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BOULDER GREEN BUILDING JOURNAL

SPRING 2007

FREE

ZERO ENERGY HOUSES

BUSTING XERISCAPE MYTHS

THE CLOTHESLINE PARADOX

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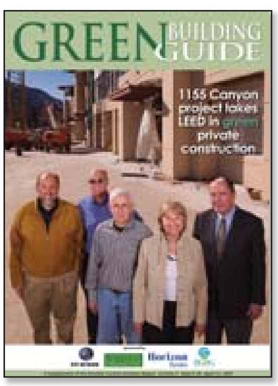

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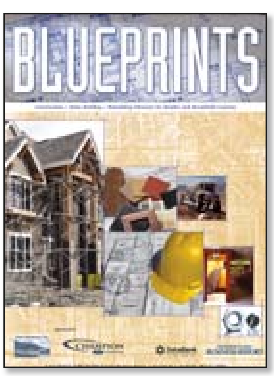

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ZERO ENERGY HOUSES

SPRING 2007

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The sunspace in the Doub family's Solar Harvest home provides heat for the house and a home for healthy plants.

IN OUR NEXT ISSUE

Green design techniques and materials both reduce the environmental impact and improve the comfort and affordability of homes. In our next issue, we focus on the information both building professionals and consumers need to make informed green purchasing decisions. We'll also include a case study of a green remodeling project.

Zero Energy, Low Impact

Only a few years ago, building homes that require no net input of purchased energy seemed like a pipe dream. Today, zero-energy houses are a reality.

In our building case study and cover story in this issue, Larry Kinney profiles a net zero-energy house in Boulder that seamlessly combines extraordinary energy performance and elegant interior finish. By paying close attention to the basics—excellent insulation and tight construction techniques—and using solar equipment to meet the reduced loads, the owner and builder created a comfortable, beautiful home for his family and a learning opportunity for the rest of us. You can access performance data on this house in real time at www.ecofuturesbuilding.com/monitoring.

Also in this issue, Paul Norton and Collin Tomb demonstrate that zero-energy homes are not just for the affluent. In "Walking the Talk—Habitat Goes Green," they tell the story of a Habitat for Humanity home in Wheat Ridge that is exceeding expectations. This home, completed in 2005 and now being monitored by the National Renewable Energy Laboratory, is actually a net energy producer—proof that affordable housing can be energy-efficient and low-impact.

At *BGBJ*, we are shifting our editorial focus slightly to include green building information and developments from around the country and the world. We hope that by casting a wider editorial net we can make *BGBJ* an even more useful tool for our local green building community. As always, feedback on this new approach is welcome.

Stay in touch, and let us know what you'd like to see in *BGBJ*. If you are involved in or come across a green building project you think we should know about, email me at maureen@mccomm.com.

We also invite you to join the Boulder Green Building Guild (BGBG) in actively promoting green building in the Boulder area. For more information on how to get more involved with BGBG, go to www.bgbg.org/getinvolved/. If you're curious, but not ready to join, go to www.bgbg.org/news/events.php for listings of BGBG events that are open to the public. If you or someone you know would like to make a tax-deductible contribution to the Boulder Green Building Foundation, the educational arm of BGBG and publisher of *BGBJ*, email *BGBJ* committee chair Larry Kinney at larryk@SynertechSystemsCorp.com.

We look forward to hearing from you!

Maureen McIntyre
Editor and Publisher

bgbj
BOULDER GREEN BUILDING JOURNAL

The Boulder Green Building Journal is printed on recycled paper with vegetable ink.

Office of Environmental Affairs
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A special thanks to the city of Boulder's Office of Environmental Affairs—a founding member of the Boulder Green Building Guild and Foundation—whose continued support for green building outreach and education helped make this printed publication possible.

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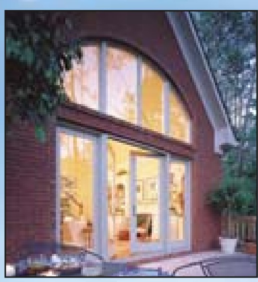
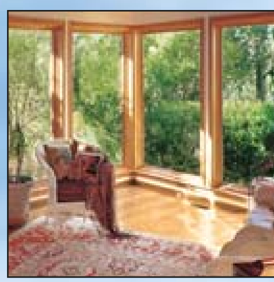

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BGBG NEWS

by Kim Master, Executive Director

The Boulder Green Building Guild (BGBG) is growing at about the same rate as my pregnant belly—FAST! To keep things up and running through the summer while I'm on maternity leave, we are pleased to announce our new interim executive director, Kelli Pousson.

Kelli comes to us from What's Working, Inc., a local green building consultancy. She is an active member of the Boulder Green Building Guild, and we are delighted to have her on board. I encourage you to contact her with your ideas, questions, and comments regarding membership or the organization as a whole, at kelli@bgbg.org.

Keep in mind that our executive director only works part time—dedicated volunteers do much of the work that makes BGBG the vibrant organization it is. Here is an overview of committee activities. Contact the committee chair to find out how you can be involved today.

OUTREACH

Since we launched the new BGBG website in January, we've been adding more interactive features, including a bulletin board that features community needs and opportunities, www.bgbg.org/discussion. We're also adding new images to highlight our members and their projects. If you have website input, don't be shy—email us! The outreach committee is also currently organizing the next quarterly green home tour and developing BGBG's green building speakers' bureau, including a semester-long green building course at New Vista High School this fall.

To volunteer, contact the chair, Elizabeth Vasatka, at vasatkae@bouldercolorado.gov.

MEMBERSHIP

BGBG now has close to 250 members! To handle membership growth, this committee is interviewing web developers to help us streamline the online membership application and renewal process. We've also created a "New Member Welcome & Happy Hour" the 2nd Wednesday of each month to help people network, learn about the benefits of membership, and be more involved in the organization. And we're designing a web page for our "member card program" to encourage members to support each other's businesses. This page will highlight the individuals or companies offering discounts to card-holding BGBG members.

To volunteer, contact the chair, Joseph Vigil, at joseph@vast2020.com.

EVENTS

Monthly brownbag workshops, monthly roundtable discussions, monthly expos, oh my! The events committee is hard to keep up with because it has so much going on every month in an effort to keep us informed and to promote our good, green companies. Keep in mind that BGBG events are highlighted in blue on our calendar (www.bgbg.org/news/events.php) as well as on our homepage (www.bgbg.org). And if you missed an event, it will be listed in our archive (www.bgbg.org/news/email_news.php) along with the PowerPoint presentation when possible. Be sure to mark your calendars for the first annual BGBG Product and Service Fair scheduled for Sunday, July 8th, on the Pearl Street Mall between 13th and 14th Streets. This event will feature BGBG members' products and services, speaking opportunities, and live music.

To volunteer, contact the chair, Julie Hauser, at julieh@lidlandscapes.com.

LEGISLATION

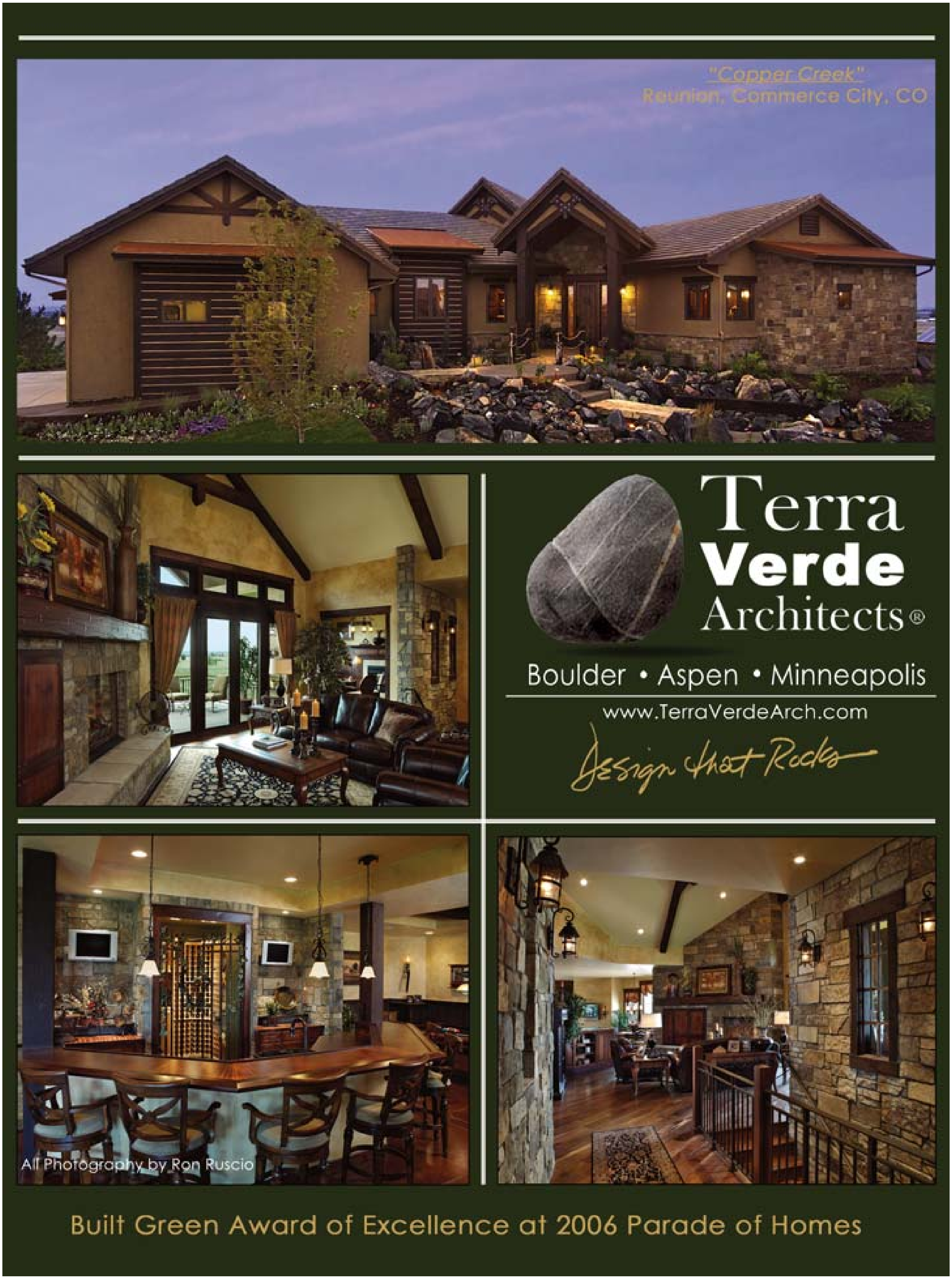
As the Capitol nears the final month of the legislative session, BGBG has seen some successes this year. First and foremost, on March 27, 2007, Governor Ritter signed House Bill 1281, doubling the renewable energy requirements originally set by Amendment 31! Senate Bill 51, also endorsed by BGBG, now awaits joint committee approval—the final step before it heads to the Governor's Office. If successful, SB-51 will require all state-assisted facilities to build and renovate green! If you're interested in more frequent updates on legislation, you can write Doug Parker or check out www.leg.state.co.us/.

To volunteer, contact the chairs, Doug Parker, at doug@bighornbuildersinc.com or Aaron Nelson, at anelson@allianceforcolorado.org.

BGBJ

We used to call this committee the "Education Committee," but realized this was somewhat misleading because every committee focuses on education. The primary activity of the committee is to develop and publish the *Boulder Green Building Journal* (*BGBJ*), a full-color online and print quarterly publication, so we renamed the committee to reflect this reality. Recently, the *BGBJ* committee decided to expand the publication's reach by including information from national and international sources that can be applied locally, while continuing to cover important local green building projects and developments. *BGBJ* relies in large part on donations—both financial and in-kind. Because the Boulder Green Building Foundation, the 501(C)(3) nonprofit arm of BGBG, publishes *BGBJ*, donations are tax-deductible. If you would like to make a donation or know of a donor you think we should contact, please email the chair. You can find the current issue and back issues at www.bgbg.org/news/BGBJ.php.

To volunteer, contact the chair, Larry Kinney, larryk@SynertechSystemsCorp.com.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The Clothesline Paradox

BY STEVE BAER

Editor's note: Steve Baer first published this essay in the New Mexico Sunpaper *in 1975 and also included it in his book,* Sunspots*, published in 1975. Here's a little historical background. Peter van Dresser (1908-1983) was a solar pioneer who lived and worked in New Mexico for many years. The Energy Research and Development Administration (ERDA) was the precursor to today's U.S. Department of Energy. Ayres and Scarlott are Eugene E. Ayres and Charles A. Scarlott, who wrote* Energy Sources: The Wealth of the World in 1952 *(New York, McGraw-Hill). Sometimes the more things change, the more they stay the same…*

© Jenny Rollo

In addition to conserving energy, fresh laundry fluttering in the breeze lends a colorful charm to urban and suburban scenes.

A few years ago Peter van Dresser mentioned the Clothesline Paradox.

Solar energy advocates are continuously humiliated by being shown "energy pies." Slices are assigned to coal, gas, oil, hydroelectric, and even nuclear, but solar energy is evidently too small to appear. I have a typical energy pie from the Ford Foundation, which cites the source as the U.S. Bureau of Mines. The large pie is split into 5 pieces: petroleum 46%; coal 18%; natural gas 31%; hydro power 4%; and nuclear 15%. (An asterisk notes that wood has been omitted—why?) We are frequently reminded that the energy we advocate—solar energy—must, after the proper technical efforts, appear alongside coal, oil, natural gas, and nuclear before it will make an "impact."

ERDA in its different energy consumption predictions assigns only a thin wedge of the pie to solar energy and then only as a faint hope 15 to 25 years from now. The demoralized reader is then ripe to be persuaded of the necessity of nuclear power plants or offshore drilling.

Attention given to such graphs and charts trains people to attempt to deliver what is shown in these accounting systems rather than what is needed.

The accounting system shows that he has done absolutely nothing with solar energy. He lacks even a trace of a useful habit or activity that he could build on. As Peter and I discussed, if you examine these figures, you find the cards are stacked against solar energy.

If you take down your clothesline and buy an electric clothes dryer, the electric consumption of the nation rises slightly. If you go in the other direction and remove the electric clothes dryer and install a clothesline, the consumption of electricity drops slightly, but there is no credit given anywhere on the charts and graphs to solar energy, which is now drying the clothes.

For perspective, consider that it takes about 1,000 Btu to dry a pound of water and each Btu is equal to 778 foot-pounds of work. Therefore, with electric power one can as easily lift a pound of water 147 miles as evaporate it using resistance heating. The water falling back to earth with no air resistance would reach 4,811 mph just fast enough for it to instantly evaporate on impact. Does the humble clothesline have to listen to the electric dryer talk about what it could have done with its electricity if it hadn't gotten stuck drying the clothes again?

