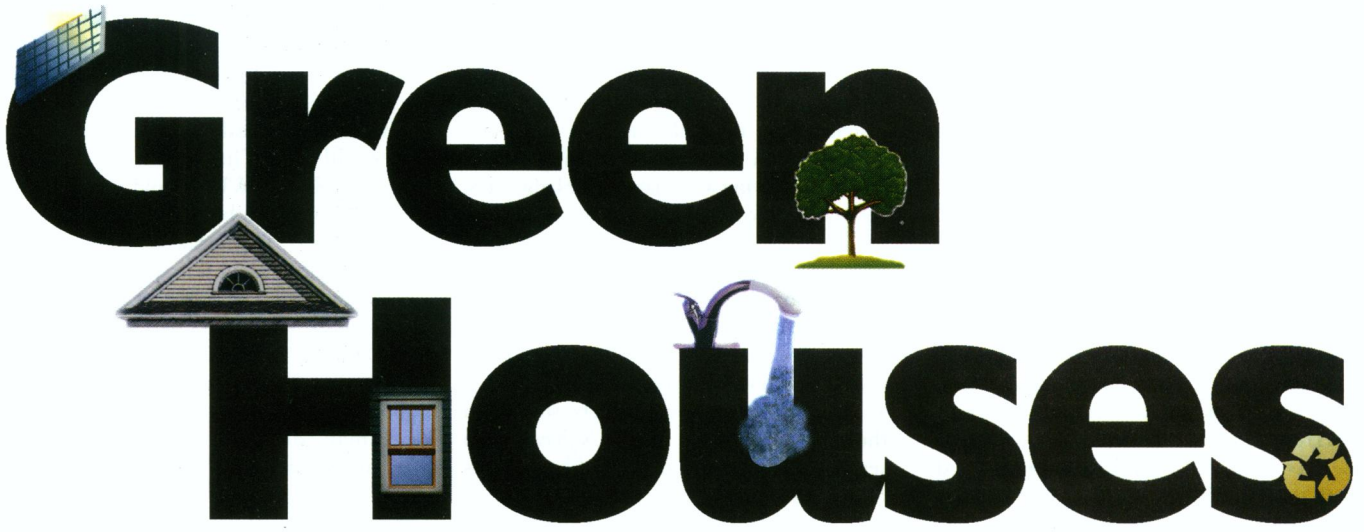
Green Houses



Architect Gail Lindsey felt dizzy and nauseous, with itchy and burning eyes, after finishing an aerobics class in a renovated gym one day in the late 1980s. "I knew that fumes from the new carpet and fresh paint job were doing me in," says Lindsey. "I began to wonder whether we know enough about the materials that we put into buildings."

As Lindsey examined ties between construction materials and human health, she discovered a small but growing movement of architects and environmentalists critical of modern building practices. Proponents of "sustainable design"—a combination of new technologies and ancient strategies that attempts to reduce unnecessary waste of natural resources while creating healthier indoor environments—argue that living and working in modern buildings not only makes some people ill, but that these structures also consume vast amounts of valuable resources and harm the environment.

For example, 25% of the virgin wood extracted from forests around the world is used in construction, according to the Worldwatch Institute, an environmental organization based in Washington, D.C. Unsustainable harvesting of forests leads to flooding, runoff into waters, and loss of endangered species. Yet wood products are often squandered at construction sites, even when the materials could be reused or recycled. A June 1993 study by the Metropolitan Service District of Portland, Oregon, a regional planning agency, showed that construction waste from three wood homes of varied sizes ranged from 3.7 to 4.5 pounds per square foot, and wood averaged 60% of the waste by weight.

Modern buildings, moreover, are profligate energy users, usually inefficiently lighted, cooled, heated, and ventilated. Buildings consume about one-third of the energy and two-thirds of the electricity in the United States and waste most of it, according to the Rocky Mountain Institute, a nonprofit organization based in Snowmass, Colorado that promotes sustainable design.

