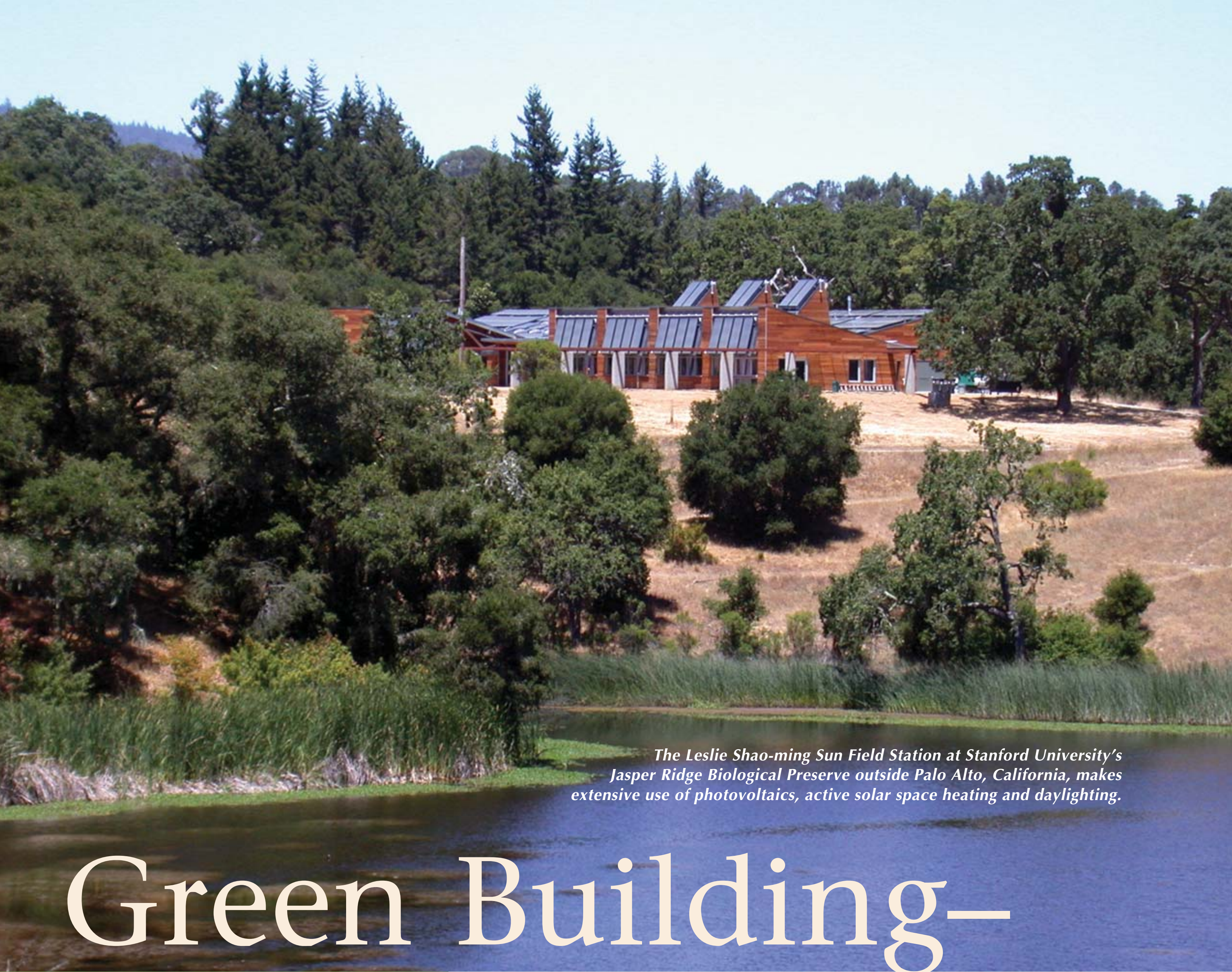

The Leslie Shao-ming Sun Field Station at Stanford University's Jasper Ridge Biological Preserve outside Palo Alto, California, makes extensive use of photovoltaics, active solar space heating and daylighting.