The poor old sun is badly mistreated by such graphs. In the first place, I should point out the obvious—that coal, oil, and natural gas are all solar energy products stored ages ago by photosynthesis, and hydroelectric power is solar energy no older than the weather patterns that dropped the precipitation flowing through the turbines.

The graphs that demonstrate a huge dependence on fossil fuels are fine in one respect. They are alarming.

But they are very bad in another respect. They are misleading.

Misleading to such an extent that they blind people to obvious answers and prime them to a frenzy of effort in poor directions. Attention given to such graphs and charts trains people to attempt to deliver what is shown in these accounting systems rather than what is needed.

If you drive a motorcycle, the gasoline you consume appears in the nation's energy budget. If you get a horse to ride and graze the horse on range nearby, the horse's energy that you use does not appear in anyone's energy accounting.

If you install interior greenhouse lights, the electricity you use is faithfully recorded. If you grow the plants outside, no attempt is made at an accounting.

If you drive your car to the corner to buy a newspaper the gasoline consumption appears. If you walk—using food energy—the event has disappeared from sight, for the budget of solar energy consumed by people in food is seldom mentioned.

The Ford Foundation's energy study shows the U.S. energy consumption in 1968 at about 62 quadrillion Btu or 310,000,000 Btu/person/year or 310/365 = 850,000 Btu/day. If the average daily caloric intake is 2500 Kcal., this is approximately 10,000 Btu/day/person—about 1.2% of the total consumption listed by the Bureau of Mines. But this 1.2% doesn't appear anywhere on the graphs. Nuclear energy with 1% does appear. The food is obviously solar energy. Why is it not included?

What about the question of the energy used in growing the food? Can't we treat this in the same way as the coal burned to generate electricity? If we use the figure of 0.5% efficiency (Ayres and Scarlott) this means we have consumed approximately 2,000,000 Btu/person/day of sunlight in producing the 10,000 Btu/person consumed.

Solar energy then immediately fills over 2/3 of the new energy pie. If we aren't allowed to show the actual sunlight required for our 10,000 Btu/person, then what about power plants? Why is it that when they burn 4 Btu of fuel for every Btu delivered as electricity all the consumption appears in the energy accounts rather than the 1 Btu?

Why wouldn't it be fair to expand the 4% slice (1973, Bureau of Mines) given to hydroelectric power by a similar factor of efficiency for the solar energy consumed in raising the water to its working head? After all, in most cases, the rain or snow fell through long unexploited distances before it went to work in a power plant.

Then there is the question of heating houses. Every time the sun shines on the surface of a house and especially when it shines through a window there is "solar heating" to some extent. How do we measure this? How do we account for this in our discussions of energy use?

According to the National Science Foundation/National Aeronautics and Space Administration (NSF/NASA) Energy Panel of 1972, the percentage of thermal energy for buildings supplied by the sun was too small to be measurable.

But is that accurate? Shouldn't we recalculate the energy consumption of every building assuming it were kept in the shade all day and then attribute the difference between this amount and its actual consumption to solar energy?

In most cases, this would result in an enormous difference. Almost every building is solar-heated to some extent. I would guess the average shaded fuel consumption to be at least 15% higher, and then of course our next concern in heating the building is what keeps the earth as warm as it is? What supplies the United States with the necessary energy to maintain

> Now that the experts have started this infantile accounting system…solar energy will be admitted only so long as it has been properly collected, stored, and transferred.

an average absolute zero? This is a heating contract no oil company would be quick to try and fill.

Clearly it would be a very difficult thing to account for every calorie or Btu that passed through us or by us every day in the various forms. It doesn't seem to be a particularly urgent job, but it is very important to examine what the limits of an accounting system are to know what the numbers and quantities displayed really mean.

If you go to a drive-in movie to watch the flickering lights on a screen, the energy consumption of the automobile and the drive-in is dutifully recorded and appears in the statistics. If you walk out on a hillside, lie on your back, and look at the stars, no attempt is made to measure the power output of the distant stars.

I don't advocate an enormous effort to measure all these things. It would just be more helpful if the graphs stated more clearly what they are about.

The design of houses can be stilted by such graphs. Now that the experts have started this infantile accounting system, which evidently finds us completely independent of the sun, solar energy will be admitted only so long as it has been properly collected, stored, and transferred.

Legislation aimed at encouraging the use of solar energy equipment by subsidizing the price of certain hardware must end by being pathetic and blundering. It would take an enormous crew of experts to determine the efficiency of different orientations of windows, different arrangements of shade trees, etc., etc. To ignore these efforts and only to reward the purchaser of "off the shelf hardware" is to further the disease of narrow-minded quantification.

It should be pointed out to the people promoting the use of solar energy in the place of fossil fuels that the accounting systems used by the experts are rigged against them. As I understand it, we are being prepared to accept that there are legitimate and illegitimate ways of using the sun. If you purchase certain kinds of hardware to exploit solar energy, it will be accounted for and a credit will be given to the sun. If you depend on more customary old fashioned uses of solar energy—growing food, drying clothes, sun bathing, warming a house with south windows—the sun credit is totally ignored.

Our present accounting system with its promise of a credit to the sun after the right hardware has been installed can only discourage good house design. If the natural solar contribution to house heating from windows is ignored, then the designer knows that expanding this share done by the sun will also be ignored. No tax incentives, no credit is given to the sun in ERDA's graphs.

I think we would be much better informed if alongside every graph showing our use of oil, coal, and uranium, there was also an indication of the total energy received from the sun. Because we can't do without it, let's not omit it from our accounts. In the case of the United States, a conservative estimate of the solar energy received in one year might be 29,300 quadrillion Btu as opposed to the 62 quadrillion shown as used during 1968 by the U.S. Bureau of Mines.

When small children first start paying close attention to money and to their allowances, they briefly commit their whole minds to their few coins and what chores they did to earn them—without even considering the budget of the family's household. We can't allow our entire civilization to be similarly ignorant for long. We must ask who's keeping score and why they have such peculiar methods.

Steve Baer (zomework@zomeworks.com) is a solar pioneer and Chairman of the Board of Zomeworks (www.zomeworks.com), a developer and manufacturer of elegant passive energy products since 1969. For more of Steve's writing, visit http://taxshine.com/.


Larry Kinney

This clothesline, installed in a sunspace, can be used in any weather, adds humidity to interior air, and avoids the cost and emissions associated with the roughly 600 kWh of electricity per year it takes to dry two loads of laundry each week in an electric dryer.

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SolarSheat 1500G Affordable Solar Space Heater

Installation is quick and easy, especially if you are mounting the SolarSheat directly on a south-facing wall. The patent-pending mounting strip is perfect for do-it-yourself installations and is also contractor-friendly.

For more information, contact (JP) Jean-Pierre Bressieux at Green Home Base Solutions, 303.587.7102, hbsboulder@aol.com, www.greenhomebase.com.

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3-form's 100 Percent product

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Continued on page 40


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Eric Doub stands in front of his family's home, dubbed Solar Harvest. The different roof slopes optimize solar performance all year.

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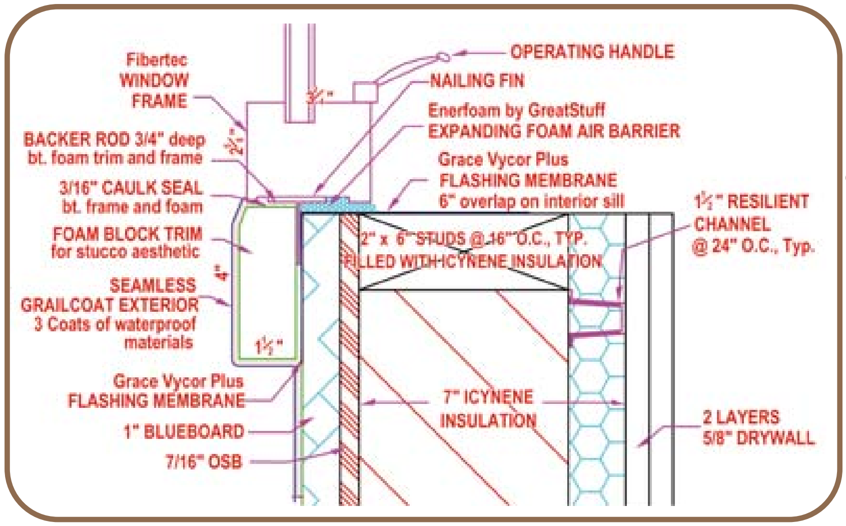
Harvesting the Sun in Boulder

A local green builder goes the distance and builds a zero-energy house for his family—with a lot of help from excellent insulation, tight construction techniques, and the sun. **BY LARRY KINNEY**

Eric Doub has always had a penchant for pushing the envelope. A founding member of the Boulder Green Building Guild (BGBG), he is the President of Ecofutures Building, Inc., a Boulder company that has been remodeling and building green for 14 years. Eric enjoys trying new materials and tactics to save energy and reduce the environmental footprints of his projects. However, when he decided to do whatever it takes to design, permit, build, and evaluate a net zero-energy home that respects green ecological principles, he decided to experiment on his own place instead of a client's.

Solar Harvest wall section.



Ecofutures Building, Inc.

The result is "Solar Harvest." It is a lovely home with 4,600 square feet of conditioned space for his family and a comfortable meeting place for sundry community organizations, including BGBG groups. It's also a pioneering proof-of-concept for a number of innovative approaches to building that have been successfully integrated to produce a home that is truly net zero-energy—and likely to stay that way for a century or two.

As its name implies, the home takes full advantage of the sun, both its lumens and watts. Nicely daylit without glare, it employs passive solar in its architecture, and has a large active solar thermal array of 12 recycled flat-plate collectors that use water in a drainback system. These solar panels heat water in a 6,000-gallon superinsulated tank nestled in the basement. Simple copper coil heat exchangers in the tank deliver warmth to two loops of radiant heaters and heat hot water for washing, showers, and a spa. In addition, there's a grid-tied 6.84-kilowatt (kW) photovoltaic array that produces more electricity than the home uses most of the time, so the utility pays Eric for net power generated.

STARTING WITH THE BASICS

As with great athletes, the key to Solar Harvest is excellent fundamentals. Most importantly, the home is heavily insulated and carefully air sealed from bottom to top. The above-ground walls include one inch of Styrofoam Blueboard® close to the outside (the north side has 1.5 inches of Blueboard) then oriented strand board (without urea formaldehyde), followed by seven inches of foamed-in-place Icynene insulation. Seamless GrailCoat flexible stucco provides waterproofing on the outside, and the home's interior is finished with two layers of 5/8 inch gypsum board (drywall). The drywall provides fireproofing and lots of indirect, distributed thermal mass. The overall value of the insulation in the walls is R-34, which amounts to excellent thermal and acoustical insulation. The foundation is GreenBlock insulated concrete forms (R-30) and the ceiling is insulated with more foamed-in-place Icynene, for an R-45.

Windows are usually the holes in the thermal envelope (see The Green Geek, page 44), but Solar Harvest's design optimizes performance with currently-available technology. Unlike most homes, which use the same glazing for all windows, the solar heat gain coefficient (SHGC) of the Alpen Heat Mirror windows in Solar Harvest is tailored to the façade where the windows are installed. The SHGC for glazing in the Solar Harvest varies from 0.62 for the south-facing sunspace and 0.54 on the south-facing second-floor to ensure good solar gain, to 0.27 on the east and west façades to protect against overheating in the summer. The glazing on the north façade has a SHGC of 0.5.

The window frames are made of fiberglass, which has low thermal conductivity and lasts a very long time. Thus, the overall U-value of the north windows is 0.12 while the U-value of the windows on the east and west facades is 0.2. In short, window thermal losses are modest, the south glazing yields good passive solar gain in the winter and very little in the summer (due to strategic overhangs)—and comfort prevails throughout the year.

The result of combining the features discussed above with a well air-sealed thermal envelope is that the heat loss on the 99% design day (2°F in Boulder) is only 29,000 Btu/hour. (According to long-term weather data, Boulder's winter temperatures are at 2°F or above 99% of the time, although the current winter outdid itself in December and January.)

GLOSSARY

R-Value
A measure of a material's ability to slow down or resist the transfer of heat energy, also called thermal resistance. The greater the R-value, the better the resistance, the better the insulation. R-values are the reciprocal of U-values.

Solar Heat Gain Coefficient (SHGC)
SHGC measures how well a window transmits solar energy, expressed as a fraction between 0 and 1. The lower the SHGC, the less solar energy the window transmits.

U-Value
A measure of the rate at which heat flows or conducts through a building assembly (wall, floor, ceiling, etc.). Also know as heat transfer coefficient measured in Btu/hr/DT, where the DT term is the difference between one side and the other of the material in question in degrees F. The smaller the U-value, the more energy-efficient an assembly and the slower the heat transfer.

BREAKING NEW GROUND

When the storage tank is charged, it stores over 4 million Btu of solar energy in the form of hot water, the energy equivalent of four person-years of labor. Accordingly, Boulder's code officials approved the home with neither furnace nor boiler, observing that Solar Harvest's power plant is 93 million miles away.

Carefully air-sealed and insulated buildings need good ventilation systems, and here's where Solar Harvest broke new ground as well. There is an efficient energy recovery ventilator (ERV) that brings in fresh air to all areas in the house. Fresh air is conditioned by exhaust air via heat exchangers that share energy (but not air) between the two streams.

But Solar Harvest also takes advantage of the fact that deep earth temperature in Boulder is at 50°F or so. Accordingly, Eric laid 260 feet of 6-inch PVC pipes in a 6- to 8-foot deep trench around his home. These pipes deliver fresh air to the ERV. Thus, even when it is quite cold, the earth heats the incoming air to above freezing, and exhaust air in the ERV raises the fresh air to 65°F or so. During the summer months, exhaust air is vented directly, while outside air is simply cooled by the PVC pipe in the earth. The result is good comfort and excellent indoor air quality at very modest energy cost.

After about a year of operation, Eric had the pipes inspected for mold and discovered several varieties. He solved the problem nicely, however, by adding an ultraviolet light before the ERV as well as filters at the pipes' intakes.

On summer evenings after a hot summer day, an efficient 1600 cfm (cubic feet per minute) Tamarack whole-house fan comes on when the outside air temperature falls below the indoor air temperature, which happens frequently in our rarely-cloudy climate. This fan features tight-sealing R-38 doors that close when the fan is off, thereby ensuring the integrity of the conditioned envelope.

