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Modular Marvel

When it comes to LivingHomes' sustainable modular residences, being called "a big zero" is a plus

By: [Heather Beal](#)



The multiple decks and terraces of architect Ray Kappe's "exploded box" design expand living space by extending it outdoors. Drought-resistant native plantings add vibrancy while requiring little water or maintenance.

A winner in this year's Evergreen Awards in the Greenhouse category, LivingHomes' prototype for a line of sustainable modular homes has been called, among other things, "a big zero." While Steve Glenn, founder and CEO of the Santa Monica, Calif.-based company, likely considers this a compliment, his ultimate goal is to earn six zeroes: zero waste, zero carbon, zero emissions, zero energy, zero water, and zero ignorance.

In 2004, after 20 years as an entrepreneur, Glenn decided to make a change. "My first love was architecture," he says, "but I learned in college that I had neither the talent nor temperament to become an architect. I also realized developers are the ones who control what gets built. Jim Rouse, who developed real estate in an enlightened way, was my first professional role model. He felt it was his responsibility to do good work of social value. I decided the world needed more developers like Rouse and I wanted to be one of them."

Diving into development, Glenn found a way to live his values. The first LivingHome not only serves as a model of how well-designed, factory-built homes can minimize negative environmental impacts, but it also is Glenn's residence.

Glenn hired world renowned architect Ray Kappe of Los Angeles–based Kappe Architects/Planners to design LivingHomes' prototype. "Steve asked if I was interested in prefabrication since he planned to start a business," Kappe says. "I said I certainly was interested and ... told him I had designed a modular prefab in the early '60s." Although Kappe had decades of experience designing homes made from pre-cut pieces, Glenn was especially interested in using modules, factory-built volumetric sections. "One of the major benefits of modular prefabrication is that it shortens the construction period while maintaining a high-level of quality control," Glenn explains. Since the mechanical and electrical systems are roughed-in and most of the exterior cladding and interior finishes are added at the factory, fewer tasks need to be completed on-site.



LivingHomes' prototype features extensive use of glazing alongside state-of-the-art resource conservation measures and renewable energy technologies.

Striving for Six Zeroes

The LivingHomes' project team used a fully integrated approach to reduce the environmental impact of Glenn's 2,480-square-foot, four-bedroom house. In April 2006, 10 modules of 10,000 pounds each were trucked from a factory in Santa Fe Springs, Calif., to Santa Monica. It took the site crew eight hours to position and connect the modules. Construction waste for the modules was 10 percent of what a site-built home typically produces. Leaving the structural steel exposed and using the slab-on-grade foundation as flooring for the first level limited the need to add finishes. An existing sidewalk was broken into pieces and used for hardscapes throughout the site.

The designers chose natural, nontoxic, and sustainably manufactured materials such as cork flooring, low-to-no-VOC paints and sealants, countertops made from 100 percent post-consumer recycled newspapers, tiles made from recycled glass or porcelain, and concrete mixed with fly-ash. FSC-certified wood was used for exterior cladding and decking and for interior ceilings and millwork.

The design also facilitates adaptation over time. The bedrooms can be reconfigured, expanded, or subdivided by moving modular storage units and opening or closing sliding partition walls. Adding a floor plate and two wallplates transforms the mezzanine into a bedroom.

Kappe's expertise played a key role in accomplishing an attractive, well-insulated envelope. In 1975, a California state energy code limiting the use of glass prompted him to research the issue. Doing so, he found ways to use glass extensively by creatively combining glazing and passive-solar strategies. As a result, nearly three-quarters of the LivingHome prototype's envelope consists of high-performance, low-E glass. A translucent polycarbonate panel on the northeast façade has twice the R-value of the insulated glass and allows natural light to enter the adjacent space while preserving privacy. Recycled denim insulation and fiberglass batting with a high R-value insulate remaining wall sections and the roof.



A multipurpose space serves as an open loft in the prototype LivingHome. It can be outfitted with a couch for more casual use or converted into a fourth bedroom by adding two wall panels and a floor plate.

Abundant daylight permeates the home, and energy-efficient light fixtures, such as dimmable downlights that use LEDs and Energy Star-rated appliances reduce electrical demand. Sun studies and energy analyses helped the team optimize the location, size, and other qualities of the trellises and overhangs that provide shade during the summer while enabling solar heat gain in the winter.

Active solar technologies include a 2.4-kW rooftop solar array linked to a battery storage system that generates 60 percent to 75 percent of the home's electrical power. A solar water heater (also situated on the roof) serves the radiant floor heating and domestic water systems, and some of the solar panels double as awnings to shade roof decks.

Situated on a hilltop a mile from the ocean, the home's design capitalizes on Santa Monica's dry climate and ocean breezes. Natural ventilation cools the interiors. The floor-to-ceiling windows and sliding doors are operable and a whole-house fan aids convection by drawing hot air upward to a roof exhaust. Ventilation fans remove moisture from the bathrooms and carbon monoxide from the subterranean garage.



Kappe first began experimenting with glazing and passive-solar strategies in the 1970s to address a California state energy code limiting the use of glass. Using the strategies he developed in the years since, nearly three-

quarters of the LivingHomes' prototype's envelope consists of high-performance, low-E glass. The abundance of natural light reduces electrical demand.

A sophisticated irrigation system reuses graywater from the sinks, showers, dishwasher, and clothes washer, as well as stormwater diverted to a 3,500-gallon below-grade cistern. The collected water is pumped as needed to a surface irrigation system that uses Web-based weather telemetry to determine when to irrigate a rooftop garden and landscaped areas populated with native, drought-resistant plants. Plumbing fixtures include dual-flush toilets and low-flow faucets and showerheads.

