GREEN BUILDING GOES MAINSTREAM

A WIDE-ANGLE VIEW OF SUSTAINABLE MATERIALS AND PRACTICES

BY ERICA GIES

Not long ago Bill and Becka Doering, of Santa Barbara, California, decided they needed a bigger house to accommodate their two young children. After a fruitless search of Santa Barbara's pricey real estate market, the Doerings took Becka's father up on an offer to trade his 102-square-meter (1,100-square-foot) tract house for their 84-square-meter place across town. That helped, but the tract house had just two bedrooms and one bath, so the Doerings remodeled, resulting in a 150-square-meter four-bedroom, two-bath house.

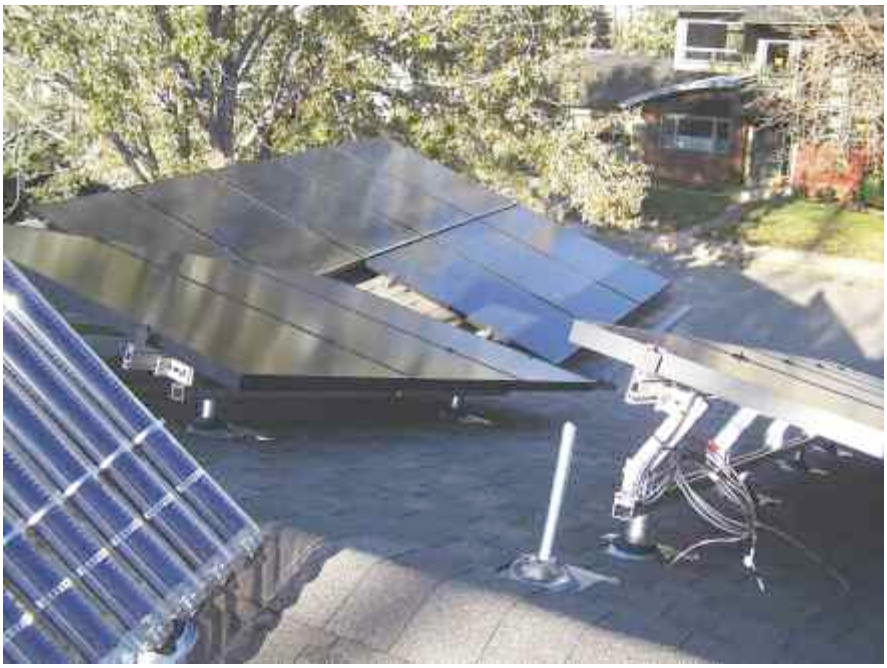
But this wasn't simply about elbow room. The Doerings also wanted their new home to be energy efficient and healthy. So they seized the opportunity to transform the building by hiring a like-minded architect and contractor to help them implement many green building principles. The remodel made improvements in site sustainability, energy and water efficiency, materials and resources, indoor air quality, and more. (See sidebar, page 17.)

Ironically, despite certain high-tech materials and the sophisticated design principles involved, the Doerings' remodel was in some ways a nod to the past. Humans used to build more sustainably and in context with place. The mud city of Djenné, Mali; the sod houses of the American prairie; African rondavals (round huts with grass roofs); the stilted, open-walled thatch shelters of Asia; igloos in the far north—all are examples of how people use natural, local materials and sited their buildings for optimum natural ventilation and climate control. Bill Doering said that following such ancient wisdom and embracing simplicity were key in his family's remodel: "Sometimes we overthink and try to overbuild when some of the most simple principles are what should be guiding us in green building." For example, Doering initially designed a single heating system for hot water and space heating, but it turned out to be prohibitively expensive. "And then we realized that this didn't really make sense," he said. "Why would we spend $30,000 on a heating system, when our whole intent was to turn it on as little as possible?" In the end, they put a solar water heater on the roof and bought an inexpensive, energy-efficient furnace.

GATHERING MOMENTUM

Green building is booming, especially in Europe and along the U.S. coasts. What started as a fringe movement in the 1990s is rapidly moving into the mainstream. In 2005, approximately 2 percent of new homes built in the United States were built "green," meaning in adherence to strong energy efficiency standards and practices, according to the 2006 *Green Building SmartMarket Report* by McGraw-Hill Construction (MHC). (The commercial sector reached 2 percent in 2004.) MHC projects both the residential and commercial sectors to increase to 10 percent of their markets by 2010. But these figures don't reflect the many undocumented piecemeal improvements made by a wide variety of building owners. In fact, 90 percent of home builders and 85 percent of commercial architects, engineers, and contractors reported some participation in green building activities, according to the MHC report.