During the oil crisis of the late 1970s, many architects attempted to reduce energy consumption by making buildings airtight. But, as a result, many buildings which now lack adequate fresh air circulation, intensifies indoor air pollution from building material emissions, dust mites, molds, and other pollutants. Such indoor air can cause headaches, respiratory problems, and other reactions in occupants, prompting the naming of the cumulative effect of such reactions "sick building syndrome." Building materials that cause symptoms in some individuals include methylene chloride in glues, varnishes, and paint strippers; formaldehydes in manufactured wood products and carpet pads; and other volatile organic compounds (VOCs) used in floor finishes, paints, and carpeting adhesives. Since 1987, the EPA's Science Advisory Board has repeatedly ranked indoor air pollution as one of the top five risks to public health. Even so, "breathing fumes from VOCs could be even more of a problem for workers installing building materials than for occupants" because most of the fumes disperse after a few weeks, says Joseph Demkin, editor of the *Environmental Resource Guide*, a book published under the guidance of the American Institute of Architects (AIA).

Today, however, the U.S. building industry could improve its environmental and health record by following a combination of strategies, according to the *Environmental Building News*, a bimonthly newsletter published in Brattleboro, Vermont. Such strategies can include:

- choosing products made from salvaged and recycled materials;
- avoiding the use of paints, adhesives, and floor finishes containing VOCs;
- providing continuous ventilation in buildings;
- reducing construction waste;
- siting buildings to reduce environmental impact on vegetation and nearby waterways;
- orienting buildings to make use of passive solar heating and natural cooling;
- using durable building materials that require little maintenance;
- choosing energy-efficient heating and cooling equipment, lights, and appliances;
- choosing water-efficient landscaping with drought-resistant native plants;
- picking water-saving toilets, faucets, and irrigation equipment;
- and designing energy-efficient buildings that use high levels of insulation.

Sustainable design is growing rapidly, says Lindsey. Five years ago, she had to teach her clients from scratch about the health and ecological benefits of environmentally friendly building. But "starting about two years ago, folks have come to me," she says, for her special expertise in sustainable design.

Roadblocks to a Sustainable Design

Many obstacles to environmentally friendly building remain, however. The building industry is often slow to accept new materials and technologies that save resources and protect indoor air quality, experts say. "The building industry is, by nature, conservative for good reason," says Alex Wilson, editor and publisher of *Environmental Building News*. "If builders weren't conservative, they'd go broke."

Most homebuilders are small businessmen, constructing 5–10 homes a year, with scant interest in learning about construction research unless new materials are inexpensive, easy to use, and come with strong local track records. In this highly fragmented industry, it takes about 17 years for new materials to

become commonplace, according to the summary report of a meeting, *Technology for a Sustainable Future Workshop on Residential Construction,* sponsored by the White House Office of Science and Technology Policy and the Department of Energy on 6–7 October 1994 in Pittsburgh, Pennsylvania.

Moreover, developers, architects, and builders are often under great pressure to work quickly and cheaply, pressure that increases in times of high demand for new structures, critics say. A 1994 book by the Audubon Society and Croxton Collaborative, Architects, entitled *Audubon House: Building the Environmentally Responsible, Energy-Efficient Office,* describes the rapid development of office buildings during the construction boom of the late 1970s and 1980s. "Fast-growing businesses looked to developers to provide them with inexpensive, ready-to-occupy space, and developers in turn rewarded architects who could churn out inexpensive buildings in record time while complying with minimum building codes and standards." According to the authors, developers and their clients ignored "the physical discomforts of the buildings' occupants and the buildings' impacts on the local or global environment."

Due to these pressures, many architects are wary of alternative techniques and materials. Building an environmentally friendly structure requires innovation and research, which are time-consuming and, therefore, costly. To use alternative products, for example, building designers must ask a series of difficult questions including which chemicals in materials seem to cause the most dangerous health reactions; will materials become unreliable or ineffective when certain chemicals are eliminated; can a material be recycled; does mining, manufacturing, or transporting a material significantly damage the environment and, if so, is the damage worse than that of a similar product; and is a "green" material just too expensive for the health and environmental benefits it brings.

