy Choices Web site: www.consumerenergycenter.org/renewable/index.html

ABS Alaskan (Home Power vendor)
www.absak.com/

California Department of Energy Consumer Guide to Renewable Energy
www.eere.energy.gov/power/consumer/

California's Emerging Renewables Incentive Programs
www.consumerenergycenter.org/erprebate/index.html

Energy Resources Related to Indian Tribes

Tribal Environmental Resource Center Renewable Energy Links
www4.nau.edu/itep/renew_energy.html

U.S. Department of Energy, Tribal Energy Program
www.eere.energy.gov/power/tech_access/tribalenergy/about.html

"Energy Consumption and Renewable Energy Development Potential on Indian Lands," Energy Information Administration, 2000.
http://wire0.ises.org/wire/Publications/Research.nsf/0/2573209718D564D1C125690E004C6DF2/$File/ilands.pdf

Dean Suagee, "Renewable Energy in Indian Country Options for Tribal Governments," Renewable Energy Policy Project (REPP) Issue Brief No. 10, May 1998
http://solstice.crest.org/repp_pubs/articles/issuebr10/issuebr10.html

Photovoltaics

National Renewable Energy Laboratories, Photovoltaics for Buildings
www.nrel.gov/buildings/pv/c_finance.html

"A Consumer's Guide to Buying a Solar Electric System," Department of Energy, 1999.
www.nrel.gov/ncpv/pdfs/26591.pdf

Biomass

CEC, Wood Heat in the Home
www.consumerenergycenter.org/homeandwork/homes/inside/heatandcool/fireplaces.html

Wind Turbines

National Wind Technology Center
www.nrel.gov/wind/

American Wind Energy Association
www.awea.org/default.htm

Small Wind in California
www.awea.org/smallwind/california.html

Hydro Power

Low Impact Hydro Power Institute
www.lowimpacthydro.org/

BOOKS

Anne Grete, *Solar Energy Houses: Strategies, Technology, Examples*, London NWI Ohj.Ulc, James & James, 1997.

Active Solar Heating Systems Design Manual, American Society of Heating Refrigeration and Air Conditioning Engineers (ASHR), 1988.

Adi Pieper, *Easy Guide to Solar Electric for Home Power Systems*, Santa Fe, NM, ADI Solar, 1999.

Solar Living Sourcebook: *The Complete Guide to Renewable Energy Technology and Sustainable Living*, Doug Pratt, ed., Real Goods Solar Living, 1999.

Paul Gipe, *Wind Power for Home and Business: Renewable Energy for the 1990's and Beyond*, Real Goods Solar Living, 1993.

NOTES

[1] "Indian Country Energy Needs Bound for Congress," Indian Country Today, August 12, 2000. www.indiancountry.com/?876

[2] California Energy Commission.

[3] California Energy Commission.

[4] National Renewable Energy Lab, http://nrel.gov/gis/femp_maps.html

[5] California Energy Commission.

[6] This example is based on information at www.windpower.org.

[7] Source: Karen Kupcha, Tribal Administrator, (760) 365-1373.

solar frequently asked questions

Are you thinking about generating your own electricity? Here are some Frequently Asked Questions that can help you decide if investing in a solar electric system is right for you.

Q - What is a solar electric or photovoltaic system?

Solar electric or photovoltaic (PV) systems use the sun's energy to make electricity. PV technology produces direct current electricity by collecting electrons freed by the interaction between sunlight and the semiconductor materials in a PV cell.

Q - Why should I consider buying a PV system?

A PV system reduces or eliminates the amount of electricity you purchase from your utility or electric service provider. A PV system can save you money on your electricity bill and act as a hedge against future price increases. The electricity generated by your PV system is clean, renewable and reliable. You help your community by reducing the load on the utility grid and you can provide additional electricity for the grid when you generate more than you use during the day, when electricity demand is highest.

Q - Do I have a good site for PV?

Your site must have clear, unobstructed access to the sun. Buildings, trees or other vegetation should not shade your site. South-facing roof exposure is best, but roofs facing east and west may be OK. If a rooftop is not available, your PV system can also be mounted on the ground.

Q - What should the size of my PV system be?

You can match the size of your system to your electricity needs and budget. The average household in California uses about 6,500 kilowatt-hours (kWh) per year. If your usage is typical of the average household, a system in the 3 to 4 kilowatt (kW) range would be adequate to meet most of your electricity needs.

To estimate the best system size for your home or business, examine your electricity usage for the last 12 months and apply this easy formula.

* A system with a capacity of 1 kW can produce about 1750 kWh per year. Divide your annual electricity usage (in kWh per year) by 1750 kWh to get the system size (capacity in kilowatts) that would meet most of your electricity needs. If you want your PV system to meet half of your electricity needs, then you should size it to meet half of your annual electrical usage. Or you can offset only a small portion of your electricity bill with a single PV panel. If you size your system larger than your average electricity needs, for example to meet your highest electricity needs on summer afternoons, your system would generate more electricity than you could use during the rest of the year.

Q - How much mounting space do I need?

A small PV system can use as little as 50 square feet. A larger system, to meet the needs of a typical household, would use between 300 to 600 square feet. As a rule of thumb, 100 square feet of PV panels produces about one kilowatt of electricity.

Q - Are there any special features I should consider?

An inverter is needed to change the direct current (DC) power from the solar panels into alternating current (AC) electricity to power your electrical devices and to be compatible with the electric grid. Batteries can provide back-up power for your home or business in case of grid outages, but they also increase your costs.

Q - How much does a PV system cost?

Although many factors affect the cost, an average PV system costs from $9 to $10 dollars a watt, including installation, or $18,000 to $20,000 for a 2 kW system.

Q - Are there any financing programs available?

The best way to finance a PV system for your home is through a mortgage loan that includes a primary mortgage, second mortgage or home equity loan secured by your property. If mortgage financing is not available, look for other sources such as conventional bank loans. A list of companies that finance PV systems can be found on the Comsumer Energy Center website at http://www.consumerenergycenter.org/erprebate/financing.html .

Q - What do I need to know about conecting my PV system to the grid?

You will need to enter into an Interconnection Agreement with your utility. This agreement addresses the terms and conditions under which your system will be safely

connected to the grid. The agreement also specifies the metering arrangements (called Net Metering). Net Metering allows you to ³bank² any surplus electricity your system generates on the electric grid.

Excess electricity might be generated during the day when your system produces more electricity than you need. Your meter would simply run backwards to record the amount of electricity banked on the grid. You can use an equal amount of electricity later without incurring any additional cost. If you use more electricity from the grid than you have banked, your utility will charge you annually for the difference. (Please refer to the Energy Commission's ABC's of Net Metering for more information.)

Q - How do I find a PV retailer?

The California Energy Commission provides a list of PV retailers . You should also check with the California Solar Energy Industries Association (see address below). Retailers either can provide installation or can refer you to installation contractors in your area. Try to find a company located in the area where your system will be installed. Price is only one factor when selecting a PV company and/or contractor.

Here are some other considerations:

Does the company have experience installing grid-connected systems?

How many years has the company been in the business of installing PV systems?

Does the company use licensed California contractors?

Does the company have any judgments or liens against it?

Will the company provide references of previous customers?

If you get more than one bid, make sure that the bids are for the same system.

Q - how can I get more information?

Additional information about solar energy can be obtained from:

California Solar Energy Industries Association
Phone: 1-800-225-7799
Website: www.calseia.org
Top of Page

Q & A About Net Metering

Did you know that Net Metering could save you money on your electric bill? Here are some answers to commonly asked questions about how net metering works and what it could mean for you.

What is Net Metering?

Net Metering measures the difference between the electricity you buy from your utility and the electricity you generate using your own solar or wind generating equipment. Your meter keeps track of this difference as you generate electricity and take electricity from the electricity transmission grid. When you generate more than you use, your electric meter spins backward!

Am I Eligible?

You are eligible for Net Metering if you are a residential or small commercial electricity customer in California, and generate at least some of your electricity using solar or wind energy, or a combination of both, with a system capacity of one megawatt or less. Your electric generating system must be located on your premises and connected to the grid.

How does Net Metering work?

Net Metering is a special metering and billing agreement between you and your utility or electric service provider (ESP). Normally your electric meter spins forward as it measures how many kilowatt-hours of electricity you buy, and is read by your utility once a month.

A Net Metering agreement allows you to use the electricity you generate first, reducing what you would normally buy from your utility or ESP. If you generate more electricity than you use, the excess goes through your electric meter and into the grid, spinning your meter backward. Your meter shows the net amount, measured as the difference between the electricity you generate and the electricity you purchase from your utility or ESP.

What are the benefits of Net Metering?

Net Metering is a simple way to get the full value of the electricity you generate. For example, if you are a residential customer, you may not be home during the day when your system generates electricity. Net Metering allows you to "store" this excess electricity on the grid, reducing or offsetting the electricity you would otherwise have to purchase.

Another benefit of Net Metering is the "baseline" rate you are charged for the net electricity you consume. The baseline is a given amount of electricity for your home or business; you are charged a lower rate for each kilowatt-hour of electricity you consume below the baseline, and a higher rate above it. If your system is sized to offset most of your electricity needs, you are charged a lower rate for the minimal electricity you purchase from your utility if your annual net consumption falls at or below baseline.

