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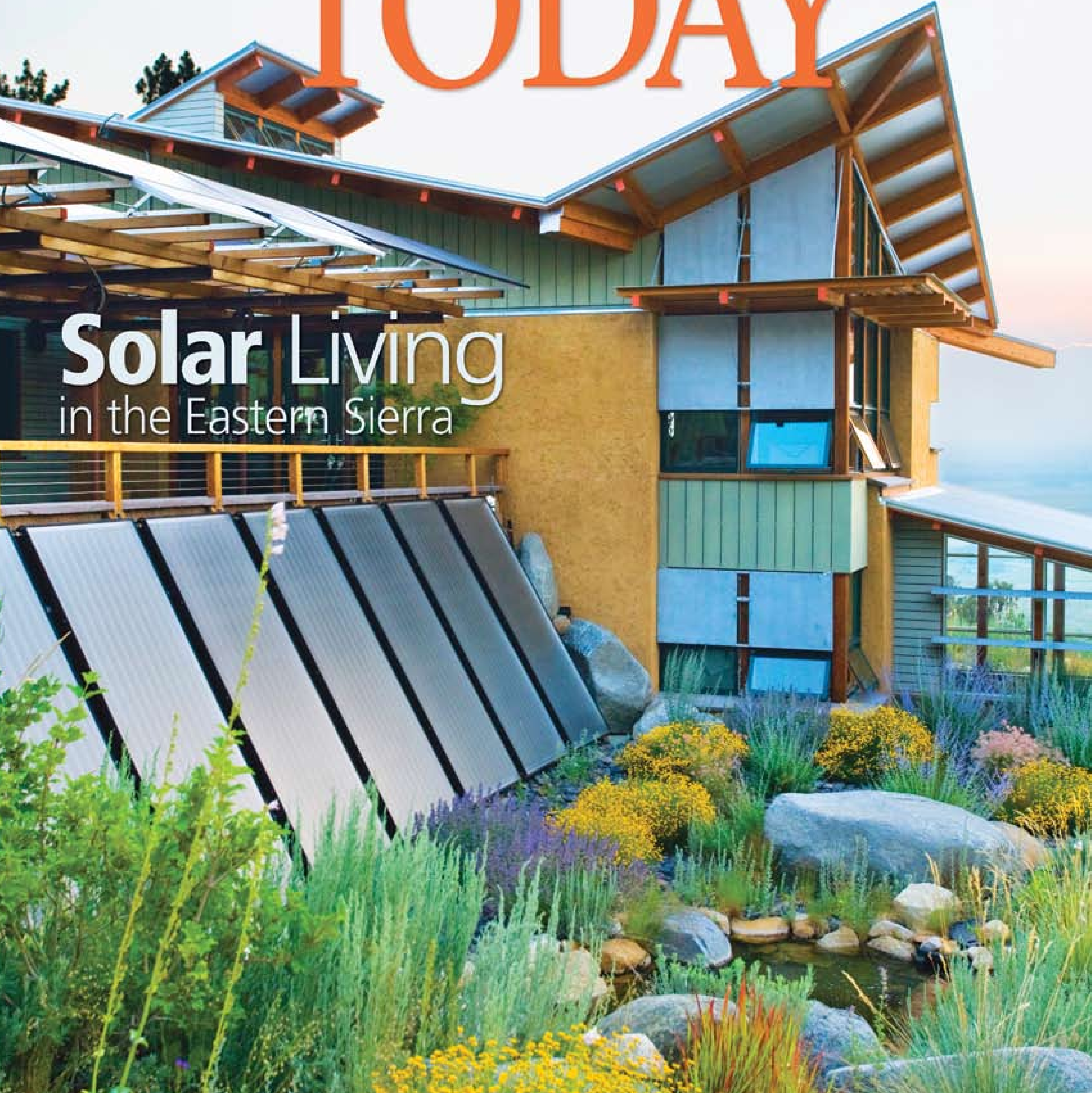
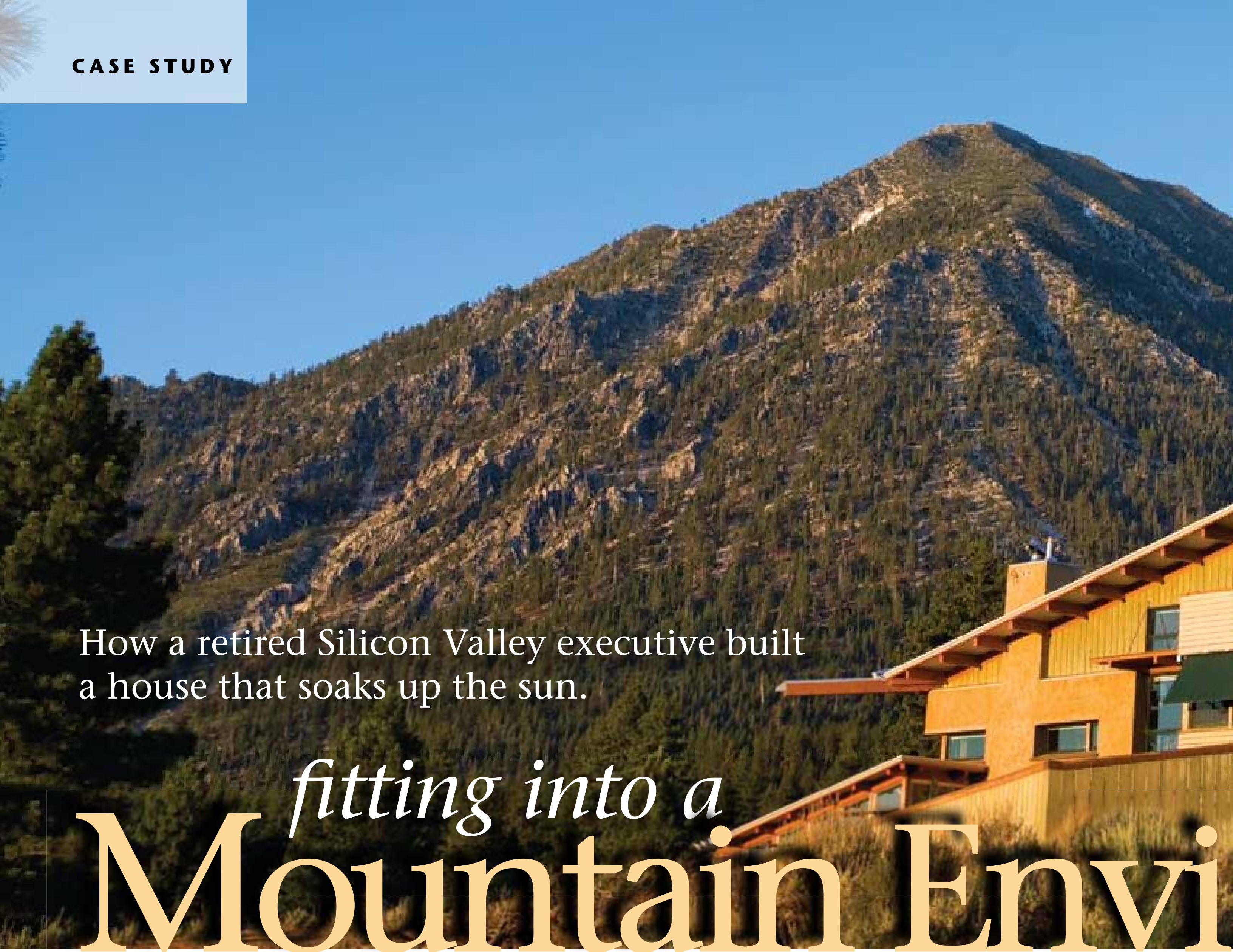


