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Beyond the Box

Modern Modular is Going Green

with Claire Anderson



Prefab homebuilding is undergoing a revival, but it's nothing like its predecessors. In its new incarnation, "green" prefab promises an efficient way of building a high-quality, energy-conserving home with smart, earth-friendly materials.



Architect Michelle Kaufmann's foray into the world of prefabricated homes was purely practical. In 2001, she and her husband, builder Kevin Cullen, began searching for a modest home in the overinflated San Francisco Bay area real estate market. After six months of being unable to find an affordable, energy-efficient, eco-friendly home, they decided they needed a new approach—create their own.

They purchased a lot in a semi-rural town in Marin County, California, and worked to complete their green design—a home that would use less water, energy, and materials than a conventionally constructed home.

Photos: Michelle Kaufmann Designs' prefab Glidehouse.



Courtesy John Swain & www.mkd-arc.com (2)

The result is a three-bedroom, 1,560-square-foot home designed for function and tailored to the climate. Strategically placed dual-paned windows and doors throughout maximize cross-ventilation and natural lighting while minimizing the need for artificial lighting and mechanical climate control. Exterior gliding wood shades help mitigate heat gain from the hot summer sun, while maintaining ventilation. The sloped roof of their "Glidehouse" facilitates hot air inside the home to move up and out of the house through small, operable clerestory windows. Oriented south, the roof also accommodates a 4.5-kilowatt solar-electric array. Inside the house, energy-saving LED and compact fluorescent lighting, and Energy Star appliances, help keep energy use low. Durable, low-maintenance materials, such as composite concrete countertops and weathering steel siding (alloyed for weather resistance by creating a thin rust sheen), were used inside and out.

Photos: Michelle Kaufmann Designs' newest modular, the Smart Home, is a model of green building and energy efficiency.



Navigating the Building Lexicon

Kit home—Kit homes, which include log homes, domes, and timber-frame homes, are typically assembled at the home site, either by an experienced owner-builder or a contractor. They usually include only the exterior shell of the house, and require further construction and carpentry for completion.

Panelized home—Wall, roof, and floor sections/panels are manufactured in a factory, which offers the advantages of better oversight over material quality and waste reduction, and more control over costs. Structural insulated panels (SIPs), which can be fabricated and customized at the factory, then assembled at the building site, are one example of panelized construction.

Manufactured home—Built on a trailer chassis and manufactured off-site using lightweight metal framing, these homes are considered portable and temporary structures. Little to no on-site labor is required. In 1994, the U.S. government revised the Housing and Urban Development building code to include higher standards for manufactured homes' mechanical systems, structural design, fire safety, and energy efficiency. Prior to 1976, these structures were known as "mobile homes."

Stick-built home—A home built using conventional framing methods entirely on-site.

Modular/Prefabricated home—Skilled factory workers assemble complete building "modules" off-site. Once complete, they are transported by truck, ferry, or train to the building site, where the modules are set onto a site-built foundation. Most modular homes require some finish work, such as tying the individual modules together and connecting wiring and plumbing. Modular homes have similar characteristics to site-built homes and must pass the same code requirements.



Intrigued by their unique home construction project, friends and colleagues asked how they could have modern, green houses too. "People are desperately trying to find healthy, green, efficient homes for their families," says Michelle. "However, the information and solutions are not always easy to find. People are uncertain of what to do and the best way to do it. People are busy, have budgets, and want simplicity. Where were the easy, affordable green solutions?"

Efficient Homes with Mass Appeal

When Michelle and Kevin were searching for a place to live, green home options were limited—and expensive. After their home-building experience, Michelle made it her professional goal to "marry good design with minimal environmental impact, and create 'green' homes that could be widely available." She says that translated into "creating a prepackaged solution using the principles of mass production combined with sensible, uncomplicated floor and roof plans, eco-friendly materials, and low-energy options."

Prefab, modern, and "green" models include (clockwise from top left): Alchemy Architects' weeHouses: two-story and cabin; Eco-Infill; B-Line Medium from Hive Modular; and Ideabox.