Net Metering offers additional benefits, depending on the size of your generating system. If you purchase a smaller, less expensive system, you can still offset most or all of your electricity needs because of the higher value of your excess electricity. If you purchase a larger system, you can "bank" or store your excess electricity on the grid and offset all of the electricity you would otherwise purchase from your utility or ESP.

How will I be billed under Net Metering?

Your utility will continue to read your meter monthly. Under a Net Metering agreement, you will receive a monthly statement indicating the net amount of electricity you consumed or generated during that billing period.

On the anniversary of your agreement, you will be billed for the net electricity you consumed for the previous twelve months. You may request the option of monthly billing. Depending on the type of agreement you have, your meter

Common Misconceptions About Net Metering

1. If my generating system produces more electricity than I need, my electric service provider must buy it from me.

Wrong: ESPs may, but are not required to, purchase any excess electricity you produce at the end of each year of your net metering agreement. State law specifically states that your ESP does not have to buy your net generation. However, some ESP, especially those specializing in selling "green" electricity, may be willing to buy your excess solar or wind electricity for resale to their other customers.

2. My electric service provider will pay me full retail rates for my excess electricity.

Wrong: If they are willing to buy this "net" annual generation, they do not have to pay you full retail prices for it. While the actual rate paid would be up to the ESP, it would likely be less than retail and closer to "wholesale" rates, which are much lower.

3. I will have to spend hundreds of dollars on special meters, inspections or fees to get my system hooked up to the electric grid.

Wrong: You are only responsible for having a simple, bi-directional meter, the type you probably already have. If your generating system meets national safety and performance standards, you cannot be charged for additional tests, certification or fees.

4. The kilowatt-hours of electricity I might still need to buy from an ESP will cost me more than before I became a net metered customer.

Wrong: Your ESP cannot charge you anything extra for being a net metered customer and no charges can be imposed on the electricity you generate.

Most electricity customers are not aware that, as a result of the recent deregulation of utilities here in California, their old electric utility no longer exists. It has now been replaced by two companies to bring them electricity, an "electric service provider" or "ESP" and a "local distribution company" or "LDC." This change is similar to the deregulation of telephone services twenty years ago. That deregulation meant that the company that sells you long distance telephone service may now be a different company from the company that maintains and owns the telephone wires into your home. This is now the same case for electricity, where the company that supplies the electricity that you purchase, your "ESP," may be a different company than the one that owns and maintains the power lines to your house, which is your "LDC." Your old utility company is most likely still your LDC and may also be your ESP, unless you have chosen to buy your electricity from one of the many new electric service providers that have been formed to market electricity. With net metering, the metering arrangement is with your ESP, while the details of how your generating system must be safely connected to the electrical grid is handled by your LDC.

might show a credit during some or all billing periods, even though the actual kilowatt-hours you generate and consume are equal.

Your utility is not required to pay you or credit your account for your excess generation each year, but it might do so. Contact your utility or ESP to discuss the option of negotiating rates for purchasing excess generation. If your current utility or ESP does not purchase excess electricity, you may contract with another company that will agree to purchase it.

What size should my generating system be?

To be eligible for a Net Metering agreement in California, generating systems cannot have a peak power output of more than one megawatt. Although a minimum size is not required, most residential systems range between two and four kilowatts. Your system size will depend on your needs and how much electricity you want to generate. You can also build your system by starting small and expanding over time. As long as your total system output is not greater than one megawatt, this modular approach is still allowable.

Common Misconceptions About Net Metering

1. If my generating system produces more electricity than I need, my electric service provider must buy it from me.
Wrong: ESPs may , but are not required to, purchase any excess electricity you produce at the end of each year of your net metering agreement. State law specifically states that your ESP does not have to buy your net generation. However, some ESP, especially those specializing in selling "green" electricity, may be willing to buy your excess solar or wind electricity for resale to their other customers.

2. My electric service provider will pay me full retail rates for my excess electricity.
Wrong: If they are willing to buy this "net" annual generation, they do not have to pay you full retail prices for it. While the actual rate paid would be up to the ESP, it would likely be less than retail and closer to "wholesale" rates, which are much lower.

3. I will have to spend hundreds of dollars on special meters, inspections or fees to get my system hooked up to the electric grid.
Wrong: You are only responsible for having a simple, bi-directional meter, the type you probably already have. If your generating system meets national safety and performance standards, you cannot be charged for additional tests, certification or fees.

4. The kilowatt-hours of electricity I might still need to buy from an ESP will cost me more than before I became a net metered customer.
Wrong: Your ESP cannot charge you anything extra for being a net metered customer and no charges can be imposed on the electricity you generate.

ESP vs. LDC

Most electricity customers are not aware that, as a result of the recent deregulation of utilities here in California, their old electric utility no longer exists. It has now been replaced by two companies to bring them electricity, an "electric service provider" or "ESP" and a "local distribution company" or "LDC." This change is similar to the deregulation of telephone services twenty years ago. That deregulation meant that the company that sells you long distance telephone service may now be a different company from the company that maintains and owns the telephone wires into your home. This is now the same case for electricity, where the company that supplies the electricity that you purchase, your "ESP," may be a different company than the one that owns and maintains the power lines to your house, which is your "LDC." Your old utility company is most likely still your LDC and may also be your ESP, unless you have chosen to buy your electricity from one of the many new electric service providers that have been formed to market electricity. With net metering, the metering arrangement is with your ESP, while the details of how your generating system must be safely connected to the electrical grid is handled by your LDC.

Can I use my current electric meter?

Most residential and small commercial customers have simple meters that are bi-directional, capable of turning in both directions. Some utilities or ESPs may want two meters for net metering, one to measure electricity going from the grid to your home or business, and one to measure the excess going from your system to the grid. If you enter into a time-of-use billing agreement, you will need to purchase a bi-directional time-of-use meter. Contact your utility for more information.

How do I sign up?

Itís simple. Contact your utility or ESP and ask if they offer Net Metering. Your ESP and the company that distributes electricity to you may be the same or different companies. Your ESP handles the billing and accounting for Net

Metering, while your local distribution company (LDC) handles how your generating system is connected to the grid. You and your LDC may also need to enter into an Interconnection Agreement, which will outline the requirements for safely connecting your generating system to the grid.

When connecting the system to your grid, your LDC cannot:
Require you to purchase or pay for any meters beyond the simple, bi-directional meter that you probably already have, with the exception of time-of-use meters.
Impose any requirements, standards, or tests on your system†if it meets existing national standards for grid-interconnected systems.
Require you to purchase any additional insurance.
Require you to buy your electricity from them or their affiliates.

Other common questions about Net Metering

Q If my generating system produces more electricity than I need, is my utility or ESP required to buy it from me?
A Utilities or ESPs may, but are not required to, purchase any excess electricity you produce at the end of each year of your net metering agreement. State law says that they do not have to buy your net generation. However, some ESPs, especially those specializing in selling ìgreenî electricity, may be willing to buy your excess solar or wind electricity to re-sell to their other customers.

Q Will I have to pay for special meters, inspections or fees to get my system hooked up to the grid?
A You are only responsible for having a simple, bi-directional meter, the type you probably already have, unless you decide to purchase a time-of-use meter. If your generating system meets national safety and performance standards, you cannot be charged for additional tests, certifications or fees.

Q Will the electricity I might still need to buy from a utility or ESP cost me more than before I became a Net Metered customer?
A No, your utility or ESP cannot charge you more for electricity because you are a Net-Metered customer, and no charges can be imposed on the electricity you generate.

How can I get more information?

CALL: 800-555-7794 inside California 916-654-4058 outside California
E-MAIL: renewable@energy.state.ca.us

Photovoltaic Systems (Modular)

Photovoltaic systems generate power from the sun's energy and are a leading form of renewable energy. They are most appropriate for buildings that use advanced energy efficiency measures.

Technology Description

In a photovoltaic system, solar energy is absorbed in a special silicon cell that creates DC electric current, which is then passed through an inverter to provide conventional AC power. Photovoltaic systems are also available that have built-in inverters, making them easy to connect with the utility grid. In most areas, power can be sold directly to the electric utility by feeding excess power onto the grid.

Photovoltaic systems fall into two broad categories:

- PV panels or arrays that serve as add-on energy production systems, and
- Building Integrated Photovoltaic (BIPV) systems in which the solar collection surface is integrated into the building envelope.

This Technology Profile focuses on modular photovoltaic systems. BIPV is discussed in detail in a separate Technology Brief.

Design Considerations

To maximize the annual energy output, photovoltaic panels are oriented to the south and tilted typically from 10 to 40 degrees up from the horizontal in most North American sites. The optimal tilt for collecting solar energy depends on the latitude of the system, the proposed use of the system and the local seasonal cloud cover profile. The primary design considerations include supporting the weight of the photovoltaic panels and securing the panels against wind and seismic movement.

Potential Energy Generation

Depending on the type of module, photovoltaic panels can generate approximately 5 to 10 watts of power per square foot of collector area in full sunlight. So a collector area of 100 to 200 square feet typically is needed per kilowatt of capacity. The annual power output varies with the latitude and climate and ranges from 1,400 to 2,000 kilowatt-hours per kW of installed capacity.

Estimated Benefits

A 10-kW photovoltaic system commonly generates between 14,000 and 20,000 kilowatt-hours in a year, depending on the latitude and climate. At $0.05 per kilowatt-hour, such a system would produce estimated annual power valued at between $700 and $1,000. At $0.10 per kilowatt-hour, a 10-kW system would produce estimated annual power valued at between $1,400 and $2,000.