A host of other details also contribute to making Solar Harvest a truly pioneering green project. It uses a good deal of salvaged materials like hardwood flooring, interior and exterior doors, tubs, and sinks. The roof is made of Ny-Slate shingles manufactured from 100% recycled post-consumer carpet material guaranteed for 50 years. It is installed with stainless steel screws and copper flashing aimed at achieving a lifetime likely to be much longer than that. The aforementioned GrailCoat exterior finish is an aggregate of acrylic polymer and cement that looks like stucco, but is warranted for 20 years to be crack-free. Of course, all electric lighting in the home is fluorescent, mostly pin-type compact fluorescent lights (CFLs).

The dryer and cook stove use natural gas, but in very modest quantities. Even after the very cold and cloudy months of December and January, over its first two years, the net amount of electricity used at Solar Harvest is sufficiently negative that it effectively outweighs the use of gas.

THE DETAILS

Project description: Zero-energy house
Owners: Eric Doub and Catherine Childs
Designers: Eric Doub and Catherine Childs
Builder: Ecofutures Building, Inc.
Engineer: John Arndt, P.E., Gebau Engineering
Location: 1887 Orchard Avenue
Size: 4585 ft^2
Heating Degree Days (65°F): 5466
Cooling Degree Days (65°F): 691

RENEWABLE/EFFICIENCY/ENERGY FEATURES

- 6.84 kW grid-tied PV system
- 12 solar thermal flat-plate collectors
- 6,000-gallon superinsulated solar storage tank
- Sunspace with distribution ducts and fans
- Double 5/8-inch sheetrock in some locations
- Expanded foam insulation
- Energy recovery ventilation system
- Ground-coupled intake air preheat and precool
- Compact fluorescent lighting
- Energy Star appliances
- Power strips and occupancy sensors
- Rigid foam insulation on perimeter walls
- GreenBlock ICFs in basement walls

GREEN FEATURES

- Fly ash content concrete for foundations and slabs
- FSC-certified framing lumber
- IPE/Pau Lope decking
- Formaldehyde-free cabinets and carpet
- AFM Safecoat paint and stains
- Roofing made from 100% recycled carpet
- Minimized and recycled construction waste
- Salvaged hardwood flooring, doors, cabinets, sinks, and windows

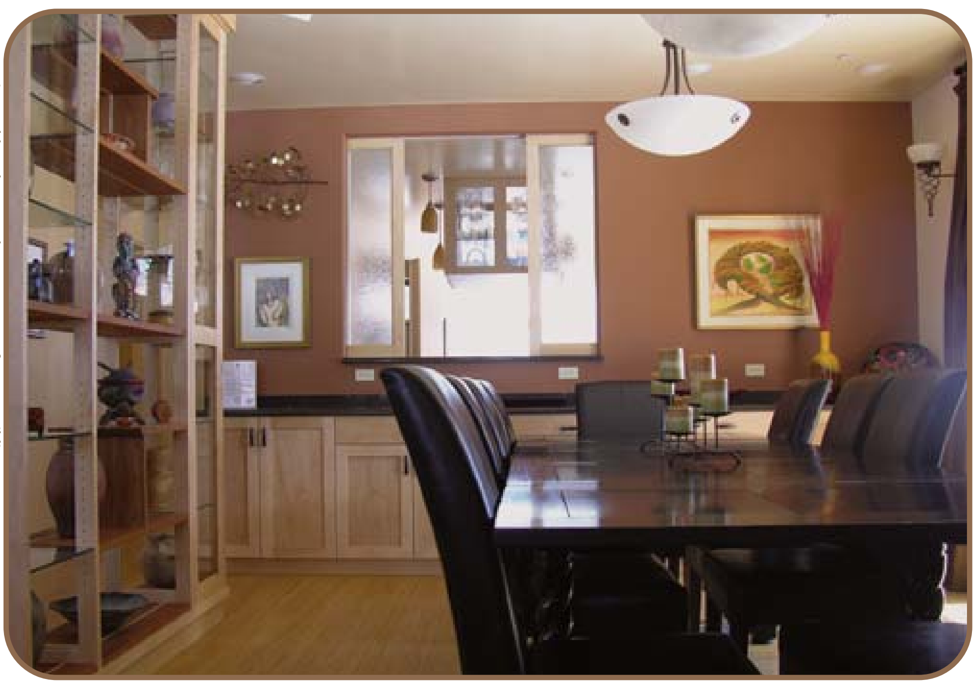
COUNTING THE BEANS

Prius drivers benefit from a dashboard-mounted animated display of current operations of battery and motor as well as indications of the short- and long-term fuel efficiency of their hybrid vehicle. Studies show that providing the driver with this data often results in better gas mileage.

By analogy, Eric recently installed a data logger for monitoring the flow of energy from sun to storage to various usages at Solar Harvest. When fully operational, the system will enable the assessment of the relative efficiencies of the active and passive solar systems, the PV system, and the ventilation system. This will enable an assessment of net energy use, the tweaking of controls at Solar Harvest, and the gathering of

The Solar Harvest kitchen features Energy Star appliances and recycled hardwood floors.

Toni DeVolder, Photographer. ©2006 Ecofutures Building, Inc.



Toni DeVolder, Photographer. ©2006 Ecofutures Building, Inc.

The dining room in the Doub's Solar Harvest home features bamboo floors, elegant cabinetry, and compact fluorescents throughout.

FOR MORE INFORMATION…

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www.icynene.com

GrailCoat
877.472.4528
www.grailcoat.com

GreenBlock
800.216.1820
www.greenblock.com

Alpen Heat Mirror
303.516.1000
www.alpeninc.com

Tamarack Fan
Tamarack Technologies, Inc.
508.759.4660
508.759.6001 FAX
800.222.5932 Toll Free
www.tamtech.com

Ny-Slate Roofing
NYCORE, Inc.
770.980.0000
www.nycore.com

practical wisdom useful in enhancing designs of systems for future zero energy buildings. To view the operation of Solar Harvest in real time, visit www.ecofuturesbuilding.com/monitoring. Ecofutures is working on four other net-zero homes (three new homes and a retrofit), plus one retrofit DNZEH (darned near zero energy home). It turns out that close counts in homes as well as horseshoes, and is frequently more cost-effective than ringers.

Interestingly, the solar strategies in each of these homes are different from one another. The common elements are the fundamentals—excellent insulation, careful air sealing, and clever ventilation strategies. In general, the cost premium for achieving net zero (or darn near) energy performance is on the order of 7% for both Solar Harvest and the other homes under construction. Not bad for securing a small ecological footprint and excellent comfort over the long haul.

Larry Kinney is President of Synertech Systems Corporation in Boulder. You can reach him at 303.449.7941 or larryk@SynertechSystemsCorp.com.

"When we build with nature and our environment in mind, we build a better future for our forests, our communities, and our world. I'm thrilled to be part of a community where people are truly building and living green."

– Elizabeth Vasatka
Founder, BGBG, Environmental Coordinator,
City of Boulder Office of Environmental Affairs

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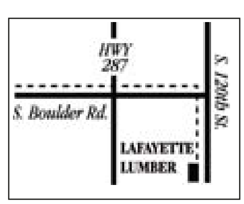

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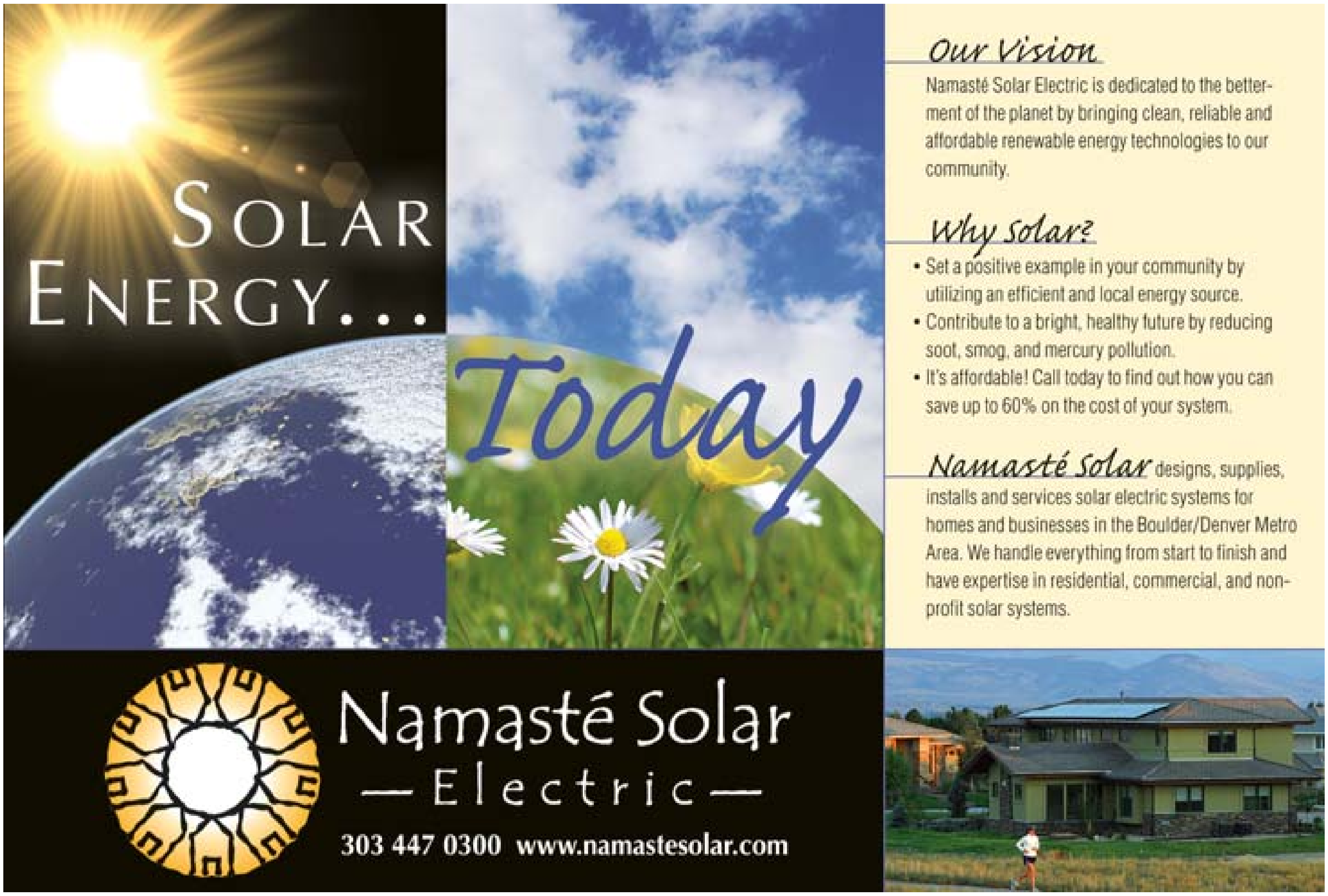
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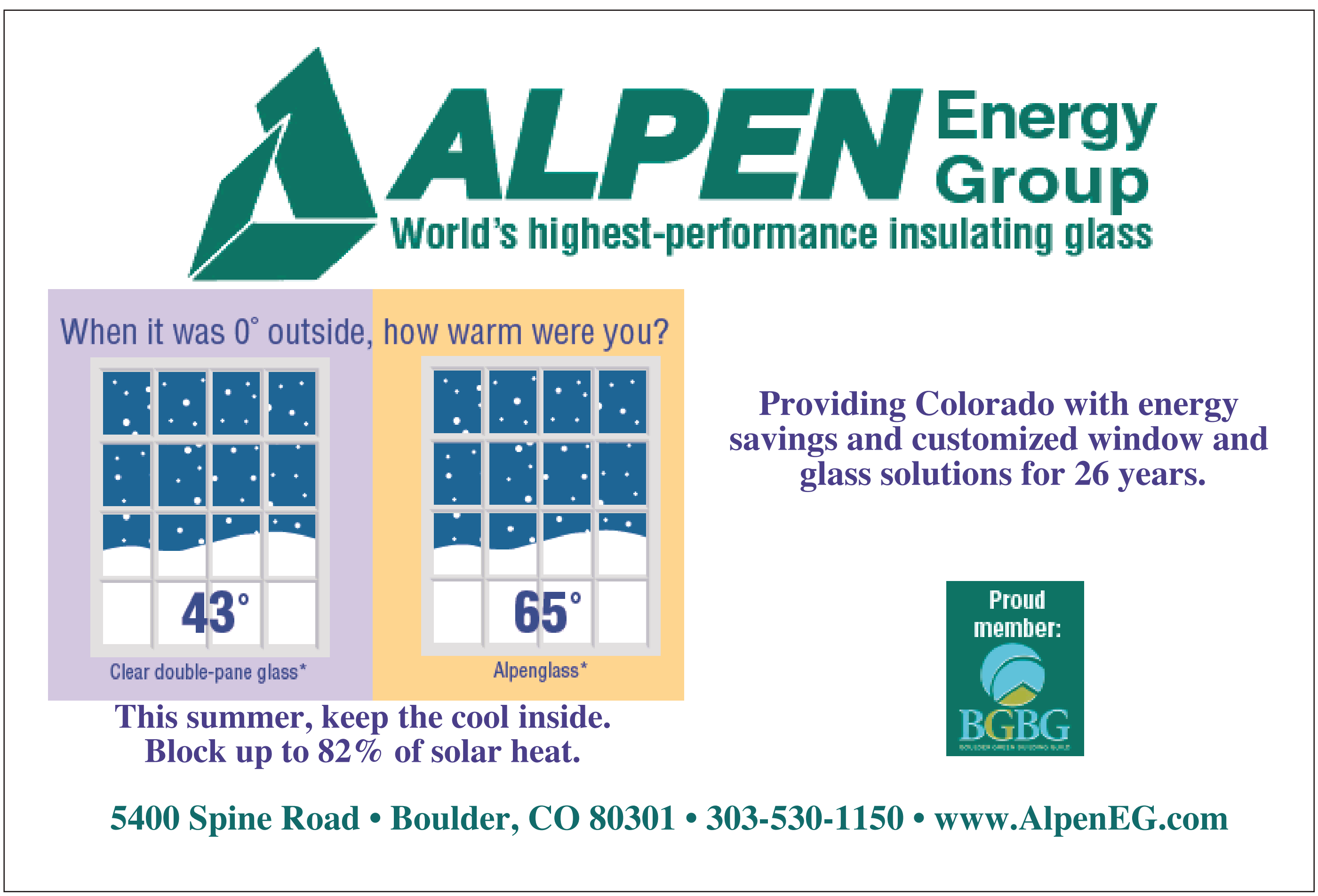
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Ann Duncan

City of Boulder News

Climate Action Plan Update

City of Boulder Office of Environmental Affairs
Spring 2007

Spring is in full swing and the city's Climate Action Plan is gaining momentum as we solidify our programs and plans for the year. The Office of Environmental Affairs (OEA) recognizes how the mission of the Boulder Green Building Guild (BGBG) and its members' values dovetail with and supplement the efforts of OEA and the Climate Action Plan (CAP). We look forward to a long and fruitful relationship with BGBG.