Solar Living in the Eastern Sierra



How a retired Silicon Valley executive built a house that soaks up the sun.

fitting into a Mountain Envi

By Suzanne Johnson

In the summer of 2000 I was working from my 1950s ranch home in Silicon Valley and talking to Arkin Tilt Architects about remodeling the house. Over the years I'd added a lot of energy upgrades, culminating with a 2.5-kilowatt (kW) photovoltaic system in 1997. I was firmly addicted to running the electric meter backwards, and had chosen the architectural firm for its history with passive and active solar homes. (Passive solar design uses sunlight for useful energy with no mechanical systems, while active solar homes include mechanical technologies.) But I was uncertain about the remodel, wondering whether I'd prefer moving to a quieter, more rural area.

Then a minivan crashed across the porch and into the front room. Happily, no one was injured. The house suffered far more damage than the van. It was a sign that I belonged elsewhere.

Elsewhere was the Carson Valley area of Northern Nevada. I loved the sundrenched high desert and had been considering property in the area for some time. I closed on my property about a month after the crash.

I asked Arkin Tilt if they would design a new house for me, rather than remodel the old one. We began to define the requirements for the new home. While taking a class from David Arkin at the Solar Living Institute in Hopland, Calif., I reawakened my chemistry background and started looking closely at healthy interiors. I have a long history of hay fever, allergies and chemical sensitivities. It was easy to prioritize finding building materials that wouldn't aggravate my health issues.

Design Responds to Extreme Weather, Dry Climate

In *The Return of the Solar Cat Book*, Jim Augustyn points out that when a cat feels cold, it very sensibly finds a sunny spot to stretch out upon. People, on the other hand, have tended to ignore the sun and generally find much more complex solutions for warmth. I wanted my new house to incorporate feline wisdom and use the sun to full advantage. I wanted to avoid the use of fossil fuels completely.

Nevada sees more than 300 sunny days per year, and state laws promote use of renewable energy and energy-efficient design. The house sits 5,300 feet above sea level on the eastern edge of the Sierra Nevada. Peaks to the immediate west reach almost 11,000 feet. The climate is extreme. Summer days reach 100°F (38°C) or higher. Winter nighttime temperatures average in the teens, and can drop to well below 0°F (18°C). Snow can reach blizzard depth and it is not unusual to lose grid power, especially during the winter snow/wind events. Winds tumbling from the peaks can hit 60 to 90 mph (100 to 150 kph) with percussive, turbulent effect. Humidity is always low and there is typically a 30°F difference between night and daytime temperatures, as well as a 100°F difference between typical winter-low and summer-high temperatures.

Water is supplied from a community well and the house design incorporates separate pipes for grey and black water. We use permaculture design, including natural and constructed swales, to channel rainwater to native plantings. The up-tilted Zincalume metal roof channels water either

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to a set of swales or into a small terrace pool. During warmer months, pool water is recirculated by a solar-powered pump through a biological filtration area. One of my favorite aspects of this roof design is the fact that I have no gutters to worry about. My neighbors use electricity to heat theirs to prevent ice clogs.

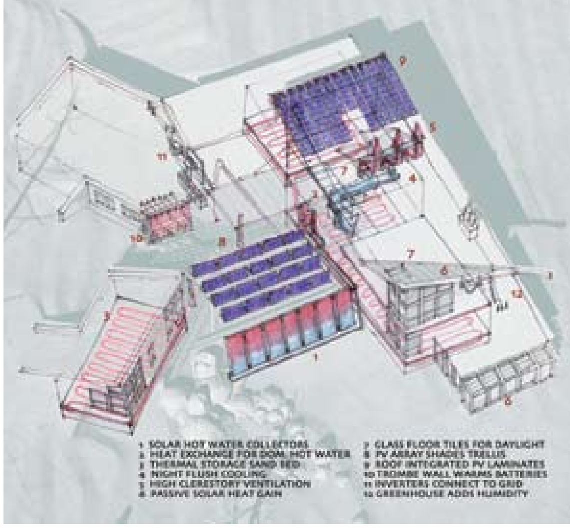
Neighbors also use humidifier systems. I have a greenhouse on the south side of the master bedroom, and it contains an "endless river" pool. When the air is dry, a humidistat turns on a simple fan to bring humid air from the greenhouse into the main house. This gives me 30 to 50 percent more humidity than I would otherwise have indoors. The unheated greenhouse is three to four USDA Plant Zones warmer than the average outside winter zone. I can easily grow citrus and lavender, as well as a variety of plants commonly found in the San Francisco Bay area. In spite of the harsh climate and difficult site, the house has become a quiet retreat, an inspirational workplace and great place to watch the weather and local wildlife.