Green Building–A Natural for This Biological Preserve

by Alex Wilson

Photos by Phillipe Cohen

When staff at Stanford University's Jasper Ridge Biological Preserve outside Palo Alto, California, first began thinking about a new field station, several things were obvious. One, a new building would have to sit lightly on the 1200-acre preserve—an oasis of oak groves, grasslands and wildlife that is ecologically important enough to be recognized as an international biosphere preserve. Two, because one of the largest research projects at the facility is the Jasper Ridge Global Change Experiment, and because thousands of visitors come here annually, the building should demonstrate solutions to global climate change.

"It only seemed reasonable that the building not contribute to one of the problems the preserve is most involved with," says Preserve Director Philippe Cohen. Thus, the staff decided early on the building would produce no net carbon emissions on an annual basis. That goal drove the energy design of the building, but it also carried over to material selection—informing decisions like the use of fly ash in concrete floors and the

Innovative design allows the Leslie Shao-ming Sun Field Station at Stanford University to demonstrate solutions to global climate change use of salvaged building materials.

The 9800-square-foot Leslie Shao-ming Sun Field Station, named for a past docent (volunteer tour guide and research assistant) whose husband provided significant funding for the building, was completed in June 2002. It replaced a cluster of mismatched buildings—including a converted hamburger stand—that had inadequately served researchers, professors, students and visitors for years.

San Diego architect Rob Quigley, FAIA, of Rob Wellington Quigley Architects, designed the building in a highly collaborative process facilitated by Cohen. Fitting into the site in an unobtrusive way was a high priority from the start. Quigley's first thought on seeing the site was that there shouldn't be any buildings—"it's just this incredibly pristine site," he says. Given that a building was going to be built and realizing that the ability to carry out research there was allowing the land to be kept pristine, Quigley took on the challenge. "We spent a whole lot of time trying to figure out how to reduce the physical impacts," he says. In fact, his first choice was to put the building underground—an idea that had to be dismissed due to budget concerns.

Because this was a design-build project, Cohen was able to involve the contractor right from the start, which was key to the success of the project. However, getting buy-in from many of the subcontractors proved more difficult. Both Cohen and Quigley lament that they weren't able to get all the subcontractors together early in the process to go over the sustainability goals and specialized green building practices; scheduling problems prevented such a meeting. "If I had to do it over, I would have made [participation in such a meeting] a requirement for getting the contract," says Cohen.

What emerged from the design process is a practical, adaptable, comfortable building that melds into the surrounding fields and woodlands. But it is also a remarkable building—with one of the smallest ecological footprints of any university building in North America.

Solar Energy Systems

The Sun Field Station makes extensive use of three different solar energy technologie—photovoltaics (PV), active solar space heating and daylighting. A 22-kilowatt (kW) PV system provides most of the power for the building. This is a grid-connected system consisting of 275 80-watt BP Solar TF-80B thin-film modules. The building's performance is lower with the thin-film modules, but because this is a research facility, the staff decided to try out the newer technology.

The PV modules are wired together in series to form strings (11 modules per string), and those strings are wired together in parallel to form three sub-arrays. There are differences in the orientation and pitch of the sub-arrays, which allows the researchers to collect some interesting comparative data. Other components in the PV system include a DC disconnect box, a Trace/Xantrex inverter and an isolation transformer (required with most grid-connected systems for safety reasons). Net metering laws in California allow the preserve to run their meter backwards when more power is being generated than the building uses.

The fact that net-metering is a fairly new concept became apparent last summer when Stanford received a $134,000 bill for electricity. Scott Gould of the utility department at the university explained that miscommunication at Pacific Gas & Electric led to the huge charge when in fact there was a net transfer of power from the building into the grid. Because loads were fairly low when the building was first occupied, the new meter ran backwards from zero. The utility reader saw all these 9s, according to Gould, and thought the building had consumed tens of thousands of kilowatt-hours, resulting in the charge. That problem was eventually worked out, but utility records of net consumption or production by the building are still hard to come by.

Dr. John Scofield, a physics professor at Oberlin College, set up a sophisticated monitoring system in the spring of 2003 to collect information on PV power production and building electrical use. This data can be viewed in real-time on a web site maintained by the Jasper Ridge Biological Preserve (see project details, page 63). Scofield notes that mounting the modules in two planes—one tilted due south and the other rotated a bit to the east—created a monitoring challenge, "but also an interesting opportunity to study the difference between morning and afternoon PV performance in the Bay Area, which frequently experiences morning fog."