This momentum is striking, and is driven partly by widening awareness of the environmental impact of the built environment and the health implications of chemically saturated indoor spaces. In the United States, 40 percent of all energy used goes to heat, light, and cool residential, commercial, and industrial buildings. An additional 8 percent is caught up in the embodied energy of construction and product man-



All photos other than those of the Doering remodel on page 17 are courtesy of Ecofutures Building Inc. (www.ecofuturesbuilding.com) of Boulder, Colorado.

This 1970s-era ranch house is getting retrofitted with both grid-connected photovoltaic panels and an evacuated-tube solar hot water system.

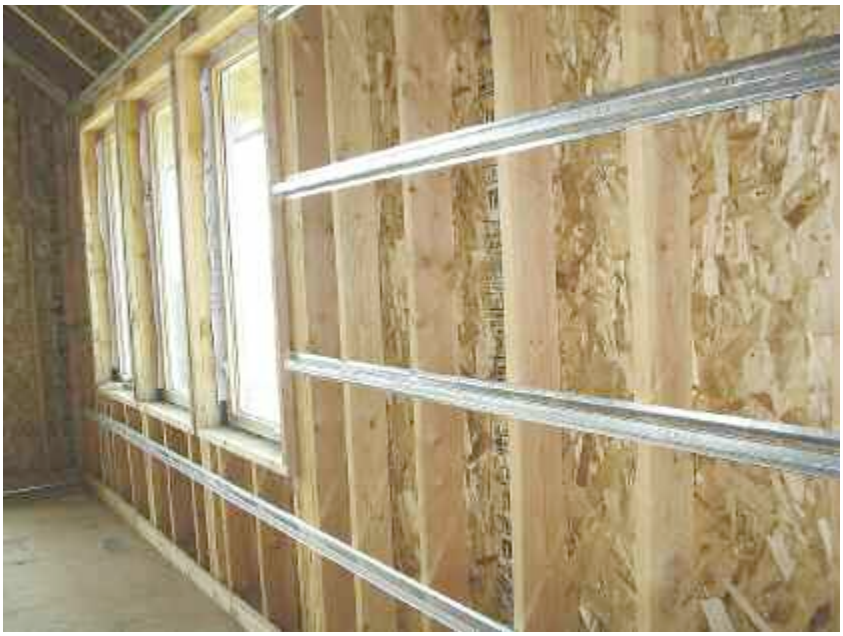
ufacturing, according to Ed Mazria, an architect who founded the nonprofit group Architecture 2030 to encourage industry and government to reduce building-related emissions. Close to 50 percent of U.S. CO_2 emissions come from buildings (43 percent for operations and 6 to 8 percent for materials and construction), says Mazria. The energy footprints of buildings in developed countries worldwide are likely comparable, he believes.

Climate-change concerns appear to be an important motivator to build green for both building owners and professionals; because the building sector consumes so much energy, reducing its usage could have a significant impact. In particular, Mazria focuses on reducing or eliminating coal usage, since coal is arguably the dirtiest fossil fuel. He says that a dramatic reduction in building energy consumption would reduce demand so much that the United States could actually shut down coal plants. Based on data from a recent McKinsey Global Institute report (*The Case for Investing in Energy Productivity*), Mazria concludes that, "in conservative terms, US$21.6 billion invested in efficiency would result in a 1 quadrillion BTU reduction [in energy consumption]." In the United States, "you would be able to close down 22.3 coal plants for every $21.6 billion invested. You would also reduce natural gas by 204 billion cubic feet a year and cut down on oil by 10.7 billion barrels a year. You'd cut CO_2 emissions by 86.7 million metric tons, you'd save consumers $8.46 billion a year, and you'd create about 216,000 jobs."

Green building is also getting a boost from efforts around the world to set standards for buildings and educate the public, industry, and policymakers. These programs aim to reduce greenhouse gas emissions and water usage and to improve practices regarding hazardous substances, pollution, and safety. Some third-party ratings systems include LEED (Leadership in Energy and Environmental Design), developed by the U.S. Green Building Council (USGBC); BREEAM (Building Research Establishment's Environmental Assessment Method) in the United Kingdom; Japan's CASBEE (Comprehensive Assessment System for Building Environmental Efficiency); LEED Canada; and Green Star in Australia. There is also a World Green Building Council (WGBC), headquartered in Toronto, Ontario, that is comparing the national ratings systems to compile best practices. The WGBC's 12 member countries represent about 50 percent of the global construction industry.