Energy Systems Provide Solar Cat-Approved Warmth

The house uses a variety of active and passive solar systems, and systems that aid ventilation, daylighting, heat retention and humidification. Because the house is located in high desert with an average of 6,500 heating degree-days per year (F), it needed solar heating as well as ventilation and cooling. The mountains loom to the west, blocking late-afternoon sun; thus the solar orientation of the house is a bit east of true south (I lose the sun at 2:30 p.m. at winter solstice). The standing-seam metal roof of the main house tilts 13 degrees from horizontal, making it a reasonable platform for part of the PV array. The rest of the array is mounted on a trellis over the terrace.

The radiant heat system is powered by seven solar collectors, each 4 feet by 10 feet (1.2 meters by 3 meters). These collectors heat a glycol/water mixture for domestic hot water (DHW) and space heating. After passing through a heat exchanger for DHW, the fluid is distributed into loops of tubing buried in sand beds under the concrete floor slab. Together, the sand and concrete serve as thermal mass to store heat and release it slowly and evenly into the living space. As the weather grows warmer, the fluid can be diverted into a heat exchanger used to heat the pool. This type of sand bed solar thermal system was explained in Bob Ramlow's article, "Warm, Radiant Comfort in the Sand" (*SOLAR TODAY*, November/December 2007). The cost was $12,000 (not including installation costs), compared to the $20,000 or so I would have paid for a nonsolar radiant heat system.

In addition to the concrete slabs, the walls provide thermal mass. They're built of straw bales above an insulated concrete form (ICF) foundation, with 2 to 3 inches of soil cement finish on the exterior and on the



ARKIN TILT ARCHITECTS

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interior to store direct solar gain. The stored heat helps to maintain comfortable temperatures through cold nights and cloudy periods. A backup electric heat pump for the coldest periods combines with a ventilation and filtration air handler. I recently upgraded to an ultra-efficient air-source heat pump, designed to work through frigid winter nights with efficiency close to that of a ground-source heat pump (gotohallowell.com). When I added the heat pump, I also needed to upgrade the furnace. The cost for both upgrades, including installation costs, was about $14,000. My winter electricity bills dropped 35 to 50 percent.

While the sun is desirable in the winter for solar gain, shading is critical to make summer months comfortable. Trellised light shelves shade the taller windows. The kitchen bay window has an operable awning. All the west-facing windows, and some east-facing windows, have exterior shutters and insulating interior shades.

Photovoltaics Minimize Energy Costs

The house was designed to allow photovoltaics to be added in a modular fashion on the metal roof. The original complement (which we have since expanded) consisted of two systems:

- 2.3 kW of roof-integrated UniSolar photovoltaic panels (uni-solar.com) laminated to the standing seam metal roof and directly intertied with a Sunny Boy 2500 inverter (sma-america.com). This system is composed of 16 UniSolar PVL-128 modules and four PVL-64 units, with the shorter modules located at plumbing vents and the roof cricket above the loft dormer.
- 2.8 kW (20 APX-140 panels) in five 48-V strings are located on custom "Arc-n-Tilt" brackets atop a trellis over the terrace. The brackets allow the panels to tilt with the seasonal sun angle. The steeper winter angle sheds snow nicely, helping to keep the panels clear. The bracket-mounted panels feed a grid-intertied Xantrex SW4048 inverter (xantrex.com) with 16 Concorde Sun Xtender sealed 12-volt batteries to provide emergency backup when the grid goes down (concordebattery.com). The batteries are housed in the garage and are warmed by a Trombe wall adjacent to the courtyard.