Much of the output from the PV system is used to operate research equipment, such as a walk-in cold-storage locker, an industrial freezer and several electric drying ovens. Electricity consumption is thus a lot higher than what one would expect in a typical classroom/office building. "The main goal of this building," notes Scofield, "is not to be a low-energy building; its main purpose is to support the teaching and research that it houses."

The active solar water heating system is also impressive. Twenty-six 4 foot by 8 foot Heliodyne solar thermal collector panels provide space heat for the facility. Propylene glycol is the heat-transfer fluid in this large and sophisticated system. The designers considered various passive solar approaches, but modeling showed that these conflicted

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This 22-kilowatt photovoltaic system, consisting of 275 80-watt BP Solar TF-80B thin-film modules, provides most of the power for the 9800-square-foot research and teaching facility.

with daylighting priorities for the building—direct-gain passive solar would have brought too much sunlight into the building. Comfortable lighting conditions for the researchers in the building won out over passive solar, so the designers turned to active solar for space heating.

This solar-thermal system is projected to provide between 60 and 80 percent of the facility's space heating needs. The solar collectors are installed above the south facade where they provide shade to prevent overheating. Propane fuels the back-up space heating, and a high-efficiency instantaneous water heater provides hot water. To date, so little propane has been used that it has been difficult to accurately measure these back-up energy requirements.

The Sun Field Station makes extensive use of daylighting. In fact, of the various energy features of the building design, Quigley is most proud of the daylighting. "It's the place where science and art coexist," he says. The butterfly-like inverted roof configuration was designed to optimize daylighting, especially through north-facing roof monitors. (This roof design also aids rainwater harvesting.) Quigley's office carried out daylight modeling during design that showed that too much south light would be entering the building, according to Quigley. To remedy this, the designers placed solar thermal collectors on the south side of the building where they block some of the south light. Quigley is very pleased with the final results. "The light is almost exactly even from the north to the south end of the building," he notes.

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The inverted roof of the building effectively captures rainwater, which is stored in a 25,000-gallon cistern.

Other Green Building Features

Responsible use of water is a high priority with the Sun Field Station. Low-flush toilets and waterless urinals help to reduce water consumption. (Waterless urinals have no water supply; a special lighter-than-urine fluid provides the sanitary trap.) A gas-fired, tankless water heater may reduce some water waste, because its small size allowed it to be installed close to the point of end use. (Building occupants don't have to wait long for hot water to reach the tap.)

The inverted roof of the building very effectively captures rainwater, which is stored in a 25,000 gallon cistern. Though not identified as an opportunity at the outset, this rainwater cistern might have eliminated the need for Stanford to bring in a water line to provide fire-suppression—a permit requirement that cost several hundred thousand dollars. Currently, the collected rainwater is being used primarily for landscape irrigation.

Other plantings at the Sun Field Station are used to control heat gain. On the south side of the building is a trellis planted with native honeysuckle vines to shade the building. Shading, high insulation levels, natural ventilation through operable windows and high-performance Heat Mirror® glazings allow the building to maintain comfortable temperatures even during hot weather. There is only one room in the building that has mechanical air conditioning—a room that houses the herbarium.

The Sun Field Station makes extensive use of green materials. As noted above, fly ash was used in the concrete to reduce the use of Portland cement. More than 15 tons of fly ash were used in the building, which offset 15 tons of carbon dioxide emissions (from the calcining of the limestone and fuels burned in manufacturing cement).

Salvaged bricks were used at the front and rear entrances. These bricks were salvaged from a residence on the Stanford campus where they had been in use since being brought over as ship ballast from Scotland in the 1880s. Fifty-year-old redwood, salvaged from one home in nearby Woodside and another on the Stanford campus, was used for siding the Sun Field Station. Bathroom partitions in the building were salvaged from a 1902 chemistry building on the Stanford campus, and most of the casework in the building was salvaged from a biotech firm in East Bay. Most of the furniture used in the building was salvaged from other buildings at Stanford.

All non-salvaged lumber used in the building was certified according to the standards of the Forest Stewardship Council (FSC). This wood came from FSC-certified forests in nearby Mendocino County.

Recycled materials used in the building include cellulose insulation in all walls and steel framing estimated to contain more than 80 percent recycled content.