Smaller organizations in various countries are also contributing. For example, Mazria's Architecture 2030 has issued the 2030 Challenge to encourage governments and industry to reduce the fossil fuel energy consumption of all types of buildings by 50 percent from 2003 levels by 2030 for similar building types in their areas. The challenge sets increasingly tighter standards so that by 2030 all new buildings will be "carbon neutral" (see discussion below). Mazria said that almost all professional organizations, many cities and states, and the U.S. federal government have taken up the challenge by means of resolutions, executive orders, or legislation. Many governments are currently applying the targets only to their own buildings, but some are working to incorporate the standards into building codes; in fact, the Doerings' home town of Santa Barbara was the first U.S. city to do so, in late 2007. Now the state of California is updating its building code to meet the targets.

Mazria notes that the ordinary workings of the market will mean a dramatic changeover of building stock by 2035. Current U.S. building stock amounts to roughly 28 billion square meters of floor space. Builders will likely demolish about 4.9



Some builders believe that resilient channels, installed over studs here, improve building envelope performance by breaking the path of thermal and acoustic conductance between inside and outside.

billion square meters over the next 30 years, renovate 14 billion square meters, and add 14 billion square meters of new stock. "So by 2035, more than three-quarters of the built environment will either be new or renovated," he says. If everyone building or remodeling implemented the 2030 targets, the changeover would dramatically reduce emissions. Mazria is hopeful that Congress and the new administration in 2009 will upgrade current federal building energy code standards so all new buildings meet the 2030 targets.

While new green buildings are sexy in their design and ambition, streamlining operations and maintenance and other retrofitting projects for existing buildings are also critical to reducing energy use. Mazria notes that, of the 48 percent of U.S. energy consumed by the building sector, 40 percent goes to building operations and maintenance. That's why improving these areas is so vital. "There are energy codes out there, but there's nothing that really requires anybody who has an existing building to make sure it's operating efficiently, other than the price of energy," says Brendan Owens, vice president of LEED Technical Development for the U.S. Green Building Council. And in the United States in particular, "the market doesn't send the right signals for the true cost of the environmental and social impacts of our energy use policies."

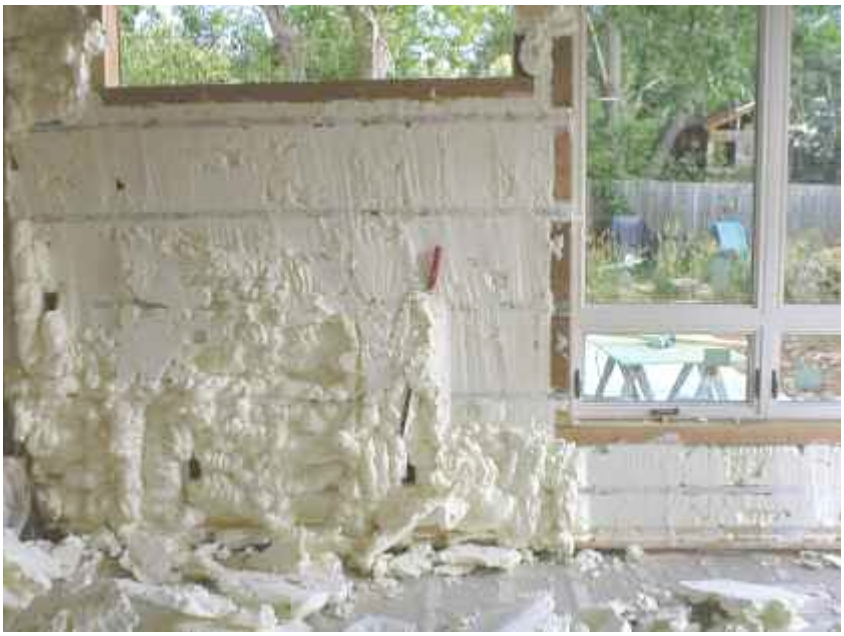
Energy auditors can maximize a building's energy efficiency by a careful room-by-room examination. Many will do a blower door test to determine where a building leaks air. The auditor puts a powerful fan in an exterior door to pull air out of the building and reduce the inside air pressure, allowing air to flow through all unsealed areas. Thermography (infrared scanning) is also an important tool to identify thermal defects and air leakage. Owens said a trained energy auditor can improve a building's efficiency by at least 30 percent with minor upgrades whose cost will be recovered within one year. Such upgrades can include lighting technology, sealing leaks in the building envelope, resealing distribution and return ducts, tuning up the mechanical system, and ensuring that the stop/start times on building systems are set optimally.