Climate Action Plan Tax – April 1, 2007

In November 2006, the city of Boulder achieved the distinction of becoming the first city in the U.S. to pass a carbon tax. Sixty percent of Boulder voters passed Initiative 202, the Climate Action Plan tax, which allows the city to tax residents and businesses on their electricity use. This initiative's passage is testament to Boulder citizens' commitment to mitigating climate change by reducing greenhouse gas emissions at the local level.

The day has finally arrived! On April 1, 2007, Xcel Energy began collecting the CAP tax through utility bills on behalf of the city of Boulder. Xcel will collect the tax through March 2013, and the revenue will support the directives of the CAP.

About the Climate Action Plan

City Council approved the CAP in June 2006. The CAP, which was conceived and created by local experts, stakeholders, and OEA, provides baseline information, including the greenhouse gas emissions (GHG) inventory,

City of Boulder News

and establishes the context for the GHG emissions reduction work in line with the goals of the Kyoto Protocol. The primary strategies for reaching the emissions reduction goal are to increase energy efficiency, shift to renewable fuel sources in buildings and vehicles, and reduce vehicle miles traveled. The specific strategies are based on programs and policies in other communities, utility energy efficiency programs, staff research, and input from a Climate Action Plan Committee. The CAP is continuously evolving in response to new information, legislation, and opportunities. You can view the CAP at www.environmentalaffairs.com. Click on Energy and Climate Programs.

City of Boulder Open Space and Mountain Parks

Looking south across Boulder to the Flatirons in the 1970s.

Next Steps for the Climate Action Plan

2007 holds many exciting opportunities for OEA staff to offer expanded programs and broader community outreach on its CAP initiatives. We will be launching a marketing campaign in summer 2007 to increase the visibility of the CAP in the community and to increase awareness about specific programs. BGBG Board member Beth Powell joined OEA on March 27, 2007, to head up marketing and communications, and a second new position within OEA will focus on transportation and alternative fuels. These new staff members join a visionary core team that saw the CAP through its infancy to its place in the sun (pun intended) today! Other city staff members who work on Energy and Climate programs include Kevin Afflerbaugh, Yael Gichon, Sarah Van Pelt, and Elizabeth Vasatka.

Many of our programs will involve continued co-sponsorship of specific BGBG events and will support BGBG member businesses and activities. The OEA looks forward to continued collaboration with the Guild!

Here are some previews of programs we believe will interest BGBG members in 2007. Please tell your clients and colleagues about these programs and encourage them to explore how they might benefit from them. Visit www.environmentalaffairs.com, click on Energy and Climate Programs or call 303.441.3878 for more information:

- ***Home Performance with ENERGY STAR training:*** A nationally recognized program developed and supported by ENERGY STAR, a joint effort of the U.S. Environmental Protection Agency and the U.S. Department of Energy, this training is designed to build a market for whole-house retrofits.
- ***Solar System Sales Tax Rebate:*** A portion of city sales tax paid on solar systems (photovoltaic and thermal) installed in the city of Boulder is eligible for a rebate.

Dave Sutherland

The city of Boulder's Open Space and Mountain Parks department has temporarily closed some areas to protect nesting and roosting raptors such as this Prairie Falcon from February 1 through July 31, 2007.

City of Boulder News

- ***Residential Energy Audit Program (REAP) (with the Center for Resource Conservation, www.conservation-center.org):*** This program provides low-cost, professional energy audits and energy conservation information to participating homeowners in Boulder County.
- Weatherization Program (with Long's Peak Energy Conservation): Offers free weatherization services to income-qualifying, owner-occupied households not served under the existing countywide weatherization program.
- ***Green Points Update:*** Boulder's mandatory green building code is in the process of being updated. Some potential highlights of the update include incorporating a streamlined approach to energy performance by using energy modeling and testing verification. The performance path is one way to satisfy compliance with the 2006 International Energy Conservation Code. We anticipate that the city of Boulder will adopt this code in late 2007.

STAFF CONTACT INFORMATION:

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Elizabeth Vasatka, Environmental Coordinator
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Planning & Development Services News

STAFFING UPDATES

Planning Director Search Process

Boulder City Manager Frank Bruno plans to post the vacant planning director position late this spring, and hopes to have it filled by the end of summer. Ruth McHeyser, a long-time city of Boulder planning manager, has been the acting planning director since former director Peter Pollock left the position in June 2006. A previous search process last fall was unsuccessful.

Land use review manager retired

Land Use Review Manager Bob Cole retired effective February 23, 2007. "It has been a privilege to work in the Planning Department," said Cole. "I have tremendous respect and admiration for the entire staff."

Cole was hired in 1992 as land use review manager and assistant planning director. On two occasions, he filled the role of acting planning director for a total of three years. Cole has worked in the public sector for 31 years, the last 15 with the city of Boulder, and plans on pursing other work opportunities.

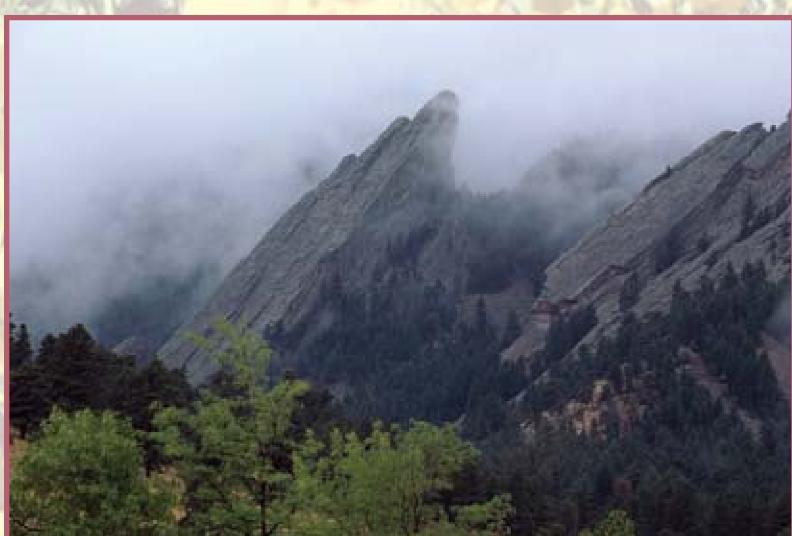
"Bob has been an integral part of the planning team and we will miss him," said Interim Planning Director Ruth McHeyser.

New Land Use Review Manager Hired

Robert Ray has been hired to assume the vacant land use review manager position. Ray joins the city of Boulder from the city of Thornton, Colorado, where he previously worked as a planning manager. He has also worked as the assistant director of community development for the city of Brighton, Colorado, and the economic development director, zoning administrator, and long range planning manager for the town of Payson, Arizona.

"We look forward to our future with Robert on the team," said McHeyser.

Ann Duncan



Misty Flatirons on a spring day in Boulder.

City of Boulder News

Wendy Marie Stuart

Painted Lady butterflies search for nectar on the flowers of an American Wild Plum at Sawhill Ponds.

TRANSIT VILLAGE AREA PLAN (TVAP) DRAFT PLAN STATUS

City staff is currently working on creating the draft Transit Village Area Plan (TVAP) for public review. In preparation for the draft plan, staff is continuing workshops with Planning Board, Transportation Advisory Board, City Council, and local property owners. The draft plan is currently on hold from public review until more work has been completed following guidance from the Planning Board.

For more information on the Transit Village Area Plan, go to www.bouldertransitvillage.net/.

2007 SPECIAL TRASH SERVICE DATES

Property owners and managers of rental properties in the University Hill and Goss/Grove neighborhoods are required to contract with trash haulers for pickup service for the following dates:

- **Spring: Friday, May 4 and Monday, May 14**
- **Fall: Monday, July 30 and Saturday, September 1**

The University Hill neighborhood boundaries are from Arapahoe Avenue to Baseline Road and Broadway to 9th Street, and the Goss/Grove Neighborhood boundaries are from Canyon Boulevard to Arapahoe Avenue and Folsom Street to 15th Street. The Environmental and Zoning Enforcement Office (EZEO) will issue a summons to property owners and managers of rental properties in these two neighborhoods if they are not signed up for the program, regardless of the extent of trash violations on their property.

The Special Trash Service code requirement was implemented in 2003 as a result of a community group recommendation. During tenant move-in and move-out periods, which occur at the beginning and end of the University of Colorado's academic year, the Goss/Grove and University Hill neighborhoods experience significant trash impacts. This program was initially developed as a pilot program in 2002. Its success resulted in the development of the specific code requirement.

For additional information, contact EZEO at 303.441.3239 or www.WelcometoBoulder.net.

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Building Inspections Administration: 303.441.4088
Building Inspection Scheduling: 303.441.3280
Cashier: 303.441.4161
Contractor Licensing: 303.441.1982
Environmental & Zoning Enforcement: 303.441.3239
Historic Preservation: 303.441.3207
Receptionist: 303.441.1960
Records & Research: 303.441.4065
Rental Housing Licensing: 303.441.3152
Right.of.Way Inspection Line: 303.441.1825

A more detailed list of contacts can be found online at www.boulderplandevelop.net under "Employee Phone List."

Norbert Klebl and the author's dog, Ivy, relax at the future site of Geos, a zero-energy, mixed-use neighborhood in Arvada, Colorado.

Michael Kracauer

Zero Energy Meets New Urbanism

Norbert Klebl's ambitious new neighborhood will offer buyers zero-energy homes at no additional cost. **BY MICHAEL KRACAUER**

Many new neighborhoods these days are built to green design standards. Some also use New Urbanism guidelines to create a traditional neighborhood design that has character, walkability, and the sustainability that goes with higher density, mixed use, and public transportation options.

But Norbert Klebl's latest project, called Geos and designed by Michael Tavel Architects and David Kahn Studio, goes beyond green design and New Urbanism to define a new cutting edge for neighborhood design. Norbert was born in Austria and holds an MBA from Columbia as well as a European engineering degree. After working in the corporate world for 25 years, he has turned his attention to creating paradigm shifts in the building industry.

Geos will be a neighborhood of zero-energy units—homes that produce at least as much energy as they consume (see What is a Zero-Energy House, page 31). Although Geos is still in the planning stages, the project has already garnered the 2006 AIA Denver Honor Award, the 2006 Denver Sustainability Award, and the 2006 AIA Colorado Citation Award. Zero-energy homes are still quite rare, even though they are all the rage in green building circles. Only one has been completed so far in the city of Boulder (see Harvesting the Sun in Boulder, page 14)—a green building Mecca—but there are several others in the design and construction phases.

Norbert's plan for the city of Arvada, just south of Boulder, is to build an entire mixed-use neighborhood—about 300 units—of zero-energy homes. He intends to accomplish this with a combination of energy efficiency, innovative design strategies, and renewable energy. As if this wasn't ambitious enough, there will be no additional cost to the buyers if Norbert's projections are accurate. The increase in mortgage payments will be more than offset by the energy cost savings.

BEYOND NEW URBANISM

This project illustrates how far we have come in our thinking about neighborhood design in a relatively short time. The town of Seaside, Florida, which is considered the first New Urbanist project, broke ground in 1981. Since then, New Urbanism has grown beyond its early emphasis on creating community and reducing sprawl, and is now embracing green building principles. For example, the Congress for New Urbanism, begun in 1993 by New Urbanist pioneers, recently teamed up with the U.S. Green Building Council to create LEED (Leadership in Energy and Environmental Design) for New Developments, the first national green standards for neighborhood design.

Although Geos is a relatively small project compared to Seaside, and is not big enough to be a town, it is a very large-scale zero-energy project, probably the largest in the nation. It is also big enough to incorporate enough New Urbanist features to achieve the critical mass and variety of a community. Along with single-family units, there will be townhouses, live/work units, stacked flats, parking villages, regular and senior cohousing, courtyard mixed-use, and a mixed-use commercial core. There will also be a beachfront pedestrian promenade, bike path, and open space adjacent to Ralston Creek.

The units are oriented to maximize passive and active solar gain, which creates some challenges. The attractiveness of Seaside and other New Urbanist developments had a lot to do with the traditional layouts of the streets. What Geos struggled with that these other communities didn't address is how to achieve a net zero-energy balance with good solar access, and still have a neighborhood street layout that retains the richness, scale, and walkability of more traditional designs.

Norbert and the design team studied many different development patterns, and worked hard to achieve a balance between solar requirements and New Urbanist goals. For example, one of the four sections of the site plan is the Checkerboard Blocks section. Here single-family units are spaced in a checkerboard pattern to allow solar access for neighboring units, which also creates interesting courtyard-like outdoor spaces between the buildings. Half of the units will have porches on the street, and the other half will be set back to the alley, with porches facing a courtyard, which, in turn, front the street. Even this innovative solution to achieving solar access has a historical precedent in the alley houses in some of Denver's older neighborhoods.

Once the designers achieve solar access, the other strategies to get to zero energy are in the design of each building and each residential unit. Europe's very energy-efficient Passive House was Norbert's basic model. The Passive House Energy Standard is considered the world's leading standard for energy-efficient design and construction. More than 6,000 units have already been built in Europe. These houses are designed to save 80% of the energy a standard code-compliant house requires. (Built Green Colorado homes, by comparison, save about 30%.)

Geos homes will meet Passive House standards. In addition, two renewable energy sources—solar and geothermal—will supply the remaining 20% of energy, making the neighborhood entirely energy self-sufficient.

FOR MORE INFORMATION...

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www.discovergeos.com

Michael Tavel Architects
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David Kahn Studio
www.dkahn.com
Passive House Energy Standard
www.passivhaustagung.de/englisch/

ZERO ENERGY AT NO ADDITIONAL COST

Moving zero-energy homes into the realm of production homes and making all these benefits cost neutral is one of the huge paradigm shifts of this project. Norbert estimates that the annual mortgage cost of all the extra features needed to achieve net zero energy is offset by the annual tax and energy savings, based on today's cost of energy.

So why would consumers buy a home like this when they won't be saving any money?

Many people would be interested in such a home simply to reduce their carbon footprint and do the right thing. But even the most magnanimous buyer will eventually realize significant cost savings, because as the cost of fossil fuels goes up, the savings will increase proportionately. And as a bonus, a zero-energy home will not only protect the homeowner from the uncertainties of future price increases, but will also help our country achieve energy independence and help restore the planet to good health.

Michael Tavel Architects

The Checkerboard Blocks section of the site plan includes single-family units spaced in a checkerboard pattern to allow solar access for neighboring units.

Michael Tavel Architects

Geos developers plan to leave 40% of the site as green space and protect the 100-year-old trees on the property during construction.

The other huge paradigm shift exemplified by the Geos project is to go beyond zero-energy homes to creating a model for an entire zero-energy mixed-use community. This neighborhood is intelligently planned to achieve a balance between the goals of New Urbanism and energy self-sufficiency. The designers have created a blueprint for change that offers a brighter future for Colorado and may even begin to change the world.