Although many alternative products cost more than conventional ones, they can often save consumers money over the long term. For example, compact fluorescent lamps (CFLs), costing about $10 each, are initially more expensive than conventional incandescent bulbs. But CFLs last about 10 times longer and are far more energy-efficient than incandescent bulbs, saving about $40 in utility bills over their life, according to the Worldwatch Institute.

Nevertheless, alternative products usually require years to catch on with the public, because reliable information on new technologies and building materials is often hard to find. Even when materials are tested by industry, architects want to know how products have held up over 20–30 years under real-world conditions. "I tell people we are all still in kindergarten," says Lindsey. "Despite all the testing done by manufacturers on new materials, using them is still a leap of faith."

But in recent years, professional societies, environmental organizations, consulting firms, and universities have increasingly studied the health and environmental impacts, cost, and performance of a wide range of building materials and technologies. Growing numbers of architects, homebuilders, and consumers are learning about environmentally friendly design from demonstration projects, which provide practical advice and field testing of alternative products. Meanwhile, several government agencies, including the Department of Energy, the Department of Defense, and the National Science Foundation, are developing sustainable guidelines for their projects. In September 1993, the National Park Service published a book, *Guiding Principles of Sustainable Design,* that describes how to design and manage parks and visitor facilities with environmentally friendly methods. The book addresses nine topics, including site design, building design, water supply, waste prevention, and energy management.

Sustainable design is a combination of new technologies and ancient strategies that attempts to reduce unnecessary waste of natural resources while creating healthier indoor environments.

Integrated Design

A few generations ago, builders often made American homes and offices with regional climates in mind. In hot regions, for example, homes were cooled by shade trees, wide roof overhangs, deep porches, and windows that faced prevailing breezes. That is, builders integrated a number of design details that had evolved over generations, helping to make residents comfortable at low energy costs.

Today, however, most developers destroy nearly every tree on homesites to make construction more efficient. And developers often ignore regional climates, building structures in New Mexico nearly identical to ones built in New Hampshire.

In contrast, homeowners should study their homesites carefully before they consider designs, experts say. For example, homeowners should learn about ancient principles for natural cooling and heating, taking in to account existing trees and other vegetation, sun orientation, and prevailing breezes. "In most parts of the U.S. simply making the building the right shape and pointing it in the right direction can cut total energy use by 30–40% at no extra cost," write Dianna Lopez Barnett and William D. Browning in a 1995 book, *A Primer on Sustainable Building,* published by the Rocky Mountain Institute.

To further reduce energy costs, some architects are integrating passive-solar and traditional techniques with new technologies such as super-efficient windows and smaller heating, ventilating, and air conditioning (HVAC) systems. High-efficiency windows, for example, cost more than conventional windows, says Lindsey, but homes that she designed in North Carolina using integrated techniques save 75% on heating and cooling bills.

Moreover, alternative energy sources such as solar photovoltaic systems are more feasible if building owners use passive-solar strategies. A conventional household on grid power often consumes 10,000 watt hours of electricity daily—more than alternative systems can produce economically. Affordable solar photovoltaic systems for single homes only provide 4,000 to 5,000 watt hours of electricity per day. Thus, homes with these systems must rely partly on natural heating and cooling, plus efficient appliances and lighting fixtures.

The building industry has the technical ability to make office structures that are far more energy-efficient than conventional ones, writes Amory Lovins, research director of the Rocky Mountain Institute, in the Summer 1994 *Rocky Mountain Institute Newsletter.* But to gain these savings, various players in the building's design and construction—developers, bankers, contractors, engineers, architects, and owners—must be brought together at the beginning of the project, argues Lovins. With this cooperation they could, for example, reduce the building's energy costs by thoughtfully orienting the building, choosing high-efficiency windows and light fixtures, and improving wall and roof insulation to allow for smaller HVAC systems.

"The building projects that seem most successful are ones that have used a highly collaborative process from the beginning," agrees Demkin. "The more you have a team cooperating, the more you have everyone understanding the project's goal, and you have more information flowing."