RENOVATING

Homeowners may wonder whether renovating at all is green, since construction generates waste and is energy-intensive both by its nature and via the embodied energy of new materials. But just 8 percent of U.S. energy consumed by the building sector goes to construction and building materials, according to Ed Mazria. So renovation makes sense if it will reduce the building's annual energy consumption.

Green building contractor Paul Cerami's business in Berkeley, California, is about 90 percent remodels. He said replacing older appliances and systems saves more energy than any other type of project. The next-best step is replacing single-paned windows with double- or even triple-paned glass.

In Cerami's area, installing insulation is a common job, as many older homes have none. He said insulation is a good place for anything recycled, such as blue jeans or newspaper (cellulose). Cerami particularly likes a new foam insulation called Icynene®, which offers a lot of insulating power in relatively small dimensions and also allows water vapor to escape, preventing mold growth. Icynene® has an R-value (a measurement showing the comparative efficacy of insulations) of 3.6 per inch. So a wall built with "2x4" dimensional lumber—which is actually just under 3.5 inches, or 9 centimeters, thick—and filled with Icynene® yields an R-value of about 13. A 2x6-inch wall (roughly 5.5 inches thick) gives about R-20. Icynene® is blown in with water, using no chlorofluorocar-



In this addition to an existing home, Icynene® has been blown between studs and is being scraped down flush with the resilient channels.

bons, and it doesn't tamp down or age like other blown-in insulations, so it's expected to maintain its optimum R-value.

Cerami said that tankless water heaters are also a popular upgrade; he installs them in 95 percent of his jobs. These electric, on-demand water heaters use less energy than standard models because they don't keep the water heated around the clock, instead heating it instantly when needed. As for the water itself, key water-saving devices include low-flow, dual-flush toilets; flow restrictors on showerheads and faucets; appliances such as front-loading washing machines and newer dishwashers; and drip irrigation in the garden.

Projects also need to take waste into account to be truly green, and they can do so at both the demolition and building stages. Demolition can produce a huge mass of materials, and it needn't all go into a landfill. The Doerings, for instance, reused or recycled most of the material that came out of their house, giving away windows and doors to neighbors, selling old flooring, and giving appliances and other materials to Habitat for Humanity and shutters to antique dealers. They reused kitchen cabinets, bookshelves, and closet shelving. Of the 100 tons of remaining material, a local waste collector helped to recycle 85 percent.

Salvage yards and house tear-downs thus become great sources for materials, and recovered products are much less expensive than new ones. These sources are also more likely to yield a piece that fits authentically with the style of an older building. And while old windows and appliances aren't good choices for energy efficiency, buying other used materials can be the least environmentally damaging way to shop because it does not generate demand for new products that consume resources. Cerami said his company has bought a lot of salvaged material for projects, from decorative wood beams to siding to old hardware such as locks.

Another important way of minimizing waste is to think long-term when planning a project and consider the life cost of the building, including operations and maintenance. Bill Doering made choices for his house based on this principle. "The color is integrated into the stucco with very little wood showing, so the upkeep will be little," he says. "The cladding on the windows is all fiberglass so that will never corrode.… We shouldn't build houses to last for 50 years; we should build them to last for 200 years."

Cerami also emphasized making timeless choices over trendy ones. "We're still burning up resources when we're doing construction remodels," he says. "It's making the choices so these things won't be torn out five years from now and redone and sent off to the dump again."

STARTING FROM SCRATCH

Done properly, a green building does more than just conserve energy and resources. "The industry is starting to get comfortable with the idea that high performance green office space is fundamentally better in quantifiable ways from a productivity standpoint," says USGBC's Brendan Owens. "People take fewer sick days…they don't complain about heat or cooling, they're more satisfied with their work environment when can see outside or they have good daylighting. And that's the type of thinking that allows employers to attract and retain key people."

New building projects allow architects, engineers, and landscapers to plan comprehensive, building-wide systems. They can optimize building orientation to make the most of daylight, solar heat, and cross breezes for cooling. Where appropriate, they can set buildings against a hill for added insulation, or incorporate certain features that are difficult or

too expensive to include in a remodel, such as hot water pipes laid under flooring to warm the building. Even traditional solar PV can be less expensive as a new feature.