Michael Kracauer (architrop@aol.com) is a LEED AP architect. His firm, architropic, specializes in green residential architecture and green corporate interiors. He is presently designing zero energy houses for Boulder, Colorado, and Miami, Florida.

GEOS ZERO-ENERGY STRATEGIES

1. Not So Big

The simplest way to reduce the environmental footprint of a building is to make it compact. The Geos homes will range from 750 square feet (ft^2) to 2,400 ft^2, and average about 1,250 ft^2. Most of the units will be either townhouses or multi-family buildings, which will also increase the energy efficiency of the units by reducing the amount of exterior wall per unit.

2. High Performance Shell

All buildings will have envelopes that are tight and well-insulated:

Walls	R-30
Roofs	R-50
Basements	R-20
Windows	R-6.5 at night

The natural ACH (air changes per hour) during the winter will be 0.15 or 1 complete air change every 6 hours.

Perhaps the most innovative feature for the building enclosure will be the automated interior insulated shades. Using Hunter Douglas honeycomb shades with side channels will increase the window R-value by about R-3 at night. The shades will be automated to allow solar heat into the house during the day and keep heat in the house at night.

3. Geo-Assisted Energy Recovery Ventilation (ERV) System

This is similar to the earth-coupled ventilation configuration used by Eric Doub in his Solar Harvest house (see **Harvesting the Sun in Boulder**, page 14), but instead of piecing together a system like Eric did, Norbert is planning to use the German-made Westaflex system, which provides all the parts in one package. Replacement air, before entering the building, will first enter an underground tube that will wrap around the building. The Earth's constant temperature at 5 to 7 feet below the surface is 50 to 55°F, which either pre-cools the air during the summer or pre-heats the air during the winter. The system can be bypassed when outside air is warmer in the winter and colder in the summer than the air from the underground tubes. The air will be filtered before entering the tubes to prevent mold from entering the air stream, and will pass through an energy recovery ventilator to recoup energy from the building's return air before being exhausted to the outside.

4. Geothermal Domestic Hot Water and Space Heating

There will be 5 or 6 shared ground source heat pump (GSHP) systems for the entire project, with each heat pump servicing about 50 homes. One kilowatt of the power from the solar electric (photovoltaic or PV) system will run the heat pumps. Geothermal systems for individual homes are expensive, but Norbert projects that the economies of scale at Geos will bring the cost per GSHP unit to $4,500, with an additional $3,000 for the 1 kW of solar PV dedicated to the GSHPs. The estimated annual savings per unit is $600/year, which is greater than the estimated additional mortgage cost for the system. This means that the solar/geothermal systems are cheaper than a natural gas tankless water heater or standard water heater. The heating requirements for the units will be minimal because of the tight, well-insulated building envelopes and the passive solar gains, but the GSHPs will provide the additional heat on the coldest days.

5. Passive Solar

Because of good solar access, the units will take advantage of both active solar and passive solar. To retain the energy gained passively and release it when needed, the ceiling drywall will contain additional thermal mass. Geos' planners are also looking at phase change drywall, which has 4 times the thermal storage capacity of ordinary drywall.

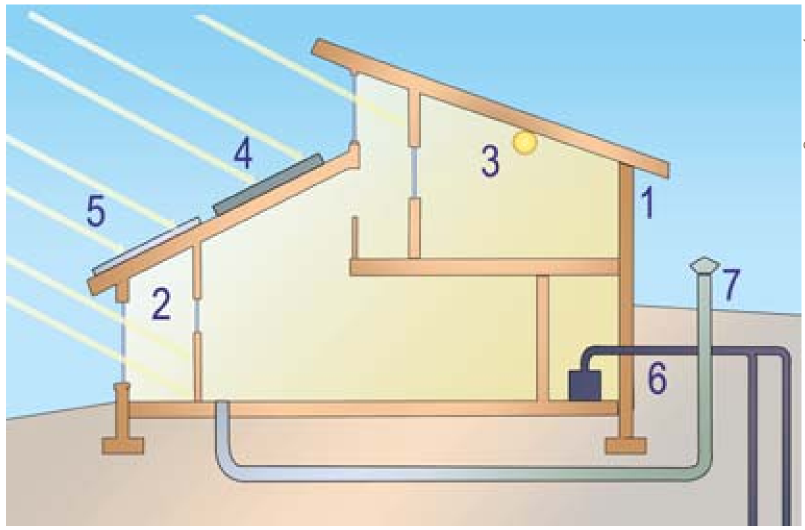
6. Solar Photovoltaic

Each unit will have 3.5 kilowatts (kW) of solar photovoltaic (PV) panels, with 1 kW dedicated to the GSHP and the remaining 2.5 kW serving the electrical needs of the unit. Norbert estimates that he can provide PV electricity for about $3/Watt ($6,000 for a 2 kW system)—a very aggressive goal—by taking advantage of all available rebates and incentives and achieving economies of scale by building a mini-utility rather than individual PV systems for each unit. The panels will be still be distributed on the community's rooftops, but energy from the units with better solar access will even out those with more limited solar access. Although 2.5 kW only accounts for about 45% of the average household's electricity consumption, the Geo units will be extremely energy-efficient. The incremental power reductions from earth cooling with an ERV (25%), earth heating with an ERV (5%), Energy Star appliances and compact fluorescent light bulbs (25%), and a daylighting and energy use monitoring system (5%) results in an energy reduction of 55% from the average household use, with the remaining 45% provided by the PV panels.

What is a Zero-Energy House?

BY HENRY W. MUELLER

There is some confusion among green building professionals and consumers about what a zero energy house is. According to the National Renewable Energy Laboratory in Golden, Colorado, the term refers to a house that produces as much energy as it consumes within a given period of time, usually a year. A zero energy house typically combines energy efficiency strategies with renewable energy technologies. The result is that annual utility bills add up to zero.



Henry Mueller Design, Inc.

A net zero-energy house may use any or all of the following strategies:

1. **Superinsulated Building Envelope.**
   Exterior walls, roof systems, and floor systems contain high R-value insulation. Values may be R-34 to R-40 for the walls, R-45 to R-60 for the roof, and R-30 for the basement walls or floor system.
2. **Passive Solar Design.**
   The house is oriented to the sun, and features south-facing windows to collect heat from the winter sun. The heat is stored in thermal mass within the envelope and released gradually to help heat the house. This mass can be stone, tile, or added layers of drywall or even water. Some systems incorporate greenhouses, sunrooms, and/or Trombe walls to deliver heat by radiation and convection to the living space as needed. The process can be reversed in the summer by flushing the internal mass with cool night air to keep the house comfortable on warm days. Moveable insulation that allows solar into the home during daylit hours while covering windows with good insulation at night enhances comfort and energy performance.
3. **Efficient Use of Electricity.**
   Designers of zero energy homes ensure as small an electrical load as possible by using efficient Energy Star-rated appliances and compact fluorescent light bulbs; installing occupancy sensors in each room; and using timers on bathroom fans and heat lamps.
4. **Solar Thermal Panels.**
   Solar thermal systems typically use collectors that circulate a liquid through tubing encased in a roof-mounted solar panel to absorb the sun's heat. A highly-insulated storage tank limits losses from the tank and a heat exchanger provides hot water for domestic use and sometimes space or even spa heating.
5. **Photovoltaic Panels.**
   Silicon wafers encased in photovoltaic (PV) modules convert sunlight directly into electricity. The electricity is used immediately, stored in batteries, or fed back to the power grid, where excess electricity can be sold to the utility company using a net metering system.
6. **Ground Source Heat Pumps.**
   Heat pumps use the Earth's nearly constant ground temperature (50°F for much of Colorado) to extract or discharge heat to be used for heating or cooling within a building. A heat pump circulates liquid through a horizontal or vertical pipe array buried below ground and used a compressor to pump it to desired temperatures.
7. **Geothermal Ventilation.**
   Similar to the ground source heat pump, this system draws fresh air into the house through an air duct buried beneath the ground. Coupled with an energy recovery system, the air can be heated or left cool, based on need.

Henry Mueller (principal@henrymuellerdesign.com) is principal of Henry Mueller Design, Inc., an architectural design firm specializing in nature-based aesthetics and sustainable design.

TOWARD A MORE PRECISE DEFINITION

Zero net energy can be defined in terms of site energy (used at the building site) or source energy (sometimes called primary energy). For electricity purchased from a utility, the source energy used to produce and distribute the electricity is typically about *three times* as much as the delivered electricity. From a societal point of view, source energy better reflects the overall consequences of energy use. The U.S. Department of Energy's Building America (BA) residential energy efficiency research program defines a zero energy house as one that has predicted zero net source energy consumption over the course of a year using typical meteorological year weather data and BA Benchmark assumptions on occupant behavior based on average U.S. behavior in terms of temperature setpoints, miscellaneous electric loads, and hot water use.

For more information, go to www.buildingamerica.gov. See also *Walking the Talk–Habitat Goes Green*, page 32.

Source: A Cold-Climate Case Study for Affordable Zero Energy Homes *by Paul Norton and Craig Christensen, NREL, presented at the SOLAR 2006 conference in Denver, Colorado.*

Walking the Talk—Habitat Goes Green

With the National Renewable Energy Laboratory's help, Habitat of Metro Denver takes green building to its logical conclusion—a zero-energy house. **BY PAUL NORTON AND COLLIN TOMB**

Paul Norton

Except for the 4-kilowatt photovoltaic system and the collectors for solar water heating on the south roof, the Habitat zero energy house looks like any other Habitat home.

One of the biggest challenges to mainstreaming green building is the perception that it is too expensive. For this reason, green building strategies often end up on the chopping block during value engineering (if they are considered at all) by builders of production and affordable homes. If we are to convince builders to adopt green practices, we need to make them affordable from the outset.

GREEN AND AFFORDABLE

Fortunately, the masters of affordability have made a move into green building. Habitat for Humanity helps families worldwide into homes that would otherwise be beyond their reach. Their motto is "simple, decent, affordable," and they strive to cultivate a sense of investment, pride of ownership, and community among the new homeowners by involving them in the construction of their homes and those of their neighbors. When homes are provided as "a hand-up, not a handout," the families value and care for their homes over the long term. Habitat has a long list of donors who provide materials and services at a discount or for free, and Habitat's construction teams are experts at affordable construction.

With the writing on the wall about rising energy costs, Habitat was among the first to see that no home will be decent or affordable if it's not also energy-efficient. In the face of rising land prices and energy costs, Habitat has begun a movement towards the energy efficiency measures that form the basis of green design.

As one indication of this effort, Habitat of Metro Denver completed a zero-energy home (ZEH) in partnership with the National Renewable Energy Laboratory (NREL) in 2005. The project, located in Wheat Ridge, Colorado, is now in the monitoring phase, and represents a major milestone in energy independence for the affordable housing market.

DEFINING ZERO ENERGY

Zero net energy can be defined in terms of site energy (energy used at the building site) or source energy (all the energy used in delivering energy to a site to perform a specific function such as space conditioning, lighting, or water heating, including power generation, transmission, and distribu-

BETTER BUILDING IN BOULDER by Collin Tomb

In Boulder, Flatirons Habitat for Humanity's Director Paul Casey emphasizes his sense of responsibility to "nurture" the families in the program, and to insulate those families from rising energy costs. Casey feels that the life-cycle performance of the building is part of that responsibility.

In 2001, the People's Clinic purchased land in a part of North Boulder that is developing into a strong community with a diverse mix of incomes, ages, and outlooks. Immediately south of the Holiday development, plans for the People's Clinic site feature an affordable health care facility and numerous multi-family buildings, including Habitat's Buildings C and E, comprising 9 units of varying sizes, 4 of which are wheelchair accessible.

In late 2003, Flatirons Habitat approached Bryan Bowen, a green architect working in the People's Clinic neighborhood. Bowen had been project manager for the Wild Sage Cohousing development, which seamlessly integrated 4 Habitat units, and he was invested in the proposition that Habitat housing could stand amid the neighborhood's playful, modern designs. His designs for Buildings C and E individualized the units with separate porches and entries, and blended archetypal symbols of home with the modern materials of other homes in the neighborhood. Acoustic isolation detailing in party walls and stairwells ensured privacy. High levels of insulation, durable and recycled cladding and decking, water-conscious irrigation design, and some energy-efficient appliances set the green baseline.

This level of attention to detail called for an innovative engineer. Keith Dietzen, founder of Keymark Engineering, has a commitment to green building and a relationship with Habitat that goes back many years. Keymark originated a computer-modeling program that extends their expertise into new ways of minimizing wood and maximizing insulation. Keymark's software allows them to pre-mark the lumber with all the information needed for assembly, including header heights and stud locations. This approach minimizes waste and makes the building project easier for volunteers to handle.

Getting It Right

To ensure that the design met technical standards of energy efficiency, Flatirons Habitat called upon a long-time partner—energy consultant Paul Kriescher, who heads Lightly Treading, Inc. Kriescher has worked with Habitat since the 1990s and was involved with the Habitat zero-energy house in Wheat Ridge. Flatirons Habitat wanted to strive for a 50% improvement on the International Energy Conservation Code (IECC) energy efficiency minimum. Paul Kriescher modeled the original design for buildings C and E to see what improvements would get them to that goal.

A principal challenge came with the site planning. The buildings will face east and west, making solar access difficult and passive solar design nearly unworkable. Nonetheless, Kriescher was able to capture some benefit by selecting Cardinal Low-E 272 glazing, which has a slightly higher solar heat gain coefficient than most low-U-value glazings available. Insulation was key, and Kriescher was able to bulk up on under-slab (R-10) and under-cladding (R-5) rigid insulation, which comes as a gift to Habitat from Dow.

Because of the buildings' orientation, the optimal strategy was to make the envelope as airtight as possible. Kriescher modeled a value of 0.18 air changes per hour by specifying a sealing protocol for sills and drywall junctures and a skim-coat (1 to 2 inches) of polyurethane foam at rim and band joists. Such a tight envelope requires a mechanical ventilation system that could bring in the 44 average cubic feet per minute (cfm) of air required by ASHRAE 62.2. Kreischer's models showed that the energy lost through this system was still one-fifth of the energy that would be lost by simply leaving the house leaky enough to meet the air change requirement.

Architect Bryan Bowen notes that these buildings are a test case for the worst possible solar orientation. By tightening the building envelope, Paul Kreischer found that he didn't need to change Bowen's window patterns to meet the efficiency goals. That the buildings are designed to meet a high level of energy-efficiency on a tight budget, with little in the way of passive solar contribution, suggests that success in affordable green design is not a pipe dream.