Photovoltaic systems offer other benefits in addition to the value of the power produced. Photovoltaic modules can be used with batteries to provide building power during outages. In some installations, photovoltaic panels can serve as shading devices on a building's exterior to help reduce solar gain and glare. Photovoltaic systems also offer a visible sign of a commitment to renewable energy and green building. Depending on sources of the local electricity supply, photovoltaic power systems can provide the environmental benefit of offsetting 1 to 2 lbs. of CO_2 emissions for each kilowatt-hour they generate (compared to fossil-fueled electric plants). And they can provide educational benefits at schools, museums, libraries and other locations.

Estimated Costs

Photovoltaic modules cost about $7 to $10 per watt installed, or $7,000 to $10,000 per kW. Therefore, a 10-kW system would cost between $70,000 and $100,000 prior to any tax credits, utility incentives, rebates or other savings (based on 2001 costs).

Financing Options

Financing may be available directly from manufacturers or from third-party equipment leasing or energy services companies. Federal and state tax credits, utility rebates and accelerated depreciation benefits may be available depending on the system and its location.

LEED™ Green Building Rating System

Photovoltaic systems may receive one LEED rating point for renewable energy if they supply at least 5 percent of the building's annual energy use. They earn two LEED rating points if they supply at least 10 percent and three LEED rating points if they supply at least 15 percent of the building's annual energy use.

LEED, which stands for Leadership in Energy and Environmental Design, is a program of the U.S. Green Building Council. The LEED Rating system is a recognized checklist of performance goals and measures that provides standardization and independent oversight for environmental performance in nonresidential building.

Projects Using Photovoltaic Modules

- The Nature Conservancy Oregon Headquarters, Portland, OR
- Viridian Place, Lake Oswego, OR
- John Inskeep Environmental Learning Center, Clackamas Community College, Oregon City, OR
- City of Ashland, City Council Chambers and Police Station, Ashland, OR

Further Resources

- "Harnessing the Sun," *Environmental Design and Construction,* July/August 1998, www.edcmag.com
- "Is Solar Still Active?", *Environmental Building News,* August 1999, **www.BuildingGreen.com**
- Astropower, www.astropower.com
- BP Solar, www.bpsolar.com
- Siemens Energy, www.siemens.com
- General photovoltaic information and links, www.solstice.crest.org
- General photovoltaic information and links, www.eren.doe.gov/pv

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Green Building Services

Green Technology Brief

Building-Integrated Photovoltaic Systems

Photovoltaic systems generate power from the sun's energy and are a leading form of renewable energy. They are most appropriate for buildings that use advanced energy-efficiency measures.

Technology Description

In a photovoltaic system, solar energy is absorbed in a special silicon cell that creates DC electric current, which is then passed through an inverter to provide conventional AC power. Photovoltaic systems are also available that have built-in inverters, making them easy to connect with the utility grid. In most areas, power can be sold directly to the electric utility by feeding excess power onto the grid.

Photovoltaic systems fall into two broad categories:

- Building Integrated Photovoltaic (BIPV) systems in which the solar collection surface is integrated into the building envelope, and
- PV panels or modules that serve as add-on energy production systems.

This Technology Profile focuses on building-integrated photovoltaic systems. Modular photovoltaic systems are discussed in detail in a separate Technology Brief.

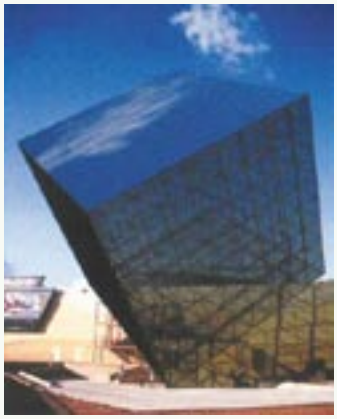
Design Opportunities

A variety of attractive BIPV products are available that allow building surfaces, such as the roof, walls, skylights and sunshades, to double as solar collectors. Integrating these products into the building envelope offers the opportunity of a large solar collection area, enabling solar power to displace more of the electricity used in the building. The cost of the photovoltaic system is offset by the fact that the BIPV products displace standard building envelope components.

Photovoltaics can be integrated into the roofing system through photovoltaic roof shingles, roof tiles and metal roof products, all of which can replace the standard roof. Alternatively, framed PV modules can be incorporated into the roofing system.

BIPV glazing systems are available that allow sloped and overhead glazing to capture solar energy. These glazing systems are insulated and also can be specified to provide the desired level of light transmission for daylighting.

The curtain wall offers significant potential for BIPVs. A wide variety of photovoltaic products can be used in place of architectural spandrel glass and vision glass.



Sunshades and skylights are common BIPV applications and have become popular in Europe. BIPV systems are available for sunshades and skylights that are visually transparent or provide partial shading. It is an easy upgrade to substitute pre-engineered BIPV sunshades for conventional sunshades.

The look and color of these building-integrated photovoltaic products vary with the application and the type of solar collector technology. The most efficient solar collectors are those that are deep-blue to black in color. BIPV products are also available that are dark gray and medium blue. Some manufacturers may produce custom-color BIPV products for large orders.

Potential Energy Generation

Depending on the type of collection medium, BIPV can generate approximately 5 to 10 watts of power per square foot of collector area in full sunlight. So a collector area of 100 to 200 square feet typically is needed per kilowatt of capacity. The annual power output varies with the latitude and climate, as well as the orientation of the building surface that comprises the photovoltaic material. The annual power output ranges from 1,400 to 2,000 kilowatt-hours per kW of installed system capacity.

Estimated Benefits

A 10-kW BIPV system commonly generates between 14,000 and 20,000 kilowatt-hours in a year, depending on the latitude and climate. At $0.05 per kilowatt-hour, such a system would produce estimated annual power valued at between $700 and $1,000. At $0.10 per kilowatt-hour, a 10-kW system would produce estimated annual power valued at between $1,400 and $2,000.

BIPV systems offer other benefits in addition to the value of the power produced. The solar electric skin of the building can serve as a distinctive and prestigous design feature, similar to premium exterior cladding systems. The BIPV system offers a visible sign

of a commitment to renewable energy and green building. Depending on sources of the local electricity supply, photovoltaic power systems can provide the environmental benefit of offsetting 1 to 2 lbs. of CO_2 emissions for each kilowatt-hour they generate (compared to fossil-fueled electric plants). BIPVs can be used with batteries to provide building power during electrical outages. And they can provide educational benefits at schools, museums, libraries and other locations.

Estimated Costs

The cost of BIPV products ranges from about $7 to $10 per watt (peak) installed, or $7,000 to $10,000 per kW. Therefore, a 10-kW system would cost between $70,000 and $100,000 prior to any tax credits, utility incentives, rebates or other savings (based on 2001 costs).

However, the net cost could be substantially less. When all factors are taken into consideration, a building with a building-integrated photovoltaic system could cost the same or less to build and operate than a conventional building.*

First, the BIPV products displace and, therefore, offset the cost of, conventional building products. In addition, the budget for most buildings includes an allowance for premium exterior design features, such as granite facades, that make an architectural statement and set the building apart from others. BIPV products present an excellent opportunity to make a distinctive architectural and environmental statement about a building. And the cost of these BIPV products typically is no more than, and can be less than, the cost of many premium exterior cladding systems. When these factors are entered into the calculation, together with the on-going value of power generation offered by photovoltaics, the overall economics of a solar building can be considerably more favorable than that of a conventional building.

Financing Options

Financing may be available directly from manufacturers or from energy services companies. Federal and state tax credits, utility rebates and accelerated depreciation benefits also may be available depending on the system and its location.

*Individual circumstances vary, ask Green Building Services for more information.

LEED™ Green Building Rating System

Photovoltaic systems may receive one LEED rating point for renewable energy if they supply at least 5 percent of the building's annual energy use. They earn two LEED rating points if they supply at least 10 percent and three LEED rating points if they supply at least 15 percent of the building's annual energy use.

LEED, which stands for Leadership in Energy and Environmental Design, is a program of the U.S. Green Building Council. The LEED Rating system is a recognized checklist of performance goals and measures that provides standardization and independent oversight for environmental performance in nonresidential building.

Projects Using Building-Integrated Photovoltaics

Projects using building-integrated photovoltaic systems include:

- The Nature Conservancy Visitor Center, Florida
- Four Times Square, New York, NY
- Center for Environmental Science and Technology Management, State University of New York at Albany
- Anaheim Convention Center, Anaheim, CA

Further Resources

- "Specifying Building-Integrated Photovoltaics," *Environmental Design and Construction*, March/April 2000, www.edcmag.com
- "Harnessing the Sun," *Environmental Design and Construction,* July/August, 1998, www.edcmag.com
- "Is Solar Still Active?", *Environmental Building News,* August 1999, **www.BuildingGreen.com**
- Astropower, www.astropower.com
- BP Solar, www.bpsolar.com
- Siemens Energy, www.siemens.com

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Solar Water Heating

Summary: This fact sheet will explain how you can use the sun's heat to provide your home with hot water, including basic information on the types of systems available and their economic and environmental benefits. To view illustrations, you can download the PDF version (PDF 235 KB) of this fact sheet (Download Acrobat Reader). See Related Links below for more publications and resources on related topics, which aren't included in the PDF version.