Pushing the Envelope on Green Prefab

For many people, the word "prefab" suggests standardized structures with little pizzazz—functional, but unlikely to garner a second glance. That's far from the case with today's modern, green modulars: a diverse array of attractive, durable, eco-friendly products are being combined to create unique, livable, high-performance homes that fit the landscape.

Most prefab designs lend themselves to some modification so customers can customize a plan to accommodate a challenging building site, change window placement for better solar gain, or even add an office annex.

Here are some of the companies across the country that are pushing the envelope on green prefab.

	Alchemy Architects Minneapolis, MN	Blu Homes Boston, MA	Eco-Infill Denver, CO	Hive Modular Minneapolis, MN	Ideabox Salem, OR	pieceHomes Los Angeles, CA	Michelle Kaufmann Designs Oakland, CA
Web site	www.alchemyarchitects.com	www.bluhomes.com	www.eco-infill.com	www.hivemodular.com	www.ideabox.us	www.piecehomes.com	www.mkd-arc.com
Location of factory	Various factory partners	West & Northeast	Denver, CO	Various factory partners	Various factory partners	Various factory partners	Various factory partners
Footprint (sq. ft.)	345-2,090	450-1,700	375+	1,000-2,500	400-1,500; + 215 s.f. cubes	320-2,500	700-2,820
Multiple floors avail.	3	2	4	4	1	4	3
Avg. time to complete in factory (months)	2-3	1-1.5	1.5-2	3	2	1-4	2-5
Avg. cost to complete setup on site	Varies; site-dependent	35% of total project costs	Varies; site-dependent	\$90 / sq. ft.	Varies; site-dependent	Varies; site-dependent	Varies; site-dependent
Wall construction	2 x 6; SIPs option	2 x 6	2 x 6; SIPs option	2 x 6	2 x 6	2 x 4 or 2 x 6	2 x 6
FSC-certified lumber	Option	Option	Option	Yes	Yes	Option	Yes
Wall insulation	R-19	R-21+; open-cell foam	R-21+; fiberglass batt	R-21; high-density fiberglass batt	R-21	R-13 or R-21; fiberglass batt	R-22.5; open-cell foam (Icynene)
Floor insulation	R-35	R-30 to R-38; spray foam	N/A, basement or crawl space	N/A, basement or crawl space	R-38	R-30	R-32; closed-cell foam
Roof / ceiling insulation	R-44	R-35 to R-48; open-cell foam	R-38+; fiberglass batt	R-50; loose-fill fiberglass	R-40; cellulose	R-33+	R-30 to R-34; open-cell foam
Roofing	EDPM (white or black)	TPO membrane; living roof option; standing-seam metal	Metal, composite; living roof option	EDPM or white Durolast; living roof option	Standing seam metal	EDPM; living roof option	Standing seam metal
Passive solar	Option	Yes	Option	Yes	Option	Yes	Option
Low-flow shower heads (<2.0 gpm)	Option	Yes	Yes	Yes	Yes	Yes	Yes
Low-flow faucets (<1.5 gpm)	Option	Yes	Yes	Option	Yes	Yes	Yes
Low-flush toilets (<1.6 gpf)	Option	Yes	Yes	Option	No	Yes	Yes
Dual-flush toilets (<1.6 gpf / <0.9 gpf)	Option	Yes	Option	Preferred standard	Yes	Option	Option
LED lighting / fixtures	Option	Yes	Option	Option	Option	Option	Option
CFL fixtures	Option	Yes	Option	Option	Yes	Yes	Yes
Energy Star appliances	Yes	Yes	Option	Option	Yes	Yes	Option
Windows	Wood or vinyl; Energy Star	Vinyl or wood; Energy Star	Vinyl, aluminum, or fiberglass-clad; Energy Star	Wood-aluminum; Energy Star	Vinyl; Energy Star	Frame depends on location; Energy Star	Wood/aluminum; Energy Star
PV / SHW system-ready (wiring & plumbing runs in place)	Option	Option	Optional PV, factory installed	Option	Optional PV, factory installed	Option; all models prepped for PV & SHW	Option
Avg. price per sq. ft.	\$117-228	\$135-175, fully installed	\$150-\$200	\$75-165	\$100	\$225	\$250-300
Independent certification	Available	Energy Star; LEED, NAHB, Built Green avail.	LEED; Built Green	Energy Star; LEED; Built Green Canada	Energy Star; NEEM; Earth Advantage	Built Green standard, min.; LEED avail.	Energy Star & American Lung Assoc. Health House