The cost issue still demands attention, of course. The up-front investment for green buildings requires Habitat to extend itself significantly more than in its conventional buildings, and Habitat is working to secure more support from the manufacturers of the most costly upgrades—windows, solar panels, and efficient appliances—to keep this trend moving. To get the homes online quickly and efficiently, Habitat is experimenting with a "contractor blitzbuild" by a local contractor who will donate services to organize and supply the volunteer crews.

To get involved in building Habitat's Buildings C and E, visit www.flatironshabitat.org/involved/.

For More Information...

Flatirons Habitat for Humanity
www.flatironshabitat.org

Keymark Engineering
www.keymark.com

Bryan Bowen
www.bryanbowenarchitects.com

Energy Star
www.energystar.gov

International Energy Conservation Code
www.iccsafe.org

Lightly Treading
www.lightlytreading.com

Keymark Engineering

Keymark Engineering's software allows them to pre-mark the lumber with all the information needed for assembly, which minimizes waste and makes the building project easier for volunteers to handle.

tion losses). For electricity purchased from a utility, the source energy used to produce and distribute the electricity is typically about three times as much as the delivered electricity. From a societal point of view, source energy better reflects the overall consequences of energy use.

The Habitat ZEH was designed to meet the definition of zero energy of the U.S. Department of Energy's Building America (BA) residential energy efficiency research program. It must have predicted zero net source energy consumption over the course of a year using typical meteorological year weather data and BA Benchmark assumptions on occupant behavior.

A UNIQUE OPPORTUNITY

For green designers and builders, a Habitat for Humanity house represents an unusual opportunity. Thanks to volunteers, much of the labor comes at no cost and it is possible to get some of the equipment donated or at reduced cost. However, in the case of this ZEH, the Habitat/NREL team figured the tradeoffs it took to get to zero energy at full material cost. Although some of the equipment in the house was donated or bought with grants at no cost to Habitat, the designers considered the full value of these items to find the balance between efficiency and PV production.

Ideally, a Habitat project should also be replicable by other Habitat chapters. The design team chose construction techniques and energy efficiency technologies based on the likelihood that they would be used in future Habitat homes. For example, when considering construction strategies and techniques, the team chose techniques that were "volunteer friendly" and tended towards low material cost. For example, structural insulated panels (SIPs) and Insulated Concrete Forms (ICFs) were eliminated because they tend to have high material costs and low labor costs—the opposite of what is needed to take advantage of Habitat volunteer labor. They considered straw bale construction because of its low material cost and high labor-intensity, but eventually eliminated this option based on the lack of standard techniques and details and the low probability of replication.

Paul Norton

The Habitat/NREL team chose double stud wall construction (above), because it has low material costs and uses familiar volunteer-friendly techniques. Raised heel trusses (below) accommodate 2 feet of blown-in fiberglass in the attic, giving the top of the thermal envelope an insulation rating of R-60.

Paul Norton

They eventually chose double stud wall construction with fiberglass batt insulation, because it has low material costs and uses familiar volunteer-friendly techniques. Another plus is that proven construction techniques and details are available from the National Affordable Housing Network (http://NAHN.com).

It was important to the design team that the home's energy-efficient attributes be as invisible to the family as possible. From the family's perspective, it should be a normal home with no extra owner operating needs. In addition, the home used off-the-shelf, proven technologies available in the marketplace today. Because the home is expected to outlive all of its mechanical systems, the designers wanted these systems to be easily replaceable by technicians the owners could find in the local yellow pages.

NET ENERGY PRODUCER!

The final design of the 1,280 square foot, 3-bedroom ZEH carefully combines a tight and well-insulated building envelope; efficient equipment, appliances, and lighting; a solar photovoltaic (PV) system; and passive and active solar thermal features (see The Details, page 35). In January 2006, a data acquisition system was installed in the home to monitor its performance over the course of a year.

From February 2006 through January 2007 the home's 4-kilowatt (kW) PV) system produced 5,113 kilowatt-hours (kWh) of AC electricity. The home consumed 3,602 kWh of electricity and 55 therms of natural gas during this period.

On a source energy basis, the home produced 24% more energy than it used. The energy used for space heating, water heating, and lighting has been dramatically reduced through superinsulation, passive solar tempering, solar water heating, compact florescent lights, and other efficiency measures. Appliance and plug loads determined by occupant choices and behavior now dominate, constituting 57% of all the energy used in the home. Because these loads are outside the control of the home designer and vary considerably with different occupants, sizing the PV system to achieve zero net energy performance is challenging.

FOR MORE INFORMATION…
Building America
www.buildingamerica.gov
Habitat of Metro Denver
www.habitatmetrodenver.org/
National Affordable Housing Network
http://NAHN.com

THE HEART OF HABITAT

Ultimately, the heart of Habitat's work is in its human capital. The involvement of volunteers—from sustainability experts to the homeowners themselves—is the means by which Habitat's work comes to be valued and recognized worldwide. If Habitat can accomplish "simple, decent, affordable, and green," there will be no reasonable argument left standing against making simple efficiency practices standard in the mainstream market. And if developers absorb Habitat's sense of lasting responsibility to the families they serve, then the intent—and not just the payback—of green building can become as integral a part of the American dream as home ownership itself.

Paul Norton (paul_norton@nrel.gov) is a Senior Engineer with the Buildings and Thermal Systems Center at the National Renewable Energy Laboratory.

Collin Tomb (collintomb@yahoo.com) specializes in green building at Jim Logan Architects in Boulder.

THE DETAILS

Project description: Single-family Habitat for Humanity home
Owner: Amy Whalen
Energy Consultants: Craig Christensen, NREL; Paul Kriescher, Lightly Treading; Paul Norton, NREL
Location: Wheat Ridge, Colorado
Size: 1,280 square feet
Construction Cost: $130,500 (not including land cost)
Date Completed: September 15, 2005
Heating Degree Days (65°F): 6,100
Cooling Degree Days (65°F): 700 (Note that the home does not include air conditioning)

ENERGY PERFORMANCE

2006 Annual Source Energy Use–Millions of Btu (MBtu)[1]

	Lighting	Equipment	Appliance and Plug Loads	Total
Base case	13	47	29	89
This project	3	18	24	45
Percent Savings	77%	62%	17%	49

1. Based on DOE2 simulation calibrated to the measured energy use data and driven with measured weather. Base case is the Building America Benchmark.

Annual Site Energy Use Intensity–Entire Building

	Electricity	Natural Gas	Energy use cost
	kWh/ft²	Btu/ft²	$/ft²
Base case	3.8	0.30	0.54
This project	-1.1	0.056	0.12
Percent Savings	129%	81%	78%

Source: DOE2 simulation calibrated to the measured energy use data and driven with measured weather. PV production is included. Base case is the Building America Benchmark. Note that the base case uses only natural gas for space heating while this project uses a mix of natural gas and electricity.

Renewable Energy Production

Renewable energy system	Energy production		
	Predicted	Measured	Difference
PV system	4892 kWh	5113 kWh	5%
Solar water heating system	10.0 MBtu	1.3 MBtu	-82%

Based on data from February 2006 to January 2007, PV prediction is based on PVWatts simulation with Solar Pathfinder shading correction. Solar water heating prediction is based on TRNSYS simulation with a U.S. average hot water consumption of 63 gallons per day. The actual hot water use was 1/3 of this expectation. The annual average thermal solar savings fraction was 78%.

2006 Calendar Year Energy Cost[1]

	Total
Base case	$692.00
This project	$152.28
Percent Savings	78%

1. The project costs are actual utility bills. The base case costs are based on the Building America Benchmark simulations calibrated to the measured energy use data, driven with measured weather and using Denver energy tariffs.

RENEWABLE/EFFICIENCY FEATURES

- 96 sq. ft. solar collector area with 200 gallons of water storage
- 4-kilowatt PV system
- Natural gas tankless water heater as backup to solar system
- Balanced energy recovery ventilation system
- Double stud wall construction for nominal R-40 walls
- Raised heel trusses accommodate 2 feet of blown-in fiberglass for R-60 attic insulation
- Floors insulated to a nominal R-30
- Double-glazed, low-emissivity (U-value = 0.30 Btu/hr-F-ft²), high solar heat gain coefficient (SHGC=0.58) glazing in south windows
- Heat Mirror® low-emissivity (U-value = 0.22 Btu/hr-F-ft²) low SHGC (0.27) in east, west, and north windows

XERISCAPE—Wow...It's Wonderful!
But Don't Let the Curmudgeons Get You

A local author and landscape architect busts the myths about xeriscaping. **BY JIM KNOPF**

Xeriscaping is all good news. There is no downside. It saves water. It typically costs far less both to build and to maintain than "traditional" landscapes. It attracts charismatic critters while discouraging wildlife mischief. It provides many great business opportunities. It offers new ways to provide year-round beauty. It is the best way ever to make gardening great by being something to do, rather than to be done with.

Dave Sutherland

A white-lined sphinx moth gathers nectar on a Rocky Mountain Penstemon, a Colorado native wildflower.

It is simply all good news.

But beware. The world is full of curmudgeons spreading destructive myths that stop people from reaping the rewards of wonderful waterwise landscaping.

With a bit of the following myth-busting even the most committed curmudgeons can be converted, so don't let curmudgeonly thinking keep you from a wonderful waterwise future.

XERISCAPE MYTH BUSTING—CONVERTING CURMUDGEONS

Myth #1 Xeriscapes are **dry only...NO!**

The original meaning of the word xeriscape was simply waterwise, or water-efficient landscaping. Even though dry-only landscaping can be spectacularly colorful and even lush, limited areas of highly watered landscape are completely consistent with wise water use, if the return justifies it—for example, heavily irrigated athletic field turf.

Myth #2 Xeriscapes are **rocks and gravel only...NO!** Although dry (xeric) rock gardens can be truly marvelous, there are an unlimited number of other choices for the xeric portions of xeriscape designs, even in the driest climates.

Myth #3 Xeriscapes are **lawnless...NO!** Some lawn can be consistent with the concept of overall waterwise landscaping. "Less-lawn, not lawn-less" is a more appropriate phrase.

Myth #4 Xeriscapes are **native only...NO!** Although there is a vast array of wonderful native plants for any region, introduced plants that are well-adapted and not invasive, are an important addition to native flora for waterwise landscapes.

HOW MUCH WATER DOES LANDSCAPING REALLY NEED?

The following information shows how to divide landscaping into different zones, based on the water needs of plants. Numbers illustrate typical Denver and Salt Lake City conditions. The same thing can be done in any climate by adjusting the number of zones, and the actual amounts of water needed, based on local experience.

HIGH WATER ZONES
Bluegrass Turf (always wet at surface)
18-20 gals./SF/season
0.5 inch, 3 times per week
Typical Plants: Kentucky Bluegrass, Redtwig, Dogwood, Pansies

MODERATE WATER ZONES
Half of Bluegrass Turf (like Turf-Type Tall Fescue)
10+ gals./SF/season
0.75 inch, once per week
Typical Plants: Turf-Type Tall Fescue, Potentilla, Purple Coneflower, many shade trees

LOW WATER ZONES
Buffalograss turf (like Denver without irrigation)
0-3 gals./SF/season
0.5 inch every 2 weeks, optional
Typical Plants: Buffalograss lawns, Rabbitbrush, Mexican Hat Coneflower

VERY LOW WATER ZONES
Too dry for any turf (drier than Denver and Salt Lake City)
No watering
Typical Plants: Piñon Pine, Yuccas, Apache Plume, Agaves, Penstemons

Jim Knopf

This moderate water landscape requires about half the water of a bluegrass lawn.

The Two Great Xeriscape Commandments

Thou Shalt ALWAYS Group Plants of Similar Water Needs
and
Thou Shalt NEVER Over-Water the Groups

Jim Knopf

This waterwise landscape provides plenty of color but requires only one-quarter the water a bluegrass lawn would use.

Myth #5 Xeriscapes **cost too much to build and maintain…NO!**
Xeriscapes can cost far less to build and maintain than traditional landscaping, which is usually dominated by high cost, manicured lawns that must be mowed weekly. A good waterwise landscape can be designed to avoid expensive automatic irrigation, and the money saved can be used for more plants. Many xeriscape designs need little or no regular maintenance, which makes maintenance by puttering become a wonderful reality. Xeriscaping actually saves money!

Myth #6 Xeriscapes are **a single style…NO!**
Xeriscapes can be any style. There are lush tropical xeriscapes, stunning Sonoran desert xeriscapes, delightful Rocky Mountain xeriscapes, eastern woodland xeriscapes, formal and informal xeriscapes. Xeriscaping is not a single style.

Myth #7 Xeriscapes are **difficult…NO!**
Xeriscaping is not difficult. In fact, it can be easier than traditional landscaping. Trying to create a manicured lawn on a rocky site is far more difficult than creating a ground cover area with vines planted in only a few spots on the same site. Xeriscaping can be truly easy. Xeriscaping might mean learning a few new things, but that's not a downside, and it can be both easy and a lot of fun.

Myth #8 Xeriscapes **need plants you can't get…NO!**
There are more than enough xeric plants for xeriscapes. It is never hard to get shrubs like junipers or rabbitbrush or flowers like iris or pensetemons or ground covers like snow-in-summer. Plants for xeriscapes are just as readily available as plants for "traditional" landscaping.

Myth #9 Xeriscapes **need more water to get started…NO!**
Most plants in good xeriscape designs need less water (even the first year) than it takes to satisfy established high water landscapes. In fact, many low and very low water plants need only be watered when first planted. Even Turf-type Tall Fescue and Buffalograss sod need less water the first year than it takes to satisfy established Bluegrass. Overall, most parts of most xeriscapes need less than half the water of established high water landscapes, even the first year.

When it's important to save water in landscaping, the first and most important thing is to put plants of similar water needs together, and then avoid excessive irrigation. That's it!

Enjoy your garden!

Jim Knopf (knopfj@comcast.net) is a writer, speaker, and landscape architect based in Boulder, Colorado.

Jim Knopf

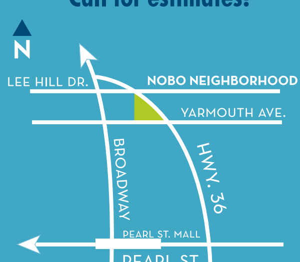
This attractive landscape uses from zero to less than one-quarter the amount of water a bluegrass lawn requires.

For More Information…

WaterWise Landscaping with Trees, Shrubs, & Vines
by Jim Knopf, Chamisa Books, 1999

The Xeriscape Flower Gardener
by Jim Knopf, Johnson Publishing Company, 1991

Jim Knopf will be the featured speaker at the Boulder Green Building Guild's lunchtime presentation on May 15, 2007, at 11:30 am at The Dairy Center for the Arts, 2590 Walnut, Boulder, Colorado. The title of his talk is "Transition Zone Xeriscapes: A Little Water Goes a Long Way!".