Green builders must be mindful not only of the energy a building consumes every day but also of the energy embodied in its making, which is consumed during the extraction of resources, the manufacture of materials and devices, their transport to the point of sale or the building site, and so on. One way to reduce the embodied energy of construction is by erecting a prefabricated building out of large, factory-made components. Modern prefabricated buildings can be energy efficient in operations and maintenance as well, and can be elegantly designed with options for originality to avoid a cookie-cutter look.

In some cases, builders may go beyond a focus on energy efficiency alone and strive to qualify their buildings as "carbon neutral" or "net zero energy." These terms are not always consistently defined, but in general, net zero energy means that a building's energy consumption is offset by clean, on-site energy generation, such as from solar photovoltaic modules or small scale wind turbines, which can sometimes be roof-mounted. A claim of carbon neutrality implies that a building's total carbon footprint is zero, i.e., that the carbon released during its construction and operation is compensated for by use of renewable energy from a utility and/or by paying others to sequester carbon. A carbon-neutral building might also rely on on-site generation for part of its energy. In practice, buildings touted for their small carbon footprints often do not account for embedded carbon from materials and construction.

Another idea shaping the design of new green buildings is the concept of "soft failure." Sparked by Hurricane Katrina, which hit the U.S. Gulf Coast in 2005, it means designing buildings that are more resilient in the face of floods, heat, and other extreme weather that could become more prevalent with climate change. For example, Brendan Owens asks, "when the power goes out, are you in a building that is uninhabitable because you can't open the windows? Or if it gets a little bit wet, do you have a significant mold problem that's an immediate health hazard? Designers are looking at increasing temperatures [due to climate change] and what that means for buildings' ability to cool themselves, whether by passive or active means." When damaged, such buildings should remain healthier and require fewer resources to rebuild. Minimizing damage should also reduce social costs, such as death, illness, community dislocation, split families, and mental health care required due to stress.

A word about materials, whether they are going into a new building or a remodeled one: determining whether a building product is green requires considering its recycled content, its material sources and whether they're sustainable, its chemical content, its environmental impact from manufacturing, the health impact on workers, the greenhouse gas footprint of the product cycle, the waste stream generated throughout its lifecycle, and how far it traveled from the point of manufacture to the project. Third-party certification and standards programs do some of this research for consumers. However, there are different programs for various categories of materials, and not all materials have been reviewed. With green building becoming so popular, experts say some companies are just hopping on the bandwagon, hoping to profit. Greenwashing can result.

Andrew Bowerbank, executive director of the World Green Building Council, has faith that the market will shake out. "We have to rely on our industry leaders to identify organizations like FSC [Forest Stewardship Council for wood], Energy Star [for appliances] and others.... In any kind of competitive market, the ones that have value, the ones that are really walking the talk, they're the ones that end up making it through the marketplace, and everyone else goes bankrupt."

Owens says that in the United States stakeholders are looking to establish a national "greenmark" for product certification. "In the meantime, I would say…'buyer beware'," he cautions. "It's going to take a little bit of education for you to understand what the product certification means.... [Buyers should] look at multi-attribute screening criteria more than single-attribute [criteria]."

LANDSCAPING

Because a building is inextricably linked to the land, sustainable landscaping is a vital part of green building. It can affect every dimension of a project, from energy use to water management, as well as appearance. For example, thoughtfully situated trees can reduce energy use by shading buildings in the summer, reducing the need for air conditioning. On the sunward sides, deciduous trees will shade in the summer but admit winter sun. On sides facing prevailing winds, evergreens can serve as a windbreak, reducing heat loss. A 2001 study from the Forest Service's Center for Urban Forest Research in Davis, California, found that increasing urban tree cover in the United States by 50 million trees over the next 15 years could save 6,100 gigawatthours of energy, the output of seven power plants. That would save consumers $1 billion a year.

Stormwater management is of increasing concern in many areas such as California, which recently passed a law requiring no net stormwater runoff for all new commercial and public buildings. Instead, the water must be collected and stored on site. There are several ways to meet this requirement, according to San Rafael, California, landscape architect Leith Carstarphen. On larger properties he constructs "vernal" streams and ponds that fill up during winter storms and run dry during the summer. He can also create wetlands that clean runoff before infiltrating it into the groundwater or irrigating the property. A wetland can also process blackwater (sewage) on-site. On smaller properties, he often digs a drywell, which is much like a regular well except that it doesn't reach ground-

The Doerings' Remodel: A Snapshot

Some of the measures taken or planned to conserve energy, water, and resources:

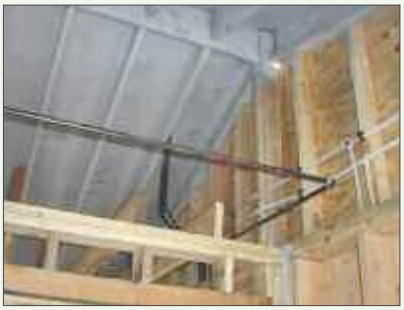
Project Site
- Drought-tolerant landscaping
- Removal of all turf grass
- Brick from demolished fireplace used to build outdoor bench
- Unsafe acacia tree removed and used as mulch

Water Efficiency
- Filtration and water softening system does not require electricity or use of salts
- Roof runoff collected in drywell to slowly percolate into groundwater
- Dual-flush toilets and other water-conserving bathroom and kitchen fixtures

Energy and Atmosphere
- Increased southern window area to admit natural light
- New overhangs and trellis reduce heat gain on south side of home
- "Radiant barrier" paint additive on underside of roof reduces attic heat gain
- Paint with ceramic particles increases walls' insulation and thermal mass capabilities
- Solar water heater supplemented by gas-fired, tankless "on-demand" water heater
- Energy-efficient, low-e2 windows with fiberglass clad exterior
- Icynene® insulation in all exterior walls
- Cellulose insulation in ceiling
- Whole-house cooling fan
- New walls built to R-19 standard
- Skylight for natural lighting
- New, tighter exterior doors
- Compact fluorescent bulbs and new LED technology for lighting
- Wiring and hardware installed for future photovoltaic panels

Materials and Resources
- Construction demolition plan diverted 85 percent of project's waste from landfill
- Further waste reduction by giving away windows, doors, furnace, appliances, toilet, and sink
- Other windows, plus shutters, fireplace mantle, and oak flooring sold
- Reused kitchen cabinets, bookshelves, and closet shelving
- Locally harvested acacia tree used for cabinet trim, shelves, and a window bench
- Used salvaged bathroom sinks, faucet hardware, and vanity light fixtures from local construction project
- Sustainable building materials including bamboo flooring, wheatboard cabinets, cellulose insulation, natural linoleum, FSC-certified wood, fly-ash in cement
- Exterior finished with color-integrated stucco and fiber cement board
- 50-year roof

Indoor Environmental Quality
- Wheatboard and formaldehyde-free melamine shelving and cabinet materials
- Zero-volatile-organic-compound interior paints and coatings
- Nontoxic sealants, adhesives, and oils
- Openable windows promote air circulation
- No carpeting
- Whole-house water filtration system



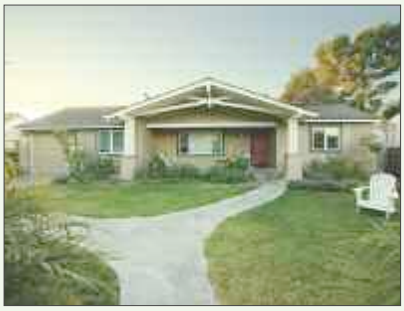
Top left: Whole-house cooling fan being installed in the attic.

Above: Paint applied to the underside of the roof contains a "radiant barrier" additive.

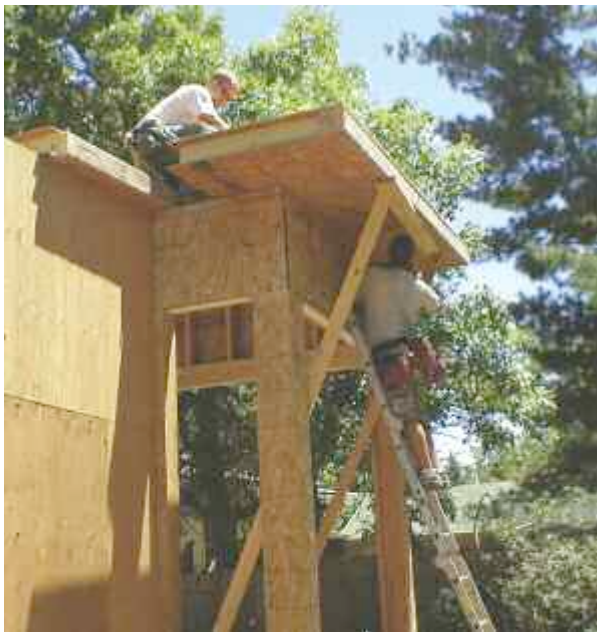
Top right: Skylight mounted in the roof, 50-year shingles awaiting installation.