Solar water heaters, sometimes called solar domestic hot water systems, may be a good investment for you and your family. Solar water heaters are cost competitive in many applications when you account for the total energy costs over the life of the system. Although the initial cost of solar water heaters is higher than that of conventional water heaters, the fuel (sunshine) is free. Plus, they are environmentally friendly. To take advantage of these heaters, you must have an unshaded, south-facing location (a roof, for example) on your property.

These systems use the sun to heat either water or a heat-transfer fluid, such as a water-glycol antifreeze mixture, in collectors generally mounted on a roof. The heated water is then stored in a tank similar to a conventional gas or electric water tank. Some systems use an electric pump to circulate the fluid through the collectors. Solar Water Heating

Solar water heaters can operate in any climate. Performance varies depending, in part, on how much solar energy is available at the site, but also on how cold the water coming into the system is. The colder the water, the more efficiently the system operates. In almost all climates, you will need a conventional backup system. In fact, many building codes require you to have a conventional water heater as the backup.

First Things First

Before investing in any solar energy system, it is more cost effective to invest in making your home more energy efficient. Taking steps to use less hot water and to lower the temperature of the hot water you use reduces the size and cost of your solar water heater.

Good first steps are installing low-flow showerheads or flow restrictors in shower heads and faucets, insulating your current water heater, and insulating any hot water pipes that pass through unheated areas. If you have no dishwasher, or your dishwasher is equipped with its own automatic water heater, lower the thermostat on your water heater to 120°F (49°C). For more information on ways to use less energy for water heating, see *Energy-Efficient Water Heating*.

You'll also want to make sure your site has enough available sunshine to meet your needs efficiently and economically. Your local solar equipment dealer can perform a solar site analysis for you or show you how to do your own. See *Assessing Climate to Improve Solar Design* for more information.

Remember: Local zoning laws or covenants may restrict where you can place your collectors. Check with your city, county, and homeowners association to find out about any restrictions.

Solar Water Heater Basics

Solar water heaters are made up of collectors, storage tanks, and, depending on the system, electric pumps.

There are basically three types of collectors: flat-plate, evacuated-tube, and concentrating. A **flat-plate collector**, the most common type, is an insulated, weather-proofed box containing a dark absorber plate under one or more transparent or translucent covers.

Evacuated-tube collectors are made up of rows of parallel, transparent glass tubes. Each tube consists of a glass outer tube and an inner tube, or absorber, covered with

a selective coating that absorbs solar energy well but inhibits radiative heat loss. The air is withdrawn ("evacuated") from the space between the tubes to form a vacuum, which eliminates conductive and convective heat loss.

Concentrating collectors for residential applications are usually parabolic troughs that use mirrored surfaces to concentrate the sun's energy on an absorber tube (called a receiver) containing a heat-transfer fluid. For more information, see *Residential Solar Heating Collectors*.

Most commercially available solar water heaters require a well-insulated storage tank. Many systems use converted electric water heater tanks or plumb the solar storage tank in series with the conventional water heater. In this arrangement, the solar water heater preheats water before it enters the conventional water heater.

Some solar water heaters use pumps to recirculate warm water from storage tanks through collectors and exposed piping. This is generally to protect the pipes from freezing when outside temperatures drop to freezing or below.

Types of Solar Water Heaters

Solar water heaters can be either active or passive. An active system uses an electric pump to circulate the heat-transfer fluid; a passive system has no pump. The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation, and the tilt angle and orientation of the collectors.

Solar water heaters are also characterized as open loop (also called "direct") or closed loop (also called "indirect"). An open-loop system circulates household (potable) water through the collector. A closed-loop system uses a heat-transfer fluid (water or diluted antifreeze, for example) to collect heat and a heat exchanger to transfer the heat to household water.

Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. They are usually more expensive than passive systems but are also more efficient. Active systems are usually easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors. But because they use electricity, they will not function in a power outage. Active systems range in price from about $2,000 to $4,000 installed.

Open-Loop Active Systems

Open-loop active systems use pumps to circulate household water through the collectors. This design is efficient and lowers operating costs but is not appropriate if your water is hard or acidic because scale and corrosion quickly disable the system.

These open-loop systems are popular in nonfreezing climates such as Hawaii. They should never be installed in climates that experience freezing temperatures for sustained periods. You can install them in mild but occasionally freezing climates, but you must consider freeze protection.

Recirculation systems are a specific type of open-loop system that provide freeze protection. They use the system pump to circulate warm water from storage tanks through collectors and exposed piping when temperatures approach freezing. Consider recirculation systems only where mild freezes occur once or twice a year at most. Activating the freeze protection more frequently wastes electricity and stored heat.

Of course, when the power is out, the pump will not work and the system will freeze. To guard against this, a freeze valve can be installed to provide additional protection in the event the pump doesn't operate. In freezing weather, the valve dribbles warmer water through the collector to prevent freezing. Consider recirculation systems *only* where mild freezes occur once or twice a year at most. Activating the freeze protection more frequently wastes electricity and stored heat.

Closed-Loop Active Systems

These systems pump heat-transfer fluids (usually a glycol-water antifreeze mixture) through collectors. Heat exchangers transfer the heat from the fluid to the household water stored in the tanks.

Double-walled heat exchangers prevent contamination of household water. Some codes require double walls when the heat-transfer fluid is anything other than household water.

Closed-loop glycol systems are popular in areas subject to extended freezing temperatures because they offer good freeze protection. However, glycol antifreeze systems are a bit more expensive to buy and install, and the glycol must be checked each year and changed every 3 to 10 years, depending on glycol quality and system temperatures.

Drainback systems use water as the heat-transfer fluid in the collector loop. A pump circulates the water through the collectors. The water drains by gravity to the storage tank and heat exchanger; there are no valves to fail. When the pumps are off,the collectors are empty, which assures freeze protection and also allows the system to turn off if the water in the storage tank becomes too hot.

Pumps in Active Systems

The pumps in solar water heaters have low power requirements, and some companies now include direct current (DC) pumps powered by small solar-electric (photovoltaic, or PV) panels. PV panels convert sunlight into DC electricity. Such systems cost nothing to operate and continue to function during power outages.

Passive Systems

Passive systems move household water or a heat-transfer fluid through the system without pumps. Passive systems have no electric components to break. This makes them generally more reliable, easier to maintain, and possibly longer lasting than active systems.

Passive systems can be less expensive than active systems, but they can also be less efficient. Installed costs for passive systems range from about $1,000 to $3,000, depending on whether it is a simple batch heater or a sophisticated thermosiphon system.

Batch Heaters

Batch heaters (also known as "bread box" or integral collector storage systems) are simple passive systems consisting of one or more storage tanks placed in an insulated box that has a glazed side facing the sun. Batch heaters are inexpensive and have few components—in other words, less maintenance and fewer failures. A batch heater is mounted on the ground or on the roof (make sure your roof structure is strong enough to support it). Some batch heaters use "selective" surfaces on the tank(s). These surfaces absorb sun well but inhibit radiative loss.

In climates where freezing occurs, batch heaters must either be protected from freezing or drained for the winter. In well-designed systems, the most vulnerable components for freezing are the pipes, if located in uninsulated areas, that lead to the solar water heater. If these pipes are well insulated, the warmth from the tank will prevent freezing. Certified systems clearly state the temperature level that can cause damage. In addition, you can install heat tape (electrical plug-in tape to wrap around the pipes to keep them from freezing), insulate exposed pipes, or both. Remember, heat tape requires electricity, so the combination of freezing weather and a power outage can lead to burst pipes. If you live in an area where freezing is infrequent, you can use plastic pipe that does not crack or burst when it freezes. Keep in mind, though, that some of these pipes can't withstand unlimited freeze/thaw cycles before they crack.

Thermosiphon Systems

A thermosiphon system relies on warm water rising, a phenomenon known as natural convection, to circulate water through the collectors and to the tank. In this type of installation, the tank must be above the collector. As water in the collector heats, it becomes lighter and rises naturally into the tank above. Meanwhile, cooler water in the tank flows down pipes to the bottom of the collector, causing circulation throughout the system. The storage tank is attached to the top of the collector so that thermosiphoning can occur. These systems are reliable and relatively inexpensive but require careful planning in new construction because the water tanks are heavy. They can be freeze-proofed by circulating an antifreeze solution through a heat exchanger in a closed loop to heat the household water.

Sizing Your System

Just as you have to choose a 30-, 40-, or 50-gallon (114-, 151-, or 189-liter) conventional water heater, you need to determine the right size solar water heater to install. Sizing a solar water heater involves determining the total collector area and the storage volume required to provide 100% of your household's hot water during the summer. Solar-equipment experts use worksheets or special computer programs to assist you in determining how large a system you need.

Solar storage tanks are usually 50-, 60-, 80-, or 120-gallon (189-, 227-, 303-, or 454-liter) capacity. A small (50 to 60 gallon) system is sufficient for 1 to 3 people, a medium (80-gallon) system is adequate for a 3- or 4-person household, and a large (120-gallon) system is appropriate for 4 to 6 people.

A rule of thumb for sizing collectors: allow about 20 square feet (about 2 square meters) of collector area for each of the first two family members and 8 square feet (0.7 square meter) for each additional family member if you live in the Sun Belt. Allow 12 to 14 additional square feet (1.1 to 1.3 square meters) per person if you live in the northern United States.