In designing electrical service, we put 120-v and 220-v circuits into separate boxes. That way, all the 120-v is backed up to the battery bank. This should give me close to a week of off-grid power. I used it for the first time in December 2004, just two weeks after moving in. It was a night of high winds and snow. At 6 p.m., as I worked at my computer, my phone started ringing. My neighbors wanted to know why I had lights when they didn't. The switchover from grid to battery power is so seamless that I hadn't noticed the grid go dark. I'd experienced this smooth transition at the Silicon Valley house, so I had a "canary light" installed in the hallway, lighting up when the grid fails. The light is attached to a shelf fashioned from the horizontal stabilizer of a Piper Cherokee, but on this occasion, the neighbors alerted me before the light did.

We added the final complement of PV last year. It comprises 2.4 kW of roof-integrated panels — 16 UniSolar PVL-136 modules and four PVL-64 units intertied to another SunnyBoy inverter. The cost for the entire system was $49,000, including installation of the most recent addition (installation costs for the initial systems were folded into the house construction costs). Based on input from my bidirectional digital meter, each electric bill shows how much electricity I've drawn from the grid and how much my PV systems have fed back. Any surplus from the previous 12 months is applied against my charges for the given month.

In figuring payback on this solar investment, I prefer looking at avoided costs compared to system costs. Neighbors with a conventionally heated house of similar square footage to mine (3,400 square feet, or 315 square meters) noted that if they were careful and kept their thermostat set no higher than 58°F (14°C) during the winter, they could still be hit with an annual propane bill of $7,500 (at $3.10 per gallon). I keep my thermostat in the 65–68°F range and use no propane. The PV on my roof and trellis keep my electric bill close to zero, annualized. Propane continues to increase in price in my area. This fall the price has been $3.50 per gallon. Based just on avoided propane costs, my solar systems will be paid for in less than four more years.

> I wanted a house that fit in with its surroundings, and I've got it.

Each winter as I watch the parade of propane trucks make numerous trips up the hill to houses in my development, I'm even more pleased to be cat-like, dependent on the sun for warmth. It's also worth noting that in Nevada, the cost of renewable energy systems is not included in the basis used to calculate property taxes.

In Nevada, one can choose between taking a buy-down (a subsidy) on a renewable energy system's cost and forfeiting to the utility the renewable energy credits associated with the electricity produced, or forgoing a buy-down and keeping the RECs. I chose to keep the RECs. In 2007, I received my first payment, of about $3,500, for the sale of RECs generated by my PV systems. Until the market for trading RECs is better established, I don't expect this to be a regular occurrence. I do believe that making the carbon-offset market accessible to the typical homeowner will cause a sea change in the attitude towards solar. Meanwhile, I can't quite understand the "experts" who say that solar is not yet cost effective.

Salvaged Materials Help Reduce Indoor Toxics

We tried to use the most resource-efficient building systems available, along with a lot of salvaged materials. The earth-bermed walls are made

**Take a virtual tour of Suzanne Johnson's house with architect David Arkin: solartoday.org.
Video courtesy of Dave Renné and Paulette Middleton, Aspen Hill Films (aspenhillfilms.com).**

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Above, photovoltaic panels on the trellis tilt toward the sun during summer and winter. They shade the patio and provide more than a third of household electrical power. Left, the house uses salvaged and sustainable materials throughout, such as the strawbale material highlighted in this "truth window."