Today, some local governments are working to integrate regionwide systems for reusing and recyling construction waste. Most

modern homes are built with little thought to recycling construction materials. Huge amounts of waste from construction sites—including solid lumber and manufactured wood products, leftover bricks, metal, drywall, yard and landclearing debris, and metal—end up in landfills. But the regional solid-waste planning agency for Portland, Oregon, learned that raising tipping fees (fees to dump trash and other materials) for its landfills became "a strong motivator" for contractors to start recycling their wastes, says Bryce Jacobson, associate planner for the Metropolitan Service District. When the district raised its tipping fees beyond $65 a ton for solid waste, a private market began to develop for recycled construction materials because contractors could no longer afford to throw away trash, Jacobson says. Today, 75 processors accept contruction waste in the Portland metropolitan area, where tipping fees are $75 a ton. Fees around the nation range from $6 a ton in some Utah municipalities to more than $100 in the Northeast.

In Missoula, Montana, where tipping fees are $18 a ton, the nonprofit Center for Resourceful Building Technology is organizing local businesses that collect recyclable materials, such as wood products, asphalt, and drywall, according to research director Tracy Mumma. Instead of pushing for higher tipping fees, the organization will educate the local building industry on opportunities to recycle. "Many builders aren't aware that these businesses exist," Mumma says. "So we are trying to coordinate all these efforts and establish a central site where builders can bring or send their materials."

Choosing Better Materials

When choosing building materials, architects consider cost, durability, and aesthetics, plus how materials resist fire, moisture, and decay, among other qualities. But most architects don't take into account the health and environmental impacts of materials, says Chris Schmitt, an architect in Charleston, South Carolina who has designed several green homes. Part of the problem, says Schmitt, is that architects have had difficulty locating credible guidance about environmental and health impacts of materials. As a result, most building designers use only conventional products that have been proven reliable for years. "The dissemination of information about alternative materials is poor," Schmitt says. "Even as an architect, it's very hard to find out about alternatives. Considering the lawsuit-crazy environment, architects are cautious about using them."

To address this problem, the AIA has published the *Environmental Resource Guide* since 1992. Guide authors gather materials research published by the government and universities, but "we work especially closely with industry because industry has most of the data," says Demkin.

The 1996 guide analyzes 20 building materials, including stains and varnishes, ceramic tile, linoleum, vinyl flooring, and wall coverings. Material assessments were carried out under a cooperative agreement between the EPA and the AIA. The project was originally motivated by the EPA's concern over indoor air quality, according to Demkin, so most categories address products that are used indoors.

The guide provides designers and their clients a way to learn about possible life histories of building materials. "Materials provide a central framework for sustainable design," says Demkin. The guide's authors analyze how products affect the environment from "cradle to cradle," says Demkin. The first cradle is when raw materials are mined or harvested. The second cradle is after materials in a structure that is being demolished or rehabilitated are made available to be recycled for another use.

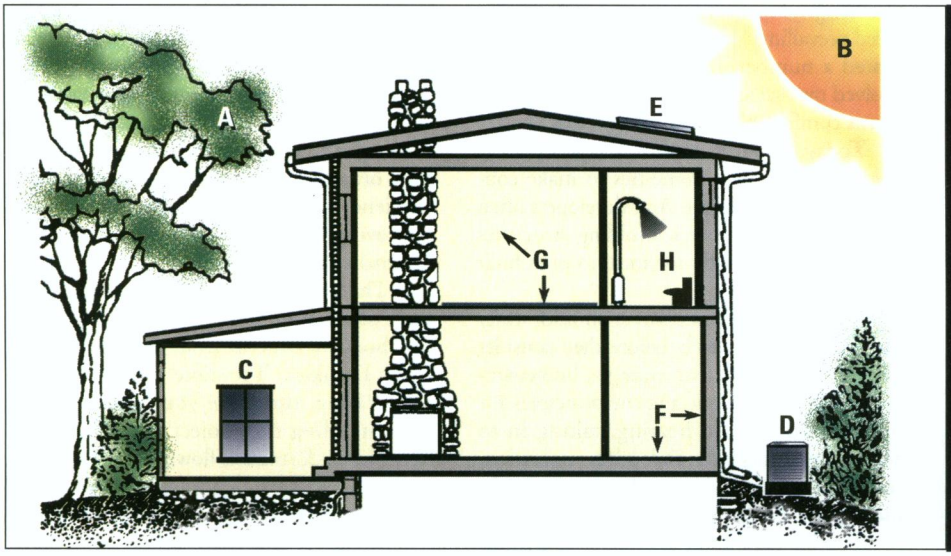
The assessments are comprehensive. "We trace all constituents of a product from acquisition through processing, manufacturing, use, and then to what happens when the building is demolished or remodeled," says Joel Todd, vice president of the Scientific Consulting Group in Gaithersburg, Virginia, which performs assessments for the guides.