A ratio of at least 1.5 gallons (5.7 liters) of storage capacity to 1 square foot (0.1 square meter) of collector area prevents the system from overheating when the demand for hot water is low. In very warm, sunny climates, experts suggest that the ratio should be at least 2 gallons (7.6 liters) of storage to 1 square foot (0.1 square meter) of collector area. For example, a family of four in a northern climate would need between 64 and 68 square feet (5.9 and 6.3 square meters) of collector area and a 96- to 102-gallon (363- to 386-liter) storage tank. (This assumes 20 square feet of collector area for the first person, 20 for the second person, 12 to 14 for the third person, and 12 to 14 for the fourth person. This equals 64 to 68 square feet, multiplied by 1.5 gallons of storage capacity, which equals 96 to 102 gallons of storage.) Because you might not be able to find a 96-gallon tank, you may want to get a 120-gallon tank to be sure to meet your hot water needs.

Benefits of Solar Water Heaters

There are many benefits to owning a solar water heater, and number one is economics. Solar water heater economics compare quite favorably with those of electric water heaters, while the economics aren't quite so attractive when compared with those of gas water heaters. Heating water with the sun also means long-term benefits, such as being cushioned from future fuel shortages and price increases, and environmental benefits.

Economic Benefits

Many home builders choose electric water heaters because they are easy to install and relatively inexpensive to purchase. However, research shows that an average household with an electric water heater spends about 25% of its home energy costs on heating water.

It makes economic sense to think beyond the initial purchase price and consider lifetime energy costs, or how much you will spend on energy to use the appliance over its lifetime. The Florida Solar Energy Center (FSEC—see Source List) studied the potential savings to Florida homeowners of common water-heating systems compared with electric water heaters. It found that solar water heaters offered the largest potential savings, with solar water-heater owners saving as much as 50% to 85%

annually on their utility bills over the cost of electric water heating.

The FSEC analysis illustrates that the initial installed cost of the solar water heater ($1,500 to $3,000) is higher than that of a gas water heater ($350 to $450) or an electric water heater ($150 to $350). The costs vary from region to region, so check locally for costs in your area. Depending on the price of fuel sources, the solar water heater can be more economical over the lifetime of the system than heating water with electricity, fuel oil, propane, or even natural gas because the fuel (sunshine) is free.

However, at the current low prices of natural gas, solar water heaters cannot compete with natural gas water heaters in most parts of the country except in new home construction. Although you will still save energy costs with a solar water heater because you won't be buying natural gas, it won't be economical on a dollar-for-dollar basis.

Paybacks vary widely, but you can expect a simple payback of 4 to 8 years on a well-designed and properly installed solar water heater. (Simple payback is the length of time required to recover your investment through reduced or avoided energy costs.) You can expect shorter paybacks in areas with higher energy costs. After the payback period, you accrue the savings over the life of the system, which ranges from 15 to 40 years, depending on the system and how well it is maintained.

You can determine the simple payback of a solar water heater by first determining the net cost of the system. Net costs include the total installed cost less any tax incentives or utility rebates. (See the box for more information.) After you calculate the net cost of the system, calculate the annual fuel savings and divide the net investment by this number to determine the simple payback.

An example: Your total utility bill averages $160 per month and your water heating costs are average (25% of your total utility costs) at $40 per month. If you purchase a solar water heater for $2,000 that provides an average of 60% of your hot water each year, that system will save you $24 per month ($40 x 0.60 = $24) or $288 per year (12 x $24 = $288). This system has a simple payback of less than 7 years ($2,000 ÷ $288 = 6.9). For the remainder of the life of the solar water heater, 60% of your hot water will be free, saving you $288 each year. You will need to account for some operation and maintenance costs, which are estimated at $25 to $30 a year. This is primarily to have the system checked every 3 years.

If you are building a new home or refinancing your present home to do a major renovation, the economics are even more attractive. The cost of including the price of a solar water heater in a new 30-year mortgage is usually between $13 and $20 per month. The portion of the federal income tax deduction for mortgage interest attributable to the solar system reduces that amount by about $3 to $5 per month. If your fuel savings are more than $15 per month, the investment in the solar water heater is profitable immediately.

Tax Incentives and Rebates

Some local or state governments offer tax incentives to encourage residents to invest in solar energy technologies. Check with your state or local energy office or Department of Revenue for information. Some electric utilities offer rebates to customers who install solar energy equipment because these installations help utilities reduce peak loads. Peak loads are periods when the utility must generate extra power to meet a high demand. Heating water in the evening is one example.

Long-Term Benefits

Solar water heaters offer long-term benefits that go beyond simple economics. In addition to having free hot water after the system has paid for itself in reduced utility bills, you and your family will be cushioned from future fuel shortages and price increases. You will also be doing your part to reduce this country's dependence on foreign oil.

Environmental Benefits

Solar water heaters do not pollute. By investing in one, you will be avoiding carbon dioxide, nitrogen oxides, sulfur dioxide, and the other air pollution and wastes created when your utility generates power or you burn fuel to heat your household water. When a solar water heater replaces an electric water heater, the electricity displaced over 20 years represents more than 50 tons of avoided carbon dioxide emissions alone. Carbon dioxide traps heat in the upper atmosphere, thus contributing to the "greenhouse effect."

Be a Smart Consumer

Take the same care in choosing a solar water heater that you would in the purchase of any major appliance. Your best protection is to consider only certified and labeled systems. One such label is put on by the Solar Rating & Certification Corporation (SRCC), a nonprofit, independent third-party organization formed by the state energy officials, and consumer advocates to certify and rate solar water heaters.

A national standard (OG-300) addresses a variety of concerns, including safety and health, durability and reliability, installation, performance, and operation and maintenance. To meet this standard, a system is rigorously tested. A certified solar water heater carries the SRCC OG-300 label, and the system performance is listed in a published directory. A similar program has been established for Florida by FSEC. Both SRCC and FSEC provide collector testing and rating programs.

Find out if the manufacturer offers a warranty, and, if so, what the warranty covers and for how long. If the dealer you are buying the equipment from goes out of business, can you get support and parts from the manufacturer, or from a local plumbing contractor?

Make sure that the workers who are actually installing the system are qualified to do the work. Ask the installation contractor for references and check them. When the job is finished, have the contractor walk you through the system so you are familiar with the installation. And be sure that an owner's manual with maintenance instructions is included as part of the package.

A Bright Future

A solar water heater is a long-term investment that will save you money and energy for many years. Like other renewable energy systems, solar water heaters minimize the environmental effects of enjoying a comfortable, modern lifestyle. In addition, they provide insurance against energy price increases, help reduce our dependence on foreign oil, and are investments in everyone's future.

You might also consider other solar energy systems for your home. Systems similar to the solar water heater are used for space heating and swimming pool heating. In fact, pool heating is a major market for solar energy systems. For more information on these systems, see *Conserving Energy and Heating Your Swimming Pool with Solar Energy*.

Source List

The following organizations can provide you with information to help you find the solar water heater that is right for you.

American Solar Energy Society (ASES)
E-mail: ases@ases.org

ASES is a nonprofit educational organization founded in 1954 to encourage the use of solar energy technologies. ASES publishes a bimonthly magazine, Solar Today, and offers a variety of solar publications through its catalogue.

Florida Solar Energy Center (FSEC)
E-mail: info@fsec.ucf.edu

FSEC is an alternative energy center. The FSEC staff conducts research on a range of solar technologies, offers solar energy workshops, and distributes many free publications to the public.

Solar Energy Industries Association (SEIA)
E-mail: Solarsklar@aol.com

SEIA provides lists of solar-equipment manufacturers and dealers and technical publications.

Solar Rating and Certification Corporation (SRCC)
E-mail: srcc@fsec.ucf.edu

SRCC publishes the thermal-performance ratings of solar energy equipment. The SRCC offers a directory of certified solar systems and collectors as well as a document (OG-300-91) that details the operating guidelines and minimum standards for certifying solar hot-water systems.

You may also contact your state and local energy offices for region-specific information on solar water heaters.

Reading List

The following publications provide further information about solar water heaters. The list is not exhaustive, nor does the mention of any publication constitute a recommendation or endorsement.

Articles

"Let the Sun Provide Your Shower," S. Baldassari, Countryside & Small Stock Journal, (78) p. 55, November/December 1994.

"Solar Hot Water for the 90s," M. Rosenbaum, Solar Today, (5:5), p. 20, September/October 1991.

"Solar Water Heaters Now," Home Mechanix, (87:760) p. 67, November 1, 1991.

"Solar Water Heating: A Viable Technology Alternative," M. Sheffer, Energy User News, (19:9), p. 44, September 1994.

"Solar Water Heating in Pennsylvania," M.B. Sheffer and A.S. Lau, Solar Today, (8:1), p. 12, January/February 1994.

"Wisconsin Public Service Company's Orphan Solar Program," J. DeLaune, Solar Today, (9:3), p. 32, May/June 1995.

Books, Pamphlets, and Reports

Consumer Guide to Solar Energy, S. Sklar and K. Sheinkopf, Bonus Books, Inc., 160 East Illinois Street, Chicago, IL 60611, 1991.

The Homeowner's Handbook of Solar Water Heating Systems, B. Keisling, Rodale Press, 1983.

Periodicals

Home Energy Magazine
Home Energy Magazine is a source of information on reducing energy consumption.