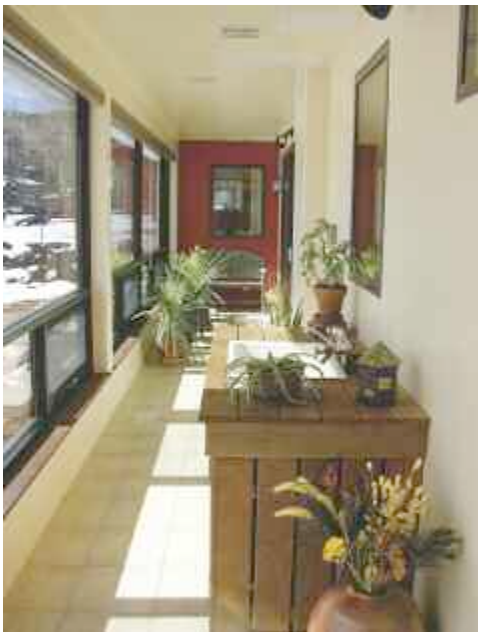
Left: Trellis being constructed to shade the patio at the back of the house.

Right: The front of the Doerings' newly remodeled home.



Four construction photographs courtesy of DoeringDesignandEngineering.com





water and so is dry unless there have been recent storms. Drainage is directed to it, and the water then infiltrates into the soil slowly. Sometimes he works with architects to build tanks with capacities of up to 1.9 million liters (500,000 gallons) into the substructure of building. These hold roof runoff until it is needed for irrigation or for household use, such as toilet flushing.

Rain barrels can capture water for irrigation, particularly in places where it rains year-round. Ideally they are placed on the highest part of the property so that water flows to the irrigation system via gravity. When that's not possible, a pump can move the water uphill. The use of native plants in landscaping can also save water as well as minimize pests and maintenance, according to Carstarphen. They also provide habitat for native insects and birds, and many attract beneficial insects to the grounds. Piles of rocks or wood create habitat for worms, insects, lizards that eat insects, and other beneficial creatures. For example, the Western fence lizard's blood neutralizes Lyme disease in ticks, and a study from researchers at the University of California, Davis, found that in areas with a lot of lizard habitat, there's no Lyme disease.

Other ways to conserve water in the garden include drip irrigation, which releases just the amount of water plants need, and graywater systems, which move used water from sinks and showers out into the yard for watering.

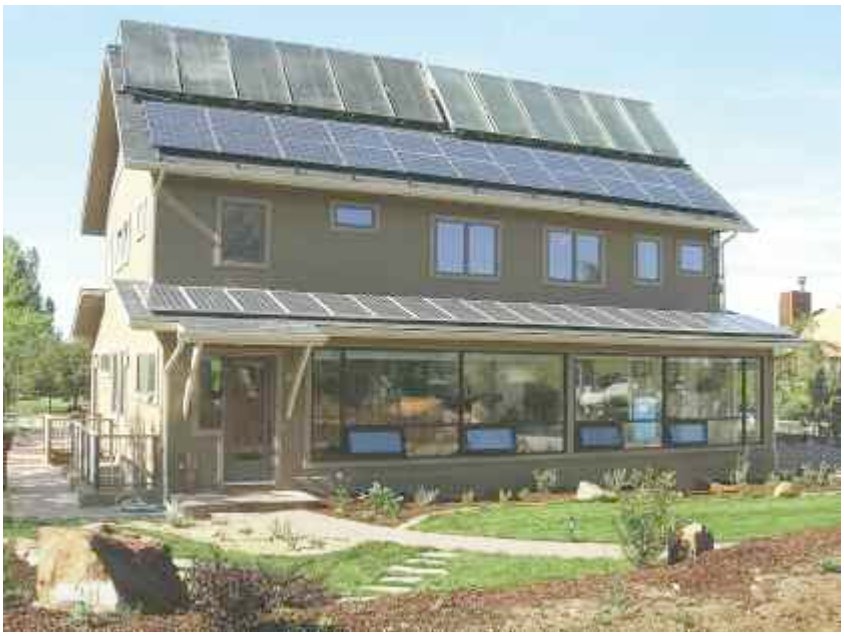
To reduce fossil fuel emissions from food production and to reconnect people with their land, Carstarphen plants food crops for all his clients. "The edible theme is really catching on as people are getting more concerned about food security and quality," he says. "You can really see everything that's going in to [the food]: the fertilizer, how it's being cared for, that the land is not destroyed in the process."