Although the assessments do not address individual products, architects and clients can identify materials that they want to avoid, Demkin says. And manufacturers can find out what parts of a product's life cycle pose environmental problems. "We can often tell which materials are better in their environmental and health effects than others in each step of their life cycles," says Todd. One section of the report allows industry representatives and environmental groups to refute points and add information.

Still, deciding which environmental and health impacts are least severe—and which is the greener building material—is tricky. So clients must know their priorities, says Wilson.

Most homeowners who pursue sustainable design want to build with recycled materials, and with paints, glues, and preservatives that do not emit toxic pollutants indoors, architects say. And they want to use materials that will last longer and need less maintenance than conventional ones. Durability is an important principle of sustainable design, because fewer resources are used when materials last longer.

Some builders and architects have found, however, that alternative products can be hard to locate and purchase, as they must be special-ordered. "Alternative materials are usually more expensive and difficult to get



Components of Environmentally Sustainable Design

A. Siting (e.g., use of trees for shade)
B. Sun orientation for heat and light
C. Super-efficient windows
D. Smaller HVAC systems
E. Photovoltaic panels
F. Recycled building materials such as drywall, asphalt, and lumber
G. Nontoxic materials such as paints, carpet glues, and varnishes
H. Water-conserving toilets and showers

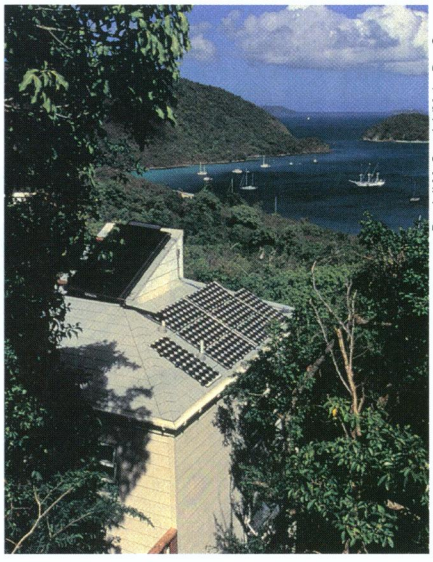
than what's found at the lumberyard," says Schmitt. Moreover, some alternative materials are difficult to install. "Some sustainable materials take twice as long to install," says Lindsey. "So builders [raise] the price."

Increasingly, though, a number of alternative products are becoming more popular with builders and architects, especially when the products fill a compelling need in the marketplace. For example, in the hot, humid Southeastern United States, some homeowners are seeking alternatives to conventional wood siding. Schmitt says, "Real wood is becoming exceptionally expensive, and the quality of wood sidings made from redwood, cypress, and cedar has declined in recent years as older trees have been cut down. The required maintenance of a wood house has also increased greatly because inferior wood warps and rots more quickly. Sophisticated clients understand that they will likely spend tens of thousands of dollars painting a wood house over the years they own it," he says.

Consequently, some homeowners in the Southeast are choosing "cement board" for siding instead of wood. The only available cement board for use in the Southeast is Hardiplank, a mixture of 10% virgin wood fibers from New Zealand and 90% cement that can be textured to look like wood siding, produced by James Hardie Building Products, based in Fontana, California. Hardiplank, which won't rot like traditional wood sidings, was developed in Australia in the 1980s and introduced in the United States about seven years ago.

Hardiplank is comparable in cost to traditional wood siding, but unlike wood, Hardiplank does not warp or shrink, is fire resistant, and doesn't require maintenance after initial staining. In contrast, the high-VOC paint required for traditional siding protection releases VOC emissions, notes Wilson. And some stains commonly applied to cedar siding may be highly toxic.