Solar Today
Solar Today covers all the solar technologies, both mature and emerging, in a general-interest format.

Related Links

Active Solar Heating System Performance and Reliability

Assessing Climate to Improve Solar Design

Building Codes, Convenants, and Regulations for Solar Energy Systems

Conserving Energy and Heating Your Swimming Pool with Solar Energy

Freeze Protection for Solar Energy Systems

Heat Exchangers for Solar Energy Systems

Heat Transfer Fluids for Solar Energy Systems

Residential Solar Heating Collectors

Scaling and Corrosion in Solar Heating Systems

Solar Energy System Maintenance and Repair

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Indoor Air Quality

MODULE 10

Americans spend on average more than 80 to 90 percent of their time indoors.[1] Over the past decade, concerns over indoor air quality have been well documented, along with effective solutions. Indoor pollutants can cause building occupants to experience acute discomfort and negative health effects, such as respiratory irritation, headaches, fatigue, etc. Some substances, like radon and carbon monoxide, can pose fatal risks. Experience and research shows that these risks can be reduced or eliminated through the strategies discussed in this module. Like daylighting, enhanced indoor air quality (IAQ) is a sustainable building strategy that can yield tangible, noticeable benefits to building users each and every day.

While energy conservation steps and other strategies to improve IAQ may modestly increase construction or operating costs, enhanced IAQ potentially averts serious health issues and can save enormous sums of money required to treat them. In commercial environments, improving IAQ has been shown to increase worker productivity by up to 16 percent. Because labor accounts for up to 92 percent of the life-cycle building costs (far outweighing energy), the value of increased worker productivity can be significant.[2] Furthermore, occupant satisfaction and healthfulness represent important, though difficult to measure, benefits of improved IAQ.

Indoor Air Quality Strategies

- ✓ **Ensure adequate ventilation.**
- ✓ **Designate indoor spaces as smoke-free.**
- ✓ **Implement tobacco smoke controls.**
- ✓ **Use low-emitting building products.**
- ✓ **Install controllable systems.**
- ✓ **Prepare an indoor air quality management plan for construction and early occupancy.**

Ensure adequate ventilation.

An essential strategy for good IAQ is to ensure that buildings are well ventilated (preferably with controllable windows and vents) with clean outside air. The most effective and noticeable comfortable ventilation systems use floor vents for input air and ceiling vents for outtake. An accepted professional standard is available for measuring ventilation and ensuring that adequate indoor air quality levels are achieved (ASHRAE 62-199, 3). Standards for designing heating, ventilation, and air conditioning (HVAC) systems to ensure acceptable indoor air quality are contained in a document called ASHRAE 62-1999. Steps for achieving adequate ventilation include evaluating the quality of outdoor air used for ventilation and the location of intake ducts, using efficient air filtration, making certain room registers and return ducts are correctly configured and never blocked, and taking measures to eliminate moisture and retard mold growth within HVAC system components. For example, intake ducts should be at least 40 feet away from possible contamination sources like exhaust fans, cooling towers, loading areas, idling vehicles, sanitary vents, dumpsters, and outside smoking areas.

Ventilation is a double-edged sword, since too much can increase heating and cooling costs. This is yet another reason why sustainable building is best undertaken on a whole building basis, considering all the trade-offs among different strategies. (HVAC system design as a heating and cooling strategy is discussed in Module 8, Energy Efficiency.)

Designate indoor spaces as smoke-free.

One of the most obvious and yet most effective indoor air quality strategies is simply to not allow tobacco smoking indoors. Secondhand smoke has been shown by numerous studies to be hazardous to bystanders. In addition to completely eliminating a key indoor air quality problem, banning indoor smoking also can greatly reduce costs for ventilation systems. If the project is smoke free, then consider low specifying emitting products (see module 6).

SOME COMMON INDOOR AIR POLLUTANTS

Mold is a type of fungus that often grows on water-damaged materials. Indoor mold can cause occupants to suffer allergies, irritated eyes, lungs, etc., and other symptoms, and may exacerbate asthma symptoms in asthmatics.

Volatile Organic Compounds (VOCs) are carbon compounds that evaporate or "off gas" from solvents, paints, and other materials. Some VOCs are carcinogenic chemicals, plus many can cause respiratory irritation, neurological reactions, and other symptoms.

Formaldehyde is a VOC that is present in pressed wood products and many building materials. It is also emitted from combustion appliances, some personal care products (for example, nail polishes), permanent pressed clothing, and many other products.

Radon is a naturally occurring radioactive gas produced by the breakdown of radon in soil, rock, and water. In certain regions, indoor radon concentrations can become elevated because air pressure inside buildings is often lower than in the soil. The U.S. EPA estimates that indoor radon is the second leading cause of lung cancer in the United States.

Implement tobacco smoke controls. When smoking is allowed in public buildings, measures should to be taken to reduce exposures to tobacco smoke. Secondhand tobacco smoke contains more harmful toxins than mainstream smoke, so it is important to design systems that protect both non-smokers and smokers. One of the easiest ways to achieve this is to allow smoking only in outdoor areas. Alternatively, smoking might be restricted to well-ventilated, segregated rooms, well away from public entries and exits. When smoking is allowed in public areas, a specially designed, powerful ventilation system should be designed to provide high rates of ventilations with direct exhaust of tobacco smoke. While they can be effective in increasing the attractiveness of casinos to non-smoking customers, these high-power ventilation systems add both up-front costs and operating costs due to their energy use and maintenance.

Use low-emitting building products. Some building products may emit chemicals that are odorous, potentially irritating, and/or harmful to the comfort, health, or well-being of contractors and occupants. For example, paint, carpet, and many other products may emit volatile organic compounds (VOC). Composite wood products, especially those made with urea-formaldehyde resins, can lead to high indoor concentrations of formaldehyde that persist for months to years. The California Integrated Waste Management Board joined with other State agencies and organizations to develop the "Section 01350" specifications for green building products.

A key element of Section 01350 is indoor air quality guidelines to protect human health. It contains an IAQ testing protocol for manufacturers for use in ordering tests on their products by independent laboratories. Selected materials are tested for chemical emissions and must conform to allowable levels identified in Section 01350 to be used in a building. If good indoor air quality is to be a reality, manufacturers should test their materials in relation to performance requirements. Section 01350 offers a proven means of achieving this objective. More information, including a list of products satisfying the specifications, is available at www.ciwmb.ca.gov/GreenBuilding/Specs/Section01350/ - Background.

Install controllable systems. When building systems are designed with local controls, the comfort level of occupants can be noticeably enhanced. For example, allowing occupants to open and close some windows, even small ones, can enhance their connection to the local environment, especially on mild days. Natural ventilation can also save energy. In addition, providing local adjustment of thermostats allows occupants a greater sense of control for their thermal comfort, which can reduce complaints and facility staff time.

Prepare an indoor air quality management plan for construction and early occupancy. Developing a system to prevent IAQ problems is more cost-effective than spending time and resources required to fix them later. A proven preventive approach is to prepare an IAQ management plan that directs activities during building construction and early

occupancy phases. During construction, HVAC systems are especially prone to contamination from particulate matter generated during construction activities. An Indoor Air Quality Management Plan should direct contractors to use measures to protect HVAC systems from contamination. Furthermore, furnishings such as carpets can be sinks for dust, volatile organic compounds, microorganisms, and other contaminants. A plan should address the manner in which materials are stored and used inside the building, plus the sequence of activities. For example, carpet should not be laid before the bulk of interior painting is completed. This practice will insure that the carpet will not absorb VOCs offgassing.

The plan should provide for a period of at least two weeks after construction ends prior to occupancy. During this time, the HVAC system should be run with maximum outside air to allow air pollutants to "flush out." Air filters should be replaced and other efforts should be made to minimize residual contaminants. As part of this plan, maintenance staff and building occupants should be educated about the materials used in the building and the proper operation of building systems.

RESOURCES

General References on Indoor Air Quality

U.S. Environmental Protection Agency
www.epa.gov/iaq

Building Air Quality: A Guide for Building Owners and Facility Managers
www.epa.gov/iaq/largebldgs/baqtoc.html

California Air Resources Board, Indoor Program, provides access to fact sheets and information on a variety of indoor air quality topics.
www.arb.ca.gov/research/indoor/indoor.htm

California Department of Health Services, Indoor Air Quality Program
www.dhs.ca.gov/iaq

Collaborative for High Performance Schools fact sheets on IAQ issues in schools
www.chps.net/manual/iaq_download.htm

Judith Heerwagen, "Do Green Buildings Enhance the Well Being of Workers? Yes," Environmental Design + Construction, July/August 2000
www.edcmag.com/

Healthy Building Network
www.healthybuilding.net/

Product Sources and Specifications

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
www.ashrae.org/. (Standard 62-1999 relates to minimum ventilation levels. Standard 62-2001 covers CO2 monitoring systems. Standard 129-1997 covers measuring air change effectiveness.)

California Department of Health Services Guidelines for Reducing VOCs in Office Buildings from Construction Materials
www.cal-iaq.org/VOC/VOC.html

CIWMB Building Material Emissions Study
www.ciwmb.ca.gov/greenbuilding/Specs/Section01350/METStudy.htm

CIWMB List of Products Passing Section 01350 IAQ Test
www.ciwmb.ca.gov/greenbuilding/Specs/EastEnd/default.htm

Green Seal Green Building Standards
www.greenseal.org/ (Green Seal's Standard GS-11 identifies low VOC paints.)

