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.

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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

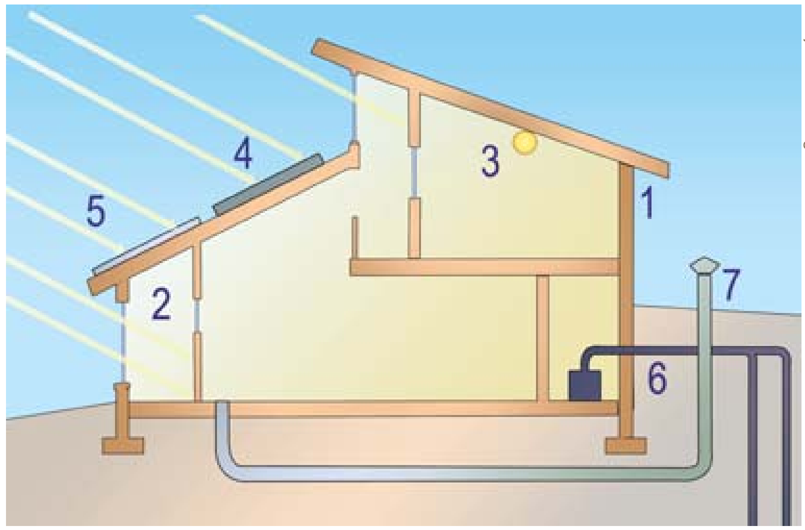
Because of good solar access, the units will take advantage of both active solar and passive solar. To retain the energy gained passively and release it when needed, the ceiling drywall will contain additional thermal mass. Geos' planners are also looking at phase change drywall, which has 4 times the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



Henry Mueller Design, Inc.

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.

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.

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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.*