Tim & Mary Coonce of Paragon Builders, Porchfront Homes

Continued from page 11

tance from 62% to 3.5% while reducing the solar heat gain coefficient from 0.48 to 0.09.

Sage Electrochromics, Inc. is partnering with window, skylight, and curtainwall manufacturers to produce both commercial and residential products. The product is currently available from manufacturers such as Velux®, Architectural Wall Systems, Inc., Harmon, Inc., the Vistawall Group, Wausau Window and Wall Systems, and YKK AP America, Inc. SageGlass is currently very expensive (increasing the cost of insulated glass six- to seven-fold), but Sage Electrochromics expects the cost to eventually become competitive with standard high-performance glazing combined with interior mechanized shades.

For more information, contact Sage Electrochromics, Inc., 507.331.4848, 877.724.3321, 507.333.0145 FAX, www.sage-ec.com.

ElectSageGlass® electrochromic tintable glazing

Composite Surface

PaperStone™, from KlipTech Composites, is a dense, hard, water-resistant, solid-surface composite material used for skateboard ramps, countertops, toilet partitions, and exterior rainscreen siding. It is made from cellulose fiber (paper) and a non-petroleum phenolic resin derived in part from a natural phenolic oil in the shells of cashews. KlipTech offers two versions of the product—standard PaperStone, which contains at least 50% post-consumer recycled paper, and the newer PaperStone Certified, which contains 100% post-consumer recycled paper. The latter product is third-party certified by SmartWood to carry the Forest Stewardship Council (FSC) recycled-content label. Overall, the product is 60% paper fiber by weight and 40% resin. KlipTech produced the PaperStone rainscreen product (PaperStone XV) exclusively for Starbucks until November, 2006, when it rolled out the product for broader uses.

PaperStone™ Certified composite surface materials is made with 100% post-consumer recycled paper.

For more information, KlipTech Composites, 360.538.9815, 360.538.1510 FAX, www.paperstoneproducts.com.

Polished Concrete System

Polishing concrete turns new and old concrete slabs into attractive, durable, finished floors. RetroPlate™ of Provo, Utah, pioneered this process of grinding, polishing, and chemically hardening (densifying) concrete in the 1990s, and its system has now been used on more than 100 million square feet of flooring. The RetroPlate process was developed by combining European stone-grinding and polishing technology with concrete hardening and densifying agents that had been used in North America.

In the process, large walk-behind diamond-wheel grinders remove between 1/16th and 1/4 inch of the concrete floor surface. Consecutively finer-grit grinding and polishing wheels achieve a fine polish (up to 3,000-grit). The sodium silicate applied during the polishing process is absorbed and reacts with the calcium hydroxide in the concrete to form calcium silicate hydrate, which crystallizes within the concrete matrix. The resultant concrete surface is highly durable, easy to maintain, free of VOC emissions, and more reflective (which can reduce light level requirements). The system enables the concrete slab to serve as the finished floor surface, thus reducing material use.

For more information, contact RetroPlate—Advanced Floor Products, Inc., 801.812.3420, 888.942.3144, 801.812.3400 FAX, www.retroplatesystem.com.

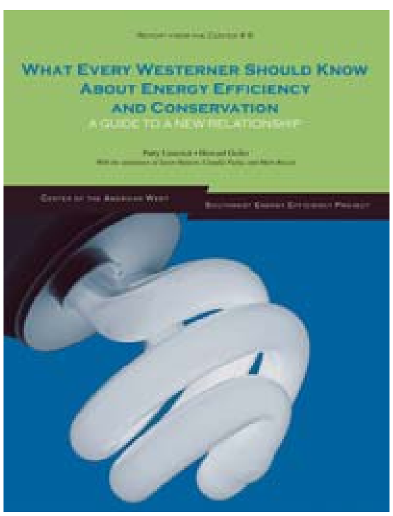
The process of polishing concrete allows a concrete slab to serve as the finished floor surface.

Giggle While You Learn

The University of Colorado's Center of the American West has teamed up with the Southwest Energy Efficiency Project (SWEEP) to publish *What Every Westerner Should Know About Energy Efficiency and Conservation: A Guide to a New Relationship*. Lead authors Patty Limerick (Center of the American West) and Howard Geller (SWEEP) have assembled the most current information on energy efficiency and conservation into an accessible, humorous, and practical guide for individuals and businesses that want to save energy—and money.

The new report demonstrates that improving energy efficiency and adopting energy conservation strategies works on many levels, from improving comfort to saving money to protecting the environment. If adopted widely, the suggestions in this report can—for example—improve the health of local economies and eliminate the need for new polluting power plants. According to the report:

"The Energy Efficiency Task Force established by the Western Governors' Association (WGA) found that it is feasible to reduce electricity use 20 percent from projected levels in 2020 if Westerners adopt energy efficiency best practices. Achieving this target would eliminate the need for 100 large new power plants, save consumers and businesses over $50 billion net, and save approximately 1.8 billion gallons of water between 2006 and 2020. …it could cost about $35 billion to finance the energy efficiency measures. But the investment does not need to be made overnight, and the return would be sizable. In this scenario, if the majority of households and businesses made significant efforts to improve energy efficiency, the economic benefits would exceed the costs by a factor of 2.5."



A practical and humorous look at energy efficiency and conservation in the west.

In addition to hard facts, the report offers something rarely found in publications touting the virtues of energy efficiency and conservation—humor. In the preface, the authors frame Westerners' relationship as a romance:

"You have been involved in a tempestuous relationship, pursuing a mad romance with fossil fuel," they tell the reader. Energy efficiency, on the other hand, brings "financial gain, emotional satisfaction, physical comfort, and a license for smug self-congratulation."

Instead of the ubiquitous list of "energy efficiency tips" exhorting energy consumers to change their wasteful ways, the authors offer tips in haiku form. Here's a sampling:

With frigid bedrooms
But a fire-lit central space
Families grow closer.

and

Low flow shower heads
Display strengths in character.
More sex will follow.

This publication is worth a look—it's definitely not your average energy efficiency and conservation report. Printed copies of the report are available for purchase at $10 plus shipping from the Center of the American West's website (www.centerwest.org). A pdf-version of the report is available as a free download from both the SWEEP (www.swenergy.org) and Center of the American West websites.

Happy Green Homeowners

A new homebuyer survey reveals a high rate of customer satisfaction among homeowners who have purchased green homes. The survey also finds that 63 percent of buyers are motivated by the lower operating and maintenance costs that come with energy- and resource-efficient homes.

The National Association of Home Builders (NAHB) and McGraw-Hill Construction, which conducted the research, released preliminary results of the findings at the 9th Annual NAHB National Green Building Conference in St. Louis March 25-27, 2007. The survey represents the first time the true green home market has been sized, screening out green homeowners from a representative panel of U.S. homeowners. These homeowners say they are extremely happy with their investments, with 85 percent saying they are more satisfied with their new green homes than with their previous, more traditionally built homes.

The new survey also backs up recent findings by the NAHB Economics staff that interest in green remodeling continues to grow. About 40 percent of those who have recently completed home remodeling or renovation work in their homes reported that they used green products or materials, the McGraw-Hill Construction research found.

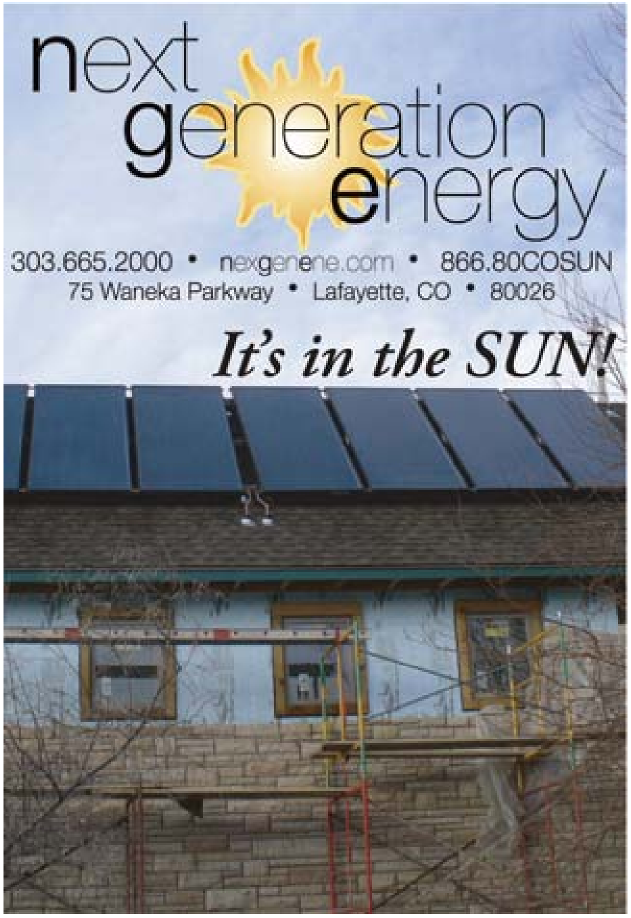
"It's interesting that people are really starting to commit to building green homes," said Harvey M. Bernstein, McGraw-Hill Construction Vice President of Industry Analytics, Alliances and Strategic Initiatives. "Though it's still a small number, builders are already getting it when it comes to the value of green homes, and it appears homeowners are too."

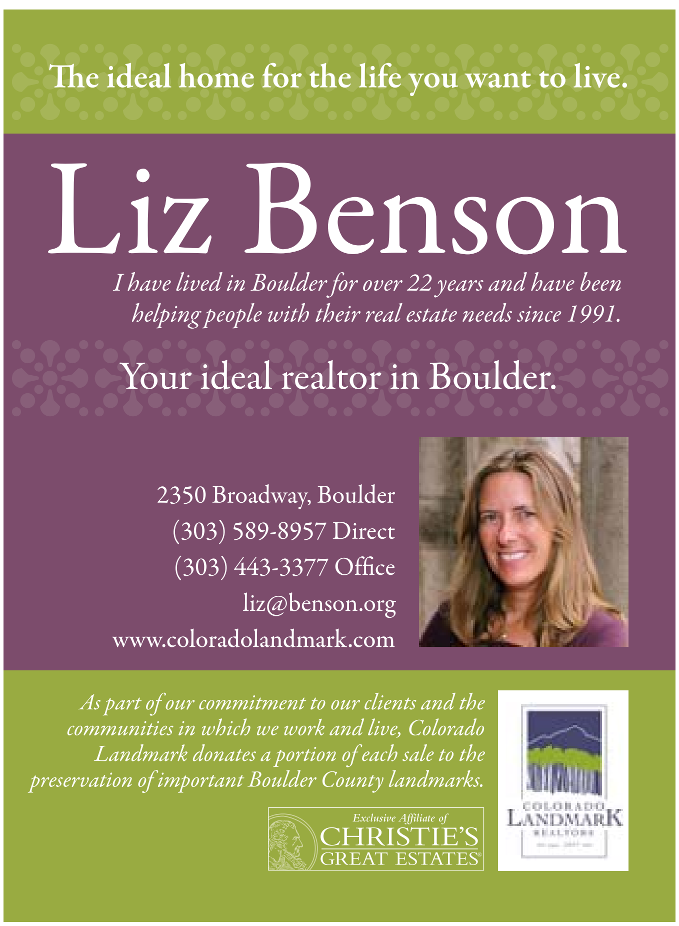
The research also found that:

- The new green homeowner is affluent and well educated, in his/her mid forties and married, and more likely to live in a Southern or Western state. Women are more likely to be green homeowners than men.
- 63 percent report lower operating and maintenance costs as the key motivation behind buying a green home. Nearly 50 percent said they are motivated by environmental concerns and their family's health.
- More than 60 percent of those surveyed say that consumer awareness, additional costs, and the limited availability of homes are obstacles to green homes gaining a bigger market share. However, when looking at the "biggest" obstacles, green homeowners view education as the biggest hurdle to overcome.

Researchers sent the survey to 450,000 homeowners, 115,000 (or 26%) of whom responded.

Survey results will be published this summer in the next issue of the McGraw-Hill Construction SmartMarket Report series and will be available at www.builderbooks.com. The next NAHB National Green Building Conference will be held in New Orleans, Louisiana, from May 11-13, 2008.





ADVERTISERS INDEX

This building in Nice makes uses roll-down exterior shutters to block direct beam sunlight in the summer, but because their insulating value is only about an R-1, they provide little energy savings in winter.

Larry Kinney

Windows and Insulating Shutters

BY LARRY KINNEY

Windows are wonderful devices—they connect us to the outdoors, provide natural light, and operable windows provide ventilation. But windows—particularly inefficient ones—are holes in the insulated envelope through which a great deal of energy can flow even when it's not in our interest. Energy flow from sunlight streaming in through windows in the winter can be part of the solution to heating our homes, but in the summer it's part of the problem. Compounding this, whenever the outside temperature is different from inside temperature, there are thermal flows due to conduction that increase with window area and the difference between inside and outside temperatures.

In short, windows often represent a major barrier to achieving very low energy use in buildings—yet they can be part of the solution. In a well-insulated and very tight home like Solar Harvest (see *Harvesting the Sun in Boulder*, page 14), which uses state-of-the art windows, nighttime heat loss in the winter from windows represent about 42% of the total heat loss of the home. These losses are offset to some extent by solar gains in the daytime—how much depends on solar availability, façade, and the solar energy transmitting characteristics of the window systems—but heat loss through windows remains significant.

In spite of the problems, great strides have been made in window technology over the last few years, and there is good reason for believing that appropriately designed window systems will soon become a full part of the solution year around. Outside insulating shutters are one of the solutions. However, to understand how and why requires a bit of background information.

RADIATION

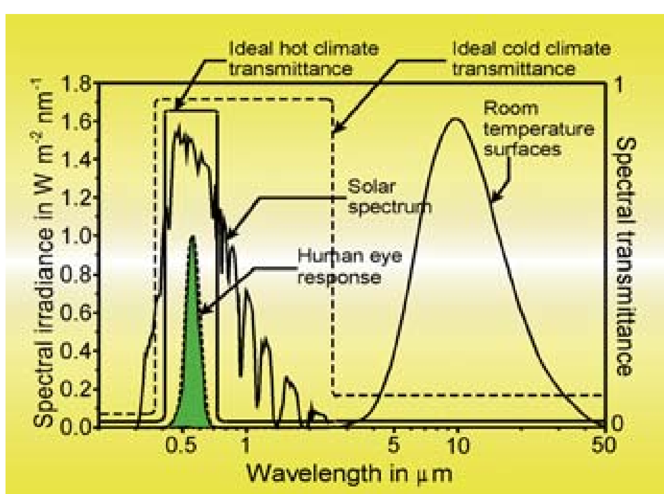
All objects in the universe radiate energy to all others. The hotter an object is, the greater the portion of radiant energy that comes from shorter wavelengths. The net amount of radiant energy that falls on our bodies depends on the apparent size, relative temperatures, and ability to emit and absorb radiation of both our bodies and the other objects. The sun is about 93 million miles away, but because it is a very good radiator and is very hot, it provides a great deal of the radiant energy we receive. Indeed, the sun enables life on earth.