List of Zero VOC Paint Manufacturers
www.aqmd.gov/business/brochureszerovoc.html

The Carpet and Rug Institute Carpet Testing Program
www.carpet-rug.com/

U.S. EPA Protocol for Environmental Requirements, Baseline IAQ and Materials
www.epa.gov/rtp/new-bldg/environmental/specs.htm

BOOKS

John Bower, *The Healthy House,* 2001, www.oikos.com/.

Dagmar Schmidt Etkin, *Indoor Air Quality Primer,* Arlington, Mass., Cutter Information Corp., 1995.

Janet Marinelli and Paul Bierman Lytle, *Your Natural Home: The Complete Sourcebook and Design Manual for Creating a Healthy, Beautiful and Environmentally Sensitive House,* Boston, Little, Brown & Co., 1995.

Indoor Air Quality Design Guidebook, Milton Meckler, ed., Lilburn Ga., Fairmont Press, June 2001.

Peter DuPont and John Morrill, *Residential Indoor Air Quality and Energy Efficiency,* Washington, D.C., American Council for an Energy Efficient Economy, 1989.

IAQ Handbook, John D. Spengler John F McCarthy and Johnathan M. Samet, New York, McGraw-Hill, 2001.

NOTES

[1] U.S. Environmental Protection Agency, Report to Congress on Indoor Air Quality, Volume II: Assessment and Control of Indoor Air Pollution, pp. I, 4-14. EPA 400-1-89-001C, 1989.

[2] Rocky Mountain Institute as quoted by the U.S. Green Building Council, LEED Reference Package, Volume 2.

California Air Resources Board

REDUCING INDOOR AIR POLLUTION

Indoor Air Pollution: A Serious Public Health Problem

This page updated May 2, 2001.

We spend most of our time indoors surrounded by sources of air pollution: consumer products, gas appliances, building materials, cigarettes, and furniture can all contribute to the problem. Yet, the toxic emissions from many of these sources are not controlled or are only partially controlled by federal, state, or local laws.

This brochure will tell you about indoor air pollution and what the California Air Resources Board (ARB) is doing about it.

Evaluating the Risk

In a 1987 study, the U.S. Environmental Protection Agency (EPA) ranked indoor air pollution fourth in cancer risk among the 13 top environmental problems analyzed. Indoor
radon ranked first. What factors contribute to the high risk from indoor air pollution?

First, people spend most of their time indoors. A recent ARB-sponsored study found that Californians spend an average of 87% of their 24-hour day indoors. If pollutants are present indoors, people will almost certainly inhale them.

Second, indoor air pollutant levels are often higher than those outdoors. Research by the ARB, the EPA, and others has shown that indoor levels of some pollutants, such as formaldehyde, chloroform, and styrene, range from 2 to 50 times higher than outdoor levels. Exposure to pollutants such as environmental tobacco smoke and radon occurs almost entirely indoors. For most of us, the amount of air pollution that we breathe is primarily determined by what is in the indoor air.

What is Indoor Air Pollution?

Indoor air pollution consists of toxic gases or particles that can harm your health. These pollutants can build up rapidly indoors to levels much higher than those usually found outdoors. This is especially true if large amounts of a pollutant are released indoors. Moreover, "tighter" construction in newer homes can prevent pollutants from escaping to the outdoors.

Sources and Potential Health Effects of Indoor Air Pollutants		
Pollutant	**Major Indoor Sources**	**Potential Health Effects***
Environmental Tobacco Smoke	Cigarettes, cigars, and pipes	Respiratory irritation, bronchitis and pneumonia in children, emphysema, lung cancer, and heart disease
Carbon Monoxide	Unvented or malfunctioning gas appliances, wood stoves, and tobacco smoke	Headache; nausea; angina; impaired vision and mental functioning; fatal at high concentrations
Nitrogen Oxides	Unvented or malfunctioning gas appliances	Eye, nose, and throat irritation; increased respiratory infections in children
Organic Chemicals	Aerosol sprays, solvents, glues, cleaning agents, pesticides, paints, moth repellents, air fresheners, drycleaned clothing, and treated water	Eye, nose, and throat irritation; headaches; loss of coordination; damage to liver, kidney and brain; various types of cancer
Formaldehyde	Pressed wood products such as plywood and particleboard; furnishings; wallpaper; durable press fabrics	Eye, nose, and throat irritation; headache; allergic reactions; cancer
Respirable Particles	Cigarettes, wood stoves, fireplaces, aerosol sprays, and house dust	Eye, nose and throat irritation; increased susceptibility to respiratory infections and bronchitis; lung cancer
Biological Agents (Bacteria, Viruses, Fungi, Animal Dander, Mites)	House dust; pets; bedding; poorly maintained air conditioners, humidifiers and dehumidifiers; wet or moist structures; furnishings	Allergic reactions; asthma; eye, nose, and throat irritation; humidifier fever, influenza, and other infectious diseases
Asbestos	Damaged or deteriorating insulation, fireproofing, and acoustical materials	Asbestosis, lung cancer, mesothelioma, and other cancers
Lead	Sanding or open-flame burning of lead paint; house dust	Nerve and brain damage, particularly in children; anemia; kidney damage; growth retardation
Radon	Soil under buildings, some earth-derived construction materials, and groundwater	Lung cancer
* Depends on factors such as the amount of pollutant inhaled, the duration of exposure and susceptibility of the individual exposed.		

Health Effects

The effects of indoor air pollutants range from short-term effects - eye and throat irritation - to long-term effects - respiratory disease and cancer. Exposure to high levels of some pollutants, such as carbon monoxide, can even result in immediate death. Also, some indoor pollutants can magnify the effects of other indoor pollutants. Based on cancer risk alone, federal scientists have ranked indoor air pollution as one of the most important environmental problems in the US.

"Sensitive" Groups

Many groups are especially susceptible to the health effects of indoor pollutants. These include infants and the elderly, those with heart and lung diseases, people with asthma, and individuals who have developed extreme sensitivity to chemicals. Unfortunately, these are the people who often spend the most time indoors.

Economic Impacts

The economic impacts of indoor pollution - including health care costs, lost productivity, legal costs, and human welfare impacts - have been estimated at billions of dollars each year.

What Can You Do About Indoor Air Pollution?

The most effective way to protect your family and yourself from indoor air pollution is to prevent or minimize the release of pollutants indoors in the first place.

Use Products Safely

Products such as cleaning agents, paints, and glues should be used outdoors whenever possible. Directions on the label should be followed carefully. If the product must be used indoors, lots of ventilation should be provided. Also, it may be possible to use safer consumer products, such as baking soda instead of harsher cleaners, or products in solid or liquid form rather than aerosol sprays.

Restrict Smoking

Restricting cigarette smoking to outdoor areas is especially important because cigarette smoke contains many toxic pollutants. It is harmful to both smokers and nonsmokers.

Use Appliances Properly

Use gas appliances, wood stoves, and fireplaces only as intended. Gas stoves should never be used to heat the house since high pollutant levels can result. Wood stoves and fireplaces should only be used to burn properly sized and aged wood, since other types of fuel may emit toxic compounds.

These combustion devices pollute less when properly maintained. Annual inspections and cleaning by your gas company's service personnel or by other qualified individuals will help reduce pollution and save energy.

Select Building Materials and Furniture Carefully

Many products, including some types of plywood and particleboard, emit significant amounts of formaldehyde or other gaseous pollutants. Try to avoid those products if possible.

You might request that new carpets or furniture be aired out by the manufacturer or distributor prior to delivery. Otherwise, you may want to air them in your garage or yard before bringing them inside.

Practice Good Housekeeping

Proper storage of solvents and frequent housecleaning to remove dust and molds are necessary steps in maintaining good indoor air quality.

Provide Adequate Ventilation

Adequate ventilation is another easy and effective way to maintain good indoor air quality, although it may not completely remove all pollutants. Increase ventilation by opening windows and doors when the weather permits. This is particularly important when using products or engaging in activities that may generate pollutants. Kitchen and bathroom exhaust fans that are properly vented to the outdoors are very effective at removing pollutants generated during cooking and showering. For effective ventilation while conserving energy during extreme weather, consider installing a heat recovery ventilator.

Opportunities for Further Action

The California Air Resources Board, working with representatives from other State and local agencies, is committed to reducing Californian's exposures to indoor air pollution by:

- Developing Indoor Air Quality Guidelines;
- Promoting preventive measures;
- Working with other goverment agencies and interested groups to reduce exposure to indoor air pollution;
- Increasing public education; and
- Increasing research into the health risks, economic impacts, and best mitigation measures for indoor air pollution.

How You Can Help

Follow the suggestions in this brochure. Educate yourself, your family, and your friends. Support the control of sources of indoor air pollution.

For further information and to obtain any of the reports mentioned in this brochure, please contact:

Indoor Exposure Assessment Program
California Air Resources Board
Research Division
P.O. Box 2815
Sacramento, CA 95812
(916) 322-8282

A Department of the California Environmental Protection Agency

"Indoor Air Facts No. 4 (revised): Sick Building Syndrome (SBS)"

Office of Air and Radiation
Office of Research and Development
Office of Radiation and Indoor Air (6609J)
April 1991

INTRODUCTION

The term "sick building syndrome" (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be widespread throughout the building. In contrast, the term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants.