Yet one builder who has installed Hardiplank says that he doesn't want to work with the material again. Homebuilder Todd Poore of Charleston, South Carolina found Hardiplank difficult to install, "sending up a tremendous cloud of dust" when it was sawed, fouling his tools. In addition, the May/June 1993 issue of *Environmental Building News* calls Hardiplank's report card as a green building material mixed at best because Portland cement requires extensive energy to manufacture, and the virgin wood fiber used in Hardiplank must be transported all the way from New Zealand. However, editor and publisher Wilson acknowledges that Hardiplank's durability and low maintenance requirements are strong positives for the environment.



Randall McCormick/Maho Bay Camps

Demonstrating sustainability. Maho Bay Camps on St. John's Island were designed with the environment in mind.

Some homeowners are also building decks and guardrails with composite lumber products made from recycled plastics and waste wood. These products are expensive initially, but could pay off down the road because they can last longer than traditional wood products, and do not have to be stained or painted every few years.

Pilot and Demonstration Projects

Sustainable building products that find wide markets usually must move through two initial stages, says Wilson. First, pioneering companies experiment with materials and technologies, developing their products. But the public rarely accepts new products until the second stage when demonstration projects show the materials. "Once that second phase begins," Wilson says, "adoption of alternative materials can happen at a much greater pace."

A number of nonprofit organizations and private developers have established demonstration and pilot sustainable design projects in recent years. In 1992, the Audubon Society completed renovations of a 19th century building for its office in New York City, using the project as a case study on sustainable design and indoor air quality. Project coordinators decided that clean indoor air was a priority and thoroughly studied substances used in various paints, drywall, furniture, and flooring. For example, they requested material safety data sheets from manufacturers to check whether building products contained harmful chemicals such as formaldehyde or other VOCs. They also rejected synthetic carpet pads and instead installed an underlay made from plant fiber. To minimize the use of adhesives, a wool carpet was laid over pads and tacked down.

On St. John's Island in the Caribbean, developer Stanley Selengut built Maho Bay Camps, specially designed tent cottages that attract "ecotourists," people who are interested in tourist destinations that preserve local wildlife and culture. Constructed on leased National Park Service property, the tent cottages are wood-framed and built on platforms that disturb the environment only minimally. In a more recent resort called Harmony, cottages were built using recycled materials. Water is collected on roofs and stored in cisterns, and electricity is provided by solar power. Now Selengut, who contributed to the National Park Service's guidelines on sustainable design, is exploring the possibility of building similar cottages on the U.S. mainland. To cope with a four-season climate, he says he could design cottages with super-insulating fabrics to keep in warmth plus special heat-reflective materials, both developed by NASA.

One of the biggest flaws of environmentally friendly design, critics say, is that it has not reached lower-income people. "It's relatively easy for higher-income folks to pursue sustainable design," says Mel Goodwin, executive director of the nonprofit Harmony Project, Inc., in Charleston, South Carolina. "But lower-income folks have fallen through the cracks and have been unable to participate." In cooperation with the EPA, the Department of Energy, *Environmental Building News*, Dewees Island (an environmentally friendly residential development) and the U.S. Green Building Council, the Harmony Project is establishing a program to create exhibits, training workshops, and practical demonstrations of sustainable design for architects, builders, and neighborhood and city leaders. The project has also opened a 10,000-square-foot Harmony Warehouse in Charleston to disseminate building materials to affordable-housing and church groups, Goodwin says. In many cases, developers of building projects have donated over-ordered supplies, such as paint and concrete block, that otherwise would have been wasted.

Demonstration projects around the country are showing that environmentally friendly structures can improve indoor air quality, save energy, and provide attractive places to live and work. Still, many developers, architects, and builders resist change. As a result, most green materials and technologies will not become part of the mainstream until they clearly out-perform conventional ones. And alternatives will not become affordable and easily available until greater numbers of homeowners, office workers, government agencies, and other consumers demand these products and create broader markets.

John Tibbetts