The home is expected to achieve a yearly electricity and gas savings of 7,471 kWh and 295 therms, resulting in an annual cost that is \$1,378 less than a comparable, stick-built house that complies with the 2006 International Energy Conservation Code.

A Model for Modularity

To help ensure proper operations and maintenance, LivingHomes provides homeowner manuals and training sessions, and Glenn's home is available for tours and special events. A sustainability scorecard summarizes LEED points associated with standard prefab units and an interactive tool on LivingHomes.net allows prospective buyers to understand the financial and ecological costs of their housing choices. A resource monitoring system provides real-time performance data.

While the prototype achieved exemplary scores in all six of its target categories, some design decisions have been refined. "It made environmental sense for us to use the flat concrete pad as the floor for the main level to avoid redundancy in materials," Glenn says. "Unfortunately, this meant the first-floor modules didn't have the same structural integrity as the second-floor modules, which came with subfloors. So we had to add glass and millwork. Now all modules come with a subfloor."

In fall 2006, the prototype became the first single-family residence to earn Platinum certification from the LEED for Homes rating system. Evergreen Awards judge Dan Rockhill says the jury was especially impressed by the home's beauty and replicable sustainable attributes, noting: "This home achieved its explicit goals of minimizing negative impacts on the environment, the community, and the resident without compromising aesthetic quality."



Photovoltaics integrated into awnings and attached to trellises collect solar energy while helping provide shade.

Materials and Sources

Adhesives, coatings, sealants, paints, and finishes: AFM Safecoat, afmsafecoat.com

Appliances: Energy Star appliances by Bosch, bosch-home.com/us

Building management systems and services: Environmental Monitoring System by Lucid Design Group, luciddesigngroup.com

Ceilings: FSC cedar by Eco-Lumber Co-op, ecolumber.ca

Concrete: Local aggregate from San Gabriel mountains, 15 percent fly-ash

Fabrics: EcoVeil window shades by MechoShade, mechoshade.com

Flooring: Cork tiles by Natural Cork, naturalcork.com; Finished concrete with embedded fly-ash

Furniture: Design Within Reach, dwr.com

Glass and Glazing: Solarban 60, low-E glass by Pilkington, pilkington.com; Polycarbonate glazing by Polygal, polygal.com



Floor-to-ceiling windows and movable walls provide the master bedroom “peninsula” with views of exterior decks on two sides and interior core living areas on a third.

HVAC: Evacuated tube solar hot water collector by Apricus, apricus.com

Radiant and solar hot-water collection design and install: Jacob Gooze, ACME Environmental, In-floor radiant heating system

Insulation: Ultratouch recycled denim by Bonded Logic, bondedlogic.com; Blown-in cellulose by Green Fiber, greenfiber.com; Low-VOC encapsulated fiberglass by John Mansville, jm.com

Lighting: Recessed LEDs by Permlight, permlight.com; Compact fluorescent lights by Artemide, artemide.us

Metal: Stainless steel railings by AGS Stainless, agsstainless.com

Millwork: Fabrication and installation by 100 X Better; Low-VOC FSC Europly by Columbia Forest Products, columbiaforestproducts.com

Pavers: Recycled concrete sidewalks

Photovoltaics: 2.4-kW photovoltaic system with gridpoint inverter and battery backup, installed by PermaCity, permacity.com; manufactured by Schott Solar, us.schott.com/photovoltaic/english

Plumbing and water systems: PEX piping in place of copper; Low-flow showerheads by Bricor, bricor.com; Low-flow plumbing and dual flush toilets by Kohler, kohler.com

Roofing: Carlisle-syntac, 60-ml TPO

Green roof irrigation: Jonas Sipaila, Rehbein Environmental Solutions, rehbeinsolutions.com

Tigerwood decking: Environmental Home Center, environmentalhomecenter.com

Siding: FSC Western Red Cedar by Eco-Lumber Co-op

Fencing: Trex, trex.com

Wallcoverings: Eco-Gres Asia recycled porcelain tile by Coverings Etc., coveringsetc.com; Recycled glass tiles by Oceanside Glasstile, glasstile.com

Walls: 2x6 walls

Windows, curtainwalls, doors: Low-E insulated, Solarban 60 glass windows and sliders by Fleetwood, fleetwoodusa.com

Green Team

Architect: Kappe Architects/Planners; LivingHomes, livinghomes.net

Interior designer: Heidi Toll Design, heiditolldesign.com

Client/owner: Steve Glenn, LivingHomes

Project manager: Daniel Cunningham, LivingHomes

Structural engineer: Reiss-Brown-Ekmekji, rbee.net

Module fabricator: Profile Structures, profilestructures.com

General contractor/site work: Hinerfeld-Ward, hinerfeld-ward.com

Landscape designer: Rich Grigsby, The Great Outdoors Landscape Design and Construction, greatoutdoorslandscapedesigns.com

Graywater and rainwater system designer: Bill Wilson

Environmental Planning, green consultant, LEED consultant and/or life-cycle performance partner: Ann Edminster, Design AVEnues, designavenues.net

Energy Consultant: Davis Energy Group, davisenergy.com

Photographs: C.J. Berg Photographics, cjbergphoto.com; Sunshine Divis Photography, sunshinedivis.com; Grant Mudford, grantmudford.com

Heather Beal writes about architecture and sustainability from Edina, Minn.