A 1984 World Health Organization Committee report suggested that up to 30 percent of new and remodeled buildings worldwide may be the subject of excessive complaints related to indoor air quality (IAQ). Often this condition is temporary, but some buildings have long-term problems. Frequently, problems result when a building is operated or maintained in a manner that is inconsistent with its original design or prescribed operating procedures. Sometimes indoor air problems are a result of poor building design or occupant activities.

Indicators of SBS include:

- Building occupants complain of symptoms associated with acute discomfort, e.g., headache; eye, nose, or throat irritation; dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odors.
- The cause of the symptoms is not known.
- Most of the complainants report relief soon after leaving the building.

Indicators of BRI include:

- Building occupants complain of symptoms such as cough; chest tightness; fever, chills; and muscle aches
- The symptoms can be clinically defined and have clearly identifiable causes.
- Complainants may require prolonged recovery times after leaving the building.

It is important to note that complaints may result from other causes. These may include an illness contracted outside the building, acute sensitivity (e.g., allergies), job related stress or dissatisfaction, and other psychosocial factors. Nevertheless, studies show that symptoms may be caused or exacerbated by indoor air quality problems.

Causes of Sick Building Syndrome

The following have been cited causes of or contributing factors to sick building syndrome:

Inadequate ventilation: In the early and mid 1900's, building ventilation standards called for approximately 15 cubic feet per minute (cfm) of outside air for each building occupant, primarily to dilute and remove body odors. As a result of the 1973 oil embargo, however, national energy conservation measures called for a reduction in the amount of outdoor air provided for ventilation to 5 cfm per occupant. In many cases these reduced outdoor air ventilation rates were found to be inadequate to maintain the health and comfort of building occupants. Inadequate ventilation, which may also occur if heating, ventilating, and air conditioning (HVAC) systems do not effectively distribute air to people in the building, is thought to be an important factor in SBS. In an effort to achieve acceptable IAQ while minimizing energy consumption, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recently revised its ventilation standard to provide a minimum of 15 cfm of outdoor air per person (20 cfm/person in office spaces). Up to 60 cfm/person may be required in some spaces (such as smoking lounges) depending on the activities that normally occur in that space (see ASHRAE Standard 62-1989).

Chemical contaminants from indoor sources: Most indoor air pollution comes from sources inside the building. For example, adhesives, carpeting, upholstery, manufactured wood products, copy machines,

pesticides, and cleaning agents may emit volatile organic compounds (VOCs), including formaldehyde. Environmental tobacco smoke contributes high levels of VOCs, other toxic compounds, and respirable particulate matter. Research shows that some VOCs can cause chronic and acute health effects at high concentrations, and some are known carcinogens. Low to moderate levels of multiple VOCs may also produce acute reactions. Combustion products such as carbon monoxide, nitrogen dioxide, as well as respirable particles, can come from unvented kerosene and gas space heaters, woodstoves, fireplaces and gas stoves.

Chemical contaminants from outdoor sources: The outdoor air that enters a building can be a source of indoor air pollution. For example, pollutants from motor vehicle exhausts; plumbing vents, and building exhausts (e.g., bathrooms and kitchens) can enter the building through poorly located air intake vents, windows, and other openings. In addition, combustion products can enter a building from a nearby garage.

Biological contaminants: Bacteria, molds, pollen, and viruses are types of biological contaminants. These contaminants may breed in stagnant water that has accumulated in ducts, humidifiers and drain pans, or where water has collected on ceiling tiles, carpeting, or insulation. Sometimes insects or bird droppings can be a source of biological contaminants. Physical symptoms related to biological contamination include cough, chest tightness, fever, chills, muscle aches, and allergic responses such as mucous membrane irritation and upper respiratory congestion. One indoor bacterium, Legionella, has caused both Legionnaire's Disease and Pontiac Fever.

These elements may act in combination, and may supplement other complaints such as inadequate temperature, humidity, or lighting. Even after a building investigation, however, the specific causes of the complaints may remain unknown.

A Word About Radon and Asbestos...

SBS and BRI are associated with acute or immediate health problems; radon and asbestos cause long-term diseases which occur years after exposure, and are therefore not considered to be among the causes of sick buildings. This is not to say that the latter are not serious health risks; both should be included in any comprehensive evaluation of a building's IAQ.

Building Investigation Procedures

The goal of a building investigation is to identify and solve indoor air quality complaints in a way that prevents them from recurring and which avoids the creation of other problems. To achieve this goal, it is necessary for the investigator(s) to discover whether a complaint is actually related to indoor air quality, identify the cause of the complaint, and determine the most appropriate corrective actions.

An indoor air quality investigation procedure is best characterized as a cycle of information gathering, hypothesis formation, and hypothesis testing. It generally begins with a walkthrough inspection of the problem area to provide information about the four basic factors that influence indoor air quality:

- the occupants
- the HVAC system
- possible pollutant pathways
- possible contaminant sources.

Preparation for a walkthrough should include documenting easily obtainable information about the history of the building and of the complaints; identifying known HVAC zones and complaint areas; notifying occupants of the upcoming investigation; and, identifying key individuals needed for information and access. The walkthrough itself entails visual inspection of critical building areas and consultation with occupants and staff.

The initial walkthrough should allow the investigator to develop some possible explanations for the complaint. At this point, the investigator may have sufficient information to formulate a hypothesis, test the hypothesis, and see if the problem is solved. If it is, steps should be taken to ensure that it does not recur. However, if insufficient information is obtained from the walk through to construct a hypothesis, or if initial tests fail to reveal the problem, the investigator should move on to collect additional information to allow formulation of additional hypotheses. The process of formulating hypotheses, testing them, and evaluating them continues until the problem is solved.

Although air sampling for contaminants might seem to be the logical response to occupant complaints, it seldom provides information about possible causes. While certain basic measurements, e.g., temperature, relative humidity, CO2, and air movement, can provide a useful "snapshot" of current building conditions, sampling for specific pollutant concentrations is often not required to solve the problem and can even be misleading. Contaminant concentration levels rarely exceed existing standards and guidelines even when occupants continue to report health complaints. Air sampling should not be undertaken until considerable information on the factors listed above has been collected, and any sampling strategy should be based on a comprehensive understanding of how the building operates and the nature of the complaints.

Solutions to Sick Building Syndrome

Solutions to sick building syndrome usually include combinations of the following:

Pollutant source removal or modification is an effective approach to resolving an IAQ problem when sources are known and control is feasible. Examples include routine maintenance of HVAC systems, e.g., periodic cleaning or replacement of filters; replacement of water-stained ceiling tile and carpeting; institution of smoking restrictions; venting contaminant source emissions to the outdoors; storage and use of paints, adhesives, solvents, and pesticides in well ventilated areas, and use of these pollutant sources during periods of non-occupancy; and allowing time for building materials in new or remodeled areas to off-gas pollutants before occupancy. Several of these options may be exercised at one time.

Increasing ventilation rates and air distribution often can be a cost effective means of reducing indoor pollutant levels. HVAC systems should be designed, at a minimum, to meet ventilation standards in local building codes; however, many systems are not operated or maintained to ensure that these design ventilation rates are provided. In many buildings, IAQ can be improved by operating the HVAC system to at least its design standard, and to ASHRAE Standard 62-1989 if possible. When there are strong pollutant sources, local exhaust ventilation may be appropriate to exhaust contaminated air directly from the building. Local exhaust ventilation is particularly recommended to remove pollutants that accumulate in specific areas such as rest rooms, copy rooms, and printing facilities. (For a more detailed discussion of ventilation, read Indoor Air Facts No. 3R, Ventilation and Air Quality in Office Buildings.)

Air cleaning can be a useful adjunct to source control and ventilation but has certain limitations. Particle control devices such as the typical furnace filter are inexpensive but do not effectively capture small particles; high performance air filters capture the smaller, respirable particles but are relatively expensive to install and operate. Mechanical filters do not remove gaseous pollutants. Some specific gaseous pollutants may be removed by adsorbent beds, but these devices can be expensive and require frequent replacement of the adsorbent material. In sum, air cleaners can be useful, but have limited application.

Education and communication are important elements in both remedial and preventive indoor air quality management programs. When building occupants, management, and maintenance personnel fully communicate and understand the causes and consequences of IAQ problems, they can work more effectively together to prevent problems from occurring, or to solve them if they do.

Additional Information

For more information on topics discussed in this Fact Sheet, contact your state or local health department, a non-profit agency such as your local American Lung Association, or the following:

Indoor Air Quality Information Clearinghouse [IAQ INFO] (sponsored by the U.S. EPA)
PO Box 37133
Washington D.C. 20013-7133
(703) 356-4020 or 800-438-4318
fax: (703) 356-5386 or e-mail: iaqinfo@aol.com

You can order additional copies of this fact sheet and others in the Indoor Air Series from **IAQ INFO**.

National Institute for Occupational Safety and Health **www.cdc.gov/niosh/homepage.html**
US Department of Health and Human Services
4676 Columbia Parkway (Mail Drop R2)
Cincinnati, Ohio 45226

Public Relations Office
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) **www.ashrae.org/**
1791 Tullie Circle, NE, Atlanta, Georgia 30329

Building Owners and Managers Association International **www.boma.org/**
1250 Eye Street, NW, Washington, DC 20005