In the 14 years Carstarphen has been in business, he's seen sustainable garden practices move into the mainstream. "Even in Home Depot and places like that…I see they have a selection of organic fertilizers and are starting to carry a few natives," he says. "It's a tiny shelf in a sea of chemicals. But they realize that there's starting to be a consumer demand, and if they don't meet it, people are going to go somewhere else."

GREENING COMMUNITIES

Green building practices are starting to encompass the structure of whole communities as well as the buildings in them. Bill Doering, for instance, said his family's move and remodel led them to a changed lifestyle that entailed conserving water and walking to errands and play, which wasn't possible in their previous home. Their old place was a part of suburban sprawl, the typical development pattern in the United States and most of the inhabited world, rich and poor countries alike, since World War II. A car is required because houses are too far apart for efficient and affordable mass transit, homes and shops are in different neighborhoods, and a lack of grid-style streets or walking easements can make it much further than the crow flies to walk places. Bill Doering's remodeled house in an older neighborhood is not part of a sprawl development, and the difference surprised him. "In this neighborhood, we're able to walk to the grocery store, walk to the drugstore, walk to dinner, walk to have the kids go play at the park," he says. "Now our kids are going to be able to walk when they go to school down the street, and that's just not something that was possible in our other neighborhood."

"It's not possible to segregate buildings and land use in any meaningful way," says Brendan Owens, who's helping to create the LEED for Neighborhood Development Rating System. "We want to educate architects that where you put a



Far left: Structural insulated panels (SIPs), R value of 42, being installed as the roof of a residential addition.

This page: Boulder, Colorado's first net-zero energy home, built in 2005. The south-facing facade uses solar power both for electricity generation and for heating water then stored in a 23,000-liter underground tank.

When air temperature in the south-facing sunroom (center) reaches 27°C, fans draw this warm air to other parts of the house.

building matters. And we want to educate building owners about the negative effects of sprawl and the negative effects of neighborhoods and communities that are completely dependent on automobile transportation."

The neighborhood development sector of green building emphasizes thoughtful community planning, expressed using a variety of monikers: smart growth, traditional, new urbanism, healthy communities, livable communities, transit-oriented development, and active living. They share the goals of higher densities to facilitate efficient mass transportation; mixed-use development that builds homes, schools, stores, parks, and other resources within a compact area so that people can walk or bike to activities; sidewalks for safety; and shared community green space. Most of these philosophies strongly favor infill—remodeling or building new within an existing community's boundary—over developing virgin land. Infill preserves habitat for wildlife, forests, farmland, and recreation, and it maintains the integrity of communities and contributes to their revitalization by improving existing infrastructure and introducing new homes and business. When infill developments are mixed use, the "active transport" (walking and biking) it encourages promotes health directly, and by shortening commutes it also frees up more time for family and friends and reduces the stress and "road rage" associated with driving in traffic. As oil prices continue to increase, such compact neighborhoods will only become more desirable.

EFFICIENCIES

Bill Doering has tracked his electrical, gas, and water usage for 18 months and compared it to his family's usage at their old house, which was 66 square meters smaller and occupied by just two people, rather than four. At the new house, gas usage is almost zero from April through November and minimal the rest of the year, an average of 25 therms per month. Doering estimates their gas usage at 25 to 40 percent below that of the old house. Water consumption is slightly below the average at the old house. He is unsatisfied with his family's electrical use at the new house, which is 25 percent higher. "Still, our average usage is 200 to 225 kilowatthours per month, which is not a lot," he said. Nevertheless, Doering hopes to make the house carbon neutral within five years by reducing consumption and either buying offsets or adding solar panels or other hardware to capture or generate renewable energy.

Industry data bear out Doering's experience. Compared to standard buildings, LEED-certified buildings are 25 to 30 percent more energy efficient, and Gold and Platinum LEED buildings save 50 percent more energy, according to a recent study from New Buildings Institute. The McGraw-Hill Construction report mentioned earlier says that green buildings decrease operating costs 8 to 9 percent, increase value by 7.5 percent, offer a 6.6 percent improvement on return on investment, and increase occupancy ratios by 3.5 percent and rents by 3 percent. These financial advantages are strong motivation for building owners to adopt green practices and should keep the green building industry growing and refining techniques and materials. The result is likely to be healthier, energy- and material-efficient, and more useful structures.

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For more information about issues raised in this story, visit **www.worldwatch.org/ww/greenbuild**.