Johnson House Highlights
Northern Nevada

- Passive and active solar house designed by Arkin Tilt Architects, arkintilt.com
- 280 square feet (26 meters) of solar hot water collectors provide water- and radiant space-heating: $12,000
- Solar electric system includes a 4.7-kilowatt roof-integrated UniSolar array and a 2.8-kW AstroPower trellis-mounted custom, seasonally adjusted array: $49,000
- Passive design features include solar orientation, sod roofs, daylighting, a greenhouse, concrete slabs and strawbale-ICF walls
- Salvaged materials like old airport hangar trusses and recycled-glass countertops used throughout
- Construction completed in 2005

of insulated concrete forms (ICFs), which require 50 percent less concrete than conventional poured walls. We specified that all concrete use fly ash to replace at least 25 percent of the portland cement. This has the additional benefit of providing better electrical grounding in the otherwise nonconductive dry, sandy soil. Interior concrete slabs are finished with ferrous sulfate stain and water-based sealers. Staining was completed with the help of a number of friends, including the architects and their children.

The main level of the house has strawbale walls, finished inside and out with sprayed earth, using site soil. Wood-frame exterior walls are constructed with wood certified by the Forest Stewardship Council (FSC) or with wood salvaged from old trusses. All exterior sheathing is slats of stained fibercement board panels. These weather well in the high-ultraviolet environment. They're also fireproof, an important quality on the edge of an alpine forest. The roofs are of 10-inch structural R-45 insulated panels (SIPs). Salvaged fir 4-inch by 10-inch splines extend beyond the walls, supporting generous 4-foot overhangs that protect the walls from the sun. The roof design eliminates eave vents, another good thing in this fire-prone area and a feature now required under the new California fire code.

A great way to reduce indoor toxicity is to use old materials that have long since finished outgassing. We made structural beams from old airport hangar trusses; ceilings from vinegar barrel staves; paneling from the off-cuts of weathered beams; aluminum shade fins on the greenhouse from airplane wing flaps and ailerons; maple floors from an old schoolhouse; custom light fixtures from mining screen (with pebbles from the original purpose still lodged in place); and countertops from recycled glass (including old manganese glass turned purple by the desert sun). We used many salvaged doors; ore-cart wheels supporting railroad track beams at the terrace trellis; and old glass panels placed as shingles to create the Trombe wall. Each of these elements has a story of its own. Visitors pause, look and ask questions.

Builder Rick Walters of Sage Design/Build in Minden, Nev., told me he especially liked being able to recycle 50-year-old hangar trusses from the California airport where he learned to fly gliders in the 1970s. "A big problem with salvaging materials is bringing them from one climate for use in another," says Rick. "But because this old-growth wood had weathered in the Nevada desert, abandoned for more than 10 years, I was able to use a very stable material. We accommodated the shapes and sizes of wood to the house design with the owner and architect." By milling them on-site, Rick used the entire trusses with zero waste. The 6x6-inch Douglas fir was shaved on four sides to provide weathered "barn wood" for the home's entry, while the "heart" was milled to provide vertical-grain interior trim. The lesser-grade wood was used for framing. The horizontal component of the trusses became beams in the master bed and bath.

Interior paints and stains are low- or no-VOC (volatile organic compounds). We avoided using carpet and hard-to-clean floor surfaces, along with vinyl and PVC. One of my favorite moments came when I overheard the subcontractor who was installing one of the solid-surface countertops: "…strangest installation I've ever done. There were *no* toxic fumes. Even the glue they supply smells like wet dirt." Non toxic building materials are good, not just for the health of the building occupants, but also for the health of the folks who have to work with the materials during installation.

I wanted a house that fit in with its surroundings, and I've got it. Bear, deer, rabbits and quail feel at home on my green roofs. Raptors perch on the metal roof and songbirds use the breezeway for shelter during wind events. Even the wildlife approve. ☼

Suzanne Johnson is a retired Intel executive, where she worked as an internet engineering manager. She now describes herself as a solar idealist.