Human eyes sense only a small portion of the radiant energy spectrum. Nonetheless, we can see a good half of the energy reaching our eyes from the sun, in what we call the visible spectrum. In addition, our skin can feel energy in the shorter wavelength ultraviolet (UV) and longer wavelength infrared (IR) portions of the spectrum that lie closest to the visible. Importantly, the glazing in modern windows can either pass or block solar radiation incident on them outside the visible portions of the spectrum, while still enabling most of the visible light to pass through.

Ideally, in summer our windows would block anything coming through the window except the light we can see, thereby reducing considerably the solar heat gain through the window. On cold winter days, however, just the opposite is true. We'd like our windows to let all of the sun's energy inside. It is difficult to make a window that works in both modes, so which kind of window you want depends on the climate you live in. In mostly cold climates, we want high solar gain windows and in hot climates we want low solar gain windows, and we'll even accept windows with reduced visible transmittance in especially hot areas, because this further reduces solar heat gain.

Here's how glazing designers achieve these two different window performance goals.

When sunlight passes through a window on its way to our bodies, the window



Ross McCluney, Ph.D., Florida Solar Energy Center

Radiation versus wavelength (μm=micrometers) reflects some of the energy, absorbs some, and transmits some. If the glass is lead free and clear, over 90% of the sun's energy in the visible portion of the spectrum passes through—along with a large portion of the energy in the UV and IR spectrums. However, it is possible to deposit on glazing layers a very thin coating that inhibits the transmission of certain wavelengths without having much effect on the others, a phenomenon called "specular selectivity."

As shown in the *Radiation Versus Wavelength* figure (page 44), it is now possible to substantially impede the transmission of much of the radiant energy from the sun in the IR and UV spectral regions, while allowing most of the visible light to be transmitted. The resulting window system would be a good choice in hot climates where solar gain must be removed by air conditioning for most of the year. Windows that allow lots of visible light to pass are said to have good visible transmittance (VT). Those that allow much of the full spectrum of solar radiation to pass through are said to have a high solar heat gain coefficient (SHGC). Windows in hot climates should have moderately high VT, but a relatively low SHGC. For example, it would generally be good to have the VT around 0.5 (50%) to 0.6 (60%) and the SHGC below 0.3 (30%).

Solar energy is concentrated in the visible and near IR portions of the spectrum where wavelengths are comparatively short and energy high. Our bodies (and other objects inside our homes) also radiate, but their energy is concentrated in the longer wavelength, lower energy portion of the IR spectrum. If a thin coat of special material is deposited on the outer face of the inner glass, it becomes highly reflective to these longer wavelengths. This warms the surface and makes the window more comfortable in winter. However, even with the coating, the glazing still allows most of the radiant energy in shorter wavelengths to pass unimpeded. As a result, we can see quite well and solar energy can come through the glazing, but radiant heat losses through windows from our bodies and the objects in the house are substantially reduced. Thus, low emissivity or "low-e" glass improves comfort and impedes radiant losses in the winter.

Of course, windows also lose energy by conduction and convection. Insulation performance in walls and ceilings, for example, is usually expressed as an R-value, which is a measure of the resistance to heat flow that occurs because of the temperature difference across the two sides of a surface. During cold weather, windows with high insulation values are significantly warmer on the inside surface than are windows with low insulation values.

The conductivity of window systems, the U-value, is the measure of choice in rating window systems. Under most circumstances, the lower the U-value, the better. The U-value is the reciprocal of R-value (U-value = 1/R-value) and is the rate of heat loss through a window *system* (which counts its frame) measured in Btu per hour per square foot per degree Fahrenheit (Btu/h-ft^2-°F). Unlike the ratings for insulation products, window U-values include the insulating effects of layers of air inside and outside.

Glass itself is a fairly good conductor of heat (a bad insulator), so its U-value is quite high (and R-value low). When part of a single-glazed window system, most of the R-value of the system results from the insulating still air layer immediately next to the pane on the inside and the not-so-still air space on the outside. Adding more layers of glazing (or suspended film) increases the number of insulating still air spaces. Substituting certain inert gasses for air in the spaces between layers lowers the U-value of the space even more. These gasses are more dense than air and provide greater insulation.

GLOSSARY

Glazing
A term used to describe the transparent or translucent material in a window, such as glass, plastic films, and coated glass.

R-Value
A measure of a material's ability to slow down or resist the transfer of heat energy, also called thermal resistance. The greater the R-value, the better the resistance, the better the insulation. R-values are the reciprocal of U-values.

Solar Heat Gain Coefficient (SHGC)
SHGC measures how well a window transmits solar energy, expressed as a fraction between 0 and 1. The lower the SHGC, the less solar energy the window transmits.

Specular selectivity
The property of specially-treated glazing materials to transmit certain wavelengths of radiant energy while reflecting or absorbing others.

U-Value
A measure of the rate at which heat flows or conducts through a building assembly (wall, floor, ceiling, etc.). Also know as heat transfer coefficient measured in Btu/hr/DT, where the DT term is the difference between one side and the other of the material in question in degrees F. The smaller the U-value is, the more energy-efficient the assembly, and the slower the heat transfer.

Visual Transmittance (VT)
The amount of visible light transmitted through a window system with respect to the amount of light that would flow through an unimpeded opening of the same size, measured as a percentage. VT values of clear single and double-glazed glass are typically 80% to 90%, whereas heavily tinted glass can have a VT of 10% or even lower. The VT of double-glazed, spectrally-selective glass is usually between 40% and 70%.

OPTIMIZING PERFORMANCE WITH SHUTTERS

In the last several decades, specularly-selective glazing systems along with low-conductivity window frames have improved window performance enormously. However, adding layers of glazing lowers the SHGC of a window.

If one lives where it's pretty hot all year around, this is a good thing. However, in a climate like Boulder's (and much of the rest of the U.S.), it's desirable to have high SHGCs on winter days to enhance solar gain, and low U-values to keep conductive losses low, particularly at night. Ideally, the SHGC would be low on summer days. However, it's just not technically feasible at the present to have both high and low SHGC in the same window, unless you consider movable exterior or interior shades or, still better, movable insulation.

An example of the latter is insulating shutters to cover window systems on winter nights and to shade windows from direct beam solar during summer days. On cooler days or when the sun is not shining directly on the window, the shutters can be moved out of the way, allowing good views and daylight.

The tradition of exterior shutters is thousands of years old in Europe, where a wide variety of shutters add charm to large and small buildings. Conventional shutters provide privacy, security, and shading, but since they are not designed for insulation, they do not help much to limit thermal losses through windows on cold nights. However, it is possible to design exterior insulating shutters that have both charm and high insulating values.

In cold weather, a major drawback of exterior insulating shutters is that to operate them one must open the window—not very appealing in the dead of winter. However, modern electronics make it possible to open and close the shutters wirelessly to optimize energy performance and comfort—while allowing users to override automatic functions if they like. Work is underway to increase the insulation and upgrade the electronics to enable wireless controls, while exploring variations appropriate for a wide variety of buildings and passive, active, and daylighting solar systems.

Meanwhile, I have done some computer-aided simulations of a range of window types with and without insulating shutters, from old fashioned single glazing with aluminum frames to double-glazed windows with different frames and low-e coatings to state-of-the-art windows with low-conductivity frames and specularly-selective glazings. In all cases, I assumed 100 square feet of glazing on each façade of a building with the U-values and SHGCs shown. For these simulations, I assumed that the insulating shutters would be closed at night in the winter, but open during the day even on cloudy days.

The system I modeled included a two-inch-thick shutter filled with urethane that is rated as R-15, but I assumed only R-13.5 for the simulation to be conservative. The software I used is called "RESFEN" (for residential fenestration) and computes energy gains and losses on an hour-by-hour basis versus solar and temperature conditions for a typical meteorological year in a variety of weather regions—in this case, Denver. It is available as a free download at http://windows.lbl.gov.

Here are the key characteristics of the systems I modeled:

Window System	**Without Shutter**		**With R-13.5 Shutter**	
	U-Value	**SHGC**	**U-Value**	**SHGC**
Single pane, aluminum frame	1.16	0.76	0.070	0.01
Double pane, thermally broken aluminum frame	0.63	0.62	0.066	0.01
Double pane, wood frame	0.47	0.62	0.064	0.01
Double pane, low-e, vinyl frame	0.37	0.38	0.062	0.01
Alpen TC88 Heat Mirror®, multi-layer, krypton fill, fiberglass frame	0.18	0.42	0.053	0.01
Alpen SC75 Heat Mirror®, multi-layer, krypton fill, fiberglass frame	0.16	0.19	0.051	0.01

Results are shown for **window energy alone** for a heating season in energy units of 100,000 Btu (therms).

Positive numbers represent energy losses in therms due to windows during the winter that must be made up from other sources, like a furnace, boiler, or even an active solar system. If the heating system uses natural gas, the numbers can be read as dollars or therms because a therm of gas costs about $1 in the Boulder area. Negative numbers represent contributions to help meet wintertime heating energy needs from the windows. These contributions can make up for losses from walls, ceilings, and air leakage, for example.

As expected, on an absolute energy savings basis, the addition of a shutter helps energy-inefficient windows much more than it does state-of-the art windows. In every case examined, the addition of a shutter brings the net energy used by windows to below zero, most substantially so. Interestingly, window systems with higher solar heat gain do better than those with lower SHGCs, even when their U-values are quite low. Thus, although the TC75 krypton system from Alpen has the best U-values because its SHGC is low, several other windows with higher SHGCs outperformed the low-SHGC Alpen system in cold climates in spite of having more moderate U-values. This is because of the very excellent solar conditions in our area and because the high insulating value of the shutters keep losses quite small on long winter nights. In areas where winter sunshine is a rarity, windows with the lowest U-value will outperform the others—especially if the design includes insulating shutters and they are closed at night. Of course, the TC88 Alpen system with a higher SHGC performs quite well.

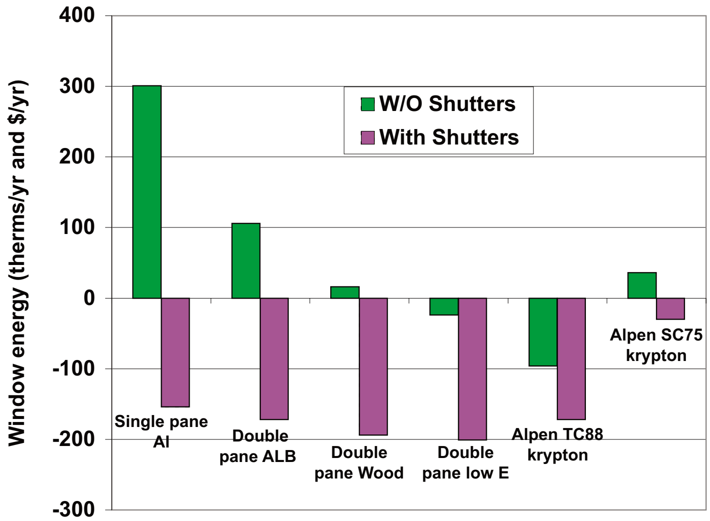
It is also useful to note that orientation of the windows systems make a big difference. The following graphs four of the systems on a façade-by-façade basis. As with the other cases modeled, each façade is assumed to have 100 square feet of window area that is not shaded.

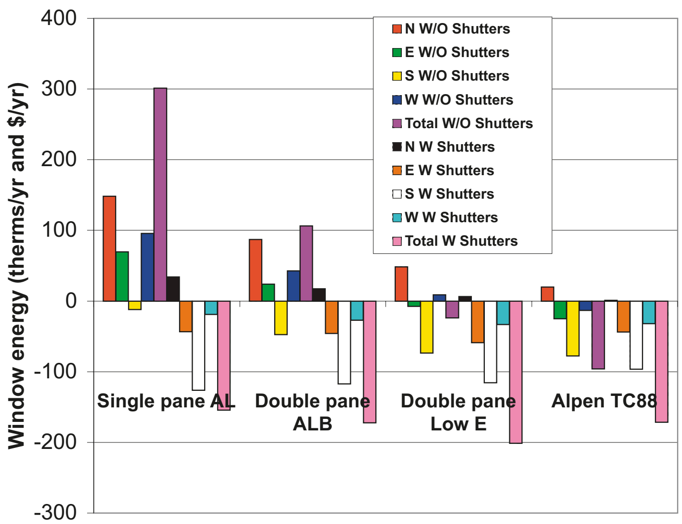
It is interesting to note that on the south façade, the single pane aluminum with shutters outperforms the other windows. This is because of its higher SHGC.

Full details of the modeling and a spreadsheet that looks at cooling as well as heating are available at www.bgbg.org/news/bgbj/Spring07_ShutterSavingsStudy.xls. As noted, the data from the simulation results shown above assume that there is no shading whatever. I ran the simulation for all window systems with more typical shading that simulates the presence of trees and adjacent buildings. These have the effect of lowering the SHGC by 20% in winter and 30% in summer. The result of the shading is that before-shutter and after-shutter energy use are both higher, but that energy and dollar savings due to the addition of the shutters remain almost identical.

In addition, the simulations showed something very important about cooling in climates like Boulder's, in which clear skies usually result in high temperature swings, typically 30°F or so on a daily basis. Thus if one can completely shade a window from direct beam solar, the energy demand associated with windows for cooling goes down to quite low values, even in a home with much less insulation than buildings designed for zero energy. The shade can be an overhang on the south, but it's important to do better on the other three sides to keep lower angle direct beam solar from causing discomfort. Movable insulation or shading outside of the envelope (before the sun can get inside) solves the problem nicely. Of course having a well-insulated building with plenty of thermal mass helps ensure comfort, as does opening windows or operating a whole house fan at night when outside air temperatures fall below indoor temperatures.

In the quest for zero energy buildings, sound building practices feature high levels of insulation, very tight envelopes, and heat recovery ventilation that maintains good indoor air quality while keeping energy demand in check. The addition of carefully-designed movable insulation to our buildings will substantially enhance their performance and comfort. It is time to enhance this ancient technology with some high-tech twists (superinsulation and the judicious use of low-cost electronics) that will improve energy performance many-fold while preserving ancient charm—or creating modern beauty.





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FOR MORE INFORMATION…

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www.fsec.ucf.edu

National Fenestration Rating Council
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RESFEN (for residential fenestration)
Computes energy gains and losses on an hour-by-hour basis versus solar and temperature conditions for a typical meteorological year. Free download at http://windows.lbl.gov

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