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While designers made an effort to find green building products, the goal was also to reduce the quantity of materials needed. They achieved this goal in several ways. First, they optimized the use of space during the programming phase of design. "If you've done really good programming," says Cohen, "the project should shrink during design." That was the case with the Sun Field Station, which was originally planned to be 12,000 square feet, but shrank to 9800 square feet during design.

Second, they reduced material use with a highly efficient structural design. Steel cables with steel and wood trusses concentrate loads on tubular steel columns—eliminating the need for material-intensive load-bearing walls (and capturing floor space that would otherwise have been required for structural support). And third, they designed the building for standard dimensions of building materials, significantly reducing waste.

The absence of load-bearing walls, including interior partition walls, increases the flexibility and adaptability of the Sun Field Station. "No one could really tell us how the building will be used 20 years from now," says Quigley in describing the benefits of the open plan and large spans. Future adaptability is an important aspect of green design, because the longer a building is in use, the longer the period of time over which the environmental and energy inputs that went into that building can be amortized.

Cost and Performance

The Sun Field Station was an expensive building at $249 per square foot, but Cohen points out that Bay Area construction costs are among the highest in the country. He compared the cost of this building to that of two other recently constructed buildings on the Stanford campus. These buildings, which were two or three times as large as the Sun Field Station, had construction costs in the same ballpark: $240 and $223 per square foot.

As for performance, Cohen sings the praises of the Sun Field Station widely. "It has outperformed our original expectations," he says. Cohen's most important yardstick for performance is the satisfaction of the people working there, and on that scale it has performed admirably. "People are delighted with it," he says.

As for the goal of producing zero net carbon emissions on an annual basis, information on how close the building is to achieving that goal won't be available for a number of months. Due to confusion with utility billing and the limited period of time over which detailed energy data have been collected, the long-term performance of the building is just beginning to be understood. Monitoring of the PV system only started in April 2003, approximately one year after the building was occupied, and a system for monitoring propane use was only put in place in June. Monthly performance for three months is available (see project details this page). And, according to the real time, online monitoring system (which had—at press time—collected energy data for three-quarters of July), it appears likely that the building will use less energy in July than it produces.

Cohen is pleased that the building has done better than that, and he believes that they are on track to meet their overall carbon emissions goal.

Indeed, the Sun Field Station is likely to be one of the top performers among higher education buildings anywhere. "I think this is going to be a slam-dunk," says a clearly enthusiastic Cohen about the building's energy performance, "and we'll have the data to prove it." ✪

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Leslie Shao-Ming Sun Field Station at Jasper Ridge

PROJECT DETAILS

Project description: Field research station with classrooms
Owner: Stanford University
Architect: Rob Wellington Quigley Architects, San Diego, California
Solar Design: Taylor Engineering LLC, Alameda, California
Peer Review: David Gottfried
Project Manager: Philippe Cohen, Jasper Ridge Biological Preserve Director
Location: San Mateo County, California
Size: 9800 square feet
Construction cost: $4.15 million (not including property, water supply line, but including professional fees and other soft costs)
Cost per square foot: $249
Date completed: June 2002
Heating Degree Days (65°F): 3017
Cooling Degree Days (65°F): 146

ENERGY PERFORMANCE

Monthly Energy Use and Production – Kilowatt-hours (kWh)(1)

	Lighting	Pumps	Total	Electricity Produced (PV)	Electricity Purchased
April 2003 (2)	547	109	3222	2282	940
May 2003	336	135	3588	2801	786
June 2003 (3)	162	123	3148	2994	154

1. Does not include small amount of propane used for water heating
2. Actual data for 26 of 30 days; scaled accordingly
3. Actual data for 28 of 30 days; scaled accordingly

Source: Dr. John Scofield and Jasper Ridge Biological Preserve
Building performance can be viewed in real time online: http://jr-solar.stanford.edu

The National Renewable Energy Laboratory's (NREL's) Paul Torcellini and Ron Judkoff provide technical oversight for these articles. The U.S. Department of Energy (DOE), through NREL, provides architects, engineers and other designers with design practices, field-tested and proven technologies and design tools that together produce cost-effective, high performance buildings.

The benefits of applying sustainable energy principles to building design and construction include increased affordability, more jobs, improved health, reduced energy consumption and less environmental impact.

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