A Small, Sustainable Footprint



This 725-square-foot residence's sustainable elements—a small building footprint, living roof, water catchment system, and recycled building materials—combine for high performance and low energy bills. A living roof and spray-foam insulation in the walls minimize energy losses due to air infiltration and conduction through the building frame, while a 1.7 kW PV array provides pollution-free electricity. Well-placed windows allow ample natural light to permeate the home, reducing the need for artificial lighting during daylight hours, while LED lighting fixtures maximize energy efficiency at night. Water-saving fixtures include low-flow showerheads and faucets, and a dual-flush toilet, as well as a greywater recycling system. As a result, the mkLotus exceeds California's GreenPoint rating system, an independent certification sponsored by the nonprofit Build It Green, by 300%.

"I soon realized I would have to start thinking less like an architect and more like a product designer," says Michelle. "I began researching mass production and working on parallel tracks. Although we had used structural insulated panels (SIPs) in our home's construction, I also researched how a factory could make the walls and roof, and how to calculate maximum dimensions for shipping a home module on flatbed trucks."

Michelle's persistence paid off when she found a prefab factory willing to give her a chance. The Kaufmann-Cullen home had taken 14 months to construct at a cost of \$197 per square foot. The factory built an identical Glidehouse in less than one-third of that time for \$40 less per square foot. Since then, Michelle has built 33 prefab homes for clients ranging from young, urban families to rural retirees. But those aren't the most impressive numbers. She estimates that compared to

conventionally constructed homes, these 33 homes together provide an energy savings of 1,934,000 kBtus per year, a water savings of 3,251,920 gallons per year, and annually save 594,000 pounds of carbon dioxide from being emitted.

Modern Modular Goes Mainstream

Michelle is not alone in her quest to bring modern, green homes to mainstream markets. In the past few years, several architectural firms have started to green their scenes (see "Pushing the Envelope" sidebar).

While their design approaches may vary, the primary goal of green modern prefabs remains the same: reduce a home's environmental impact by maximizing energy efficiency, reducing water use, and using eco-friendly materials, while making it a healthy, comfortable space for its occupants.

"The opportunity to do better seems extraordinary," says Bill Haney, president of the Boston-based prefab design company, Blu Homes. "Other countries do better. The average footprint and the amount of space and energy costs for the average family of the same income in Europe is dramatically lower. Other countries make a lot of their housing in factories, so they are able to use fewer materials and be much more efficient—so they don't have big waste. In Finland, about 70% of the houses are built in factories before they get to the site. In the United States, it's more like 0.7%."

The Sunset Breezhouse, codesigned by Kaufmann and Sunset magazine, blurs the line between inside and outside living.



Point & Counterpoint:

The Cost of Going Green & Prefab

Does prefabrication make green houses more affordable? BuildingGreen associate editor Allyson Wendt asked this question in 2007 when she was working on a feature article on the topic. Back then, the answer was "not quite yet." Here's what she has to say today.

More than a year later, the answer still seems to be "not quite yet," at least according to Chad Ludeman, developer of the 100K house in Philadelphia, in an article on the green building blog, www.jetsongreen.com.

He argues that most of the modernist houses could be site-built for less money; that overengineering in the prefab industry makes the less-waste argument specious; that long waiting lists for prefab homes make time savings irrelevant; and the green aspects of prefab rest largely on the "no waste" element.

Ludeman's arguments are good ones, especially as the majority of the industry stands right now. If green features—superinsulation, benign materials and finishes, and energy- and water-efficient appliances and fixtures—aren't standard, prefabrication doesn't offer many cost benefits over site-built homes, since prefabrication depends on volume to realize its claimed benefits. Most companies producing modernist, green, or modernist-green prefabs are still small and don't yet have enough volume to significantly lower material and labor costs. For larger companies, green features mean modifications to their stock plans, which means extra expense.

Ludeman suggests a semi-custom approach with prefabricated components and custom, local finishing—an approach many production builders already use for large developments. Adjusting this approach for infill development would be a great idea. There are several companies out there that mix and match prefabricated components in custom and semi-custom structures.

However, environmentally speaking, the jury is still out, and the potential benefits of prefab green (worker transportation, site impacts, etc.) go far beyond the waste reductions.

Unlike Ludeman, I'm not ready to give up on prefabrication just yet. I still think there's promise in the idea of prefabricated green, especially in the mainstream and affordable housing markets. As for green modernist housing, the benefits of prefabrication may never come through for such a relatively small market.

As an industry insider in the modular home business, Blu Homes' Maura McCarthy says she agrees that conventional prefab companies are not outperforming site-built homes. But, she points out, smart prefab companies have the opportunity to do a lot better.

"If you take the scale efficiencies of manufactured homes, and introduce products like spray foam insulation," says McCarthy, "all of a sudden you are providing spray foam at half the cost of spray foam provided on-site by a skilled subcontractor. This kind of 'scale' logic also holds true for a number of other functions, like the fabrication of countertops made of new, green materials, prefab components like kitchen/bath/utility pods, etc. Moreover, prefab companies have more possibility for innovation given their indoor facilities and opportunity to do research on new technologies."

As for the waste issue, she fully disagrees that the waste in prefab building is comparable to that for site-built homes. "My experience is that most prefab companies produce at least 50% less waste than normal construction. And although you can certainly hire someone to come and haul away the huge garbage bins of waste that you see at every single site-built construction site, the amount of waste in factory versus site-built homes is just not comparable. There are a host of reasons for this, including precise volume purchasing by factories, better storage areas (i.e., not out in the rain) that keep materials protected, and so on. Prefab manufacturers may have gotten a few things wrong, but less waste is not one of them in my opinion."

She thinks that Ludeman makes many of the right points and criticisms of existing prefab companies, but believes these criticisms are of a very nascent industry—that is, the modern prefab homes industry—which needs to break away from its older brother, the modular homes industry.

"With a new U.S. administration that values 'greener' technologies, American consumers who are not only much better educated on the carbon footprint of their homes, but more demanding about the convenience with which their homes are delivered, coupled with the current housing crisis that is wiping out many of the low performers," says McCarthy, "the macro trends toward more green prefab seem positive."

Courtesy JB Spector & www.mkd-arc.com (3)





Modern prefab designs offer all the desired conveniences with style and efficiency.

Prefab proponents say that one of the main advantages of prefab over kit, panel, or site-built homes is the amount of work done off-site. Most of the home is factory built, from the shell down to the kitchen cabinetry and even lighting fixtures, allowing predictable time and cost estimates while maintaining quality. By decreasing on-site work and increasing factory assembly, prefab home providers say they have greater control over the quality, schedule, and cost of construction.

What's in a Name?

Several home-rating programs today are helping consumers cut through the confusion of what is and what isn't green. Most familiar is the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) for Homes. Established in 2007, this program establishes independent, third-party verification that a project meets criteria for a set of stringent green-building standards spread over 35 different categories. According to the USGBC, the benefits of a LEED home include lower energy and water bills; reduced greenhouse gas emissions; and less exposure to mold, mildew and other indoor toxins.

Through a strategic partnership with the National Association of Home Builders, the nonprofit Green Building Initiative has unveiled their Green Globes rating classification as an alternative to the LEED system. This certification program integrates a comprehensive environmental assessment protocol, software tools, and qualified assessors with green building expertise.

Local green building programs can be even more applicable, since they can address regional differences. In California, the nonprofit Build It Green has established their GreenPoint rating system, which grades homes on five categories: energy efficiency, resource conservation, indoor air quality, water conservation, and community.

Because the site work and home construction can happen simultaneously, the overall construction schedule for modular homes can be shortened, and homes can often go up in a hurry. Besides offering potential time-savings, says Kaufmann, building in a factory nearly eliminates the uncertainties of scheduling that often plague traditional building projects, such as delays or damage due to weather.

Blu Homes is focused on making site work quicker and more efficient. "We really feel that customers suffer when they have site-cost overruns," says Blu Homes' Maura McCarthy. "Pier foundations, for instance, can save between \$8,000 and \$15,000 compared to conventional foundations, and also have positive benefits in terms of the environment, since the site is disturbed less and less material is needed for the foundation." In some cases, McCarthy says, a hydraulic truck can be used instead of a crane to place the modules, which offers both savings and less disruption to the site. Blu Homes is also looking at ways to ship "more house on less truck" to minimize shipping costs and fuel use for transportation.

Details & Design

Modular homes all meet local and national building codes, but also can exceed them. Because they have to withstand the rigors of shipping and, possibly, being crane-lifted into place, modulars are typically built with more framing and strapping details to maintain their building integrity. According to Kaufmann, the additional materials for that extra strength can be offset many times over by the savings in construction waste achieved by prefabrication. Critics of prefab take issue with the "less waste" argument, considering that, in some areas, waste removal companies are available that will pick up on-site construction materials for recycling, making the comparison moot.

Jason Pelletier, founder of the eco-home improvement site Low Impact Living, says that a distinct advantage of prefab construction is that "hard-to-find green materials can be bought in bulk and used for many projects, minimizing delays and ensuring that no shortcuts are taken due to unavailable materials." He points out that the opportunity for "bulk purchasing and the delivery of a small number of completed modules to the home site can dramatically reduce pollution from transportation to and from the site."

McCarthy says that "there's absolutely no doubt that you get efficiency of scale with large purchases or large products, and having them shipped to a factory," and that using local factories to put together homes "reduces the amount of travel and shipping costs." But, she says, focusing on the home's embodied energy doesn't give a true picture of the more important aspect—its performance over time. "When you look at a home's embodied energy compared to its 50-year life-cycle cost, it's minuscule. Over a home's lifetime, the energy it consumes could be 30 to 50 times its embodied energy."

Efficiency & Energy

Up-front affordability has always been the bane of modern homes, whether customized or prefab, and, many say, the jury is still out on whether prefab can bring modern to the mainstream (see "Cost of Going Green & Prefab" sidebar). But others argue that the more important consideration is long-term costs.

"If you're the average family, you're figuring out what mortgage payment you can make, and insurance is probably calculated into that mortgage payment, and probably property taxes are calculated into that," says Haney. "Maintenance costs? That's your own nickel. And energy? You're all on your own. We're trying to refocus the questions: What would it take to buy a house? How long will it be on site? What will it cost to operate it?"

Blu Homes puts their prefab designs through off-the-shelf and proprietary modeling software to get detailed estimates on how they will perform in various climates, and works with clients to tailor the envelope—insulation, framing, and window placement—to their specific climate and needs. "Just like you can find out a car's fuel economy before you buy it, we think people should have a sense of 'gas mileage' for their homes before they buy," McCarthy says.

Kaufmann agrees. "To avoid repeating the dire situation so many homeowners are in today, it is critical that our thinking evolve around home costs," she says. "Once we start to equate monthly costs with the true costs of a home, the positive impact will reverberate among homeowners, who will be less likely to find themselves living in homes they cannot afford and more likely to choose green homes, which are often more affordable in the long term."

Premiums, Prefabs & A Greener Future

In 2005, green homes made up just 2% of the market—but in 2008, they were expected to account for anywhere from

6% to 10%. By 2012, that market share is expected to jump to between 12% and 20%. Yet U.S. builders cite "consumer willingness to pay" as the second largest obstacle affecting green home-building growth, and say that the higher up-front costs of the "green premiums" attached to sustainably designed homes is a barrier to green building's expansion into the mainstream. However, what people are realizing is that, spread out over the terms of a 15- or 30-year mortgage, these higher up-front costs can be easily absorbed and offset by lower utility bills and, to varying degrees, lower maintenance costs and higher tax deductions.

"If we can come up with a system that is more affordable for the average family to live in, is better for the natural world, is more healthful for them and their children—I think that's the kind of thing the average family is looking for," says Haney. "Working with the Massachusetts Institute of Technology and others on energy modeling software has convinced us that it's not that hard to do."

Access

Managing editor Claire Anderson (claire.anderson@homepower.com) spends her spare time poring over green home designs and trying to master SketchUp.

Recommended Reading:

Prefab Green by Michelle Kaufmann & Cathy Remick (Gibbs Smith, 2009)

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